PROJECT PLAN

FOR

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

A

Next Generation Air Transportation Project

This Document Contains Confidential and Proprietary Information from ISI, Georgia Tech, AMTI, and Vector Systems

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AMENDMENT HISTORY

ISSUE	DESCRIPTION	AMENDED BY

Page Revisions

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Latest Rev No	0	0	0	0	0	0	0	0	0	0	0	0	0		

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REFERENCES

[1] Ren, L., Clarke, J.-P., "A Separation Analysis Methodology for Designing Area Navigation Arrival Procedures," Journal of Guidance, Control, and Dynamics 30(5): 1319-1330 (September-October 2007).

[2] Clarke, J.-P., “Project MEM," Presentation to the NGATS Institute at the Kickoff Meeting for 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, 20 September 2007.

1 INTRODUCTION

This document forms the Project Plan as specified in the Aircraft Sequencing and Spacing Optimization Sponsored Work Agreement. This document is prepared in accordance with DTFAWA-05-A-00005 – Task Order E1-07, Schedule of Work Subtask 1. This document will describe how the contract will be handled, the responsibilities for completion of subtasks and the project schedule.

2 SCOPE

This document details how Innovative Solutions International, Inc. (ISI) intends to manage, co-ordinate and control the completion of the overall task (comprised of several subtasks) as defined in the Schedule of Work in DTFAWA-05-A-00005 – Task Order E1-07.

2.1 Scope of Project

ISI will perform planning and prototype development to establish a terminal area testbed at Memphis airport. Using the emerging technologies of the Ground Based Augmentation System (GBAS) Terminal Area Path (TAP) Procedures, real time two-way data exchange, and dynamic sequencing application software and algorithms, the effort will 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

The contract effective date is August 17, 2007 and delivery milestones will be as detailed in the Sponsored Work Agreement.

Figure 1 below shows the scope and operational concept for optimizing the aircraft sequencing and spacing in the terminal airspace during the flight test and demonstration in the planned terminal area test bed at Memphis airport.

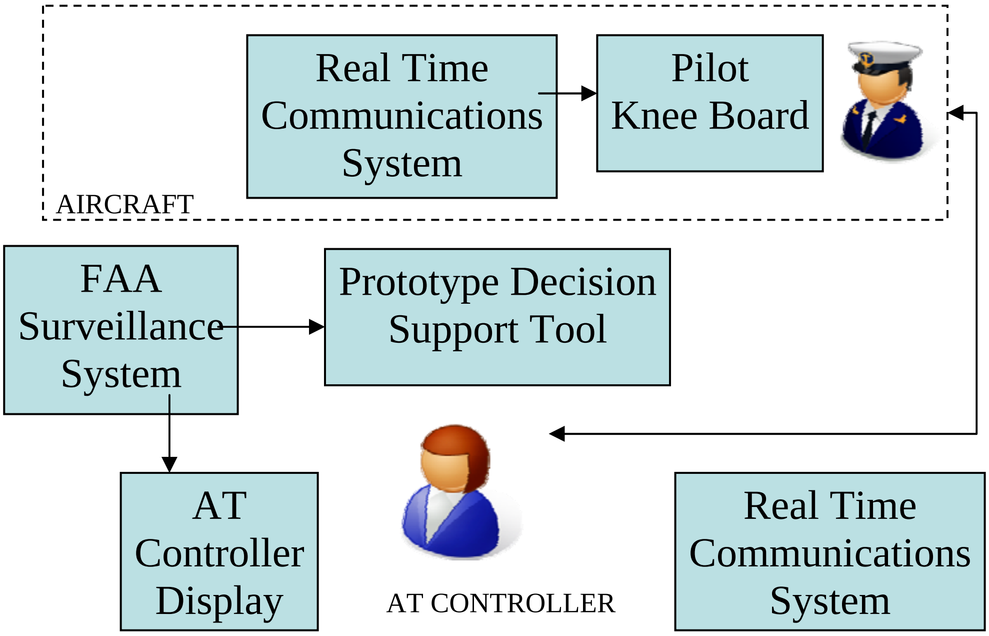


FIGURE 1 – SCOPE AND OPERATIONAL CONCEPT

2.2 *Scope of Project for First Year*

This program plan is only limited to the scope to be covered in the first year of this project. The following are the subtasks that were awarded to ISI on August 17, 2007:

Subtask 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 and provide written Project Plan. (Due Nov 17th)

Subtask 2: Develop different formulations and cognitive engineering models to support the terminal area airspace issues and operations, and provide written report on formulations and cognitive models. (Due Jan 17th)

Subtask 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 written report on feasible concepts for optimizing the sequencing and timing of aircraft and in the terminal area airspace to increase airport throughput and reduce fuel burn and emissions. (Due Jan 17th)

Subtask 4: Integrate prototype decision support tool with the surveillance tool methodology and required flight operations. Provide draft design of TAP procedures and draft design of integration of two-way Realtime Communications Systems. (Due June 17th)

Subtask 5: Design TAP procedures for an airport and a design to integrate a prototype two-way Realtime Communications Systems. (Due Aug 17th)

3 PROJECT IMPLEMENTATION

3.1 Project Execution

This project will be conducted in two tasks over a two year period, and conducted as two phases. The scope of the first task or first phase is addressed in this project plan and will be conducted in the first year of the project. This plan will be updated when the second task is awarded in 2008. This plan addresses project planning and development, including analysis, tool development, NAS integration approach, and operational procedure development required for the first phase. As required, our first phase encompasses development of the infrastructure required to support a terminal area test bed. The second phase will consist of establishing the test bed and conducting the flight trial scenarios developed under the first phase.

3.2 Project Launch

ISI coordinated and hosted a meeting with key participants and sub-contractors. The purpose of the initial meeting was to introduce the Team and provide an overview of the contract. The meeting also discussed the specific objectives that will be demonstrated during the phase II activities at a selected airport. Based on the participants, it was agreed that the selected airport would be Memphis, which is the base of operations for one of the key participants. At this meeting, tasks were discussed and final details were defined to ensure subcontracts would be in place to enable progress by team members. It was clarified at this meeting that ISI will coordinate additional meetings and terms and conditions from the prime contract will be flowed down to sub-contractors as appropriate.

