Air Force Operations Center Scheduling (AFOCS)

OR 680 / SYST 798 Capstone Project
Final Presentation
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Scott Genberg, Rebecca McCrabb, Ashley Rock, Amar Zabarah

Outline

- Problem Definition
- Statement of Need and Scope
- Technical Approach
- Requirements
- The Model
- Testing and Validation
- Recommendations
- Deliverables to the Client
- Future Work
- Acknowledgements

Problem Definition

- Supporting a USAF group which consists of three squadrons
- Each squadron is responsible for staffing 5 operations centers (op centers), one of which is the Squadron Command Post (SCP)
- The staffing schedule is forecasted a month in advance
- Scheduling the staffing of these op centers is a time consuming manual process (1½ - 2 weeks)
- Once the staffing schedule has been established, daily changes to staff availability require the schedule to be reconfigured to meet demand

Problem Definition

- Scheduling includes not only staffing the op centers, but also scheduling the training events, training resources, and trainers necessary to maintain current certification
- Personnel are categorized according to their functional roles. The four functional roles are:
  - Crew Member(CW), Instructor (INST), Evaluator (EVAL), Flight Commander (FLT CDR)

Shifts

- 24 hours long (7 a.m. to 7 a.m.)
- Next day is an "O-day"
- Require two functional positions:
  - Crew Commander (CDR) and
  - Deputy Crew Commander (DEP).

Training

Event	Duration	Trainer	Frequency
TR	4 hr	INST - 2 ea	Monthly
T1	8 hr	INST - 2 ea	Monthly
T3	4 hr	INST - 2 ea	Monthly
T4	4 hr	INST - 2 ea	Monthly
AE	4 hr	EVAL - 3 ea	Annually

Statement of Need and Scope

Statement of Need

- Develop an optimization model to automate the scheduling process to improve efficiency and performance of the existing scheduling process
- Model must be dynamic to handle daily changes and produce a re-optimized solution while still adhering to all the scheduling conditions and minimizing disruption in the initial developed schedule

Scope

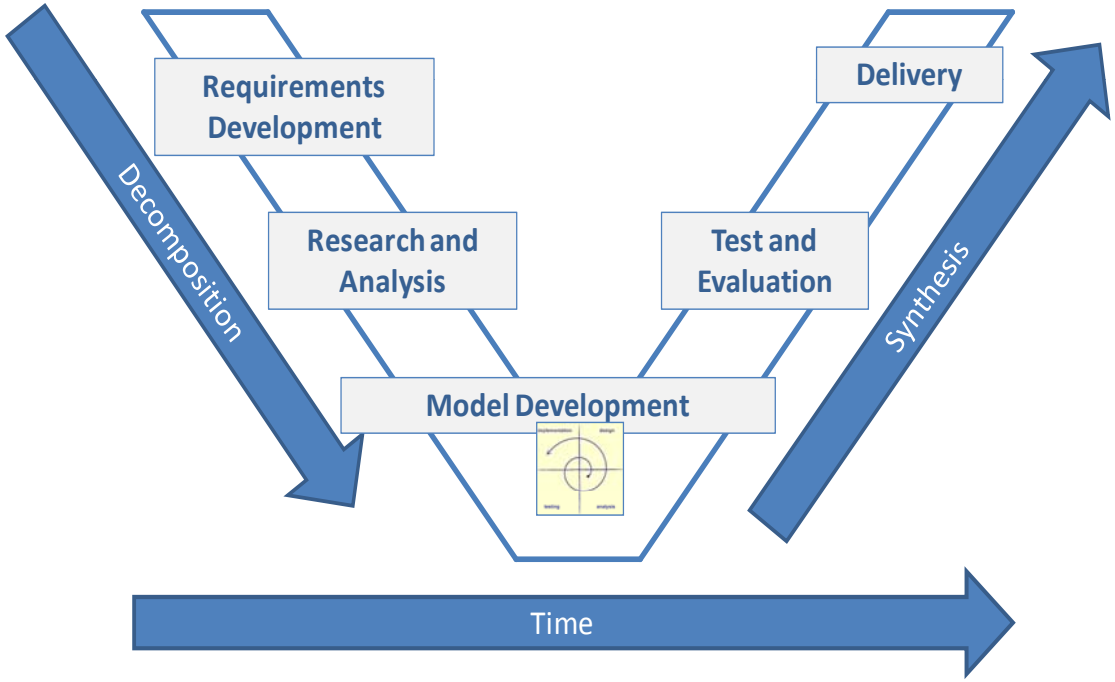
- **In Scope**
  Develop an optimization model to improve efficiency and performance of the existing scheduling process. The AFOCS team will test and analyze the optimization model
- **Out of Scope**
  The AFOCS team will not be responsible for implementing code to merge the model with the current system

