DTFAWA-05-A-00005

Optimizing Aircraft Sequencing and Spacing in the Terminal Area Airspace to Increase Airport Capacity, Reduce Fuel Burn and Emissions, and Reduce Noise on Developed Terminal Paths

Purpose: This purpose of this effort is to conduct investigations for the integration of CNS/ATM technologies to support applications that will reduce fuel burn, emissions and noise, and eliminate terminal area airspace congestion. This investigation will also illustrate increases in airport throughput by demonstrating how currently-available technologies can optimize aircraft flight tracks, sequencing, and timing in the terminal area airspace. These technologies exploit advances in Communication, Navigation and Surveillance systems. The project is envisioned as a joint endeavor by academia and industry to validate the proposed concepts and quantify the benefits that can be achieved for all partners.

The validation of this concept can provide a path forward for Next Generation Air Transportation System (NextGen) implementation of safer, cleaner, and more efficient terminal area operations across the U.S. By applying these technologies, the government, aircraft users, and airport operator/owners can collaborate to achieve both operational goals and environmental/community goals such as noise and emissions reduction, achieve flexibility in terminal airspace, and provide for capacity growth.

Background: Many airports today are generally considered to be reaching their maximum level of capacity and are currently planning for future growth. While very few new airports have been built over the past twenty years and few new runways have been added to the system, the quantity of air traffic has been growing steadily, bringing current airports to the edge of, or sometimes beyond, their capacity. The result is increased pollution of the air and noise spectrums from terminal area airspace "traffic jams." Aircraft find themselves relegated to long, airborne queues for arrivals (sometimes hundreds of miles from the airport)—and, in turn, queued in long departure lines on the airport surface waiting to take off. All the while, they are burning fuel and making noise—adding to every airport's environmental problems.

Airports and Airlines Lack Precise Positioning Data

An aircraft's exact current location is not available to either airport or airline operations once it is outside the terminal area. Using data like the take-off time, heading, and aircraft performance specifications for each aircraft in the fleet, airlines estimate destination arrival time in their schedules, and airports look to make contact with arriving aircraft as they reach the outer radius of the terminal airspace. Any deviation from the expected can lengthen the flight track of an aircraft, and like dominos, one aircraft's deviation can affect any number of flights behind it. Due to the lack of navigational certainty with most aircraft in terminal area airspace, air traffic controllers depend heavily upon radar control and they make approach corridors extra wide and keep aircraft separated by large margins to preclude mid-air collisions. This need for separation also lengthens flight tracks, as each aircraft in turn needs to maintain an adequate distance from the one before it.

Fuel Burn and Emissions Cost Airports Community Goodwill

Fuel burn and emissions at airports are significant concerns to both airport users and the community at large. The increasing cost of fuel has a clear detrimental impact on airline profitability. Airline profitability, in turn, impacts airport profitability in reduced gate and services fees. Emissions, both fuel pollutants and noise, cause concerns regarding local air quality and quality of life around airports, especially at those airports that have not attained environmental compliance. Currently, most aircraft making precision landings use radar-guided approaches/transitions to the final approach segment. As noted above, these procedures usually require multiple changes in vector to line up incoming aircraft with the runway on which they land. Each change in vector is likely to require throttle adjustments to compensate for changes in approach speed and other aircraft variables as the pilot achieves the required altitude or azimuth—and each throttle adjustment generates more noise and fuel pollutants.

Continuous Aircraft Data Communication is Vital

This investigation requires a data communications capability that can continuously transmit and receive the appropriate data points from each source—aircraft, airline, and airport—to enable real time calculation of the optimum location, airspeed, and descent profile for each aircraft as it approaches the terminal airspace. To ensure timely and sufficient data on each en-route flight, each aircraft must have a defined arrival time and maintain constant communications. The capability must provide two-way, secure, encrypted, tracking and communications. It must have the capability to be keyed on-off remotely from the command center, and has capability for both air-ground and air-air surveillance. It can provide collaborative decision making between all the parties in the system, and has the capability for users to receive all the commands similar to today's voice system. The application must be usable as a universal location and message communication system with several unique characteristics: global, near real time, two-way over-the-horizon (OTH) secure data transmission; user-to-user communication; interoperability among users and organizations (if required); geo-location; high capacity; 24/7 availability, and security.

Precise Flight Tracks

A LAAS ground facility (LGF) constantly transmits navigational messages up to any equipped aircraft within the terminal area airspace. An aircraft equipped to receive this data can use a Required Navigation Performance (RNP) procedure that has been calculated to provide the most efficient flight path and rate of descent to land without constant adjustments. This greatly reduces the necessary communication between the terminal area radar controller and the aircrew. An RNP-capable aircraft can receive clearance for the RNP approach at the outer fringes of the terminal area and no further navigational guidance transmissions are required until the aircraft is cleared to land. The aircrew is free to concentrate on getting the aircraft configured to land, thus reducing the cockpit workload and increasing their "situational awareness." The LAAS LGF allows the FAA a unique capability to provide a service to older analog aircraft which will facilitate the transition period to satellite service. That analog service is provided through an up-linked terminal area path (TAP) which will provide an equivalent RNP level of service. This is key to increasing terminal area capacity.

