Air Force Operations Center Scheduling (AFOCS)

OR 680 / SYST 798
Capstone Project Proposal

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TABLE OF CONTENTS

1. Problem Definition

1.1 Introduction

U.S. Air Force operations require staffing numerous operation centers with trained and certified personnel. Scheduling the staffing of these operation centers is a time consuming manual process. Scheduling includes not only staffing the operation centers, but also scheduling the training events, training resources, and trainers necessary to maintain current certification. The goal of this project is to develop an optimization scheduling model that will enable the automation of the scheduling tasks for a USAF group-level organization (Group).

1.2 Background

The Group provides staffing to 15 operation centers (op centers). Each op center requires two functional positions: Crew Commander (CDR) and Deputy Crew Commander (DEP). The shifts are 24 hours long (7 a.m. to 7 a.m.). Shifts are referred to as "Alerts," however, in this document the term shift will be used.

1.3 Organization

The USAF group consists of three squadrons. Each squadron is responsible for staffing five op centers, one of which is the Squadron Command Post (SCP) which requires an additional certification for the personnel manning this op center.

1.4 Personnel

Personnel are categorized according to their functional roles. The four functional roles are:

1. Crew member
2. Instructor (INST)
3. Evaluator (EVAL)
4. Flight Commander (FLT CDR)

Crew members are the individuals whose primary function is to perform op center duty. Each shift requires one CDR and one DEP for each op center. Pairing the same CDR with the same DEP is referred to as "crew integrity". Maintaining a crew integrity level of 80%, that is 80% of the time each person is assigned to a shift or training they are paired with the same partner, is a high priority for the organization. Crew members can pull up to a maximum of 8 shifts in a calendar month. All CDRs can pull duty as DEPs if necessary.

The other three sets of individuals, in addition to their role as INST, EVAL, or FLT CDR, are also qualified as either CDR or DEP. These individuals are required to pull two shifts per calendar month.

1.5 Required Training

Individuals are required to participate in mandatory monthly training events to maintain current certifications to perform duty. The monthly training events are:

- TR
- T1
- T3
- T4

Additionally, there is an annual evaluation requirement. **Error! Reference source not found.** summarizes the training requirements for the personnel to be qualified to perform op center duty.

Table 1: Summary of Required Training

Training Event	Frequency	Type	Duration (hrs)	Trainer	Comments
TR	Monthly	Simulator	4	INST – 2 ea	
T1	Monthly	Classroom	8	INST – 2 ea	
T3	Monthly	Classroom	4	INST – 2 ea	Often paired with T4
T4	Monthly	Classroom	4	INST – 2 ea	Often paired with T3
Annual Evaluation	Annually	Simulator	4	EVAL – 3 ea	

There is a maximum of 45 days between performing duty in the op center. However, for the personnel assigned to perform SCP duty, the maximum time limit is increased to 60 days between performing duty in the SCP.

1.6 Down Time

The day immediately following a shift is an Off day (“O”day) for the personnel who performed duty during the shift. Additionally, all personnel are required to have nothing scheduled during the twelve hours immediately preceding the shift. Sundays and federal holidays are normally training holidays with no scheduled training, however shifts are still scheduled.

1.7 Training Resources

The group has two simulators and numerous classrooms available to conduct the monthly required training. Simulator availability is dependent upon the operations tempo (op temp) for the group. The simulators are available in four 4-hour blocks from 7 a.m. to 11 p.m. during regular op tempo or in five 4-hours blocks from 6 a.m. to 2 a.m during increased op tempo. Simulator availability and classroom availability will each be constraints as the number of simulators and simulator slot times are limited as well as the number of available seats in each classroom.

2. Statement of Need

An optimization model needs to be developed for automatic scheduling for operations centers to improve efficiency and performance of the existing scheduling process. As a result, the primary objective of the AFOCS team is to develop a dynamic algorithm to handle daily changes and produce a re-optimized solution while still adhering to all the scheduling conditions.

This algorithm will be designed within the 14-weeks class period. The analysis of the concept and design of this algorithm will be concluded by May 5th. Also, a cumulative final report will be prepared by May 2011.

3. Statement of Work

To construct a better and faster scheduling process, AFOCS team should develop an optimization algorithm. To do so, the AFOCS team will:

- Completely understand the existing scheduling process;
- Perform research on similar problems (i.e. literature review);
- Establish connection and dialogue with the client to extract client's need and requirements;
- Develop an optimization algorithm to improve efficiency and performance of the existing scheduling process ;
- If time permits, compare the existing and new process with the developed algorithm.