Technical Approach

The project was completed in five overlapping phases:

- Requirements Development
- Research and Analysis
- Model Development
- Test and Evaluation
- Delivery

Systems Engineering Approach



Team AFOCS

Requirements

- Op Center Staffing Functional Requirements:
  - Schedule 15 op centers (3 sets of 5), plus one standby crew
  - 24 hour shifts (7 a.m. to 7 a.m.) – called ‘alerts’
  - Each shift followed by a day off – called ‘O-Day’
  - Minimum 2 days between shifts
  - Maximum of 45 days between shifts for CWs
  - At most 8 shifts per month for CWs
  - At most 2 shifts per month for INSTs, EVALs, and FLT CDRs
  - Maximize Integral Crew Rate (% of time crew mates are paired together)
- Op Center Training Functional Requirements:

Event	Type	Duration	Trainer	Comments
TR	Simulator	4 hr	INST – 2 ea	
T1	Classroom	8 hr	INST – 2 ea	
T3	Classroom	4 hr	INST – 2 ea	Paired with T4
T4	Classroom	4 hr	INST – 2 ea	Paired with T3
AE	Simulator	4 hr	EVAL – 3 ea	

Model Summary

- The developed model is a mixed-integer program (MIP) with binary decision variables that assign personnel and resources to specific events on each day of the month
- The model both creates the original monthly schedule and dynamically re-optimizes the schedule to handle daily disruptions in personnel availability
- The objective of the model is to:
  1. Maximize Integral Crew Rate (ICR)
  2. Spread out the assignment of alerts within each job category
  3. Spread out the assignment of classroom and simulation training events across the instructors and evaluators
- The model executes in 4 consecutive phases:
  1. Assign Personnel to Alerts
  2. Assign Personnel to Training
  3. Assign a Backup Crew
  4. Assign Personnel with Simulation Training to Simulator Slots
- Model runtime is limited to 3 hours

Model Phases

Assign Personnel to Alerts

- This phase performs the assignment of personnel to shifts at each of the 15 sites
- Each site requires one CDR and one DEP each day, with the possibility of having a CDR fill the DEP position
- Personnel must have two off days between shifts
- The day after a person is on shift is scheduled as their “O-day”, or off-day
- The day after their “O-day” is scheduled as their “B-day”, which is a placeholder to ensure no alerts are assigned on that day

Assign Personnel to Training

- This phase performs the assignment of personnel, instructors, and evaluators to classroom and simulation training in fulfillment of monthly training and annual evaluation requirements
- Each person is required to complete the T1, T3, T4, and TR training events monthly
- The T3 and T4 training classes are either held separately or together on the same day, thus the reason for the T3/T4 training event
- If a person attends the T3/T4 class, then they receive credit for both T3 and T4

Model Phases (cont'd)

Assign a Backup Crew

- This phase performs the assignment of personnel to the backup crew, which consists of one CDR and one DEP
- The backup crew is used when a person who is assigned to an alert on a particular day becomes unavailable to pull that alert, at which time the backup crew is activated
- The assignment of a person to backup on a particular day is limited based on the number of alerts that person is scheduled for over the month and the timing of those alerts in relation to the backup day being scheduled

