
OPTIMIZING AIRSPACE SYSTEM CAPACITY THROUGH A SMALL AIRCRAFT TRANSPORTATION SYSTEM: AN ANALYSIS OF ECONOMIC AND OPERATIONAL CONSIDERATIONS

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ABSTRACT

America's air transport system is currently faced with two equally important dilemmas. First, congestion and delays associated with the overburdened hub and spoke system will continue to worsen unless dramatic changes are made in the way air transportation services are provided. Second, many communities and various regions of the country have not benefited from the air transport system, which tends to focus its attention on major population centers. An emerging solution to both problems is a Small Aircraft Transportation System (SATS), which will utilize a new generation of advanced small aircraft to provide air transport services to those citizens who are poorly served by the hub and spoke system and those citizens who are not served at all. Using new innovations in navigation, communication, and propulsion technologies, these aircraft will enable users to safely and reliably access the over 5,000 general aviation landing facilities around the United States. A small aircraft transportation system holds the potential to revolutionize the way Americans travel and to greatly enhance the use of air transport as an economic development tool in rural and isolated communities across the nation.

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INTRODUCTION

For all the benefits of the hub and spoke system that evolved in the United States after deregulation and throughout the world as air carriers recognized the system's efficiencies, there are some serious social and economic implications for communities unable to take full advantage of the system. Small, rural, and otherwise isolated communities struggle to maintain air service as air carriers pursue their rational commercial interests and concentrate their activities in larger markets and strategically defined route networks. With changes in the way society and the economy function, air service has become even more important for future growth and development.

This paper examines the plight of small and rural communities in the U.S. and briefly examines some of the current policies for alleviating the negative impact of the hub and spoke system. Finding these political solutions lacking for a variety of reasons, the paper examines the Small Aircraft Transportation System (SATS) as a technological solution emerging from cooperative work between government, industry, and academia. An important point about this solution is that it does not argue for the elimination of the hub and spoke system for long haul air carrier operations. In fact, SATS should alleviate some of the pressure on capacity-constrained hub airports by optimizing the use of non-hub and general aviation airports. Moreover, SATS promises to bring reliable cost-effective air service to communities that have been marginalized by the hub and spoke system without altering the way in which air carriers conduct their business. The needs of rural and isolated communities can be addressed without political arm-twisting or "re-regulation" of the airlines. These needs can be addressed without costly subsidization of regional carriers who would otherwise not serve these low-demand communities. SATS offers a rare opportunity for government and industry to work together to efficiently meet the political and social needs of the nation's small communities and rural areas.

The balance of the paper examines the need for SATS through an analysis of recent trends in air transport, the economy, and society more generally. The discussion focuses on the inherent problems of the hub and spoke system, the emergence of the information or digital economy, and important social and demographic trends that will determine the demand for transportation services in the future. Once the problem is defined, the paper explores conventional political solutions and examines the difficulties associated with such efforts. The paper then details the SATS concept and examines the potential for SATS to improve air transport services in small and rural communities in the U.S. Finally, the paper

assesses the exportability of SATS to other parts of the world where alternatives to hub and spoke are attractive and in other places where any form of reliable and efficient air transport services would be welcomed.

HUB AND SPOKE

The hub and spoke system that emerged following regulatory reform of the airline industry in the U.S. has been a double-edged sword for the industry and the nation. Hub and spoke provides efficiencies that are unavailable in point-to-point and other route network systems (Hanlon, 1996; Gialoretto, 1988). The ability of carriers to consolidate operations, better coordinate vast route networks, and control hub airports has benefited both the carriers and the communities that host hub airports (Button, Lall, Stough & Trice, 1999). Unfortunately, hub and spoke is not without its problems and these problems are becoming increasingly clear. Hub airports throughout the U.S. are rapidly reaching capacity. According to the National Civil Aviation Review Commission (NCARC, 1997) the nation's aviation system is quickly heading towards gridlock (NCARC, see also Long et al., 1999 and Donohue, 1999). In 1999, approximately 680 million passengers boarded airplanes in this country (USDOT, 2000). The capacity for our hub-and-spoke system is estimated at one billion boardings, and at the forecasted growth rate in the United States we will reach that capacity somewhere between 2005 and 2010 (FAA, 1998). By 2020, the demand for boardings will approach 1.5 billion if enough additional capacity can be developed in time (NCARC, 1997).

