出國報告(出國類別：軍售訓練)

赴美陸軍後勤大學「作業研究/系統分析軍事應用課程Operations Research/Systems Analysis Military Applications Course (ORSA- MAC)」軍售訓練心得報告

服務機關：國防部參謀本部資電作戰指揮部
級職姓名：海軍少校 吳振宇
派赴國家：美國
報告日期：101 年9月5 日
出國時間：101 年 5 月 14 日至 101 年 8 月 27 日

摘要

本次受訓係奉國防部101 年5 月4 日國力培育字第1010001593 號令，核定赴美陸軍後勤大學(Army Logistics University, ALU)參加「作業研究/系統分析軍事應用課程」（Operations Research/Systems Analysis Military Applications Course）進修15 週。期程自101年5 月14 日至101年8 月24 日止；本項課程係為美軍為培養作業研究分析員所設立班隊，其目的在於教導訓員運用數學、科學及工程等分析方法來決定較佳方式並提供決策者參考，以達到有效使用財務、材料、設備與人力。

本心得報告係檢討彙整在美受訓期間之經歷過程、課程重點及學習心得等事宜，並結合國外所見及我國現況，就相關事項進行經驗傳承、知識分享與提出改進建議，俾充分發揮受訓效益。

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壹、 目的

職奉國防部101年5 月4 日國力培育字第1010001593 號令，赴美國美軍後勤大學(Army Logistics University, ALU)參加「作業研究系統分析軍事應用班」（Operations Research/Systems Analysis Military Applications Course, ORSA MAC）進修15週，本課程係為培養作業研究分析員所設立班隊，其目的在於教導訓員運用數學、科學及工程等分析方法來決定較佳方式並提供決策者參考，以達到有效使用財務、材料、設備與人力。

本期班隊班號ORSA-MAC-2012-004，全班學員計27員，含國際學生4員（埃及陸軍上校1 員、本國海軍少校1 員、新加坡陸軍上尉1 員及土耳其陸軍上尉1 員），餘17員為美軍中尉（O2）至少校（O4）之軍官，及6員文職聘雇人員。

職啟程赴美，經洛杉磯與亞特蘭大轉機後抵達陸軍後勤大學所在地－維吉尼亞州李堡(Fort Lee, Virginia)報到，參加「作業研究/系統分析軍事應用課程」，順利於1001年8月25 日結訓，並取得課程畢業證書，於101年8月27日返國報到。

貳、 受訓過程

一、 學校簡介

美國陸軍後勤大學(Army Logistics University)位於維吉尼亞州首都李奇蒙(Richmond)南方約30 英哩處的李堡(Fort Lee)，其鄰近城市為彼得斯堡(Petersburg)、哈波維爾(Hopewell)及柯隆尼爾高地(Colonial Height)。基地內目前除陸軍後勤大學(Army

Logistics University)外，另包含各兵科學校， 如經理學校(Quartermaster School)、運輸學校（Transportation School）及兵工學校（Ordnance School），其中兵工學校係原位於馬里蘭州亞伯丁測試場（Arberdin Proving Ground)，近年來搬遷至此。李奇蒙國際機場位於李堡北邊約30 英哩，沒有公車及巴士可達基地，因此出國前承辦國軍赴美軍售之各軍聯絡官，皆會建議到此受訓學員須先聯絡國際學生辦公室(International Military Student Office,IMSO)安排接送事宜，否則由計程車接送車資約為50 美元。基地以美國南北戰爭南軍指揮官名將李將軍（General Lee）命名，為一歷史著名戰場名勝古蹟。基地內及對外交通不便，大都以計程車代步，從宿舍至學校步行約30 分鐘，故平常上課期間國際學生辦公室提供免費計程車接送。

基地內生活設施頗為齊全，食衣住行育樂皆可於基地內滿足，有銀行、福利社、生鮮超市、餐廳、速食店、服裝部、理髮院、加油站、修車廠、訪客宿舍、單身宿舍、家庭住宅、教堂、幼稚園、軍官俱樂部、騎馬場、網咖、保齡球館、高爾夫球場、電影院、健身房、室內籃球場及露天運動場，另訪客宿舍(Army Lodging)提供免費簡易西式早餐。

二、 受訓狀況

抵達李堡市陸軍後勤大學報到後，第1週為國際學生準備週，包括資料填寫、證件申辦、銀行開戶、電腦發放(每位學生均由學校發給筆記型電腦乙部，結訓繳回)、資安教育

(Information Assurance Training)、兩性教育、美軍組織簡介及校區與週遭環境介紹等，俟隔週美國學員報到後，方正式展開為期14週之專業課程。

係為美軍為培養作業研究分析員所設立班隊，除要求受訓人員資格須具工程、數學、管理科學等作業研究相關領域學位，且熟練大學程度以上之代數、微積分、統計學與機率等數理科目外，另外也要求必須熟悉微軟應用程式Excel軟體以及一般軟體編輯知識。其課程內容安排相當廣泛且全面，並包含各項科目之考試、報告撰寫、專題報告、及綜合演練等，課程相當緊湊且紮實，授課老師也一再強調，授課內容廣泛非要受訓學員完全記住，而是要學員有此概念，日後需要時可由相關手冊、網站、組織或策略夥伴詢問得知。本次課程設計分為2階段共12門課程，各課程均相關聯，因此要求訓員必須通過第1階段各課程測驗後，始可進行第2階段課程：