Timing and Sequencing Increase Efficiency

Optimizing the timing and sequence of arriving aircraft is critical to increased efficiency. This requires fairness in terms of the number of positions in the arrival queue that any one aircraft can be moved back to achieve better throughput or reassigned to another runway end without loss of time and landing sequence. Even greater increases in throughput could be achieved if arriving traffic are re-sequenced and re-timed en route. In addition, optimizing the flight speeds and flight levels of aircraft en route also can thereby reduce delay and fuel burn; the optimum altitude and speed of each aircraft can be determined by searching for the speed and altitude that kept the aircraft closest to the operating condition where its operating cost was minimized. In analyzing timing and sequencing, it is important to explicitly consider aircraft performance limits such as maximum speeds and service ceilings. Up to 8.5 minutes of delay could be mitigated on average in the Northeast corridor of the U.S. when traffic levels increase to those for which NextGen is being designed. The resulting reduction in fuel burn and emissions (and their effects on both local and global air quality) would help to relieve the constraint that the environmental impact of aviation places on growth. As is to be expected, optimization of traffic flows in general, and the movement of individual aircraft in particular, requires precise knowledge of the location and the potential future trajectories of each aircraft, as well as aircraft with the ability to precisely follow a prescribed trajectory. There are at least four reasons why LAAS TAPs and the continuous aircraft data communications provide an avenue through which such optimization could be implemented. First, the GPS-based LAAS system provides very accurate estimates of current aircraft location. Second, the algorithms used to generate the LAAS TAP must by definition consider all the potential future trajectories of each aircraft, thus they can be readily provided to the optimization algorithm. Third, the LAAS TAP already provides mechanisms for precise trajectory following. Fourth, the continuous aircraft data communications equipment provides the dynamic data from aircraft in the terminal area that is required for conformance monitoring, as well as the communication mechanism to adjust trajectories if required.

Rationale: Air traffic controllers rely on radar and voice communications for aircraft position which leads to longer, more inefficient flight paths. The longer, more inefficient flight paths lead to increased fuel burn and emissions and more terminal area noise. The investigation should use three different pieces to solve these problems and quantify potential environmental and capacity benefits: (1) continuous data communications, to have a precise 4-D picture of flights transitioning from en route to the terminal area airspace; (2) TAPs that are compatible with RNP to design shorter, more precise flight tracks, thereby reducing fuel burn, emissions, and noise; and (3) a dynamic sequencing and timing tool to optimize the sequence of aircraft that are in the arrival queue based on the type and performance of the aircraft, which will increase airport throughput.

The Task Request is to research integrating these different components to realize maximum environmental benefits and optimum airport capacity. The investigations will culminate in demonstration flight tests at a major U.S. airport in late 2007. These flight tests will provide invaluable knowledge about the relative importance of continuous communications, precise flight paths, and timing and sequencing in achieving these benefits. Eventually, the concept can lead to an operations data fusion center combining weather, air traffic, airline, airport, and surface movement data.

Statement of Work: The awardee shall perform planning and prototype development to establish a terminal area testbed at a major airport and conduct a phased series of flight trials. Using the emerging technologies of GBAS Terminal Area Path (TAP) Procedures, real time two-way data exchange, and dynamic sequencing application software and algorithms, the effort should seek to illustrate the following benefits in the terminal area:

1. Decreased Fuel Burn and Emissions
2. Reduction in Noise
3. Increased Approach Availability
4. Decreased Minima where possible
5. Optimized Aircraft Sequencing in Real Time
6. Stable Arrival/Approach Procedures to Terminal Area Operations
7. Constant Rate of Descent Throughout Arrival and Approach
8. Minimized Flight Time in Terminal Area
9. Minimized Impact to ATC

A major strength of this approach is the potential for rapid, real-world application of its results. Participation by an air carrier who can quickly transition the project benefits into worldwide operations and collaboration with an airport can model achievements for other communities where the population has grown around and beyond the airport location.

The investigations should culminate in demonstration flight tests at a major airport in late 2007. These flight tests should use RNP-compatible TAP approaches in combination with continuous aircraft communications and timing and sequencing tools to quantify the fuel burn and emissions benefits, terminal airspace noise reductions, and potential airport capacity increases resulting from shorter flight tracks that can be achieved in the short-to-medium-term through implementation of current and emerging technologies. The specific tasks leading up to the demonstration flight tests are described below, including the potential team members and the Integrated Product Team (IPT) linkages within the JPDO.

Subtasks

There are five subtasks and corresponding deliverables for this project:

1) Coordinate with airline, industry, academia, and airport personnel to reach agreement with the project objectives and understand air traffic controllers' national and local constraints. Develop Project Plan.

