SMALL AIRCRAFT TRANSPORTATION SYSTEMS

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INTRODUCTION

Air transportation systems are based on a variety of vehicles including fixed wing aircraft and helicopters. The most diverse and developed category remains the fixed wing aircraft with sizes ranging from single seat to 555 seats in the case of the Airbus A380. This size characterization relates to passenger vehicles. However, cargo aircraft have similar range of sizes. The largest fraction of commercial air transportation is performed using 50 to 300 seat aircraft. However, there exists a segment of the air transportation market that relies on smaller vehicles.

OVERVIEW OF CURRENT SMALL AIRCRAFT TRANSPORTATION SYSTEMS

For the purpose of this study, small aircraft were defined as aircraft able to transport from 2 passengers, like the Cessna 172 or the Piper PA28 aircraft up to 12 passengers such as Gulfstream V or similar business jets. Of course, similar size aircraft used for freight transportation are included in the analysis.

Vehicles & Technology

As shown on Table 1, the largest fraction of small aircraft is powered by piston engines with 170,500 registered aircraft in the United States in 2001. However, compared with the size of the fleet of major airlines like American Airlines (over 800 aircraft), the number of jet aircraft is significant with 7000 aircraft operated in the United States in 2001. Turboprops are the least numerous category with 5800 registered aircraft.

Piston	170,500
Turboprop	5,800
Jet	7,000
Total	183,300

Table 1: Number of aircraft by type [1].

Modes of Operation

Because from an acquisition and operating cost perspective, small aircraft are much more accessible than their larger counterparts, the modes of operation are much more diverse.

General Aviation

General aviation is the term used to define [2] aircraft operations that encompass all civil aviation other than scheduled airline flights and military aviation. It includes everything from a privately-owned light single-engine aircraft to business jets, police, pipeline patrol, emergency medical flights, crop-dusting, rotorcraft, sport ballooning and many other aerial activities. From an operational perspective, general aviation

operations can be segregated into three major categories. Table 2 shows the utilization of aircraft for various type of flying. The activity where most of the vehicles are used is the "personal" category. This category is probably the most heterogeneous in term of operations since it regroups everything from non transportation activity such as leisure flying around an airport, antique aircraft collection to transportation purposes like private pilots owning their aircraft and using it as a substitute to other modes of transportation.

Corporate	11,000
Business	25,200
Personal	148,200
Instructional	14,900
Flight	4,300
Aerial observation	5,100
External load	200
Other work	1,800
Site seeing	900
Air tour	300
Air taxi	3,700
Air medical	900
Other	1,000
Total	217,500

Table 2: Number of aircraft by type of flying [1].

Corporate & Business Aviation is another significant mode of operation. In this case, aircraft are owned by companies (users) or owned and managed by charter companies who provide service to various customers. The largest fraction of these operations is non-scheduled. However there exist some scheduled services, mainly in the case of corporate aviation where a company owns one or multiple aircraft and uses them to move its personnel from one company site to another.

Finally, the last category may regroup all type of operations based on a specific professional need. For example, aircraft are utilized for aerial observations, tourism like site seeing, or for critical transportation purposes like air medical or air ambulances.

In term of vehicle operation, much of the traffic in general aviation is flown under Visual Flight Rules (VFR). However, as this is the case for airline traffic, certain part of general aviation, mostly the commercial part is flown by reference to Instrument Flight Rules (IFR) wherever ground facilities adequately support that type of navigation. Basically, the VFR flights require that good weather conditions exist all along the flight pattern. This makes this type of flying unreliable from a service perspective. On the other hand, IFR flights, as performed by corporate and business aviation, use the same rules and procedures as commercial airlines. Therefore, they are not constrained by the weather and service is more reliable.

Infrastructure

In January 2001, the US airport system was composed of 19306 airports of which 5314 were public (Figure 1).

Figure 1: Current set of airports in the U.S [3].

The ground facilities needed for most general aviation flights are generally less sophisticated than those required by the airlines operating scheduled flights, but there are many differences between the smaller grass aerodromes and the airports capable of accepting large corporate aircraft.

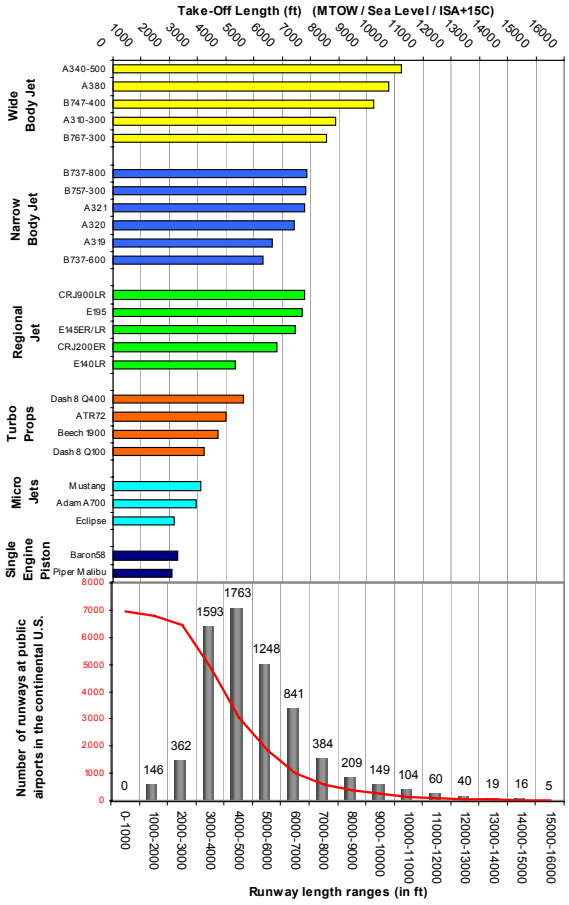

Figure 2: Aircraft performance vs. airport capabilities in the United States [4] [5].