"Traffic data and trends indicate that adding just a few minutes of delay to each airline flight in the United States will bring the aviation system to gridlock with dramatic negative impacts on the economy" (NCARC, p. I-2). It can cost \$1 billion to build a single new runway and as much as \$10 billion to build a new airport. With an average lead-time of ten years between conception and construction, it is unlikely that we will be able to generate the infrastructure needed to keep pace with demand (U.S. GAO, 1997).

Some improvements include possibly squeezing the maximum capacity from what we already have through annual maintenance, better management, increased use of intelligent transportation innovations, and cost-effective improvements in capacity (Hansen, 2000). Even if it were politically and socially possible to augment the current system through 24-hour operations, the use of super jumbo jets, more regional jets, free flight, aggressively reducing aircraft separation requirements, and completing the few new runways currently planned, the system would still be overwhelmed. The problem, however, is that even many of these solutions are not practical in the current or foreseeable future.

The concept of 24-hour operations ignores both the demands of the consumer for convenient flight schedules and the demands of airport communities for quiet evenings. The use of super jumbos will depend on the commercial strategies of air carriers and the willingness and ability of airports to make necessary infrastructure improvements to handle these enormous aircraft. More regional jets might help, but only if these smaller aircraft begin to avoid hubs and fly more point-to-point routes. Free flight and reduced separation will allow for more efficient use of airspace, but both require technological developments and cultural changes within the air traffic control community that are slow in coming (see Aviation Foundation, 1996). Moreover, even if airspace issues can be addressed successfully, problems remain on the ground where aircraft interface with other parts of the intermodal system. Unfortunately, the prospect of new runways and new airports diminishes in the face of huge costs, environmental concerns, and intransigence by air carriers who loudly voice their fears about bearing the brunt of the costs.

More importantly, though, for the purposes of this analysis, squeezing these improvements out of hub and spoke would not adequately address the long-term needs of air transport or the specific needs of the communities that are ignored by the present system. The system needs a solution that both helps to alleviate the current and future pressure on system capacity and brings air transport services directly to more areas of the country.

Current efforts to address the latter issue are problematic because they rely on government to restructure the market to provide air transport services to communities that are not served in the hub and spoke system. While there is demand for air transport in these communities, the demand is not sufficient to attract the attention of air carriers who are seeking to maximize revenues with traditional business plans (USDOT, 1998a). Regional jets are unlikely to serve the interests of these communities since these aircraft are larger and require infrastructure that is often unavailable. As hubs get more crowded, pressure will increase to utilize larger aircraft and fewer flights. This is the case in San Francisco, where the airport has requested that United Airlines fly fewer regional or commuter aircraft into the busy airport.

Since the air carriers are continuing to move away from small communities, political leaders have taken initiatives to preserve or enhance air transport services through legislation. Since deregulation some small communities have relied on the Essential Air Service program to preserve their air service (USDOT, 1998b). This subsidy program uses tax dollars to subsidize air transport services to communities with load factors that are too low to attract purely commercial service. According to the U.S. Department of Transportation, the EAS will cost over \$30 million this year

and provides twice a day turbo-prop service between 77 small communities and hub airports. Unfortunately, preserving air services in this manner is costly and not necessarily effective in meeting the real needs of the community. More recently, some states have embarked on their own efforts to secure or enhance air transport services. Maryland is initiating a subsidy program to enhance air service between a number of small airports and Baltimore Washington International (Maryland DOT, 2000). New York has also embarked on a subsidy program that will, according to the schemes' proponents, deliver badly needed air services to rural and small communities in the state (State Budget, 2000).