(一) 第1階段：

複習機率、統計學、微積分及資料分析與模式化等課程，這些為進行作業研究時，必備之基本知識。在機率部分；先講解集合與交集與聯集等定義後，則集合與機率計算、條件機率、獨立事件、貝氏定理、相依與互斥定理最後講解常態、指數及卜松等機率分配。統計部分；先從敘述統計學開始介紹，接著講解中數、眾數、平均數、標準差、變異數、直方圖繪製及假設推論等。資料分析與模式化部分；以教授微軟公司EXCEL 應用軟體及其功能運用，透過簡單

個案分析建立模式，其目的在使學生能收熟悉EXCEL 中之各項功能及操作介面並解決個案所面臨的問題，使學習實務化。在為期4週的第1階段裡，各科目均安排測驗，以瞭解訓員學習狀況。

(二) 第 2階段：

本階段則為前階段運用，學習科目更多，延伸上述相關基本概念，課程計有線性統計模型、數學規劃、模擬學、決策分析、成本分析、資料分析(VBA)、戰爭模型及綜合演練等8項。係以教授基礎數理，並以軟體操作進行個案之各項數據分析，再進行分析結果之判讀。分別以筆試測驗、分組專題報告及編寫程式等方式進行學習成果驗收。綜合演練部分，則是運用課程所學解決問題的技巧與方法，將所學應用於方案分析，本次課程為一想定推演，想定內容為阿提卡(Attica) 及伊利斯(Elis)2個緊鄰的國家將開戰，而美軍將協助與西方國家關係密切的伊利斯對抗阿提卡，並摧毀阿國內通訊塔、雷達、步兵連、機場及飛彈陣地等100個鎖定目標。本次想定採分組報告方式實施，各組所扮演的角色為作業研究分析中心的分析員，而身為分析員則是要以給定的武器/載台進行分析研究並提供最佳行動方案建議給聯3作戰人員參考，除摧毀鎖定目標外，更有減少友國傷亡、減少附加損壞及最大限度降低作戰成本等考量條件。本課程為分組報告，課程時間長達3週之久，各組必須完成2次簡報製作並報告及1次研究計畫，而學校為使受訓學員獲得更多客觀與實務的回饋意見作為研究精進參考，特別還邀請曾在美陸軍參四及國防部服務的學者

擔任評審，此這部分可供我國在後續各類專精教育訓練參考。本課程目的除要求訓員能運用所學外，也強調美軍之軍事決策過程(MILITARY DECISION MAKING PROCESS, MDMP)，讓學員了解並熟悉此決策作業流程，使學員能做出正確之決策；有關軍事決策過程(MDMP)介紹如下：美軍軍事決策過程，其目的在建立軍事決策標準作業程序，以完美的思維、完整的邏輯、專業的判斷以了解任務，達成命令或指揮官的意圖以利於進行任務分析(Mission Analysis)、發展、分析及比較關鍵條件以決定最佳行動方案(Course of Action, COA) 並完成作戰計畫概念(Concept of Plan)得以進行軍事行動。其執行步驟如下；

1. 接受任務(Receipt of Mission)：從上級、總部或指揮官接受命令。
2. 任務分析(Mission Analysis)：瞭解上級、總部或指揮官命令後，分析獲得之情資並決定限制性任務(specified tasks) 、隱含任務(implied tasks)與必要任務(essential tasks)。檢視部隊有效資產與部隊能力並進行假設以產出限制條件，接著進行風險分析，最後決定指揮官關鍵初始要求(Commander’s Critical Initial Requirement, CCIR)。
3. 行動方案發展(Course of Action Development)：瞭解指揮官意圖後，各參共同討論進行兵棋推演以發展出各種可能之行動方案。

4. 行動方案分析/比較(Course of Action Analysis/Comparison)：經由相關的後勤因素(如地形、氣候、兵力、時間、距離、彈性度、風險…等因素)進行比較分析以決定最佳行動方案。
5. 行動方案核准(Course of Action Analysis Approval)：提報行動方案經指揮官同意後核准行動方案。

參、 心得

一、 作業研究係起源於第二次世界大戰的一種科學計量管理技術，應用於建構雷達，搜索敵軍潛艇，與後勤供補；由於其發揮成效受到重視，現在已發展出新分析方法，出現在許多和平用途，其中應用於管理大型組織，以便達到有效使用財務、材料、設備與人力。因此在專案管理方面可運用作業研究的方法來瞭解進度、資源配置、系統設計、績效評量、排程等專案工作，如能充分運用作業研究的技巧，應能使國軍各項專案工作有事半功倍之效。

二、本次受訓除習得美軍在作業研究上的方法外，亦由各次專題分組任務時，能實際將所學之課程運用在其中，使同學不至於紙上談兵；並可了解作業研究的領域相當廣泛，不論在商業、工業與軍事應用上，都可套用其概念。

三、 美軍上課方式多元、輕鬆卻不隨便，相較於我國趨於保守之風土民情，授課教官主導上課情形之方式，美軍在課堂上開放的風氣，實可作為我國學習的對象；美軍上課注重課程內容研討及互動，美軍軍官並樂於分享其在不同單位歷練之經歷，並針對

特定課程主題提供個人意見，使上課內容生動多元，不侷限於授課教官所安排之內容；而各領域所選派之授課教官，亦在相關專業領域中歷練多年，具有相當豐富之經驗，使得書本及教則上的知識與實務經驗能相結合。