Assign Personnel with Simulation Training to Simulator Slots

- This phase performs the assignment of personnel, instructors, and evaluators to simulator slots to conduct the TR and AE simulation events
- There can either be four or five available slots per day, each with one or two simulators available in each slot
- Instructors teaching TRs can be assigned to at most 2 slots on a given day, which must be consecutive slots
- Personnel assigned to simulator training who are pulling alert the next day must be in the first three slots

Dynamic Portion

Heuristic Approach

- The heuristic approach is applicable to perform the re-optimization of the schedule when only 1 or 2 people become unavailable on a single day
- The method pulls the backup crew member with the same position as the person who becomes unavailable and assigns the backup crew member to that person's site
- The method changes the alert and O-day schedules for the backup crew member and the person now unavailable to match the new assignments
- The procedure then assigns a new person to the backup crew to fill the vacancy

Automated Approach

- The dynamic approach must change multiple schedules and still ensure that all the scheduling requirements and original constraints are satisfied
- This approach has variables that calculate the difference between the original schedule and the new schedule being formed
- The goal is to minimize the difference between the original schedule and the new schedule while still adhering to all constraints from the original schedule assignments

Example Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13
Person1		T1	E-SCP (M)	O-day			TR		T4	A (M)	O-day		
Person2		B (D)	O-day									T3/T4	
Person81		T1	E-SCP (D)	O-day			TR		T4	A (D)	O-day		
Person82		B (M)	O-day									T3/T4	
Person3			A (M)	O-day	TR				B (M)	O-day			D (M)
Person4		E-SCP (D)	O-day	T3		E-SCP (D)	O-day		E-SCP (D)	O-day			
Person5		T3				T4		C (M)	O-day			D (M)	O-day
Person6		T1			C (D)	O-day					B (D)	O-day	
Person7						T4	D (M)	O-day			E-SCP (M)	O-day	T1
Person8		T1			B (D)	O-day				B (D)	O-day		
Person9				B (M)	O-day				C (M)	O-day			
Person10		T3	T1	E-SCP (D)	O-day			E-SCP (D)	O-day			E-SCP (D)	O-day
Person11			C (M)	O-day	T1			A (M)	O-day		A (M)	O-day	
Person12		D (D)	O-day	T3	TR		C (D)	O-day	T4				B (D)
Person13		T1						D (M)	O-day			T3/T4	E-SCP (M)
Person14		A (D)	O-day	T3	D (D)	O-day			A (D)	O-day			
Person15			D (M)	O-day	TR				T4		C (M)	O-day	
Person16		C (D)	O-day	TR			E-SCP (D)	O-day					
Person17				C (M)	O-day	T4	B (M)	O-day					
Person18		T3			T1	A (D)	O-day				D (D)	O-day	
Person19			TR	T3	T1				T4	C (M)	O-day		
Person20	C (D)	O-day				B (D)	O-day		D (D)	O-day			
Person21			T1	T3		C (M)	O-day		T4				
Person22	A (D)	O-day						B (D)	O-day	T3			
Person23	B (M)	O-day	T3/T4	D (M)	O-day								A (M)
Person24			B (D)	O-day		T4				D (D)	O-day		C (D)
Person25	E-SCP (M)	O-day	T3/T4			D (M)	O-day						
Person26					A (D)	O-day	TR		T4			C (D)	O-day
Person27		T3			F (M)	O-day			H (M)	O-day		TR	

Testing and Validation

Testing

(1) Ensured the model met the requirements
- Ran the model and compared the model outputs relative to the requirements

(2) Compared solver runtime against best solution obtained
- Run the model for a specified amount of time and compared how close the best solution found was to the upper bound

