

Airport Departure Flow Management System (ADFMS)

Project Proposal



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1. PROBLEM DEFINITION

1.1 Problem Description

Air Traffic Management (ATM) or Air Traffic Flow Management (ATFM) systems and procedures have been effectively implemented for air operations between major U.S. airports to include enroute, arrival, and departure separation. The U.S. airspace is controlled by the Department of Transportation's Federal Aviation Administration (FAA) air traffic control systems, which includes a tiered system of Air Traffic Control operators that oversee arrival and departure (Tower Control), approach control (Terminal Radar Approach Control – TRACON), enroute control (Air Route Traffic Control Centers – ARTCCs), and overall coordination and control (Air Traffic Control System Command Center – ATCSCC) of the National Air Space (NAS). The Air Traffic Control system is supported by an automated system of systems that effectively controls the separation and throughput of air traffic.

The ATCSCC's implementations of Ground Delay Programs (GDPs) improve airline efficiency by delaying aircraft departures at origination airports rather than using the more costly holding pattern method. The use of GDPs provide a more cost effective option to holding patterns through the reduction in fuel consumption, reduced aircraft operating hours (reduced aircraft maintenance), reduced emissions, and reduced piloting hours. GDPs also improve airline safety as separation on the ground is significantly less complicated than airborne separation and much less catastrophic.

All major airports have Ramp Control or Ground Control procedures for the management of separation of all surface movement on airport taxiways, inactive runways, holding areas, transitional aprons, and intersections. However, the procedures do not provide for efficiency of airline operations on the ground. Airlines and airplanes establish a queue for departure at the runway threshold. The queue is not controlled, but instead a free-for-all where airlines depart their gates when ready (and approved by Ground Control) and taxi based upon instructions from Ground Control personnel. Departing aircraft establish a departure queue that is not based upon departure time or announced arrival time, but instead based upon a first-come, first-served basis, where Ground Control's primary purpose is to ensure separation and safety. Once established within a queue on a taxiway, the queue cannot be reordered if the width and configuration of the airport aprons, taxiways, and runways cannot support the simultaneous movement of aircraft within what is normally restricted space.

Stakeholders in the air transportation industry have long recognized the need for an automated system to better manage and improve the operation of the departure queue. The ability to establish a virtual queue for departure that would improve the efficiency for participants is highly desired. This virtual queue would hold an aircraft at its gate until the right time so that the aircraft could taxi directly to the departure runway with minimal taxiway delays as well as best support airlines in meeting departure and arrival times that are so important to airline rating systems.

1.2 Project Definition

The GMU Center for Air Transportation Systems Research (CATSR) has a requirement for the definition and design for an Airport Departure Flow Management System that would improve the collective efficiency of airline operations from the gate to departure at a major U.S. airport.

Team AirportDFM will define the requirements and prepare and prove a preliminary design for an Airport Departure Flow Management System (ADFMS) for the Philadelphia International Airport (PHL). Team AirportDFM will also conduct a Cost-Benefits Analysis for each of the stakeholders for the proposed system.

Team AirportDFM's objective is to define system requirements, create a concept of operations, develop an initial design, and perform scenario analysis through modeling and simulation for an automated system with supporting operational procedures for a virtual queue implementation and optimization to provide collective benefits to all stakeholders at PHL.

1.3 Project Scope

While major U.S. airports have many common operations and functions, the physical scale and configuration of each airport's terminals, gates, taxiways, and runways, as well as differences in the numbers of carrier, capacity for individual aircraft as well as maximum sustainable departure rates, result in a unique problem for each airport.

The scope of the Airport Departure Flow Management (DFM) System definition and design for this proposal is PHL. Team AirportDFM will analyze current ground operations and queuing at PHL. For the purposes of this project, 'ground operations' is limited to the movements and sequencing of aircraft from the gate until departure.

Although airport departures and arrivals are highly coupled, in order to best focus the project, the project team will not make any consideration of airport arrivals. The project team will also not make considerations for the impact to departure operations due to the weather or ground delay programs (GDPs). The project team will limit the study to airlines that share common terminals, taxiways, and departure runways: there will be no consideration for general aviation aircraft that normally utilize a separate hanger space, apron, and runway.