ISI coordinated and hosted a second meeting which included Government participants. The objective of this meeting was to lay the foundation for project execution with an integrated team by reaching agreement on execution timeframe and sequencing methodology. Participants were assigned responsibilities and given authority to proceed with tasks where appropriate.

3.3 Project Organization

ISI has gathered some of the world's preeminent organizations to work on this project. The Team is compromised of ISI, the Federal Express Corporation (FedEx), members of the Georgia Technical Institute's faculty and Advanced Management Technology Incorporated (AMTI). In addition, we plan to expand the team to include Vector Systems. Working together, these individual organizations comprise a team that is able to meet the NGATS Institute's requirements to optimize 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. In addition, the team has unique technologies that will enable validation of the operational concepts required to meet the requirements.

Our integrated Team includes Government representatives from the Federal Aviation Administration (FAA), United States Air Force and NAVCanada. Figure 2 depicts our integrated team.

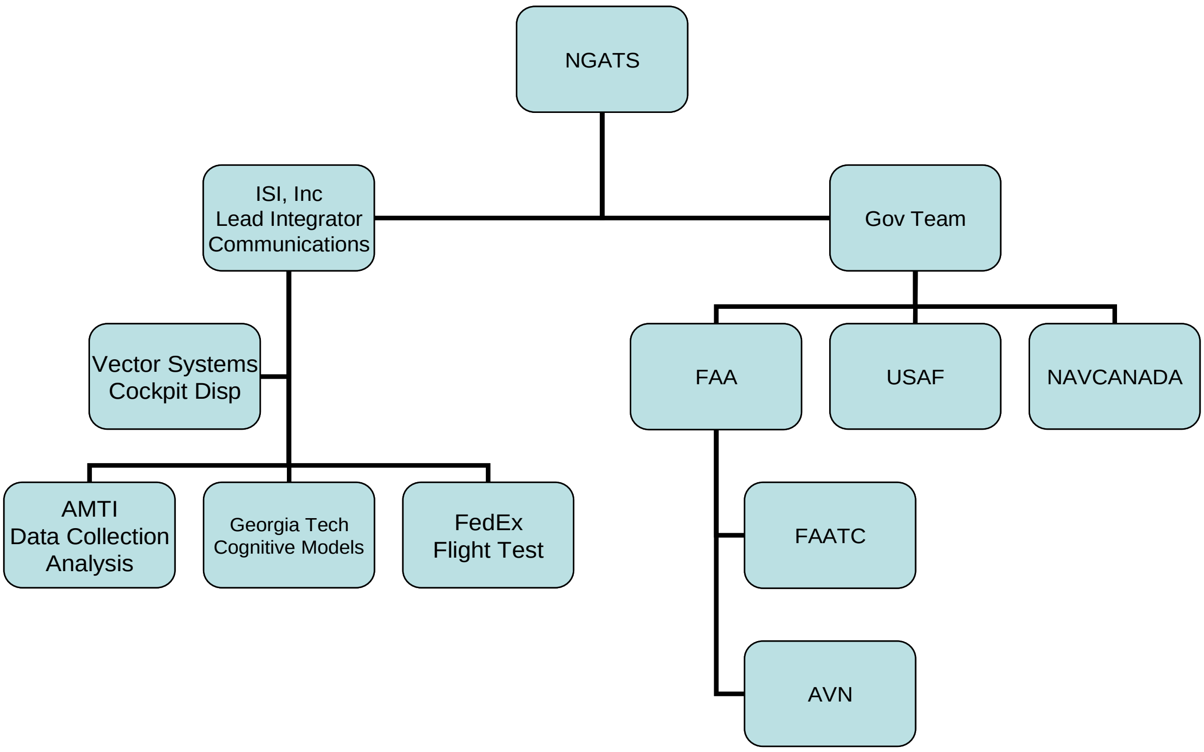


FIGURE 2 – INTEGRATED TEAM

3.4 Project Responsibilities

The overall task described in section 2.1 of this document is broken into five subtasks. These subtasks were evaluated by the Team and responsibilities were divided based on expertise. The subtasks are defined below, followed by the organization leading the task.

Subtask 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 and provide written Project Plan.

Task Lead - ISI

Subtask 2: Develop different formulations and cognitive engineering models to support the terminal area airspace issues and operations, and provide written report on formulations and cognitive models.

Task Lead – Georgia Tech

Subtask 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 written report on feasible concepts for optimizing the sequencing and timing of aircraft and in the terminal area airspace to increase airport throughput and reduce fuel burn and emissions.

Task Lead – Georgia Tech

Subtask 4: Integrate prototype decision support tool with the surveillance tool methodology and required flight operations. Provide draft design of TAP procedures and draft design of integration of two-way Realtime Communications Systems.

Task Lead - ISI

Subtask 5: Design TAP procedures for an airport and a design to integrate a prototype two-way Realtime Communications Systems.

Task Lead – ISI

4 PROJECT METHODOLOGY

Even though this project plan only covers phase I, it is important that in this section on methodology covers both phases I and II. Phase I will mostly be analytical work to show on paper and computer that 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 will illustrate the benefits identified in Section 2.1. The methodology for Phase I is straight forward whereby Georgia Tech evaluates and develops different formulations and cognitive engineering models, and applies them to a simulated airport to demonstrate the effectiveness of their dynamic sequencing application software and algorithms. Georgia Tech will also integrate their prototype decision support tool with the FAA's required surveillance system. ISI will provide management and coordination for the entire team, and also provide designs for a real time two-way data exchange system. In addition, ISI will also develop draft TAP procedures to be used during Phase II. AMTI will develop techniques and software that will be used to analyze the flight test data and evaluate air traffic controllers' national and local constraints. Vector Systems will provide a design to interface the two-way data communications system with the required aircraft and avionic system(s). FedEx, FAA and other organizations will provide the test aircraft as listed in Appendix B. Every company or organization will coordinate and attend meetings as necessary to ensure that all systems can be integrated and demonstrated during Phase II.