四、 本次課程於正式開始前，每位學員均配發一部筆記型電腦，筆電可攜出教室，亦可攜出營區使用，對資訊媒體之管理相當開放，且無相關管制作為（無需填寫攜出入營區管制文件）；所有課程教學大綱、授課簡報、研讀資料等，皆於課程前即放置於網路伺服器中，供同學下載預習，各項作業之繳交亦經由網路上傳至專用網路硬碟中；而網際網路的使用相當健全，全校區建置無線上網環境，同學可攜帶公發筆電於校區中之各處上網蒐集及查詢資料，此種授課環境對同學來說相當便利。

五、 美軍體能測驗部分項目與我國相同，包含了跑步（2 英里，約3,200公尺）、仰臥起坐及伏地挺身等3 項，其相關要求標準相較於我國來的低，整體來說我國較美軍嚴格，惟目前國軍人員體測合格率仍偏低，每位同仁均應加強訓練，自我要求鍛練強健體魄，通過各項體能測驗。

肆、 建議事項

一、 未來參加軍售訓練之學員，除應針對語言自我加強外，也應先於網站或向已受過訓同仁蒐集課程或生活上資料，以消除初至美國之不熟悉與緊張心理。聽聞在德州語言訓練中心的課程，是針對後續專長訓練(Follow-on Training)課程所需而做的語言上

訓練，此部分訓練對於後續課程所需之研究報告資料蒐整、演講訓練、簡報製做及提報、討論方法及技巧以及閱讀寫作方法均加強練習，因此對於後續課程之銜接具有正面意義與極大幫助，而且老師也會於課堂上介紹美國人生活習慣與文化，以減少文化衝擊，對於初訪者有極大的幫助，故建議各項專長訓練課程前，仍能搭配語言訓練課程，使後續銜接專業課程時，能儘快進入狀況，不至產生太大落差。

二、 美國幅員廣大，其國民平均年所得約我國國民之3 倍，生活物價水準遠高於台灣，然而目前國軍人員赴美進修、受訓學員之月支生活費，無論派訓地點，統採一致標準，且已十餘年未檢討調整(近十年來美國平均消費者物價指數年增率約2.55%)顯不符現況。以本次受訓地點維吉尼亞州李堡(Fort Lee, Virginia)為例，營區內住宿(Army Lodging)房價為每日55 美元（經查2006 年前之每日房價皆低於36 美元，5 年間漲幅已達36%），而國軍軍售訓練學官之住宿費補助為每日36 美元，月支生活費900 美元，故職須由月支生活費中支出近600美元（每日19元）補貼住宿費，所剩之生活費僅餘500 美元，應付日常生活所需已捉襟見肘，若受訓學員無自備部分經費，更遑論參加與其他與美軍同學及國際同學間之交際聯誼活動。雖另有在外租屋的選擇，亦僅補助350美元，以美國現今物價，實不合理。另經職向其他美援國家（職所參訓之班隊包含埃及、土耳其及新加坡）之學官詢問，美方除全額支助受訓學員住宿費用外，另每日提供生活津貼約22 美元，

而其政府亦提供每月500~1000 美元不等之生活津貼，故我國受訓學員月津貼扣除每月需補貼之住宿費用後，學員可支用之月生活費僅餘 500 美元，已屬國際學生中最低標準，若住宿房價持續每年上漲，後續受訓學員將面臨無足夠生活費可支用之窘況，故建議業管單位能依現況檢討我赴美進修、受訓學員之各項補助標準，俾利後續受訓人員無後顧之憂。

四、 本次受訓期間，授課教室外走廊及國際學生辦公室內，皆有各國歷屆受訓學員所致贈之具代表性紀念品，置於特定櫥窗中展示，使美軍及各國學員能認識來自不同國家之風土及特色；而職於出國前攜帶了些具有台灣特色的小禮品，於結訓典禮後贈予班上同學與授課講師，也算達成國民外交，唯遺憾的是未準備具有國軍特色之紀念品致贈校方，故建議後續出國受訓人員，可由業管單位準備具留念價值之紀念品，使受訓學員於相關重要場合(國際學生週或畢業典禮上)正式致贈校方或授課教官，除達成國民外交外，亦可提高我國能見度。

伍、附件

附件1----作業研究/系統分析軍事運用課程畢業證書

附件2----受訓期間各項活動照片

附件3---- 想定簡報資料


United States Army Logistics University

Let it be known that

MAJ Chen-Yu Wu

is a graduate of the

ORSA Military Applications Course

In testimony whereof, and by the authority vested in us, we do confer this

Diploma

Given at the US Army Logistics University
Fort Lee, Virginia

This 24th day of August 2012

Dean
College of Professional and
Continuing Education

President
Army Logistics University

結業證書

專題報告

結訓合影

CJTF-Freedom Phase IV
Force Package Recommendation

Team Sphinx

COL Essam Abbas
MAJ Sean Madden
LCDR Wu, Chen Yu
Ms. Shana Smith
CPT Lucas Lease
2d Lt Steven Chandler

Agenda

- Purpose
- Background
- Problem Statement and Objective
- Constraints – Limitations – Assumptions
- Study Issues:
  - Dendritic Chart
  - Tools and Analysis
- COA Analysis
- Recommendation
- Conclusions

Purpose

- **Provide the J3 with the best recommended course of action (COA) to destroy 100 identified Attican targets IOT allow freedom of maneuver during phase IV operations.**

Background/ Road to War

- The country of **Attica** is vying for regional dominance and opposes Western influence in their region of the world
- The country of **Elis** is a fledgling democracy, with strong ties to the West
- Tensions have risen between Attica and Elis, culminating in Attican forces attacking into Elis
- A "Coalition of the Willing" agrees to deploy forces to restore the border and force Attica to agree to UN resolution calling for Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) inspections
- CJTF-Freedom is preparing to conduct operations in Attica to prevent Attican aggression in the region and set conditions to enforce Attican compliance to UN resolution
- We are currently preparing for Phase IV operations

Problem and Objective

Problem Statement:
On order, CJTF-Freedom requires freedom of maneuver in Attica to conduct Phase IV operations IOT prevent Attican aggression in the region and set conditions to enforce Attican compliance to UN Resolution.