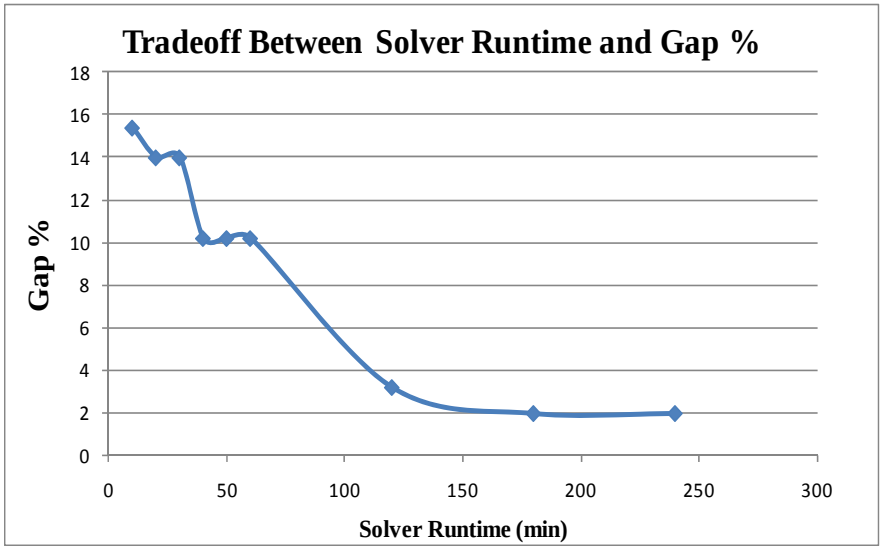
Model Performance

- Assign Alert phase took the longest amount of time to solve

Validation

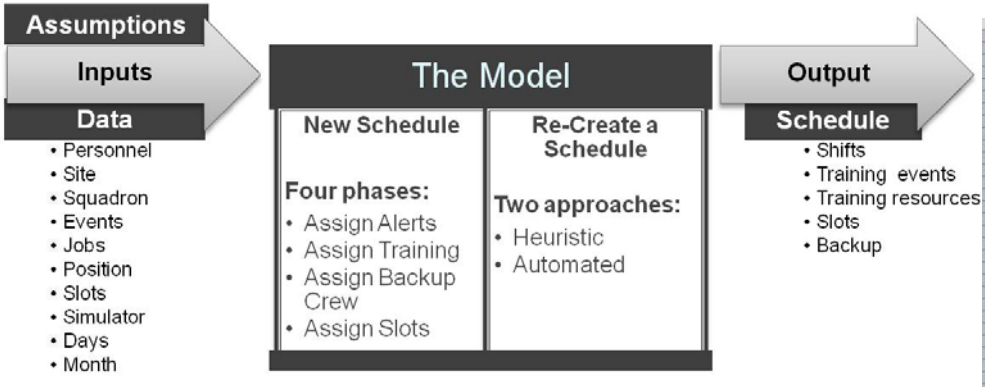
- Used a “Requirements Verification Matrix” to verify requirements

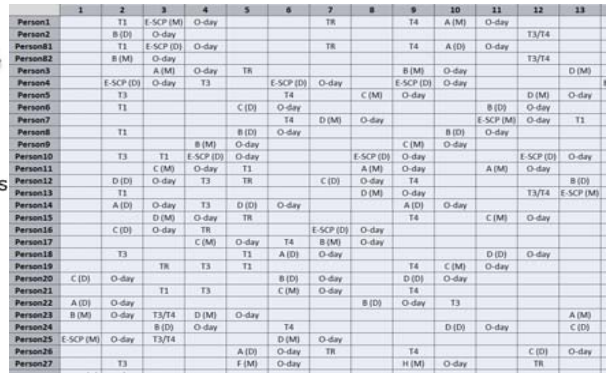
Number	Requirement Statement	Method	Result	Comments
3.2.1.1	The model shall schedule 15 op centers plus one standby crew.	Test	Passed	N/A



Recommendations

- AFOCS Team recommends the incorporation of the model developed using AIMMS into the scheduling process for the operations centers





Deliverables to the Client

- The Model
- Literature Review Report
- System Requirements Document (SRD)
- Final Report
- Final Briefing

Future Work

Possible work efforts that could be implemented in the future:

- To broaden the span, multiple month schedules can be considered
- Implementation Research/Design – investigate automating the outputs of AIMMS into TimePiece
- Test Plans/Procedures – to test the integration of the model into the client's system
- Additional Constraints – additional requirements as determined by the client
- Architecture Diagram – to show how the different pieces of the model flow together

Acknowledgements

Kepler Research, Inc.