2. PRELIMINARY REQUIREMENTS

2.1 Project Requirements

- 2.1.1 Team AirportDFM shall develop a system requirements document.
- 2.1.2 Team AirportDFM shall develop a concept of operations.
- 2.1.3 Team AirportDFM shall develop a preliminary design for the ADFMS.

- 2.1.4 Team AirportDFM shall develop an executable queuing model which will be used to evaluate departure delay, aircraft emissions and fuel burn.
- 2.1.5 Team AirportDFM shall document Scenario Analysis results.
- 2.1.6 Team AirportDFM shall develop a Cost-Benefit Analysis for stakeholders of the proposed ADFMS.
- 2.1.7 Team AirportDFM shall provide regular progress reports at time defined by the class schedule.
- 2.1.8 Team AirportDFM shall provide a final presentation and final report that includes all deliverables.
- 2.1.9 Team AirportDFM shall develop an ADFMS web site to publish all project documentations and ADFMS results.

2.2 Composite Requirements

- 2.2.1 The ADFMS shall implement a virtual queue of planes waiting for takeoff to replace the physical queue currently established on the taxiway.
- 2.2.2 The ADFMS shall be able to support an airport configuration consisting of one runway dedicated to arrivals and one runway dedicated to departures.
- 2.2.3 The ADFMS shall be available over the internet.
- 2.2.4 The ADFMS shall account for interaction with air traffic control, ground control and airlines.

2.3 Functional Requirements

- 2.3.1 The ADFMS shall have a planning component based on flight schedules or airline departure slot reservations.
- 2.3.2 The ADFMS shall be able to accept flight schedules as input.
- 2.3.3 The ADFMS shall have a real-time component to handle flight delays and flight changes.
- 2.3.4 The ADFMS shall minimize the duration of time that aircraft use the taxiway and holding areas prior to take off.
- 2.3.5 The ADFMS shall output pushback times that account for current airport traffic.
- 2.3.6 The ADFMS shall maintain a departure slot for flights scheduled to depart from the airport.

2.4 Performance Requirements

- 2.4.1 The ADFMS shall be capable of handling 12 flights every 15 minutes
- 2.4.2 The ADFMS shall be capable of storing 3 months worth of departure slots

3. TECHNICAL APPROACH

An evolutionary acquisition incremental approach will be applied to the ADFMS to allow for the incorporation of emerging technologies, changing user needs, and knowledge

gained during operation. Team AirportDFM will apply the concept of the DoD Systems Engineering Process as shown in Figure A-1, throughout the life cycle of the ADFMS.

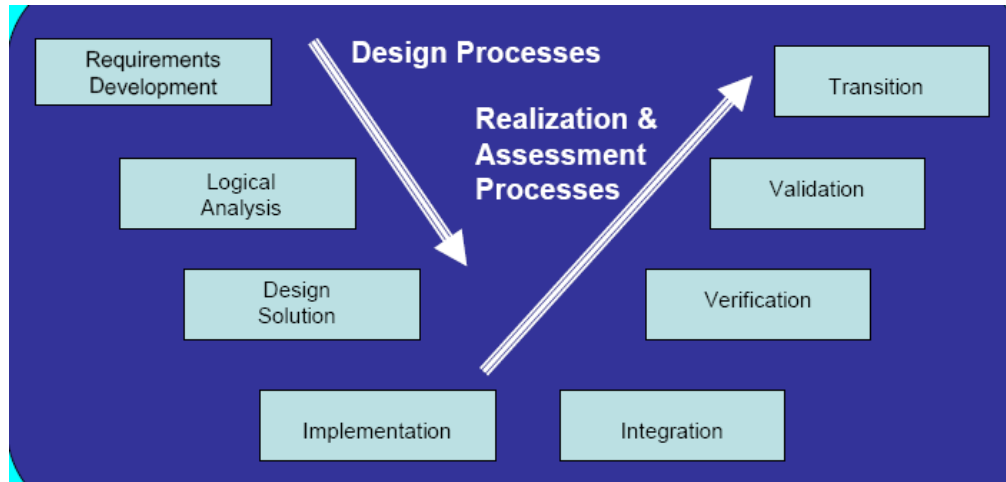


Figure 1 DoD Systems Engineering Process

3.1 Requirements Development

During the requirement development phase Team AirportDFM will conduct the following activities:

- Understand the requirements from the stakeholders: This activity includes meeting with various stakeholders to understand their needs, understand the current problem through review of literature and historical data, and research for solutions in similar problems.
- Develop the system life cycle requirements: This activity identifies all the life cycle system requirements in order to develop, design, test, operate and sustain the system.
- Develop the system requirements consistent with the stakeholders' requirements: This activity includes the documenting of the requirements gathered from the stakeholders and various research efforts into the system functional requirements and system performance requirements.
- Validating the requirements: This activity is to ensure that specified requirements are correct and consistent with the stakeholders' requirements.

3.2 Logical Analysis

During this phase Team AirportDFM will decompose the requirements to obtain architectures that explain and show relationship of the system's functional and behavioral characteristics.

Team AirportDFM will use UML modeling to develop both the functional architecture and behavioral architecture.

3.3 Design Solution

During this phase Team AirportDFM will use the output from the Logical Analysis and functional architectures to establish the product architecture and finalize the system design requirements.

3.4 Implementation

The Implementation phase involves the modeling of ADFMS from the established product architecture and system design requirements. The Arena Software will be used to model the ADFMS.

3.5 Integration

The Integration phase involves an analysis of all different models created during the implementation to come up with the final proposed solution for the ADFMS.

3.6 Verification and Validation

The verification phase involves comparing the final model of ADFMS to the established requirements to see whether the model meets the requirements. The validation phase involves demonstrating the model to the stakeholders to determine whether the model meets the stakeholders' requirements.

3.7 Transition

This phase involves the gathering of all documentation and the packaging of the model's coding into an executable model to be delivered to the stakeholders.

4. EXPECTED RESULTS

Through iterative system definition and system design processes, Team AirportDFM expects to provide refined system definition and design documentation. Initial system definition activities will result in an initial system design. Through modeling and simulation of the design, Team Airport DFM expects to refine the initial system definition and design until a feasible executable model can be established that meets the stakeholder objectives for the virtualization of the departure queue at PHL. Simulation will be performed to validate various scenarios within the problem set.

The refined system definition, design, and scenario will provide a foundation for alternative follow-on activities:

- Additional systems definition and design to account for conditions out of scope of this initial effort

- Statement of Work (SOW) and Request for Proposal (RFP) formulation for initial system development

4.1 Deliverables:

The major deliverables for ADFMS are as follows:

4.1.1 Concept of Operations (CONOPs) Document

The CONOPs document shall describe the characteristics of a proposed system from the viewpoint of an individual who will use the proposed system and how the system will be used. It will be used to communicate the quantitative and qualitative system characteristics of all stakeholders.

4.1.2 System Requirements Document

This document shall consist of a structured collection of information that would constitute the requirements of the system. These requirements shall be based on the business and system needs of the clients and the stakeholders, and help identify the potential problems and propose solutions.

4.1.3 Scenario Analysis Document

This document would involve the process of analyzing possible future events by considering the alternative possible outcomes (scenarios). This analysis would allow improved decision-making by allowing consideration of outcomes and their implications.

4.2 System Design Results

The desired and expected outcomes of the operational functionality of the ADFMS project to be achieved at completion are as follows:

- The most fundamental and primary functionality of the ADFMS shall comprise a queuing model based on departure slots in which the airlines would be able to reserve slots and trade or exchange them in the event of a delay or disruption.
- The ADFMS shall provide the cost-benefit analysis and tradeoff, based on mathematical and numerical calculations.
- The ADFMS shall also minimize the losses incurred from departure delays, aircraft emissions, and fuel burns by alleviating the problem of unnecessary taxiway congestions.