Analytic Objective:
Recommend the optimal force package that will meet the following objectives in priority order:

1) Destroy 100 strategic high value targets
2) Minimize friendly casualties
3) Minimize collateral damage
4) Minimize cost

Preliminary Analysis

Available Platforms :
CCM-Range:1100 KM
MLRS-Range: 300 KM
F-16-Range: Unlimited

Platform combinations (MaxTGT)
COA1: F-16 only (100)
COA2: F-16 and MLRS (100)
COA3: F-16 and CCM (100)
COA4: F-16/MLRS/CCM (100)
COA5: CCM only (55)
COA6: MLRS only (49)
COA7: CCM and MLRS (78)

Only COAs 1,2,3 & 4 destroy 100 targets

COA1: F-16 only COA2: F-16 and MLRS COA3: F-16 and CCM COA4: F-16/MLRS/CCM

Constraints and Limitations

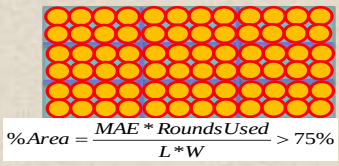
Constraints	Obj 1: Destroy 100 Targets	Obj 2: Minimize Casualties	Obj 3: Minimize Collateral Damage	Obj 4: Minimize Cost	Analytical Considerations
Seven defined COA (Force packages)	X	X	X	X	X
100 CCM available	X		X	X	
9 Munition types available	X		X	X	
Target/Platform locations	X	X	X	X	
Weapons range	X	X	X	X	
Time to complete study					X

Limitations	Obj 1: Destroy 100 Targets	Obj 2: Minimize Casualties	Obj 3: Minimize Collateral Damage	Obj 4: Minimize Cost	Analytical Considerations
No access to classified data	X	X	X	X	
Limited access to detailed data	X	X	X	X	
No support and logistic data					X
Minimal subject matter expertise					X
Minimal access to developed models					X
Minimal access to analysis software					X

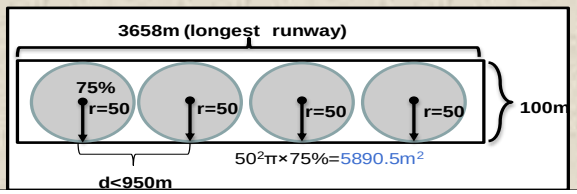
Constraints and limitations drive methodology development

Assumptions: Target Destruction

Assumptions (Target Destruction)	Obj 1: Destroy 100 Targets	Obj 2: Minimize Casualties	Obj 3: Minimize Collateral Damage	Obj 4: Minimize Cost	Analytical Considerations
Placement of friendly forces maximizes target destruction	X	X	X	X	
Probability of hit must be at least 90%	X		X	X	
For point targets: a hit is a kill	X		X		
Infantry company and battery targets are destroyed once 75% of target area hit	X		X		
Terrorist training camps are considered destroyed once 30% of target area hit	X		X	X	
Enemy aircraft (MIG-27) require 950 meters of usable runway to takeoff	X				
Airfield runways are treated as 4 smaller area targets	X		X		
MAE of munitions do not overlap	X		X		

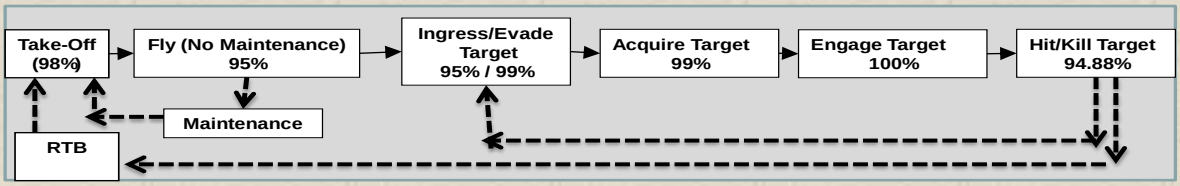


$$\%Area = \frac{MAE * RoundsUsed}{L * W} > 75\%$$



Assumptions: Casualties

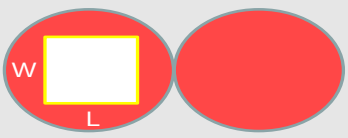
Assumptions (Casualties-Pilots)	Obj 1: Destroy 100 Targets	Obj 2: Minimize Casualties	Obj 3: Minimize Collateral Damage	Obj 4: Minimize Cost	Analytical Considerations
Risk for casualties are F-16/SAM engagement		×		×	
An aircraft successfully engaged by SAM results in one pilot fatality		×		×	
SAMs will be targeted first to minimize pilot fatality		×			
Sequence of other targets not considered		×			
F16 have a 5% chance of being shot down while at least one SAM radar is active.		×			
F16 have a 1% chance of being shot down while at least one SAM missile is active.		×			
F-16 have a 0% chance of being shot down once all SAM targets are destroyed		×			