- Brian Collins (brian.collins@keplerresearch.com)
- Matt Prebble (matt.prebble@keplerresearch.com)

George Mason University

- Kathryn Laskey (klaskey@gmu.edu)

Questions?

Backup Slides

Requirements

- The algorithm must schedule personnel and resources to meet both the staffing needs of the ops centers and the mandatory training requirements for each person
  - Op Center Staffing Functional Requirements:
    - The model shall schedule 15 op centers plus one standby crew.
    - Each op center shall be staffed by one Commander and one Deputy.
    - Each op center shall be 24 hours (7 a.m. to 7 a.m.).
    - Each shift shall be followed by an off day (O Day).
    - …etc
  - Mandatory Training Functional Requirements:
    - Each squadron has one SCP. The SCP shall be staffed by SCP qualified personnel.
    - SCP qualified crew members shall accomplish one SCP alert at a minimum of every 60 days to maintain certification.
    - When one squadron has a mandatory squadron training day, the other two squadrons shall fill in the five op center sites for that day.
    - The model shall maximize crew integrity.
    - …etc

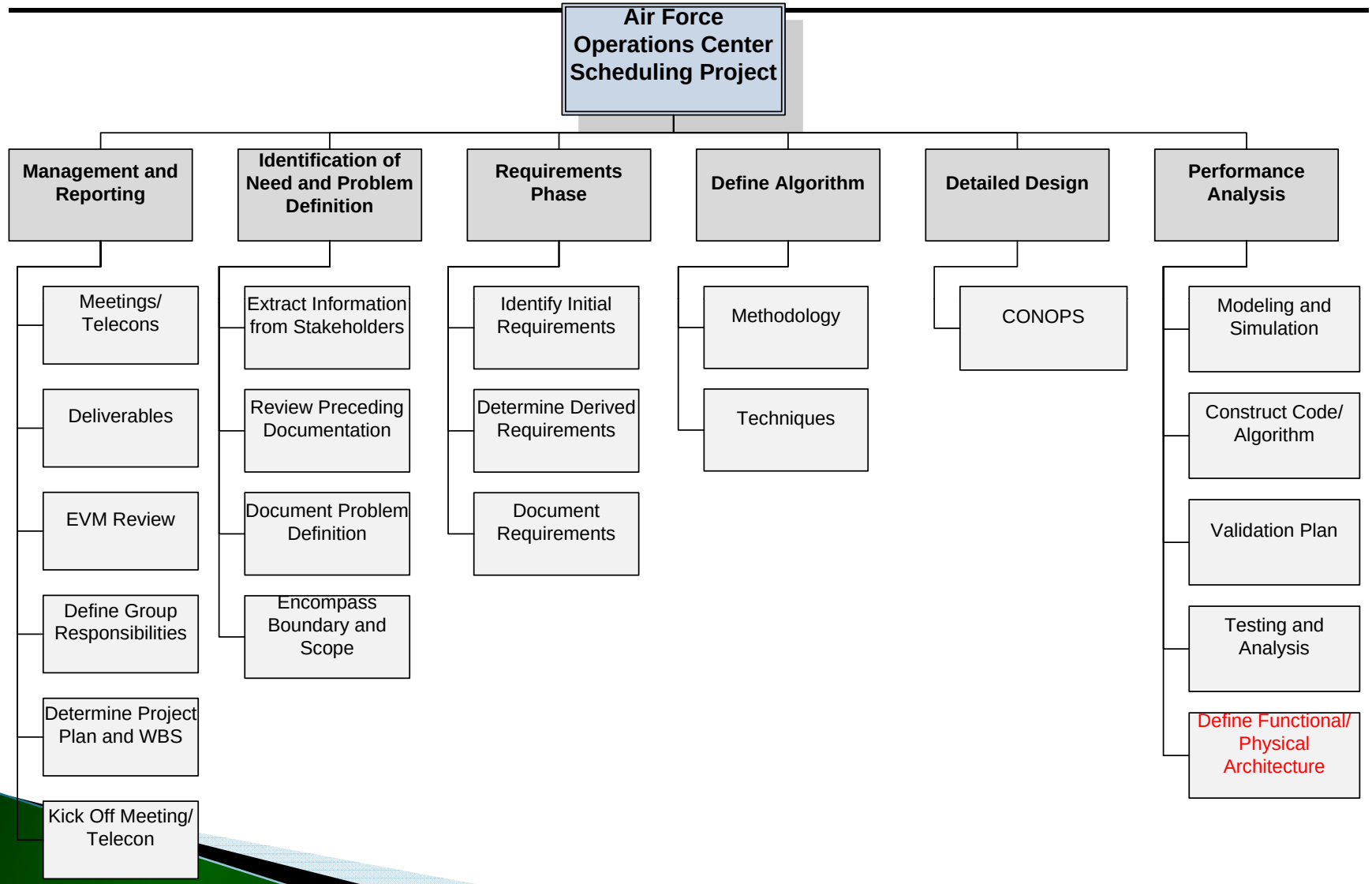
Literature Review

- Researching existing documentation on scheduling shifts:
  - Scheduling tools to include TimePiece, which is currently used for constructing the monthly schedules
  - Compare how each tool is similar to and how it varies from the others in terms of approaches to the problem
  - Review our approach
  - Analyze and interpret
    - Other methods to the optimization problem
    - Validation and testing criteria
- Currently have 12 pieces of research to include in the literature review plus information pertaining to the various tools