As a result of this work, the scheduling process and preparation time should be improved and more efficient than the existing process.

4. Scope

4.1 In Scope

The emphasis of this project will be to develop an optimization algorithm to improve efficiency and performance of the existing scheduling process. The AFOCS team will test and analyze the optimization algorithm.

4.2 Out of Scope

The AFOCS team will not be responsible for implementing code to merge the algorithm with the current system.

4.3 Assumptions

In developing the optimization algorithm, the AFOCS team has the following assumptions:

- Project sponsors will be available to answer questions and clarify business rules for scheduling resources.
- The AFOCS team will have access to the AIMMS software platform for developing the optimization algorithm.
- The optimization algorithm has two functions:
    1. Produce a set schedule of resources (personnel, equipment, and classrooms) for a given input calendar month;
    2. Re-optimize the schedule due to unforeseen unavailability of resources.
- The optimization algorithm will have, at minimum, the following data for input:
    - Calendar month/year to be scheduled;
    - Pre-scheduled days for training classes;
    - Classroom availability for trainees;
    - Number of instructors required for Trainer Rides;
    - Number of slots per day available for Trainer Rides and Evaluations;
    - Number of personnel and their job titles and roles;
    - Unavailable days for personnel due to Leave, Duty Not Including Alert (DNIA), Temporary Duty (TDY), etc.

5. Preliminary Requirements

These preliminary requirements are intended for the project sponsor to document that Team AFOCS has a preliminary understanding of the sponsor's needs. The requirements will be developed further as the project progresses.

5.1 Project Requirements

5.1.1 Team AFOCS shall develop an optimization algorithm/model.

5.1.2 Team AFOCS shall compare performance of different algorithms/approaches.

5.1.3 Team AFOCS shall develop a Requirements Document.

5.1.4 Team AFOCS shall develop an Architecture diagram using a data model to show the different pieces of data and how the pieces flow together. This will help ease the tracking of the outputs from the model and where the outputs originate.

5.1.5 Team AFOCS shall prepare a Systems Engineering Management Plan (SEMP).

5.1.6 Team AFOCS shall develop a Test and Evaluation Master Plan (TEMP).

5.2 Functional Requirements

5.2.1 The model shall schedule 15 op centers plus one standby crew.

5.2.2 The model shall schedule monthly and annual required training.

5.2.3 The model shall maximize crew integrity.

5.2.4 The model shall schedule one or two instructors (INST) for each monthly training event.

5.2.5 The model shall schedule three evaluators (EVAL) for each annual evaluation.

5.2.6 The model shall be able to rebuild the schedule anytime during the calendar month due to an unforeseen absence of an individual.

5.2.7 The model shall minimize rescheduled events due to an unforeseen absence of an individual.

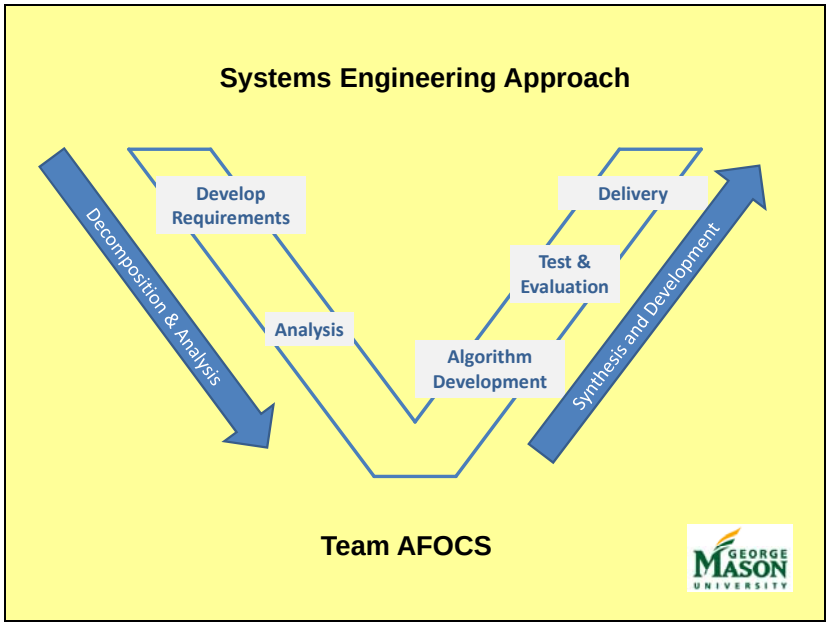
6. Technical Approach

Team AFOCS will apply a standard Systems Engineering vee-design approach to this project. Due to the very short period of performance, some of the activities will occur concurrently. The project will be completed in five overlapping phases. The phases are:

- Requirements Development
- Analysis
- Algorithm Development
- Test & Evaluation
- Delivery

Error! Reference source not found. shows the customized Systems Engineering approach to this project.

Figure 1: Team AFOCS Technical Approach



6.1 Requirements Development

Initially, Team AFOCS will examine the sponsor's stated requirements, needs, and desired outcome. The team will derive further detailed requirements. A large portion of the requirements phase will be spent developing the functional requirements of the model. The sponsor will provide feedback during the requirements development phase and approve the finalized functional requirements. The requirements phase will be conducted concurrently with the Analysis phase described in the next section.

6.2 Analysis

The Analysis phase of the project will consist of two major interrelated activities. The first activity is the continuation of the requirements analysis from the first phase in the project. This analysis will discover any previously unknown interrelations and dependencies.

The second major activity in this phase will be a literature review for similar models and algorithms. The team will use the resources of the George Mason University Systems Engineering and Operations Research department, in addition to any other corporate resources to which the individual team members might have access. TimePiece, a product developed by Kepler Research, Inc. is the current scheduling tool used by the USAF group. The current practices will also be analyzed. Any possible algorithms, models, or code will be considered by Team AFOCS for reuse.

6.3 Algorithm Development

Design and development of the optimization algorithm, the model, will be conducted through an iterative approach. The model will be developed using Linear Programming and Integer Programming techniques. Team AFOCS intends to use the AIMMS v3.11 as the primary software tool (www.aimms.com).

The optimization will produce monthly schedules for personnel in three phases. The first phase focuses on scheduling the shifts for the op centers as fulfilling shift demand is the top priority. After shifts are scheduled, the model's second phase will schedule training events for each person to meet the monthly training requirements. The training events require the coordination of (1) personnel to complete the training, (2) instructors to perform the training, and (3) simulators or classrooms to serve as the platform for training, with each component having limited availability and scheduling conflicts.

The final phase of the optimization algorithm development will be the capability to reschedule mid-month due to an absence of one or more personnel. A major goal of this model is to minimize schedule disruption for the remainder of the month if an individual cannot perform duty due to an illness or injury.

6.4 Test and Evaluation

The optimization algorithm will be tested iteratively throughout the model development. Final testing will be accomplished with simulated data. Testing and Evaluation will be further described in the Test and Evaluation Master Plan (TEMP).

7. Expected Results

Team AFOCS expects to develop an efficient optimization algorithm that can automate the scheduling task. The algorithm will be dynamic to address the daily changes and produce a new optimized solution that still adheres to all the conditions for the schedule. The USAF group will use the algorithm to improve efficiency and performance of the existing scheduling process.

Team AFOCS expects to find usable models and analyses from the literature review. This research will be used to compare the performance of different approaches to the algorithm based on various models and analyses. Additionally, the literature review will be used to create the requirements document, the Systems Engineering Management Plan (SEMP) and Test & Evaluation Master Plan (TEMP).

The final products produced will be the actual optimization model developed in AIMMS and associated documentation, including a final report and final presentation.

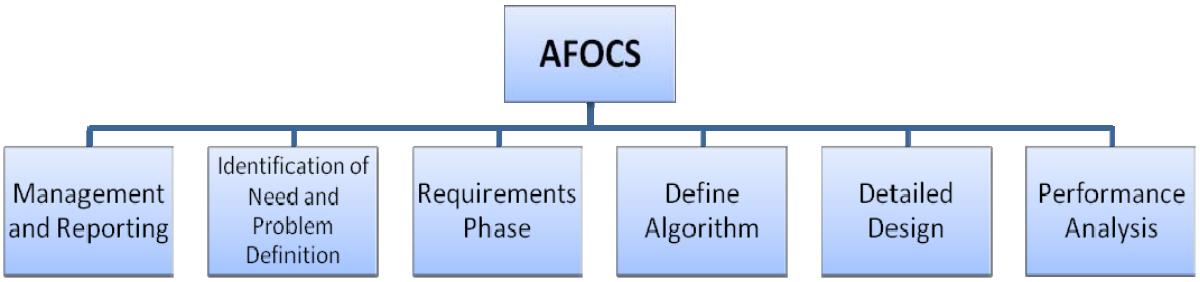
8. Initial Project Plan

The AFOCS team will use Microsoft Project to manage the Work Breakdown Structure and Schedule.