In the end, such schemes are problematic. On a financial level, the services provided are expensive. The operation of 19-seat aircraft on routes that only provide 25 percent load factors is an obvious waste of money. Unfortunately, the way the air carrier industry is structured, both commercially and in terms of regulations, these aircraft are typically the smallest equipment that can be used. The use of such aircraft raises additional concerns such as passenger perceptions about small propeller-driven aircraft. Passengers may forego flights on these aircraft even if the service is provided because of unpleasant experiences on such aircraft or perceptions about safety and comfort. These aircraft are also more prone to cancellation due to weather than their larger jet counterparts. Travelers who rely on the small aircraft to take them to a hub to make connections to flights on major airlines discover that the regional leg of their journey is often the most unreliable. A delay or cancellation at the regional airport can completely disrupt an itinerary. Taken together, perceptions about safety, reliability, and comfort work against the regional carrier. Potential passengers will avoid the service by driving or foregoing their trips, a phenomenon known as leakage.

DEMOGRAPHIC AND SOCIAL CHANGE

The current limitations of the hub and spoke system will be exacerbated by two trends in modern American society. First, demographic trends suggest that more Americans will move away from metropolitan areas and into rural communities (Johnson and Beale, 1998). Second, early indications from the information age suggest that time and travel speed will be motivating factors for personal and consumer decisions (Schafer and Victor, 1997). Taken together, these trends describe a population whose needs are unlikely to be met by the current hub and spoke system. More travelers will live away from metropolitan areas and hub airports. These same travelers will be acutely interested in reducing travel times and having reliable access to a variety of new destinations.

THIRD MIGRATION WAVE

America's 'first migration wave' from rural communities to the cities can be traced back to the era of Andrew Jackson in the 1820s. In total population, however, rural America still continued to grow, but at a much slower pace than urban America. The growth that remained in our rural communities was almost exclusively due to the fact that rural women bore enough children to offset rural deaths and out-migrations of families to the cities.

The 'second migration wave' from the cities to the suburbs is closely associated with the affordability of the automobile and with the baby boom that followed World War II. While the swelling of metropolitan areas and the growth of suburbs defined American life for the first seven decades of the 20th century, a new trend might define the next seven decades. Recent information indicates that "What the United States experienced between 1970 and 1996—and is continuing to experience, according to recently released Census Bureau data—is population de-concentration. People are gradually moving away from larger, more densely settled places toward lightly settled areas" (Johnson & Beale, 1998, p. 18). Economic and technological change is allowing many Americans to choose where they want to live.

This third migration wave or 'in-migration' from the suburbs to rural and remote communities is driven by economic, social, and technologic forces. The requirement for large numbers of blue-collar workers reporting to nearby factories has been greatly reduced in the Information Age. Human/intellectual capital is displacing the role that physical capital played in the industrial age. The rise in information technology has made rural areas much less isolated, at least in terms of communications and information, than they were at the height of the industrial age. The paradoxical result of this latest wave of migration is that as the information age frees people to move away from urban and suburban areas, it also forces them to consider time more carefully. The speed of commerce and information increases, but the speed of travel remains stagnant or even declines as capacity limits are met in both surface and air transport sectors.

MEETING THE TRANSPORT NEEDS OF THE NEW ECONOMY

We will soon see an inevitable clash between a population that is becoming more dispersed and concerned about door-to-door travel speeds and an air transport infrastructure that is rapidly approaching saturation. For the variety of reasons mentioned earlier traditional solutions are unlikely to be of much lasting help. A new approach to transportation and a new framework for cooperation between industry and government is

required. Old ways of doing business will only produce expensive half-measures, such as publicly subsidized turbo-prop air service, which fail to provide the desired levels of service at an acceptable cost.

This new approach will build on newly developed aircraft technologies and existing infrastructure. The key, however, is that the technology will allow for dramatic increases in usable airport and airspace capacity. While scheduled commercial air service is provided to consumers at a mere 400 airports in the United States, general aviation can provide services to over 5,000 public facilities and as many as 18,000 landing facilities if private airports are included (GAMA, 1999). Studies show that over 90 percent of the U.S. population lives within 30 minutes of a public-use general aviation airport (Holmes, 2000). The existing general aviation airport infrastructure represents a vast, underutilized capacity for the nation. By expanding all-weather access to the nation's existing public-use airports, the National Airspace System capacity (measured in annual seat-departures) could be increased by a factor of ten compared to the existing commercial hub and spoke system. This increased accessibility and throughput of a more fully utilized infrastructure would contribute substantially to the National Airspace System safety, cost, and efficiency.