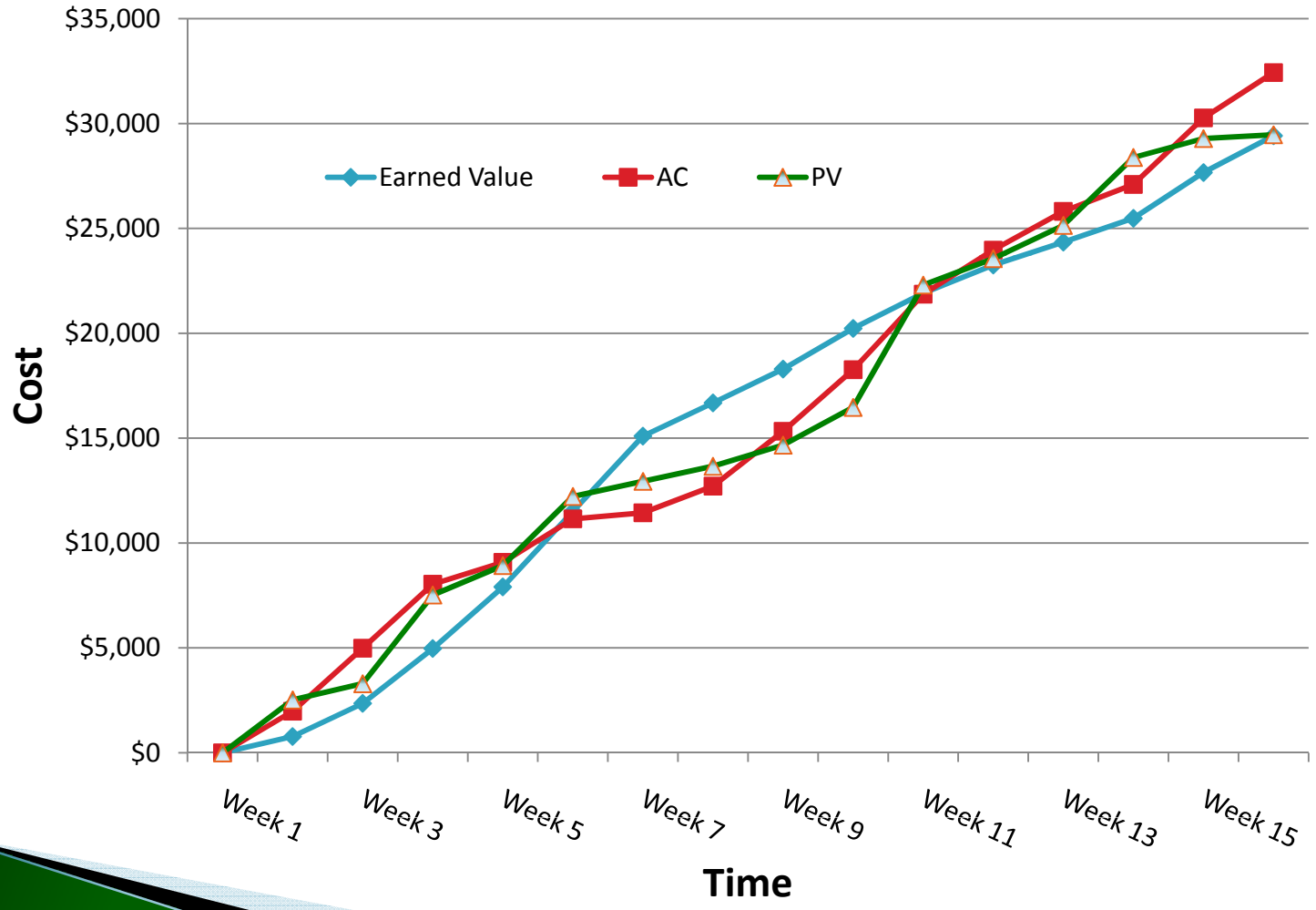
Task Breakdown

Name	Major	Task Lead
Scott Genberg	Systems Engineering	Requirements
Rebecca McCrabb	Operations Research	Model Development
Ashley Rock	Systems Engineering	Literature Review
Amar Zabarah	Operations Research	Website, EVM and Documentation

Work Breakdown Structure



Earned Value Management (EVM)



Website

- Current address of the website:
  - http://mason.gmu.edu/~azabara2/Projects/AFOCS/Home.html

- Sections of the website
  - Home Page
  - Project Summary
  - Deliverables
  - Team Members
  - Related Links

Problem Definition

Background

- Scheduling includes not only staffing the op centers, but also scheduling the training events, training resources, and trainers necessary to maintain current certification.

Shifts

- 24 hours long (7 a.m. to 7 a.m.)
- Require two functional positions:
  - Crew Commander (CDR) and
  - Deputy Crew Commander (DEP).

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- Personnel are categorized according to their functional roles. The four functional roles are:
  - Crew Member(CW), Instructor (INST), Evaluator (EVAL), Flight Commander (FLT CDR)

The Model

Model Execution

Assumptions

Inputs

Data

- Personnel
- Site
- Squadron
- Events
- Jobs
- Position
- Slots
- Simulator
- Days
- Month

The Model

New Schedule

Four phases:

- Assign Alerts
- Assign Training
- Assign Backup Crew
- Assign Slots

Re-Create a Schedule

Two approaches:

- Heuristic
- Automated

Output

Schedule

- Shifts
- Training events
- Training resources
- Slots
- Backup

Problem Definition

Background

- The USAF group consists of three squadrons.
- Each squadron is responsible for staffing 5 op centers, one of which is the Squadron Command Post (SCP).
- Scheduling the staffing of these op centers is a time consuming manual process. (~1½ - 2 weeks)
- Unexpected changes to staff availability requires the schedule to be reconfigured daily to meet demand