8.1 Work Breakdown Structure (WBS)

The AFOCS project was broken into 6 different phases; level 1 is shown in **Error! Reference source not found.**.

Figure 2: Level 1 WBS of the AFOCS Project



8.1.1 Management and Reporting:

During the management and reporting tasks the AFOCS team will:

- Determine project plan and Work Breakdown Structure (WBS)
- Define Group Responsibilities
- Schedule Telecoms with the client
- Monitor the production of deliverables

8.1.2 Identification of Need and Problem Definition

Within the identification of need and problem definition phase, the AFOCS team will develop a better understanding of the existing scheduling process. Then, the AFOCS team will define the statement of need and the scope of this work.

8.1.3 Requirements Phase

During the requirements phase, the AFOCS team will define the project's and the client's requirements.

8.1.4 Define Algorithm

At this stage, the AFOCS team will define a methodology of the algorithm that the AFOCS team will be developing.

8.1.5 Detailed Design

For the detailed design, the AFOCS team will construct the Concept of Operations (CONOPS) and document it.

8.1.6 Performance Analysis

For the performance analysis phase, the AFOCS team will design the fundamental aspects of the algorithm and define the specifics of its behavior. A significant aspect of this phase will be developing the algorithm and implementing it using a mathematical tool calls "AIMMS". Next, the AFOCS team will do more analysis and will evaluate the algorithm. Once the analysis and evaluation of the algorithm has been completed, the algorithm will be tested to meet the performance criteria. Also, the AFOCS team will apply some decision and sensitivity analysis to some constraints of the problem.

8.2 Project Schedule

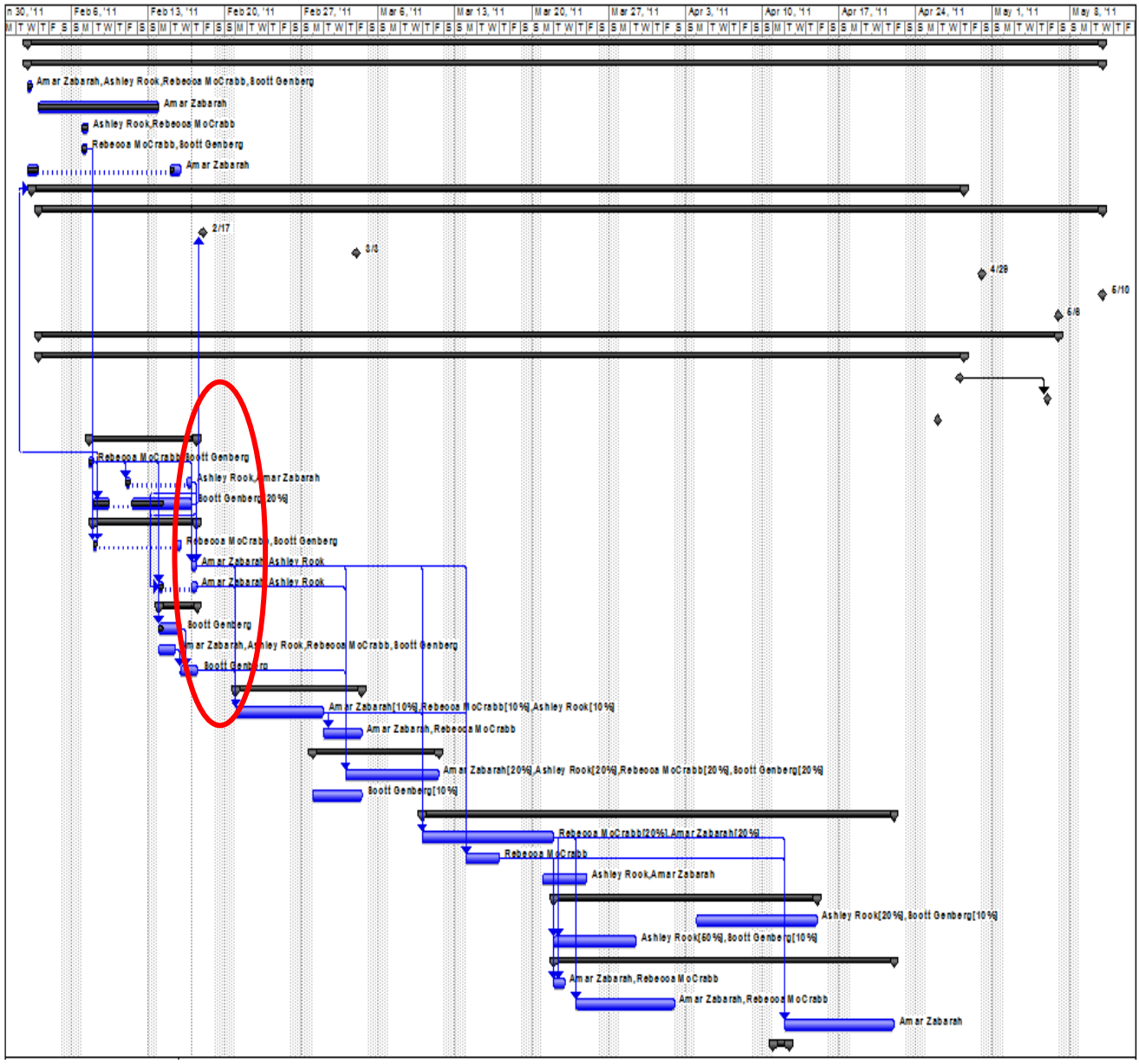
The AFOCS team created a work breakdown structure using Microsoft Project to track the completion of the project through the spring 2011. The tasks for the project are shown in **Error! Reference source not found.** while the associated Gantt chart is shown in **Error! Reference source not found.**.