For Phase II, the flight or demonstration test, it is critical that all stakeholders agree to the primary objectives that will be demonstrated and evaluated during and after the flight tests. For this project, the main objectives of the demonstration and flight test during Phase II are the following:

Objective 1: Demonstrate that we can safety space and merge two streams of air traffic coming in from opposing directions to land onto a single runway with the following conditions:

- After the opposing air traffic has already been initially spaced and merged before or at the two arrival corner posts
- After the opposing aircraft streams have already started their Continuous Descent Approaches (CDA)
- With aircraft of different types, capabilities and avionic equipage
- Using RNP-compatible Terminal Approach Procedures (TAP)

Figure 3 below depicts our scenario for this flight test and demonstration

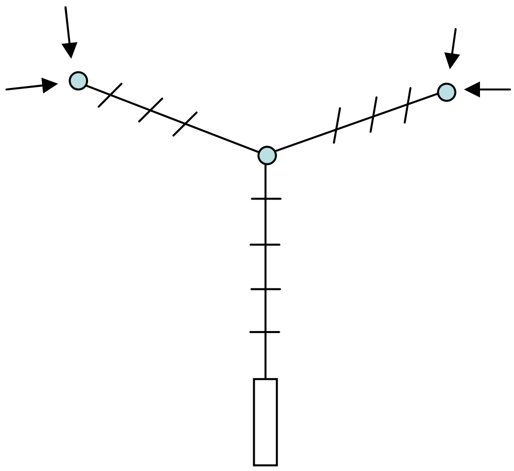


FIGURE 3 – DEMONSTRATION OBJECTIVE

Objective 2: During the flight test and demonstration, data and information will be collected from both the project unique systems and equipment and also from the current FAA systems and equipment so that the following benefits can be estimated and compared for the different flight trails:

1 Shorter distance and less time in terminal area (Decreased Fuel Burn and Emissions)

2 TAP procedures over factories and other less noise sensitive areas; shorter distance and less time at approach altitudes (Reduction in Noise)

3 Reduced time from arrival in terminal area to landing of all aircraft (Increased Approach Availability)

4 TAP procedures with lower minimums (Decreased Minima where possible)

5 Reduced time in terminal airspace, less air traffic controller intervention (Optimized Aircraft Sequencing in Real Time)

6 Minimum deviation and changes from CDA once descend approach profile has been initiated and established (Stable Arrival/Approach Procedures to Terminal Area Operations)

7 Minimum deviation and changes from CDA once descend approach profile has been initiated and established (Constant Rate of Descent Throughout Arrival and Approach)

8 Direct measure of total time in terminal airspace for all test aircraft (Minimized Flight Time in Terminal Area)

9 Reduced number of controller commands and coordination for the flight test aircraft, and minimum of additional controller actions for non test aircraft (Minimized Impact to ATC)

5 FLIGHT SCENARIOS

The objectives of the flight scenarios are to demonstrate increases in airport throughput by demonstrating how currently-available technologies that exploit the advances in Communication, Navigation and Surveillance (CNS) systems, optimize aircraft flight tracks, sequencing, and timing in the terminal area airspace.

The flight scenarios, both the Phase I simulated flights and the Phase II real flights, will document reduced fuel consumption and noise reductions through the use of the Continuous Descent Approach Terminal Area Path approaches. The tests will use a prototype decision support tool that demonstrates the throughput, fuel burn, and emissions benefits that can be achieved in the short- to medium-term through proper sequencing and timing. The tool will allow for multiple spacing of the aircraft to merge them onto a path without slowing down. This path and spacing will be calculated for the optimum fuel reduction, best glide path ratio, and most direct route to the runway, resulting in a reduction in fuel burn, noise and emissions.

5.1 Cognitive Tool Development and Modification

5.1.1 Constant Descent Arrival (CDA)

CDA is sequence and spacing achieved during descent from cruise altitude (top-of-descent) to altitude at metering point. There is no vectoring during descent to runway (i.e. below altitude at metering point) and the location of metering point is dependent on traffic conditions.

The environmental benefits of a CDA are higher trajectory and reduced thrust over much of the arrival and approach results in reduced noise impact. As well as, less time spent below “mixing height” and reduced thrust results in reduced emissions. There is also fuel and flight time savings due to less vectoring and less time flying low and slow.

The Flight Trials in Memphis will support the following objectives:

1. Design “static” arrival procedures that

   a. Reduce noise, fuel burn, and emissions
   b. Can be flown by aircraft with or without a Flight Management System (FMS)
   c. Allow for merging within the terminal area streams of air traffic from different directions destined to the same runway

2. Determine the “relative” timing between aircraft from the same or different direction so that
   a. Target times for aircraft (at their corresponding metering fixes) can be determined for a given aircraft sequence
   b. Spacing between aircraft will be near the separation minimum when the leading aircraft in each pair arrives at the runway threshold
   c. Runway and airport arrival throughput is maximized
3. Develop sequence and spacing algorithm so that
   a. Optimal aircraft arrival sequence is determined, i.e. aircraft sequence that requires the least amount of additional fuel to achieve
   b. Target times at metering fixes and the corresponding cruise speeds required to achieve these target times are computed
4. Implement a communication system so that
   a. Target times at metering fixes and cruise speeds are communicated to the aircraft
5. Implement a guidance system so that
   a. Each aircraft arrives at its metering fix at its target time
6. Measure aircraft performance so that
   a. Noise, emissions, an fuel burn reductions can be estimated
   b. Spacing functionality can be evaluated
7. Test Matrix

   a. 2 direction-scenarios
      i. Single stream from same direction (control)
      ii. Two streams from opposing directions
   b. 2 initial sequence-scenarios (with random initial inter-aircraft spacing)
      i. Aircraft types optimally sequenced
      ii. Aircraft types alternating as much as is possible
   c. 2 sequencing-scenarios

i. Sequencing
ii. No sequencing

Specifically, we will conduct the following runs:

- Run 1
  - Single stream from same direction
  - Aircraft types alternate
  - No sequencing
- Run 2
  - Two streams from opposing directions
  - Aircraft types alternate
  - No sequencing
- Run 3
  - Single stream from same direction
  - Aircraft types optimally sequenced
  - No sequencing
- Run 4
  - Single stream from same direction
  - Aircraft types alternating as much as is possible
  - Sequencing
- Run 5
  - Two streams from opposing directions
  - Aircraft types optimally sequenced
  - No sequencing
- Run 6
  - Two streams from opposing directions
  - Aircraft types alternating as much as is possible
  - Sequencing

Additional information regarding cognitive tool development and modification is available in Appendix A of this document.

