The Small Aircraft Transportation System Project: An Update

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Mobility is Freedom.
To all peoples in all parts of the world throughout history, the ability to move about easily is a fundamental element of freedom. The American people have given the researchers at the National Aeronautics and Space Administration (NASA) the responsibility of developing technologies that enable "people and goods to travel faster … with fewer delays." (Ref 1) They have charged NASA to increase their freedom and that of their children knowing that their quality of life will improve as our nation's transportation systems improve.

In accepting that challenge, NASA considered where mobility might be limited. Automobiles do reasonably well for local travel. They can be used on demand, can travel reasonably fast, and can go nearly everywhere. For trips of more than three hours, however, they lose much of their attractiveness. After about three hours people need to stop to eat or stretch and that stop impacts the efficiency of automobile travel. Furthermore, the hours spent driving are largely unproductive; a difficult price to pay in today's world where everyone is striving to strike a healthy balance between work and family time.

On the other end of the travel spectrum, airlines do reasonably well at moving people and goods for trips in excess of about a thousand mile, but for trips less than that, many factors cut into their travel efficiency. Among them are the fact that one in three Americans has to drive more than thirty miles to get to a commercial airport (Ref 2), they have to arrive at least an hour prior to their flight, most will have to wait for a connecting flight in a city probably not between their origin and their destination, and they will have to get out at their destination airport and probably drive at least thirty minutes to their final destination. Add to that the fact that the airline travels on its schedule not on the traveler's schedule and it's clear that travelers are also probably spending an hour or two at a hotel near their destination that they would have rather spent with their family or in their office.

Though neither automobiles nor airlines are their most useful for trips of 150 miles to 1000 miles, people use them for those trips and arrive stressed and exhausted. NASA has the vision that a revolution in human travel is within our reach. If personalized air travel could be made safe, reliable, and affordable, people would choose to use that for those intermediate length trips.

In pursuit of this safe, reliable, and affordable personalized air transportation option, in 2000 NASA established the Small Aircraft Transportation System (SATS) Project. As the name suggests personalized air transportation would be built on smaller aircraft than those used by the airlines. Of course, smaller aircraft can operate from smaller airports and 96% of the American population is within thirty miles of a high-quality, underutilized community airport as are the vast majority of their customers, family members, and favorite vacation destinations. (Ref 2)

Challenges addressed in the SATS Project

Though there are many obstacles to the vision of a time when nearly every trip of more than one hundred and fifty miles is taken by air, the focus of the SATS Project was on providing reliable access to the nation's 3400 public-use airports that have paved runways at least 3000 feet long. (Ref 2) If people can't assume that they will be able to access their community airport reliably, they won't plan future trips around those airports.

Since most of those airports don't have ground-based navigation aids and are difficult, if not impossible to find in poor visibility, one objective of the SATS Project was to lower the landing minima at those airports to conditions in which there is a 200 foot ceiling and the visibility is ½ mile. With that limitation, those airports would be accessible more than 98% of the time. (Ref 3) It is assumed that adding expensive ground-based infrastructure to thousands of airports would be unacceptable to small communities and to the Federal Aviation Administration (FAA), so the new capabilities would need to be aircraft-based.

During poor visibility operations at these non-towered airports, most of which do not have radar coverage to the surface, current air traffic control procedures restrict operations to one operation at a time. That allows only three to five landings per hour. (Ref 3) Travelers may feel very good about their short drive to their nearby community airport and about their ability to depart on their schedule directly to their destination airport, but if they arrive and find that airport has become popular, they may discover that they have to wait two hours to travel the last twenty miles. They won't consider that to be "reliable" access. Consequently, a second objective of the SATS Project was to enable greater operational efficiency at those airports in poor visibility conditions, once again, without requiring expensive ground-based infrastructure. The goal was to enable simultaneous operations at those airports in instrument meteorological conditions (IMC).

The SATS Project also wanted to provide pilots new tools that make it easier to fly safely. The objective was to develop tools that would make a median-proficiency instrument-rated pilot confident that they could navigate safely to that fogged-in community airport and land in that high-traffic environment.

Finally, the SATS Project wanted to assure that SATS traffic would be able to integrate with the existing en route traffic in the NAS. Solutions to these four challenges are referred to as the four SATS operating capabilities. The project was responsible for developing technologies and demonstrating that those capabilities are feasible. The project was also responsible for assessing the impact on mobility, the environment, and the NAS that would result from implementing those capabilities.

Partnership

Because NASA recognizes that there are powerful resources outside of the agency and since it prizes technology transfer, the project was conducted in partnership with the private sector (those who take new technologies and build them into products that will ultimately improve quality of life) and with the FAA (those who manage the airspace system). NASA's contribution to the partnership was in providing most of the funding and much of the technology development and flight experiment expertise, aircraft, and equipment.