Figure 3: AFOCS project schedule

AFOCS_Project Plan

ID	Task Name	Duration	Start	Finish	Predecess	Resource Names
1	**Air Force Operations Center Scheduling Project**	**568 hrs?**	**Wed 2/2/11**	**Tue 5/10/11**		
2	**Management and Reporting**	**568 hrs**	**Wed 2/2/11**	**Tue 5/10/11**		
3	Kick-Off Telecon	2 hrs	Wed 2/2/11	Wed 2/2/11		Amar Zabarah,Ashley
4	Determine Project Plan and Work Breakdown Structure	4 hrs	Thu 2/3/11	Thu 2/3/11		Amar Zabarah
5	Define Group Responsibilities	4 hrs	Mon 2/7/11	Mon 2/7/11		Ashley Rock,Rebecca
6	Kick Off Meeting	2 hrs	Mon 2/7/11	Mon 2/7/11		Rebecca McCrabb,Sc
7	EVM Review	16 hrs	Wed 2/2/11	Tue 2/15/11		Amar Zabarah
8	**Meetings/Telecon (Biweekly)**	**496 hrs**	**Wed 2/2/11**	**Thu 4/28/11**	35	
16	**Deliverables**	**560 hrs**	**Thu 2/3/11**	**Tue 5/10/11**		
17	Proposal	32 hrs	Fri 2/11/11	Thu 2/17/11	37	Scott Genberg[20%]
18	Interim Progress Report I	72 hrs	Mon 2/21/11	Thu 3/3/11		Amar Zabarah[10%],A
19	Interim Prohress Report II	72 hrs	Tue 4/19/11	Fri 4/29/11		Amar Zabarah[10%],A
20	Optimization algorithm(s)	72 hrs	Thu 4/28/11	Tue 5/10/11		Rebecca McCrabb[25
21	Website	72 hrs	Tue 4/26/11	Fri 5/6/11		Amar Zabarah[25%]
22	**Presentation that communicates results**	**544 hrs**	**Thu 2/3/11**	**Fri 5/6/11**		
23	**Status Report (Biweekly)**	**490 hrs**	**Thu 2/3/11**	**Thu 4/28/11**		
31	Dry Run	4 hrs	Thu 4/28/11	Thu 4/28/11		
32	Final Presenation	8 hrs	Fri 5/6/11	Fri 5/6/11	31	
33	Final Techincal Report	72 hrs	Tue 4/26/11	Fri 5/6/11		
34	**Identification of Need and Problem Definition**	**69 hrs**	**Mon 2/7/11**	**Thu 2/17/11**		
35	Extract Information from Stakeholders	2 hrs	Mon 2/7/11	Mon 2/7/11		Rebecca McCrabb,Sc
36	Review Preceding Documentation	4 hrs	Fri 2/11/11	Wed 2/16/11	35	Ashley Rock,Amar Za
37	Document Problem Definition	48 hrs	Tue 2/8/11	Wed 2/16/11	35	Scott Genberg[20%]
38	**Encompass Boundary and Scope**	**67 hrs**	**Tue 2/8/11**	**Thu 2/17/11**		
39	Define Objectives	4 hrs	Tue 2/8/11	Tue 2/15/11	6,35	Rebecca McCrabb,Sc
40	Define Assumptions	2 hrs	Thu 2/17/11	Thu 2/17/11	35,36,37	Amar Zabarah,Ashley
41	Define Constralnts	4 hrs	Mon 2/14/11	Thu 2/17/11	35,36,37	Amar Zabarah,Ashley
42	**Requirements Phase**	**27.9 hrs**	**Mon 2/14/11**	**Thu 2/17/11**		