5.2 Data Collection and Analysis for Both Simulated and Real Flight Tests

The data collected will be used to evaluate aircraft and pilot performance, and include commands from the Multimode Receiver (MMR) to the aircraft. The data collected will provide for interpretation between what is actually being flown by the pilot and MMR functions. This includes the performance of the aircraft and truthing source that indicates where the aircraft is versus where the MMR indicates that aircraft's position is. The data will also be used to validate and quantify the proposed benefits of the CDA.

One objective of our data analysis is to analyze environmental and economic benefits.

We plan to verify the following:

1. Verify procedure design and operation goals; provide support to the procedure approval process
2. Fuel and flight time savings
3. Reduction in emissions
4. Reduction in noise pollution

We plan to analyze the following

1. Understand the interaction between aircraft performing newly designed procedure; add the development of sequencing and spacing tool
2. Spacing at the metering point
3. Evolution of spacing along the flight path

We will follow the process below to collect and analyze the data:

1. Capture Flight Data Recorder(FDR) and MMR data via the truthing system installed on the aircraft.
    a. Interface hardware/software required for the data downloaded from the MMR and Flight Data Recorder (FDR)
2. Run the collected data using noise and emission modeling software
    a. Integrated Noise Model (INM)

   b. Emissions and Dispersion Modeling System (EDMS)
   c. Noise Integrated Routing System (NIRS)
3. Perform the analysis to assess the noise and emissions performance with PBN
4. Analyze and present briefing on results

5.3 Terminal Area (TAP) Procedures

The TAP approaches will initially be flown as a continuous low power approach from a cornerpost, about 30 nautical miles from the airport, at the edge of the terminal area down to a decision height. It is assumed ATC will vector the pilots to the cornerposts for the approaches. The pilots will fly down to 50 feet above the threshold and fly the centerline. The pilots will then fly as directed by ATC to join existing area traffic and go back to a cornerpost to fly another approach. The pilots will fly the approaches very precisely, as if in actual IMC.

To better analyze the timing, merging, and sequencing benefits of this plan, the approaches will also be designed starting at a point further from the airport, about 60 nautical miles, in the enroute structure.

Appendix B contains examples of draft TAP approaches for Memphis Airport.

5.4 Flight Trial and Aircraft Installation Approach

The flight trials during Phase II will occur on weekends because FedEx is using a revenue aircraft for these tests. The ISI Installation Team will arrive in Memphis on the Thursday prior to the agreed upon weekend. The following day (Friday) will be dedicated to installation and ground testing. The flight trials will consist of three flights per day in 2 hour blocks on Saturday and Sunday. The teams will depart on Monday morning.

The Installation Team will bring all items required for installation the Thursday prior to the first weekend of Flight Trails. Upon completion of the first set (weekend) of Flight Trails, the Installation Team will remove all hardware with the exception of the cables and antennas. The Installation Team will return for the next flight trials on the Thursday prior with all equipment and follow the same schedule as the previous tests. Upon completion of the demonstration, all hardware will be removed from the aircraft.

ISI has identified the following items in an installation package:

1. Dual function antenna (GPS and two-way data),
2. Knee Board/SA Display,

3. Data collection,
4. Satellite Transceiver,
5. Power (if required),
6. Cables

5.5 Flight Trial Aircraft

ISI is coordinating the Flight Trial Aircraft and is working to coordinate participation from several organizations. The Team has identified the following potential aircraft:

1. Two FedEx Boeing 727's
2. FAA Aviation System Standards (AVN-230) Lear 60
3. NAVCanada CRJ-200
4. USAF Lear 35
5. FAA Tech Center Bombardier Global Express 5000

Details regarding aircraft and points of contact are available in Appendix C.

6 MASTER PROJECT SCHEDULE

The Master Project Schedule is in Appendix D.

APPENDIX A

COGNITIVE TOOL DEVELOPMENT AND MODIFICATION

Principal Investigator

Dr. John-Paul Clarke

Associate Professor, School of Aerospace Engineering

Director, Air Transportation Laboratory

Georgia Institute of Technology

Narrative

Based on the discussions that have occurred thus far regarding the above-referenced project, the goals of the broader team as we understand them are to:

- Design “static” arrival procedures that reduce noise, fuel burn, and emissions; can be flown by aircraft without an FMS; and allow for merging within the TRACON of streams from different directions destined to the same runway.
- Determine the “relative” timing between aircraft from the same or different direction so that target times for aircraft (at their corresponding metering fixes) can be determined for a given aircraft sequence; spacing between aircraft will be near the separation minimum when the leading aircraft in each pair arrives at the runway threshold; and runway and airport arrival throughput is maximized.
- Develop sequence and spacing algorithm so that the optimal aircraft arrival sequence is determined, i.e. aircraft sequence that requires the least amount of additional fuel to achieve; target times at metering fixes and the corresponding cruise speeds required to achieve these target times are computed.
- Implement a communication system so that target times at metering fixes and cruise speeds are communicated to the aircraft.
- Implement a guidance system so that each aircraft arrives at its metering fix at its target time.
- Measure aircraft performance so that noise, emissions, and fuel burn reductions can be estimated; and the spacing functionality can be evaluated.