In fact, the ability for an aircraft to use a particular runway is dictated by its take off performance, which is also defined by the take off field length. Because this distance is a function of the aircraft weight, and its propulsion and aerodynamics capabilities each aircraft has a specific take off field length. Therefore, a large aircraft which requires a long take off field length will be more restricted in term of airport access than a smaller aircraft. For example, single piston engine aircraft have access to more than 6500 runways in the United States (Figure 2).

Issues about current small aircraft transportation systems

There are several barriers that limit the utilization of small aircraft and make it a less popular mode of transportation than scheduled airline services or ground transportation by car, etc.

First, in the case of business and corporate aviation, the use of expensive jet aircraft and the low utilization rate of these assets impose high costs per mile compared to services offered by scheduled airline. Even though some business models based on fractional ownership, that allow users to buy a share in a type of aircraft, lowers the costs, these options of travel remain inaccessible to the general public.

In the case of personal general aviation, pilots using piston engine aircraft have to fly in good weather conditions unless they have a specially equipped aircraft and a special IFR license. Because of the weather constraint, this mode of transportation is not reliable. In addition, small airports that are utilized by general aviation do not provide the same ground services, such as car rentals, etc, as the one found at major airports [6]. Therefore, this mode of transportation is less attractive.

Due to high costs, unreliability of service in some cases, the demand that would exist for small aircraft transportation often find substitute modes of transportation such as scheduled airlines or cars.

RECENT EVOLUTION IN SMALL AIRCRAFT TRANSPORTATION SYSTEMS

However, a technological breakthrough on the vehicle side may allow a wider utilization of small aircraft as a safe, fast and efficient mode of transportation.

Breakthrough in vehicle technology

A new technological breakthrough in small aircraft engines leading to the development of more efficient engines will eventually bring on the market new four to six seat aircraft, for half the price of current similar jets and with significantly lower operating costs. As of 2004, at least 6 manufacturers are in the process of bringing aircraft to certification, among them Eclipse, Adam aircraft, Cessna, etc.

Long term vision: "The SATS Program"

In the 1990s, as the new engine technology was starting to be developed, NASA saw in this emerging technology a way to develop personal air transportation. The program called "Small Aircraft Transportation System (SATS)" [6] was lead by NASA Langley. The goal was to test an innovative concept for personal air transportation, as well as developing key technologies that would be required to achieve such goal. Once these technologies would have been put in place, the new very light jets, and the current set of more than 5300 un-congested airports in the United States, would allow the emergence of new on-demand, point-to-point high speed (Figure 3) and low fare personal transportation between suburban, rural and remote communities.

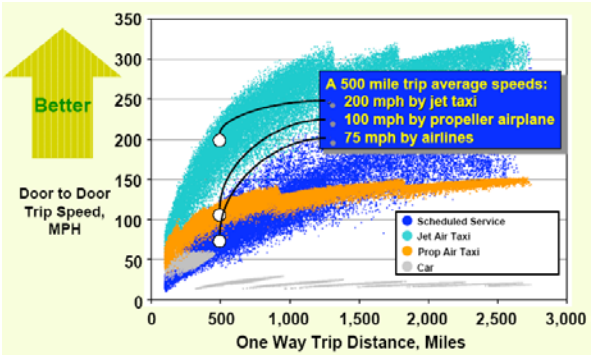

Figure 3: Door to door trip speed for various mode of transportation (SATS) [7].

Limitation of the SATS program

However, the SATS program remains a concept of operation and there exist several limitations to this concept in the current air transportation environment.

The failure of Williams International, the engine manufacturer that started the development of the efficient small jet engines (EJ22), to deliver the announced performance constitutes a first limitation. Other engines for small aircraft such as Pratt & Whitney PW610 and PW615, the Williams FJ33 will become available eventually if they are certified; the performance levels are not as revolutionary as the one the EJ22 would have offered. Engine lower performance means higher operating costs and therefore makes the operation of the aircraft slightly less attractive.

The currently long certification process required for aircraft certification make it costly for manufacturers to quickly develop new aircraft pushing the innovation and evolution process fast as it is the case, for example, in the automobile industry.

Another limitation remains the level of training required from a pilot that would own and operate its aircraft for personal transportation. Unlike current piston engine aircraft, very light jets are faster and fly higher which require more training and experience to fly. This training issue of private pilot willing to fly very light jets comes with insurance issues where insurances are expensive and require pilots to go through special training courses.

From a cost perspective, the acquisition and operating cost requires the aircraft to be operated several hundred hours per year to justify such costs.

These are several barriers that make the concept difficult to implement on a wide scale, at least in the short term.

Near term models: Air Taxi

However, on-demand point-to-point air transportation may not be accessible, in the short and medium term, to masses of individual owning their plane and using it as conveniently as their car, similar services might be available in the upcoming years. The solution would come from aviation companies, who would own and operate large fleets of these small aircraft and offer on-demand point-to-point air transportation services for significantly lower fares than current business and corporate aviation. The air taxi based concept solves the limitations of the SATS program that have been illustrated earlier. In fact, the higher utilization of the aircraft implies lower unit costs. The safety and training issue is solved by flying the aircraft with two professionally trained pilots, etc.

CONCLUSION

Starting from the current state of the small aircraft transportation system, this paper has addressed the current limitations of this transportation system. In addition, future evolutions of the system enabled by emerging technologies were analyzed and limitations for short to medium term development were addressed. Finally, a business and operational model that might be the first step towards a more accessible, reliable and efficient small aircraft transportation system was presented.

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