Assumptions: Collateral Damage & Cost

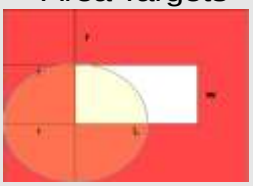
Assumptions (Collateral Damage & Cost)	Obj 1: Destroy 100 Targets	Obj 2: Minimize Casualties	Obj 3: Minimize Collateral Damage	Obj 4: Minimize Cost	Analytical Considerations
Collateral damage can be assessed by number of civilians killed			×		
Population density from 2010 census approximates potential civilian casualties			×		
Collateral damage will not exceed radius of MAE for troops/civilians			×		
Munition costing data accurate				×	
Cost of one coalition F-16 is $26.9 million				×	
Supply and maintenance costs will not impact recommendation				×	
Infinite refueling capability				×	×

Point Targets



$$Collateral\,Area = MAE \times Rounds - L \times W$$

Area Targets

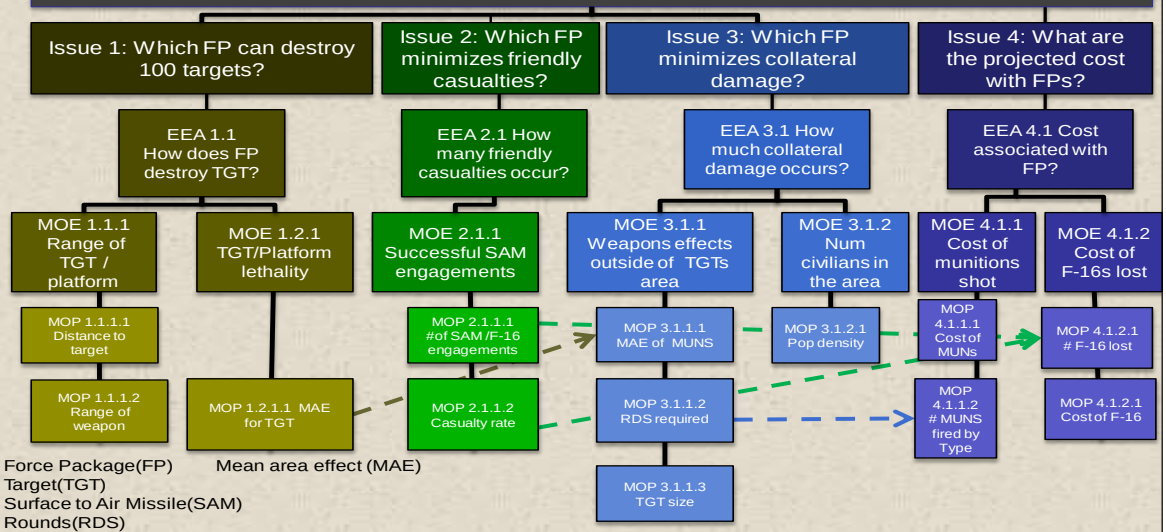


$$(2r+L)*(2r+W)-(L*W)=4r^2+2rL+2rW$$

Dendritic Chart

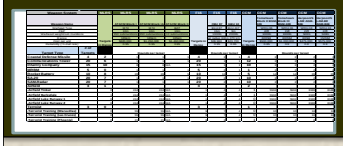
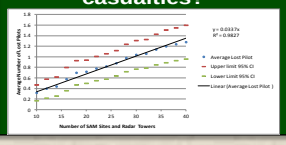
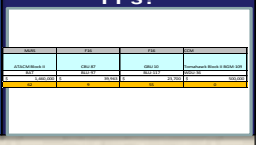
Problem statement: On order coalition forces must destroy 100 strategic high-value targets inside Attican territory, minimizing risk to coalition forces and collateral damage while considering cost.

Objective: Evaluate the appropriate force packages required to destroy all targets while minimizing friendly casualties and collateral damage and considering cost.



Force Package(FP)
Target(TGT)
Surface to Air Missile(SAM)
Rounds(RDS)
Munitions(MUNS)
Mean area effect (MAE)

Methodology

Issue 1: Which FP can destroy 100 targets?	Issue 2: Which FP minimizes friendly casualties?	Issue 3: Which FP minimizes collateral damage?	Issue 4: What are the projected cost with FPs?
			
Kill Matrix	Pilot Casualties Factor	Collateral Damage Matrix	Costs

- **Issues are optimized in order of priority**
- **All tools combine to give the optimal solution (Kill Matrix)**
- **Uses linear programming methods**
- **Provides the optimal solution for each COA**

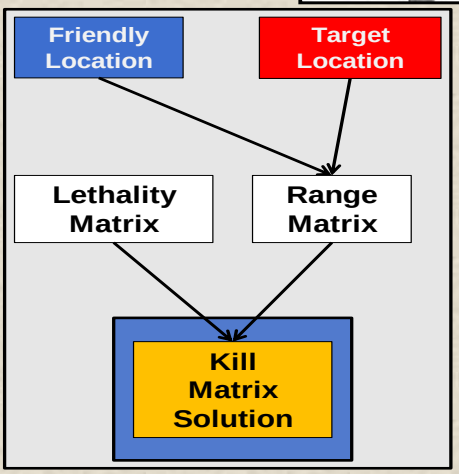
Kill Matrix identifies optimal solution for each COA

Issue 1:
Which FP can destroy 100 targets

Platform/Target pairing constrained by:

- Range Matrix
  - Great Circle Formula
- Lethality Matrix
  - Mean Area of Effect Table
- Platforms available
  - Changes with each COA