Complete evaluation of the aforementioned optimization algorithms, communication system, and guidance system requires a test matrix that “spans” the range of conditions that will be seen in the typical operating environment. Given that the winds and the direction in which aircraft are traveling relative to said winds are the main operational considerations, we believe that this objective will be met the following parameters and values (as the winds are outside our control and the initial inter-aircraft spacing has infinite possibilities and is difficult to control):

- 2 direction-scenarios
  - Single stream from same direction
  - Two streams from opposing directions
- 2 initial sequence-scenarios (with random initial inter-aircraft spacing)
  - Aircraft types optimally sequenced
  - Aircraft types alternating as much as is possible
- 2 sequencing-scenarios
  - No sequencing
  - Sequencing

Specifically, we propose to conduct the following runs:

- Run 1
  - Single stream from same direction
  - Aircraft types optimally sequenced
  - No sequencing
- Run 2
  - Single stream from same direction
  - Aircraft types alternating as much as is possible
  - Sequencing
- Run 3
  - Two streams from opposing directions
  - Aircraft types optimally sequenced
  - No sequencing
- Run 4
  - Two streams from opposing directions
  - Aircraft types alternating as much as is possible
  - Sequencing

These four runs will allow for evaluation of our performance in terms of achieving the best possible timing given a initial sequence that is optimal, and the best possible timing and sequencing given an initial sequence that is far from optimal (alternating aircraft types), for a single stream and for two streams from opposing directions (and thus experiencing different winds). If time allows, we will repeat each run to develop statistically significant values for the benefits.

The spacing that is required at a metering point upstream of the runway to ensure (to a desired probability) that aircraft performing CDA will be conflict free will be determined using the methodology [1] and the accompanying tool for the analysis of separation and throughput (TASAT). The methodology requires the building of a model of the winds around MEM, Monte Carlo simulation of the different aircraft types over the entire range of possible wind conditions to determine how the spacing between aircraft changes as a function of time given a particular wind condition, and then the application of probability theory to determine the initial spacing that ensures (to a desired probability) that the remainder of the CDA can be performed without interruption.

The optimum sequencing will be determined by enhancing the algorithm (to determine the optimal changes in the cruise speeds of a known sequence of aircraft to achieve the required spacing at the metering point) that has been recently developed by Georgia Tech [2] to account for changes in the aircraft sequence. Specifically, the range of possible sequences will be enumerated, and then an assignment problem will be solved to determine the sequence of the arrivals that achieves the lowest objective function, where the objective function is a weighted sum of the economic and environmental efficiencies, and the constraints are the earliest and latest possible arrival time. A novel of feature of this assignment problem will be the sub-problem in which the cost of achieving a given sequence will be determined using the aforementioned algorithm to determine optimal changes in cruise speeds. By incorporating this feature, the solutions that are developed using the algorithm will be globally optimal rather that just optimal for the descent.

APPENDIX B

SAMPLES OF DRAFT TERMINAL AREA PATH PROCEDURES

RNAV (GLS) RWY 36R

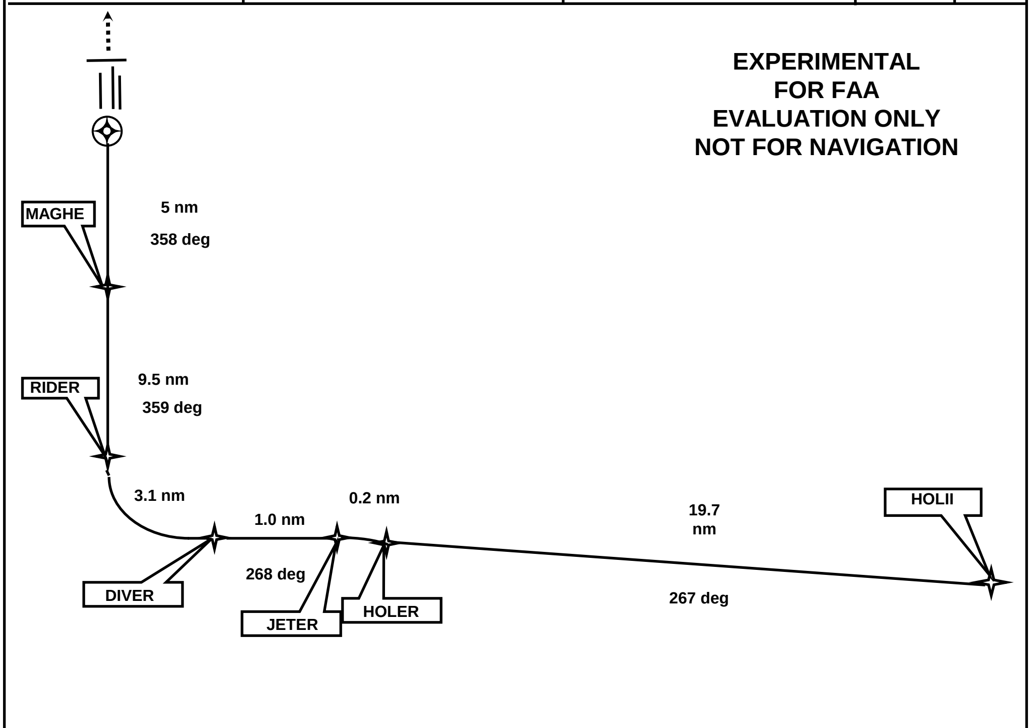
MEMPHIS INTL (MEM)

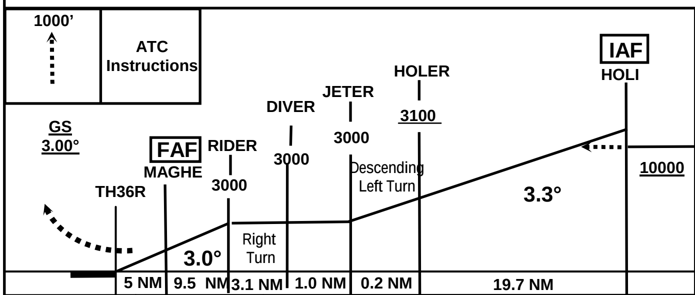
LAAS Chan 33885	APP CRS 358°	Rwy Ldg 9000' TDZE 335' Apt Elev 341'