2) Develop different formulations and cognitive engineering models to support the terminal area airspace issues and operations, and develop report.

3) Mathematical and cognitive engineering models of the operations at an airport, that can be used in future JPDO work related to airport operations. Provide feasible concept for optimizing the sequencing and timing of aircraft and in the terminal area airspace to increase airport throughput and reduce fuel burn and emissions.

4) Integrate prototype decision support tool with the surveillance tool methodology and required flight operations.

5) Design TAP procedures for an airport and integrate a prototype two-way Realtime Communications Systems

Team Members

Any person or entity bidding on this task should identify team members across multiple disciplines to perform the subtasks described in the Statement of Work. The potential team members of the subtasks described above are academic researchers and industry (including manufacturers and air carriers). The researchers provide the academic expertise. Manufacturers provide tool development, communication hardware, and integration expertise. Air carriers provide the operational expertise and the means of implementation. The task will require collaboration with FAA air traffic control experts. All team members should be willing to work with each other and bring resources to the effort that would otherwise not be available. Their qualifications are described below.

The academic contributors should have relevant expertise developing algorithms and prototype decision support tools, and conducting demonstration tests. They also should have extensive expertise in modeling, simulation and control, and have conducted prior research in the area of departure planning and operations. They should have developed models and algorithms that are an ideal foundation for the proposed work. They should also have expertise in cognitive engineering research, mathematical programming and large-scale optimization, and airline scheduling and operations research.

The industry (manufacturers) contributors should have relevant experience developing real time, over-the-horizon (OTH) data communications capability for applications in the Department of Defense and Homeland Security. They should also have expertise in civil aviation procedure design, airspace management, and CNS/ATM technologies. They should have experience in the operational implementation and certification approvals for GBAS systems like LAAS.

The operator should be a major air carrier, and ideally be responsible for the vast majority of operations at an airport during significant time periods. This avoids many of the issues associated with conducting demonstration tests with multiple airline participants (that are not relevant to showing the benefits of better sequencing and timing). The air carrier should have a need to further develop the continuous communications tool for their own use, and be agreeable to conducting the demonstration test at one of their hub airports.

This project will be conducted in two tasks over a two year period. The scope of this task, to be conducted in the first year of the project, addresses project planning and development, including analysis, tool development, NAS integration approach, and operational procedure development.

Schedule and Deliverables – Year 1

SUBTASK 1

Description	Coordinate with airline, industry, academia, and airport personnel to reach agreement with the project objectives and understand air traffic controllers' national and local constraints. Develop Project Plan.
Deliverable	Project Plan
Due Date	3 months after contract initiation
Cost	10%

SUBTASK 2

Description	Develop different formulations and cognitive engineering models to support the terminal area airspace issues and operations, and develop report.
Deliverable	Report on formulations and cognitive engineering models
Due Date	5 months after contract initiation
Cost	20%

SUBTASK 3

Description	Mathematical and cognitive engineering models of the operations at an airport, that can be used in future JPDO work related to airport operations. Provide feasible concept for optimizing the sequencing and timing of aircraft and in the terminal area airspace to increase airport throughput and reduce fuel burn and emissions.
Deliverable	Report outlining feasible sequencing concepts
Due Date	5 months after contract initiation
Cost	10%

SUBTASK 4

Description	Integrate prototype decision support tool with the surveillance tool methodology and required flight operations
Deliverable	Draft design of procedures
Due Date	10 months after contract initiation
Cost	20%

SUBTASK 5

Description	Design TAP procedures for an airport and integrate a prototype two-way Realtime Communications Systems
Deliverable	a) Final design of TAP procedures for an airport and b) Final Integration of prototype two-way Realtime Communication Systems
Due Date	12 months after contract initiation
Cost	40%

* Total year 1: Not to exceed (NTE) $250,000 *

A summary table of Year 1 subtasks, deliverables, costs and, due dates is listed below.

Subtask	Deliverable	Due Date	Cost
1	Project Plan	3 months	10%
2	Report on formulations and cognitive engineering models	5 months	20%
3	Report outlining feasible sequencing concepts	5 months	10%
4	Draft design of procedures	10 months	20%
5	a) Final design of TAP procedures for an airport b) Final Integration of prototype two-way Realtime Communication Systems	12 months	40%
Total			NTE $250k[1]

Desired Resource Selection Criteria

In addition to the minimum criteria specified in Section 8.1 of the Institute's Task Award Process, there are five desired resource selection criteria:

1) Participation by an air carrier
2) Knowledge of existing research supporting aircraft sequencing and spacing.
3) Participation and support from a major airport, preferably one in the OEP
4) Capability to model terminal area airspace with support from the air carrier, airport and local air traffic controllers
5) Capability in development and integration of two-way Realtime Communication Systems

[1] Payment on contract is contingent on availability of FAA funds and work products being accepted as having been satisfactorily completed.

Criteria for Acceptability of Deliverables

Participation by an operator and demonstration in an operational environment.

Detailed report which can be used to apply the approach at other airports.