Identifies optimal platform/target pairing to destroy all 100 targets



Kill Matrix constrained to feasible platform/target pairings

Issue 1:
Target Destruction Analysis

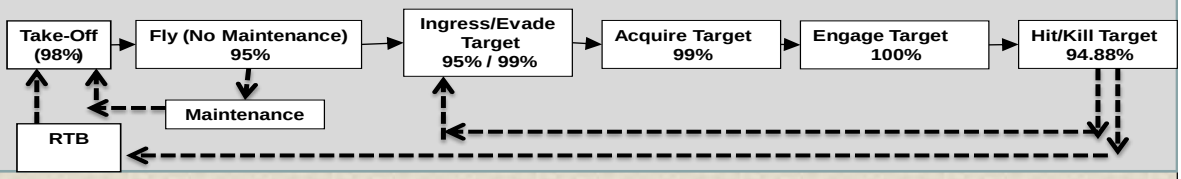
4 force packages can destroy all 100 targets

- COA 1: F-16s only
- COA 2: MLRS and F-16s
- COA 3: CCM and F-16s
- COA 4: CCM, MLRS, F-16s

Max number of targets reached without F-16's is 78

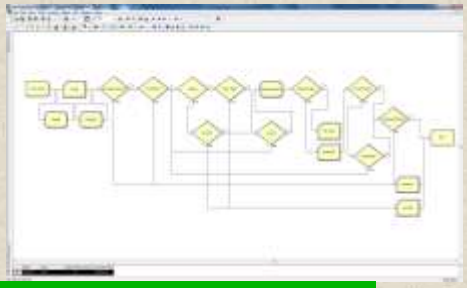
F-16 is required in force package to satisfy Issue 1

Issue 2:
How to Minimize Casualties?



- Casualties are defined as F-16 pilots lost in F-16/SAM engagements
- Use Simulation (ARENA) to analyze expected casualties
- Optimize Kill Matrix solution to minimize casualties

ARENA Model

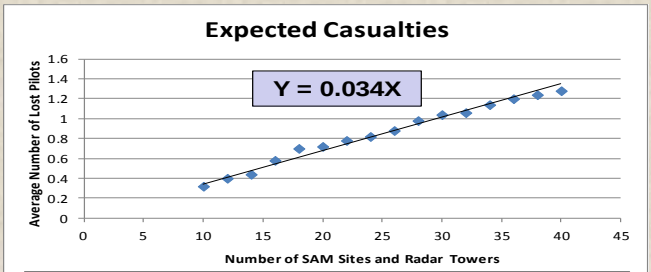


F-16/SAM engagements drives casualties

Issue 2:
Casualty Analysis

	SAM Sites	95% Confidence Interval
COA4	10	(0.17 - 0.47)
COA3	20	(0.50 - 0.94)
COA2	26	(0.64 - 1.12)
COA1	40	(0.96 - 1.60)

- Statistical Comparison of COAs:
  - COA4 better than others
  - COA2 same as COA3
  - COA1 same as COA2
  - COA3 better than COA1
- Minimum feasible F-16/SAM pairings is 10

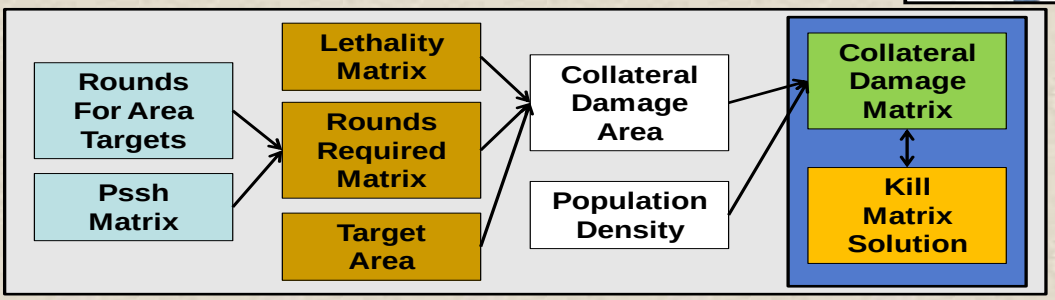


Expected Casualties = 3.4% x SAM Sites Engaged

Minimizing F-16/SAM pairings reduces casualties

COA1: F-16 only COA2: F-16 and MLRS COA3: F-16 and CCM COA4: F-16/MLRS/CCM

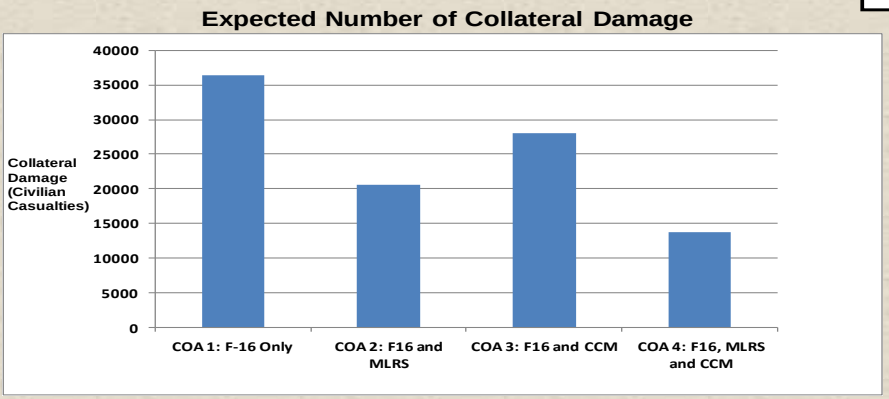
Issue 3:
Which FP minimizes collateral damage?