NA

MISSED APPROACH: Climb to 1000 then climbing right turn to 5000 via 051° course to OROCU Int/MEM 15 DME hold

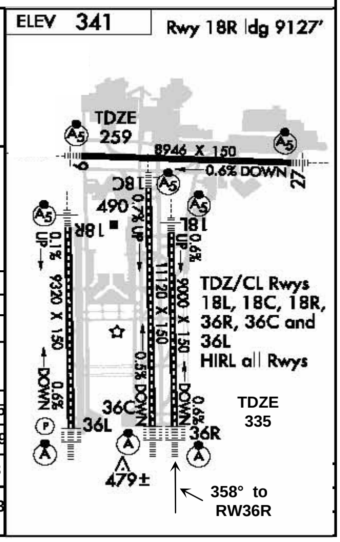
MEMPHIS APP CON	MEMPHIS TOWER	GND CON	CLNC DEL	ATIS
119.1 291.6 (176°-355°) 125.8 338.3 (356°-175°)	(Rwy 9-27) 118.3 257.8 (Rwy 18C/L-36C/R) 119.7 257.8 (Rwy 18R-36L) 128.425 257.8	(Rwy 9-27) 121.0 379.2 (Rwy 18C/L-36C/R) 121.9 379.2 (Rwy 18R-36L) 121.65 379.2	125.2	127.75





CATEGORY	A	B	C	D
GLS DA	535 - ½		535 - ½	
CIRCLING	800 - 1½ 459 (500 - 1½)	920 - 1½ 579 (600 - 1½)		920 - 2 579 (600 - 2)

Ground Speed	100	105	110	115	120	125	130	135	140	145	150	155
Bank Angle (DEG)	4.2	4.6	5.0	5.5	6.0	6.5	7.0	7.6	8.1	8.7	9.3	9.9
Vert Speed (3.00°)	531	557	584	610	637	663	690	716	743	770	796	823
Turn Time (90°)	1:53	1:48	1:43	1:38	1:34	1:31	1:27	1:24	1:21	1:18	1:15	1:13



Orig 060801 35°03'N-89°59'W MEMPHIS INTL (MEM)

RNAV (GLS) RWY 36R

LAAS Chan 33885	APP CRS 358°	Rwy Ldg 9000' TDZE 335' Apt Elev 341'

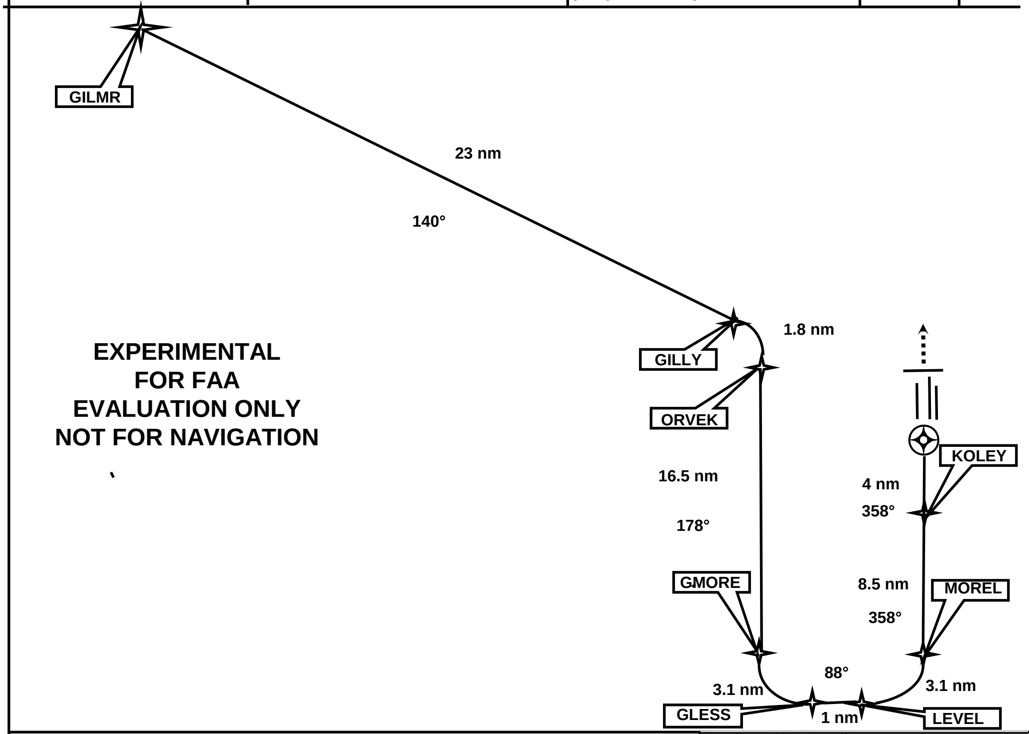
RNAV (GLS) RWY 36L

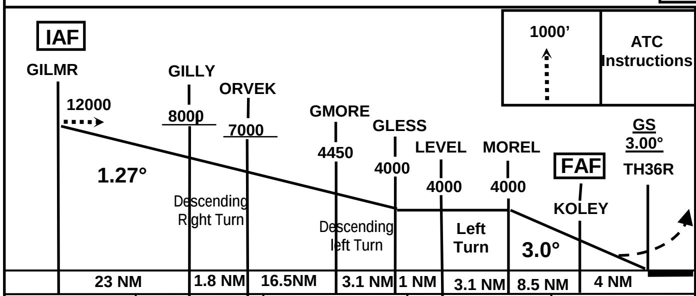
MEMPHIS INTL (MEM)