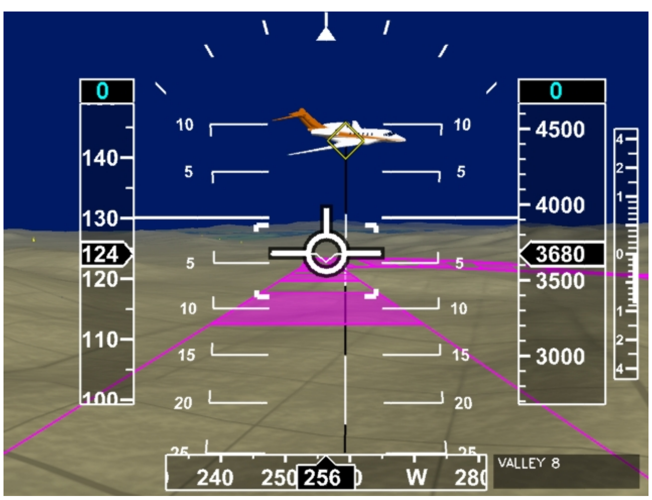
The "private-sector" partners are more appropriately described as the non-federal partners because they include some state and regional aviation authorities as well as universities. This group of more than 130 organizations formed into six SATS Labs in the central and eastern United States. Collectively, they are called the National Consortium for Aviation Mobility (NCAM). The six SATS Labs are the Indiana SATS Lab, the Maryland and Mid-Atlantic States SATS Lab, the Michigan SATS Lab, the North Carolina and Upper Great Plains SATS Lab, the Southeast SATS Lab, and the Virginia SATS Lab. As the project matured, more than a dozen other states expressed interest in organizing SATS Labs and joining the consortium, but, with the project ending early in 2006, it wasn't practical to grow the consortium. NCAM's contribution to the partnership included private sector funding and expertise for technology development as well as airports for testing and demonstrations. As the technology development draws to a close, NCAM's members are developing commercial products and pursuing certification through the FAA. As a consortium, they will advise others in achieving FAA certification for their products and will advocate for the preservation of small airports across the nation.

Of course, products will only improve lives if the FAA accepts them into the NAS. For this reason, the FAA was active in all technology development decisions made in the project. They participated in laboratory and flight simulations conducted to evaluate and to demonstrate some of the developed technologies. They advised the partners on regulatory and certification requirements and are helpful as products are now being brought forth for certification.

Accomplishments

As mentioned above, the project was responsible for developing technologies and demonstrating that the four SATS operating capabilities are feasible. Many of the accomplishments have been reported, recently, in technical conferences (Ref 4 – 33). To provide nearly all weather access to the thousands of small airports around the nation, the SATS technology developers relied primarily on Global Position System with the Wide Area Augmentation System (GPS/WAAS), an on-board terrain database, and advanced cockpit display technologies to provide the pilot a high quality synthetic view of the outside world. Such systems can provide forward-looking views from the cockpit or external views of the area from any vantage point the pilot may choose. With traffic rendering, this provides unprecedented situation awareness in all weather conditions. Since it would be dangerous to land on a synthetic runway (there may be a real deer on that synthetic runway), a low-cost (90% price reduction when compared to comparable systems available today) enhanced vision system has been developed which uses a coincident low-light camera and infrared (IR) imager to present the pilot a view of the real runway before the pilot could see it with natural vision. Combining the synthetic vision with the enhanced vision the pilot is presented a high quality synthetic image that transforms into a grainy low-light/IR image as the pilot descends to decision altitude. This system has demonstrated the feasibility of reliably navigating to any runway end in IMC as severe as 200 foot ceiling and visibility of just ½ mile.

To increase the operational efficiency of small airports in IMC, the alliance developed a strategy and a system in which pilots are provided increased situation awareness through the use of ADS-B (Auto Dependent Surveillance – Broadcast) and some simple operational rules and are given the responsibility of self-separating in the terminal area. When all of the aircraft approaching an untowered airport are properly equipped, they can perform this procedure within a designated Self-Controlled Area (SCA) around the airport. When demonstrated publicly in June of 2005, six aircraft operated simultaneously in simulated IMC within the SCA and, from the moment the first aircraft requested clearance to enter the SCA to the moment when the sixth aircraft landed, only thirty-one minutes had passed. This is a factor of four increase in throughput compared to current operations. Under these procedures, if an unequipped aircraft approaches the facility, the en route air traffic controller holds that traffic until the equipped traffic already within the SCA have landed, then operations revert to today's procedural separation until the unequipped traffic has landed and is clear of the runway. Under operations where all aircraft are equipped, a pilot approaching the SCA would send a datalink message to an autonomous Pentium-class sequencing computer, the Airport Management Module (AMM) located at the airport. That message would be a request to enter the SCA. The AMM would either delay entry (if the SCA is "full") or would grant entry and tell the pilot which initial approach fix to proceed to and at what altitude, the tail number and type of the aircraft they are to follow for the remainder of the procedure, and the missed approach procedure to follow should they not be able to land. From that point, the pilot need only follow the SCA procedures and stay safely in trail behind the one aircraft they have been told to follow. A new conflict detection and alerting system cautions pilots before they get into dangerous situations. Simulations with professional air traffic controllers show the system reduces controller workload (Ref 24) and pilots report that the increased situation awareness actually makes this task less stressful than a conventional IMC approach in which they are not responsible for separation.