Building on the success of the NASA led Advanced General Aviation Transport Experiment (AGATE) consortium and the General Aviation Propulsion program, the NASA-led National General Aviation Roadmap (Holmes, 1999) establishes a framework for coordinating public and private sector investments leading to development of a national Small Aircraft Transportation System (SATS). The Roadmap goal is to cut inter-city travel time in half in 10 years at a total system cost that is competitive with Interstate highway travel.

The Small Aircraft Transportation System, in conjunction with the existing network of general aviation airports, holds the potential to provide the nation with a transportation innovation that relieves current pressures on our ground and air systems, land use, and environment (Whitehead, 1997). SATS will be a safe travel alternative, freeing people and products from transportation system delays and creating access to more communities in less time. Virtually every small community in the nation will have the potential to be served by SATS.

WHAT IS SATS?

The Small Aircraft Transportation System grows out of the successful collaboration of industry and government to improve general aviation technologies through the AGATE consortium. NASA officials and industry representatives recognize that new technologies could dramatically change the face of general aviation and move small aircraft from the domain of the

hobbyist or aviation enthusiast to the domain of the cost-conscious, safety-minded traveler. These technologies include improved avionics, more reliable and efficient power plants, improved flight management equipment, and enhanced information technologies. The current three-pronged SATS effort seeks to develop small aircraft and related technologies that are:

1. Capable of flight in near all-weather conditions,
2. Suitable for high-density operations; and
3. Built with the techniques and processes adopted from the automotive sector.

In each case, the goal is to produce an air vehicle that is safe, reliable, and cost-competitive. More importantly perhaps, the emphasis is on the vehicle and will not rely on expensive or extensive infrastructure improvements, such as longer runways, increased land-use, or elaborate ground-based communications, navigation, or surveillance systems. Table 1 outlines the technical components of the SATS concept. The first three items are the focus of the current program, while other technologies will be developed or integrated as the program evolves.

Table 1. Technical Components of the Small Aircraft Transportation System

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- Virtual Visual Meteorological Conditions (VMC), which includes virtually autonomous vehicles, human aided automation, virtual terminal procedures, integrated vehicle and air traffic services automation, control de-coupling, and envelope protection.
 - High Density Operations, which includes client-client-based separation and sequencing in non-radar airspace, and non-interfering approaches at Class B airports.
 - Automotive Synergies, which include affordable manufacturing of vehicles through the use of thermoplastics, aluminum, composites, and integrated airframe design and manufacturing processes.
 - Airborne Internet, which includes satellite-based communications-navigation-surveillance in all airspace.
 - Ultra-propulsion, which includes non-hydrocarbon and heat engine options, low-noise/emissions, and low maintenance engines.
 - Smart Airports, which include airport database for remote sensing and monitoring of airport, runway, and weather conditions.
 - Wireless Cockpit, which include open architecture systems, through-the-window displays, and software-enabled controls.
 - Cyber-tutor and Internet-based training, which includes both embedded and onboard training and expert systems.
 - Extremely slow take-off and landing, which includes configuration aerodynamics for slow and vertical operations as well as roadability of vehicle.
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SATS will begin with a 5-year focused program effort to prove that “SATS works.” While NASA works to show that the technologies integrated into SATS aircraft will work to dramatically change the way Americans think about air travel, other stakeholders, especially the states will explore social, economic, and environmental impacts. Current plans call for a multi-state demonstration of SATS in 2005.

WHAT SATS CAN DO FOR RURAL AND SMALL COMMUNITIES

SATS has the potential to solve the problem of access to safe, reliable, and affordable air transport. Rural and small communities that suffer from inadequate or nonexistent air service can reap the benefits of SATS without the considerable expense typically associated with airport infrastructure development. SATS does not rely on new or expanded runways or prohibitively expensive instrument landing systems. Communities therefore can avoid the risk associated with a “build it and they will come strategy.” Such a strategy is fraught with problems since commercial air carriers are unlikely to make service decisions based solely on the quality of the landing facilities. Adequate infrastructure is a necessary, but not sufficient, requirement for attracting commercial air service in the current market. Fortunately, SATS will allow small communities to reap the benefits of reliable air service without having to provide costly infrastructure up-grades or the load factors expected by commercial airlines.