- The ADFMS would propose such a strategy in which the airplane would wait at the gate before the clearance to go ahead. Once the airplane departs the gate and leaves for the runway, there is minimal or no waiting period involved.
- At the completion of the project, the expected business value would be derived.
- The ADFMS would operate in real-time dynamically, accepting the schedule data and building the queuing slot model based on that.
- The feasibility studies of the proposed systems solution would be carried in the technical domain.
- The ADFMS would also propose a centralized management and control authority for the proper operation and functionality of the system.
- The ADFMS would replace the first-come, first-served (FCFS) queuing method with an efficient queuing algorithm taking into account ground control factors and constraints.

5. INITIAL PROJECT PLAN

Team AirportDFM's initial project plan for the ADFMS definition, design, assessment and transition follows. Team AirportDFM will refine the project plan during the system definition phase:

5.1 Work Breakdown Structure

The project WBS is structured according to the deliverables that Team AirportDFM will prepare during the course of the project duration.

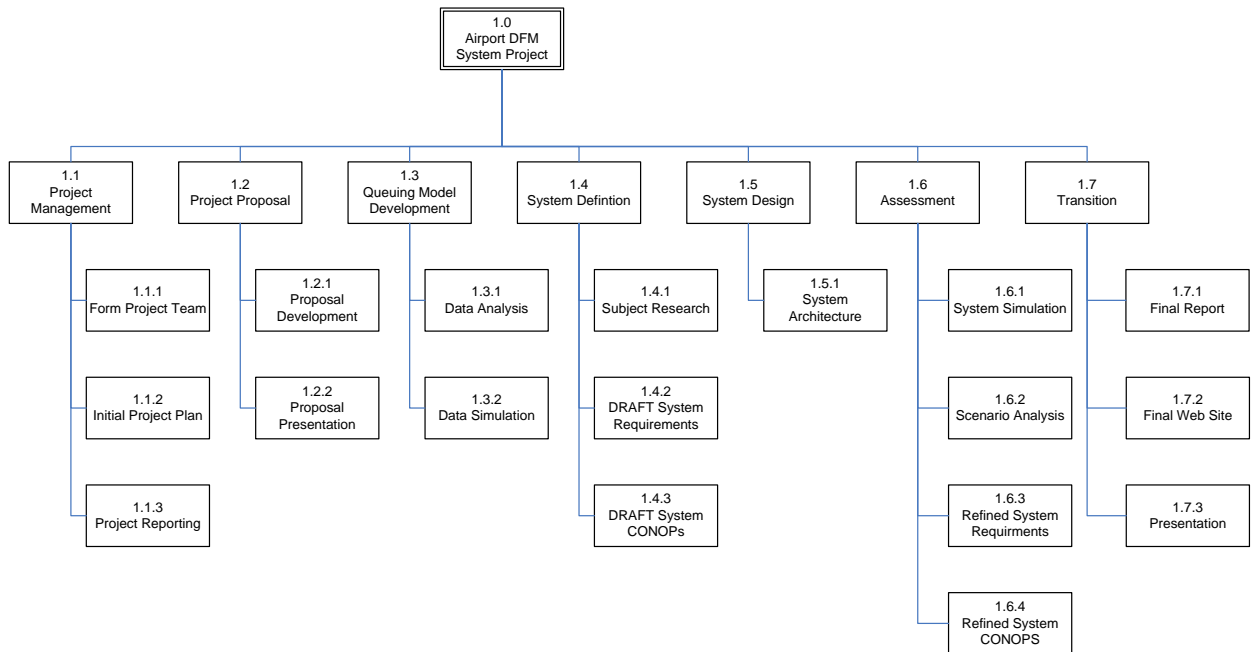


Figure 2 Team AirportDFM System Project Work Breakdown Structure

Project Schedule

The following high-level project schedule is designed to best meet Team AirportDFM milestones and deliverable due dates. Due to time limitations, queuing model development is concurrent with the system definition and design phases at the recommendation of the project sponsor.