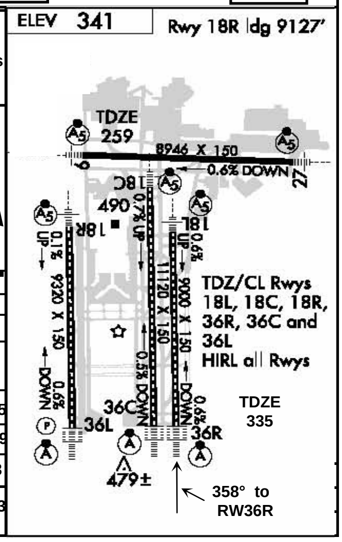
A NA

MISSED APPROACH: Climb to 1000 then climbing right turn to 5000 via 051° course to OROCU Int/MEM 15 DME hold

MEMPHIS APP CON	MEMPHIS TOWER	GND CON	CLNC DEL	ATIS
119.1 291.6 (176°-355°) 125.8 338.3 (356°-175°)	(Rwy 9-27) 118.3 257.8 (Rwy 18C/L-36C/R) 119.7 257.8 (Rwy 18R-36L) 128.425 257.8	(Rwy 9-27) 121.0 379.2 (Rwy 18C/L-36C/R) 121.9 379.2 (Rwy 18R-36L) 121.65 379.2	125.2	127.75







CATEGORY	A	B	C	D
GLS DA	535 - ½		535 - ½	
CIRCLING	800 - 1½ 459 (500 - 1½)	920 - 1½ 579 (600 - 1½)		920 - 2 579 (600 - 2)

Ground Speed	100	105	110	115	120	125	130	135	140	145	150	155
Bank Angle (DEG)	4.2	4.6	5.0	5.5	6.0	6.5	7.0	7.6	8.1	8.7	9.3	9.9
Vert Speed (3.00°)	531	557	584	610	637	663	690	716	743	770	796	823
Turn Time (90°)	1:53	1:48	1:43	1:38	1:34	1:31	1:27	1:24	1:21	1:18	1:15	1:13

Orig 060801 35°03'N-89°59'W MEMPHIS INTL (MEM)

RNAV (GLS) RWY 36R

APPENDIX C
POTENTIAL AIRCRAFT

FAA Tech Center (FAATC) Aircraft

The FAATC has a Bombardier Global Express 5000 (N-47). The N-47 has a Rockwell Collins red label GNLU 930 Multimode Receiver (MMR) that is rack mounted for TAP flight trials. It has a Honeywell Flight Management System (FMS) but it cannot do a LAAS procedure on its own.

The POC is:

John Warburton

FAA William J. Hughs Technical Center

Atlantic City International Airport, New Jersey 08405

Phone: 609-485-6782

John.Warburton@faa.gov

NavCanada:

NavCanada is willing to participate with their Canadair Regional Jet (CRJ)-200. It is a regional jet with 50 seats. They have a Rockwell Collins 4200 FMS with a Wide Area Augmentation System (WAAS) capability. We will work with NavCanada and the Tech Center to get it LAAS capable.

The POC is:

Jeffrey N. Cochrane

NAV CANADA

Manager, CNS Service Design

77 Metcalfe Street, 5th Floor

Ottawa, Ontario

Canada K1P 5L6

Ph.(613) 563-3740

Cell. (613) 294-7460

Oklahoma City Aviation System Standards (AVN-230)

AVN-230 has a Lear 60 with a Universal 1F dual FMS with an independent 930 Multimode Receiver (MMR). To do TAP work, they either have to borrow a red label TAP capable MMR from Tech Center, or download theTAP software into their current boxes. They are working with the Tech Center to determine what is best for the flight trials. AVN-230 has a Truthing System based on their inertia flight inspection equipment.

The Primary Pilot and POC is:

Dan G Burdette/AMC/FAA

AVN-230

405-954-6164

Dan.G.Burdette@faa.gov

The engineer is Duke Pham 405-954-6696

FedEx

FedEx has a LAAS capable Boeing 727 with a Rockwell Collins 930 MMR. By February 2008 it will be black label STC for LAAS straight in procedures only. For the flight trials we will install the Tech Center Red Label TAP Capable MMR. They do not have a FMS on this aircraft. It has a Rockwell Collins Truthing System built in.

The POCs are:

Joel Murdock

901-485-6872 cell

901-224-4861 desk

jmmurdock@fedex.com

Scott Foster

901-224-4425

Scott.Foster@fedex.com

United States Air Force, USAF

The USAF has a Lear 35 (C-21 in Air Force Terms). Currently, it only has a Universal FMS. but they are modifying it for the next 4 months and it should then be LAAS capable and have a Truthing System.

The POC is:

Major Martin J.Towey

HQ AFFSA/A3O

Martin.Towey@tinker.af.mil

Chief of Communication Systems, HQ/AFFSA

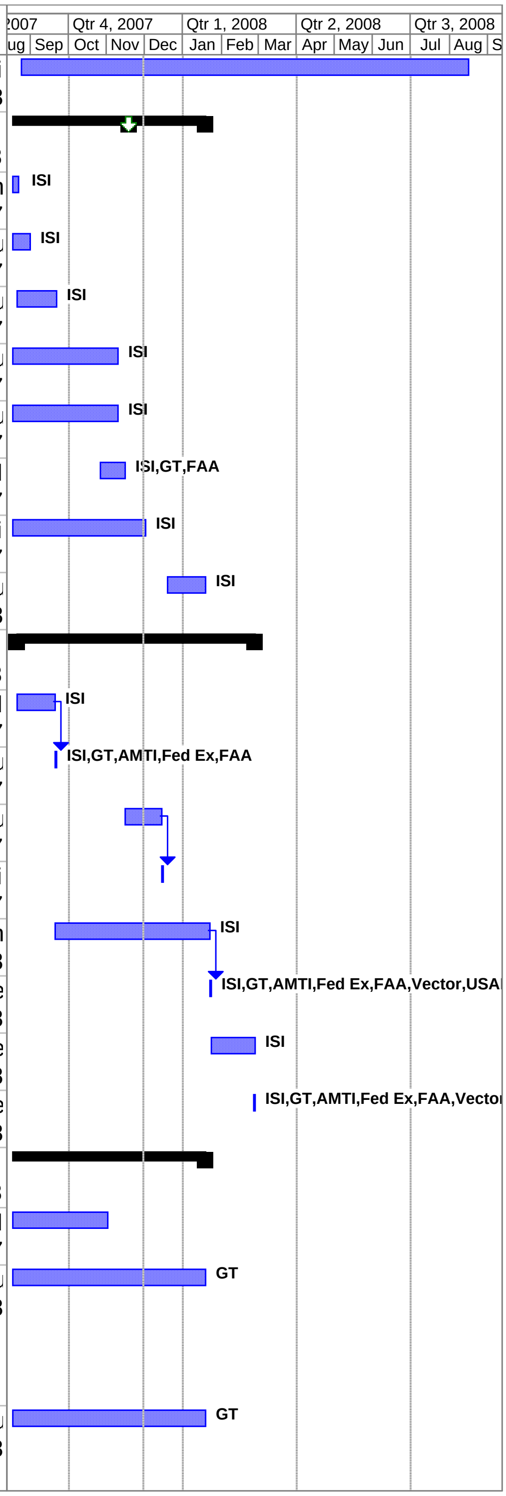
405-739-9981 Desk

405-641-8977 Cell.

APPENDIX D

MASTER PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	NGATS Project	261 days	Thu 8/23/07	Fri 8/15/08
2	**Subtask 1**	**110 days**	**Fri 8/17/07**	**Thu 1/17/08**
3	Organize/Host kickoff meeting	2 days	Fri 8/17/07	Mon 8/20/07
4	Put subcontracts into place	10 days	Fri 8/17/07	Thu 8/30/07
5	Organize/Host IPT meeting	24 days	Mon 8/20/07	Thu 9/20/07
6	Coordinate with airline/industry t reach agreement regarding	60 days	Fri 8/17/07	Thu 11/8/07
7	Coordinate with airport personnel to reach agreement	60 days	Fri 8/17/07	Thu 11/8/07
8	Coordinate with Team regarding input for Project Plan	14 days	Fri 0/26/07	Wed 11/14/07
9	Create and deliver Project Plan	76 days	Fri 8/17/07	Fri 11/30/07
10	Update and deliver Project Plan	23 days	Tue 2/18/07	Thu 1/17/08
11	**IPT Meeting Coordination**	**137 days**	**Mon 8/20/07**	**Tue 2/26/08**
12	Organize/Coordinate IPT meeting at ISI	23 days	Mon 8/20/07	Wed 9/19/07
13	Host IPT meeting at ISI	1 day	Thu 9/20/07	Thu 9/20/07
14	Organize/Coordinate IPT meeting at ISI	21 days	Thu 1/15/07	Thu 12/13/07
15	Host IPT meeting as ISI	1 day	Fri 2/14/07	Fri 12/14/07
16	Organize/Coordinate IPT meeting at MEM	88 days	Thu 9/20/07	Mon 1/21/08
17	Attend meeting at MEM to determine aircraft and	1 day	Tue 1/22/08	Tue 1/22/08
18	Organize/Coordinate IPT meeting	25 days	Wed 1/23/08	Tue 2/26/08
19	Attend/Host IPT meeting	1 day	Tue 2/26/08	Tue 2/26/08
20	**Subtask 2**	**110 days**	**Fri 8/17/07**	**Thu 1/17/08**
21	Deliver Components of Project Plan	54 days	Fri 8/17/07	Wed 10/31/07
22	Develop different formulations and cognitive engineering models to support the terminal area airspace issues and operations	110 days	Fri 8/17/07	Thu 1/17/08
23	Prepare and provide written report on formulations and cognitive models	110 days	Fri 8/17/07	Thu 1/17/08



ID	Task Name	Duration	Start	Finish
24	**Subtask 3**	**110 days**	**Fri 8/17/07**	**Thu 1/17/08**
25	Develop mathematical and cognitive engineering models of the operations at an airport, that	90 days	Fri 8/17/07	Thu 12/20/07
26	Provide written report on feasible concepts for optimizing the sequencing and timing of aircraft and in the terminal area airspace to increase airport throughput	110 days	Fri 8/17/07	Thu 1/17/08
27	**Aircraft Evaluation**	5 days	Mon 2/4/08	Fri 2/8/08
28	Travel to location of aircraft	1 day	Mon 2/4/08	Mon 2/4/08
29	Meet with organization POC to discuss installation of equipment on	0.3 days	Thu 2/7/08	Thu 2/7/08
30	Evaluate aircraft to determine required equipment and designate location for equipment during	3 days	Tue 2/5/08	Thu 2/7/08
31	Travel home	1 day	Fri 2/8/08	Fri 2/8/08
32	**Subtask 4**	**222 days?**	**Fri 8/17/07**	**Tue 6/17/08**
33	Define the operational and integration concepts	82 days?	Fri 8/17/07	Mon 12/10/07
34	Finalize the operational and integration concepts	152 days?	Fri 8/17/07	Mon 3/17/08
35	Draft the concept TAP procedures	152 days?	Fri 8/17/07	Mon 3/17/08
36	Draft the concept of the integrated prototype decision support tool with the surveillance	71 days	Mon 3/17/08	Tue 6/17/08
37	Provide draft design of TAP procedures and draft design of integration of two-way Realtime	1 day	Tue 6/17/08	Tue 6/17/08
38	**Subtask 5**	**261 days**	**Thu 8/23/07**	**Fri 8/15/08**
39	Design TAP procedures for Memphis airport	131 days	Wed 1/16/08	Thu 7/10/08
40	Verify TAP procedures for Memphis airport	6 days	Fri 7/11/08	Fri 7/18/08
41	Develop a design to integrate a prototype two-way Realtime	43 days	Mon 6/2/08	Wed 7/30/08
42	Verify the design of the integrated prototype two-way Realtime	11 days	Thu 7/31/08	Thu 8/14/08
43	Deliver the a design to integrate a prototype two-way Realtime	1 day	Fri 8/15/08	Fri 8/15/08