SATS can effectively lower the barriers to quality air transport services. Currently planned aircraft, such as the Eclipse and the Safire are exciting precursors to SATS aircraft. These small jets will be the first shots in the battle to revolutionize personal transportation. Powered by innovative engines and guided by the latest flight management technologies, the Eclipse and the Safire will make on-demand, point-to-point air travel price competitive with current coach travel, which entails all the downsides of the hub and spoke system. The Eclipse, for example, is a six seat pressurized jet aircraft with projected operating costs of less than \$.50 per airplane mile (Eclipse Aviation, 2000). Further technological advances and the automotive synergies that are a primary goal of the SATS program will further drive costs down and eventually extend the reach of such air service to small, remote landing facilities with even the most minimal level of infrastructure.

Such technological advances will address the problems posed earlier in this paper. With the hub and spoke system reaching saturation and time becoming the most precious commodity in our information-oriented society, travelers will demand fast, efficient, and reliable transportation

tailored to their needs in terms of schedules and destinations. While some conventional airlines may recognize this market and seek to address its demands with smaller regional jets, truly small and remote communities will still lack the infrastructure and the load factors necessary to attract adequate air service. Those communities will not be able to participate fully in the global economy unless those air service needs are met. An attractive solution to this problem is the Small Aircraft Transportation System described in this paper.

IS SATS EXPORTABLE?

This paper has focused almost entirely on the problems and prospects for air transport in the U.S. One can easily imagine, though, that the SATS concept offers considerable hope for other countries facing air transport dilemmas. Although not similar in all regards, the congestion at major U.S. airports is mirrored at Europe's major airports. While enhancing its already exceptional rail service might be an attractive means for reducing air transport congestion, rail is still governed by fixed schedules to hub cities. As time becomes a more important criterion to savvy travelers in Europe, the SATS concept might become an attractive option.

More likely, however, is that SATS will have appeal in nations with widely dispersed, small communities that need air service but do not receive it without substantial government subsidy for conventional air carrier service. As is the case in the U.S., such service rarely meets the needs of the traveler and requires the government to spend scarce resources on a service that is inadequate. Such inadequate service, as in the U.S., achieves a political goal but too often does not satisfy more important social and economic goals. Nations such as Australia, Canada, Brazil, Russia, and various other nations throughout South America and Africa would be good candidates for SATS since they tend to have limited and unreliable air transport services for their small, rural communities. SATS aircraft could provide access to areas previously without service because of the lack of adequate landing facilities for all but the smallest, most antiquated aircraft. SATS aircraft could effectively serve these communities with reliable, safe, and efficient services without the need for substantial state subsidy or a constant stream of revenue passengers as required in the air carrier business.

The impact on economic development is obvious. Investors will be able to develop new production facilities in areas previously eliminated from practical consideration because of the lack of air service. New investment and the subsequent development of infrastructure in remote communities might ease the pressure of migration to urban areas taking place in

developing countries. These communities will also benefit from the timely and cost-effective provision of social services. The social and economic development potential of SATS is exciting and worth serious consideration by investors, policy makers, and those interested in spreading the wealth of opportunity the global economy offers.

CONCLUSION

SATS is a concept that proposes a technological solution to a number of critical transportation and economic development problems. It is certainly not a cure-all since it will not likely prevent the gridlock forecasted for the hub and spoke system. The demand for conventional air transport services will continue to grow as the economy grows and the result will be a system saturated to the point where the needs of many travelers are no longer met. SATS is also not a panacea for every small community that lacks adequate air service. SATS is not a promise to provide air service as an entitlement. It does, however, offer a much better means for providing access to reliable and efficient air transport than the current system, within which air carriers focus on large markets and within which government subsidies seem to waste scarce resources subsidizing services that fail to meet most travelers' needs. SATS can reduce the need for substantial infrastructure investment and reduce the demand threshold for attracting reliable air transport services. In the end, SATS promises to be a paradigm shift that will make air transport an even more useful tool for business and leisure.

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