- Determine collateral damage area of munition/target
  - Rounds required to destroy area targets
  - Probability of a single shot hit (Pssh) for point targets
  - Uses MAE for civilians
- Determine population density of target
- Optimize Kill Matrix solution to reduce collateral damage

MAE outside of target area creates collateral damage

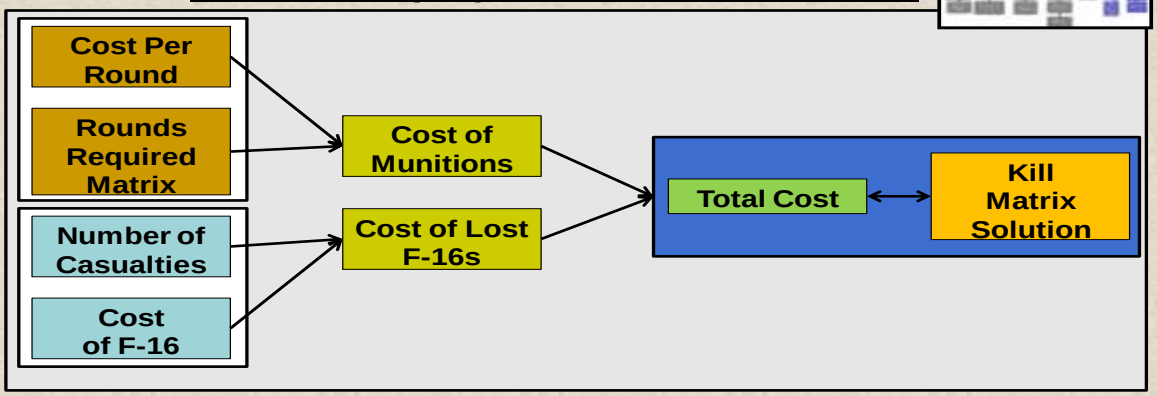
Issue 3:
Collateral Damage Analysis



- Collateral Damage relative to COA4
  - COA3 generates 103% more casualties
  - COA2 generates 50% more casualties
  - COA1 generates 164% more casualties
- F-16 munitions have the largest civilian MAE radius

More F-16 munitions leads to more collateral damage

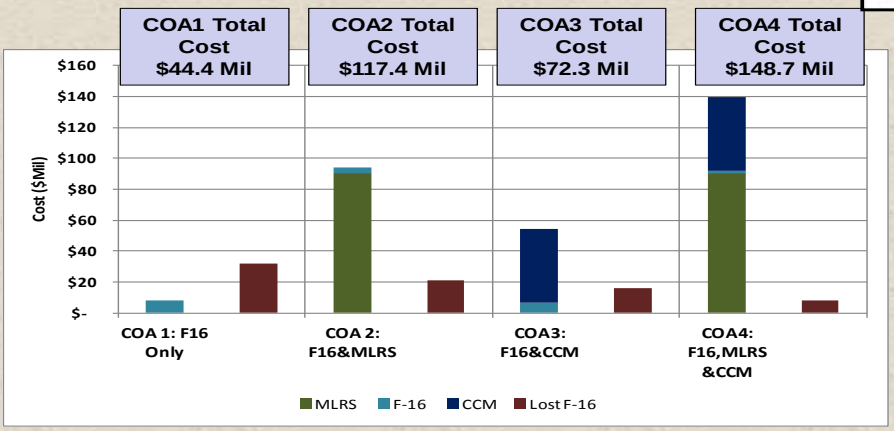
Issue 4:
What is the projected cost of each FP?



- Determine rounds required per target
- Determine number of casualties
- Calculate Costs of munitions and lost F-16s
- Optimize Kill Matrix solution to minimize total cost

Munition is the primary factor when determining cost

Issue 4:
Cost Analysis



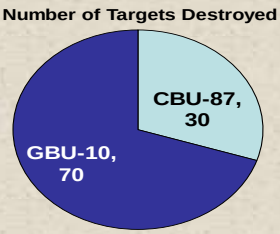
- COA4 is 2 times as expensive as COA 2
- COA4 is1.3 times as expensive as COA 3
- COA4 is 3.3 times as expensive as COA 4

F-16 munition requirement is the least expensive

COA 1: F16 Only

Issue 1: Targets Destroyed

Meets Priority



•All 100 targets destroyed

Issue 2: Casualties

300% Increase from COA4

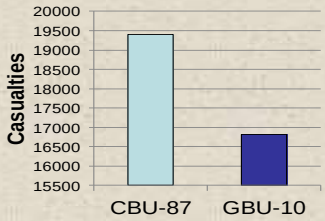
•40 SAM Sites Targeted by F16s

•95% Confidence Interval (0.96,1.60)

•Expected casualties = 1.348 pilots

Issue 3: Collateral Damage

164% Increase from COA4



•Collateral Damage = 36,219 civilians

Issue 4: Cost

Best COA

	CBU 87	GBU 10
Cost Per	$ 39,963	$ 23,700
# Used	150	90
Subtotal	$5,994,450	$2,133,000

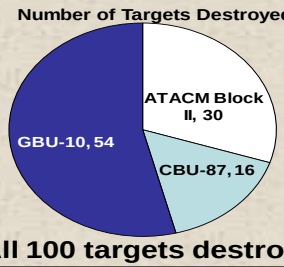
•Munition Costs = $8,127,450
•Lost F16 Cost = $36,261,200