To make the task of safe flying easier, several new tools were developed. These include system monitoring and decision-aiding tools, low-cost (estimated 90% cost reduction over similar military systems) head-up display systems, and "Highway in the Sky" (HitS) systems. The HitS systems work with the synthetic vision systems to show a safe and efficient path from the aircraft to the desired destination. The system develops the highway based on current position, current heading, current altitude, obstacle locations, local terrain elevation, airspace restrictions, desired runway orientation and altitude and location, required altitude for all phases of the flight, vertical speed, and aircraft climb and turn performance. Today, all of these pieces of information are available to pilots from a variety of sources and pilots have to integrate them properly in their head to know where they need to be. HitS does this data mining and data integration task for the pilot and reduces the task of navigation to simply keeping the vehicle on the “road” and occasionally checking speed – the same tasks continuously performed while driving a car. Professional pilots flying an IMC approach using HitS after fifteen minutes of instruction performed with 80% less horizontal flight path error and 50% less vertical flight path error than when flying the same approach using the localizer and glide slope indicators with which they had decades of experience. They also reported that the task was significantly less stressful. (Ref 34) Low-time instrument-rated pilots performed with 90% less flight path error than when using a conventional navigation system. (Ref 35)

The integration of SATS traffic with the rest of the traffic in the NAS was assessed in two ways. First was the transition of aircraft into and out of the SCA described above and second was the impact on delays in the NAS due to air traffic controller workload. Procedures for transitioning into and out of the NAS were developed and were tested with professional controllers at the FAA Technical Center in Atlantic City, New Jersy. Forecasting the future was more challenging.

Forecasting tools were developed based on socioeconomic data for the nation, destination desirability (historical data), the current NAS, the current highway system, the current airline system, historical weather data and associated delays, the performance and costs associated with owning and operating small aircraft, current rental car and lodging costs, and the decision-making process that travelers use when selecting which way to travel. Though most of the future demand is expected to swell operations at underutilized airports, a few large commercial airports are also expected to experience increased demand – notably, Midway (MDW) and Las Vegas (LAS) are both projected to see a demand for more than 350 additional operations each day by the year 2014. (Ref 36) The small airports will need to respond to the new large demand for ground transportation and some may need to seek low-cost runway/taxiway lighting and low-cost local weather monitoring systems – two other areas addressed within this project. Unfortunately, delays in the NAS are forecast to increase by more than 300% by the year 2010 just due to the addition of Very Light Jets that are expected to generate air-taxi traffic in already congested air traffic control sectors. Attempts to mitigate this impact by restricting this traffic to visual operations (weather permitting) below 18,000 feet or by rerouting this traffic around congested sectors did not solve the problem and would probably be unacceptable to both operators and passengers. (Ref 17) This forecasting tool is now in use by the Joint Planning and Development Office who has the responsibility of designing the Next Generation Air Transportation System to accommodate as much as a tripling of air travel demand by the year 2025. (Ref 37)

Future direction

Our national transportation system contributes to the quality of life of all Americans, and represents America to the rest of the industrialized world. It’s time for America to lead the next major transformation in mobility. Private citizens, providers of goods and services, and industrial leaders and public policy makers, alike, all have a stake in how people and things move around our country. There’s no part of our citizens’ lives that wouldn’t benefit from the continued economic growth and the improved freedom of travel embodied in the SATS vision. Keep in mind that the forecasts discussed above do not consider those trips not previously taken because they weren’t practical by any available means of travel.

Today, the nation is at a crossroads. The vision of the future is clear, but more must be done to make that vision a reality. What is less clear is who should perform that work. Additional research and development could remove remaining barriers to realizing the vision (Ref 38). In pursuit of the SATS vision, the areas that should be worked next include making it still easier for pilots to fly safely, increasing the reliability of traveling by small aircraft, and reducing the noise and emissions of aircraft. The increasing demand for pilots will require more efficient methods of pilot training and, ultimately, easier to use vehicles, communication methods, and airspace. The increased demand for aircraft will enable manufacturers to take advantage of mass production techniques such as those widely used in the automotive industry. The interagency Joint Planning and Development Office (JPDO) promises to help the nation use its airspace and airports more efficiently making all air travel more reliable. As more aircraft begin operating from community airports, environmental and safety concerns will drive engine technology and safety feature improvements such as those that have helped the automotive industry. Improvements in all of these areas will, in turn, continue to drive even greater demand. Eventually, the market will likely reach a tipping point where prices will drop dramatically as happened in the automotive, computer, and cell phone industries. NCAM and others in the private sector are seeking ways to take advantage of the opportunities created by this future.

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