43	Identify Initial Requirements (originating)	16 hrs	Mon 2/14/11	Tue 2/15/11	35	Scott Genberg
44	Determine Derived Requirements	12 hrs	Mon 2/14/11	Tue 2/15/11		Amar Zabarah,Ashley
45	Document Preliminary Requirements	12 hrs	Tue 2/15/11	Thu 2/17/11	43,44	Scott Genberg
46	**Define Algorithm**	**76 hrs**	**Mon 2/21/11**	**Fri 3/4/11**		
47	Methodology	48 hrs	Mon 2/21/11	Mon 2/28/11	40,41,45	Amar Zabarah[10%],F
48	Techniques	28 hrs	Tue 3/1/11	Fri 3/4/11	47	Amar Zabarah,Rebec
49	**Detailed Design**	**76 hrs**	**Mon 2/28/11**	**Fri 3/11/11**		
50	Concept of Operations (CONOPS)	52 hrs	Thu 3/3/11	Fri 3/11/11	40,41,45	Amar Zabarah[20%],A
51	Determine and Document Final Mission Requirements	36 hrs	Mon 2/28/11	Fri 3/4/11		Scott Genberg[10%]
52	**Performance Analysis**	**248 hrs?**	**Thu 3/10/11**	**Thu 4/21/11**		
53	Modeling and Simulation	64 hrs	Thu 3/10/11	Mon 3/21/11	40,47	Rebecca McCrabb[20
54	Construct Code/Algorithm	24 hrs	Mon 3/14/11	Wed 3/16/11	40,47	Rebecca McCrabb
55	Validation Plan	32 hrs	Mon 3/21/11	Thu 3/24/11		Ashley Rock,Amar Za
56	**Define Functional/Physical Architecture**	**144 hrs**	**Tue 3/22/11**	**Thu 4/14/11**		
57	Define Operational Architecture	72 hrs	Mon 4/4/11	Thu 4/14/11		Ashley Rock[20%],Sc
58	Requirements Traceability	44 hrs	Tue 3/22/11	Tue 3/29/11	53,54	Ashley Rock[50%],Sc
59	**Analysis**	**184 hrs?**	**Tue 3/22/11**	**Thu 4/21/11**		
60	Evaluate Algorithm	8 hrs?	Tue 3/22/11	Tue 3/22/11	53,54	Amar Zabarah,Rebec
61	Testing	56 hrs	Thu 3/24/11	Fri 4/1/11	53	Amar Zabarah,Rebec
62	Decision Analysis	64 hrs	Tue 4/12/11	Thu 4/21/11	53,54	Amar Zabarah
63	**Cost Analysis (Maybe)**	**10 hrs**	**Mon 4/11/11**	**Tue 4/12/11**		

Figure 4: AFOCS Gant Chart



8.3 Earned Value Management (EVM)

Using Project Management, the AFOCS team assigned resources and a budget for individual tasks. Also, the AFOCS team assigned overall budget of approximately $ 30,000. The EVM chart to keep track of the tasks and dates was originally produced on 10 February 2011, as seen in **Error! Reference source not found.**. Earned Value Management will be calculated weekly and reported graphically.

Figure 5: AFOCS EVM as of February 10th 2011