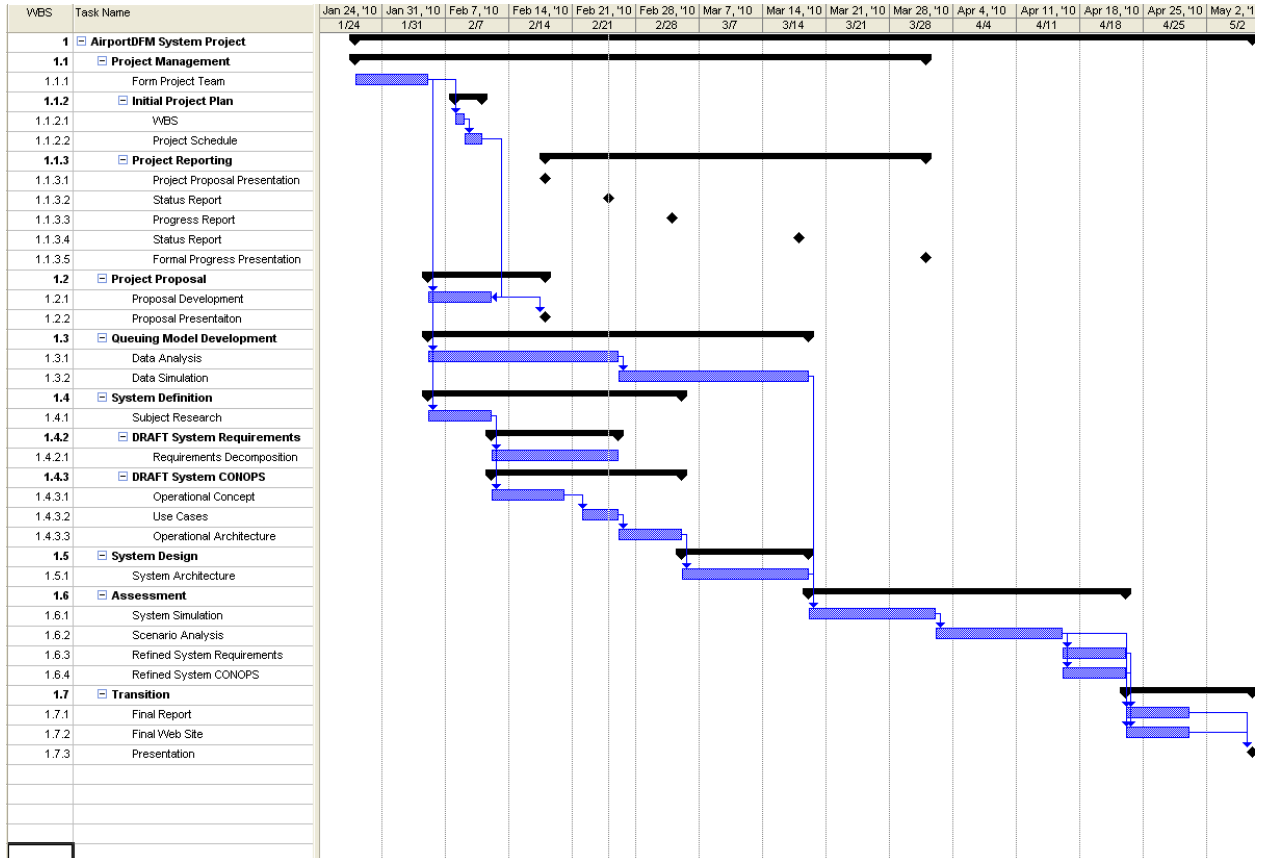


Figure 3: Team AirportDFM System Project Schedule

5.2 Project Deliverables

Team AirportDFM proposes to provide project deliverables in accordance with the following schedule:

Project Deliverables	Delivery Date
Project Proposal	11-Feb-10
Status Report	18-Feb-10
Progress Report	4-Mar-10
Status Report	18-Mar-10
Formal Progress Presentation	1-Apr-10
Final Report *(includes AirportDFM System deliverables)	29-Apr-10
Project Web Site	29-Apr-10
Final Presentation	7-May-10

Figure 4: Team AirportDFM System Deliverables Schedule

The Final Report will include, along with the class requirements, the AirportDFM System deliverables:

- System Concept of Operations (CONOPs)
- System Requirements Document
- Scenario Analysis document