•Total Cost = $44,388,650

COA 2: F16 and MLRS

Issue 1: Targets Destroyed

Meets Priority



•All 100 targets destroyed

Issue 2: Casualties

160% Increase from COA4

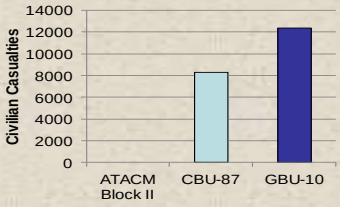
•26 SAM Sites Targeted by F16s

•95% Confidence Interval (0.64,1.12)

•Expected casualties = .8762 pilots

Issue 3: Collateral Damage

50% Increase from COA4



•Collateral Damage = 20,655 civilians

Issue 4: Cost

#3 COA

	ATACM Block II	CBU-87	GBU-10
Cost Per	$ 1,460,000	$ 39,963	$ 23,700
# Used	62	40	74
Subtotal	$ 90,520,000	$ 1,598,520	$1,753,800

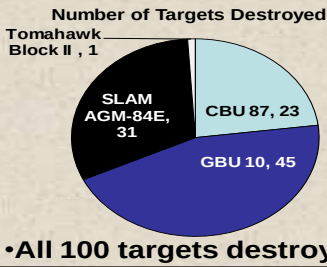
•Munition Costs = $93,872,320
•Lost F16 Cost = $23,569,780

•Total Cost = $117,442,100

COA 3: F16 and CCM

Issue 1: Targets Destroyed

Meets Priority



•All 100 targets destroyed

Issue 2: Casualties

100% Increase from COA4

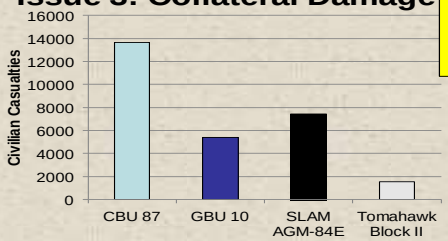
•20 SAM Sites Targeted by F16s

•95% Confidence Interval (0.50,0.94)

•Expected casualties = .674 pilots

Issue 3: Collateral Damage

103% Increase from COA4



•Collateral Damage = 28,001 civilians

Issue 4: Cost

#2 COA

	CBU 87	GBU 10	SLAM AGM-84E	Tomahawk Block II
Cost Per	$ 39,963	$ 23,700	$ 475,000	$ 500,000
# Used	119	65	86	14
Subtotal	$ 4,755,597	$ 1,540,500	$40,850,000	$ 7,000,000

•Munition Costs = $54,146,097
•Lost F16 Cost = $18,130,600

•Total Cost = $72,276,697

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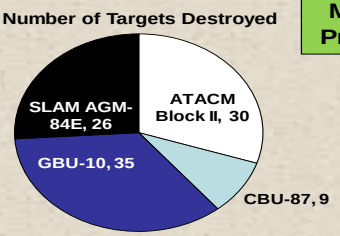
COA 4: All 3 Platform Types

Issue 1: Targets Destroyed

Meets Priority



•All 100 targets destroyed

Issue 2: Casualties

Best COA

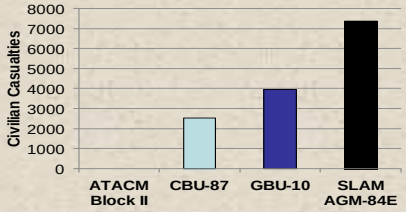
•10 SAM Sites Targeted by F16s

•95% Confidence Interval (0.17,0.47)

•Expected casualties = .337 pilots

Issue 3: Collateral Damage

Best COA



•Collateral Damage = 13,814 civilians

Issue 4: Cost

Highest Cost

	ATACM Block II	CBU-87	GBU-10	SLAM AGM-84E
Cost Per	$ 1,460,000	$ 39,963	$ 23,700	$ 475,000
# Used	62	9	55	100
Subtotal	$ 90,520,000	$ 359,667	$ 1,303,500	$ 47,500,000

•Munition Costs = $139,683,167
•Lost F16 Cost = $9,065,300

•Total Cost = $148,748,467

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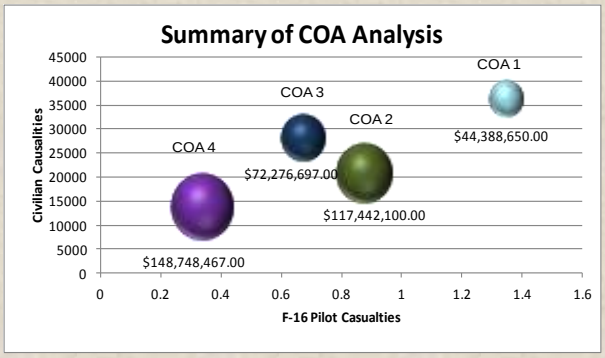
Summary

Recommend COA 4:

- Will destroy 100 targets
- Best for reducing Casualties
- Best for reducing Collateral Damage
- The most expensive option



	COA4 - All 3	COA2 - F16/MLRS	COA3 - F16/CCM	COA1 - F16
DESTROY ALL TARGETS	YES	YES	YES	YES
CASUALTIES	0.337	0.8762	0.674	1.348
COLLATERAL	14K	21K	28K	36K
COST	$148.7M	$117.4M	$72.3M	$44.4M

Recommended Future Analysis

- **Time to conduct operations**
  - **Sortie generation rate**
  - **MLRS reloading capabilities**
  - **Operation sequencing**
- **Logistical requirements**
  - **Aerial refueling**
  - **Maintenance**
  - **Supply battalion limitations**
- **Additional costs**
  - **Fuel**
  - **Maintenance**