



Extended Area Protection & Survivability (EAPS) Gun and Ammunition Design Trade Study



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Distribution A: Approved For Public Release.



System Analysis Division



Mission:

10-1: Serve as TACOM-ARDEC Systems Analysis organization-provide analytical services to all operating segments

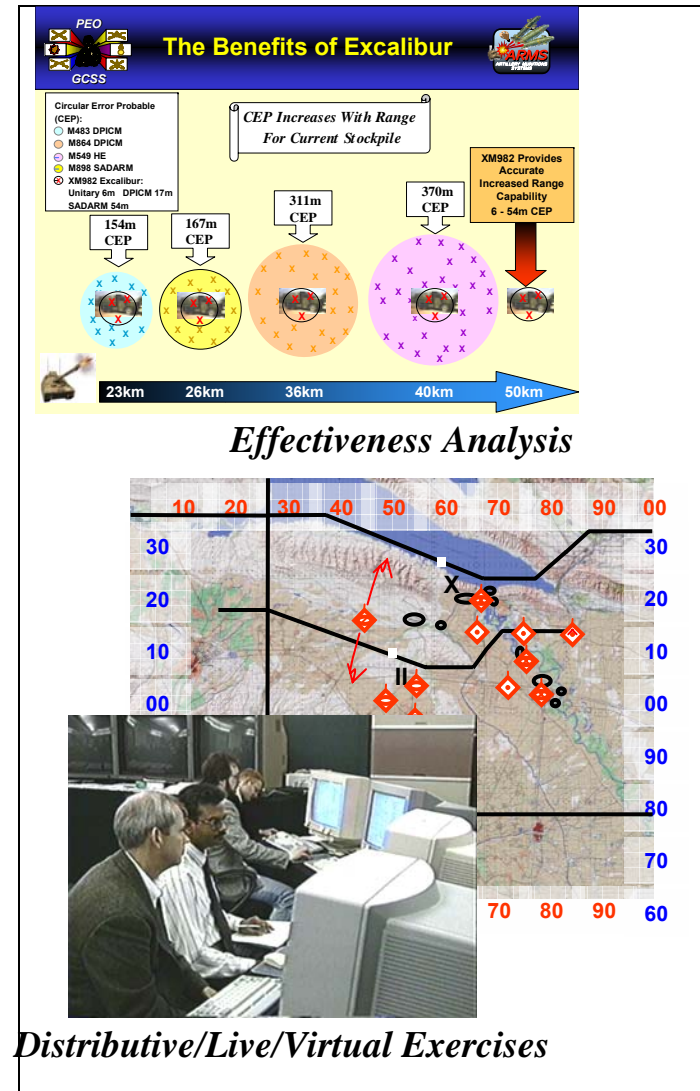
Vision:

Our Systems properly represented in the M&S Environment

-- Complete knowledge and understanding

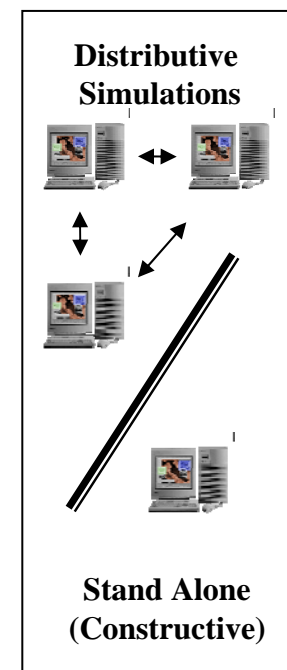
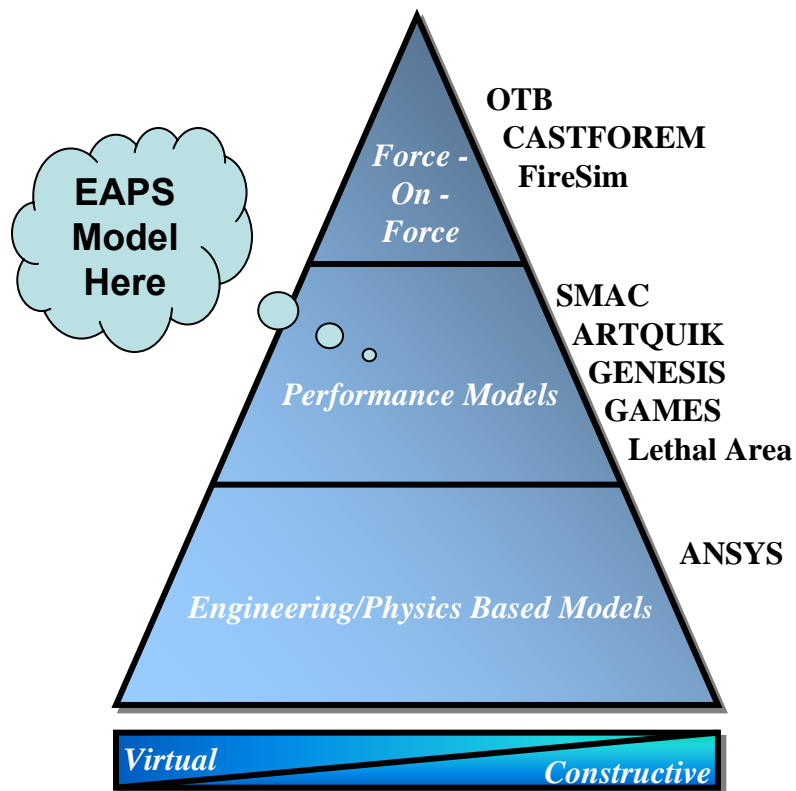
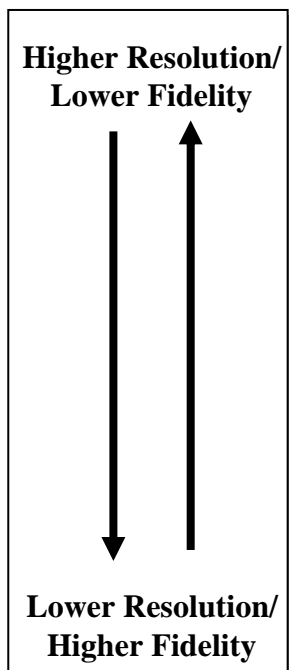
Team:

- 29 Personnel
- Almost all S&Es, Multidisciplinary
- Engineers, Physical Scientists, Computer Scientists, Physicists, Mathematicians





Hierarchy of Modeling & Simulation



M&S Hierarchy

Tools used by Projects are defined by the Simulation Support Matrix!



Initial (3/2005) Concept Of EAPS Requirements



- Notional Requirements:
 - Targets: Mortars, Cannon Artillery, Rockets
 - Engage All Threats Within A Ground Protection Radius Prior To Coming Within Specified Distance From Ground
 - Defeat Single / Multiple Threats
 - High/Low Order Detonation Of Payload (Primary)
 - Detonation or Destruction of Fuze (Secondary)
 - Destabilization of the Round; Damage To The Flight Body (Tertiary)
 - Quick Response Time
 - Improved Logistics and Cost
 - Low Collateral Damage
 - Mobile / Transportable

Study Objective: To Determine The Feasibility Of Meeting EAPS Requirements And (If Possible) To ID a Gun / Ammo Solution



EAPS System Analysis Evaluation Method



Basic Approach To The Problem

1. Use brainstorming and QFD to develop the range of gun systems and munitions likely to address the threat and customer needs.
2. Determine details of the threat and weapon systems sufficient to allow a detailed analysis to be conducted.
3. Develop a computer simulation which models the EAPS environment with sufficient accuracy to compare system alternatives.
4. Run the simulation for all system alternatives.
5. Evaluate results and make recommendations.



Initial SME Selections: Most Promising Options (5/13/05)



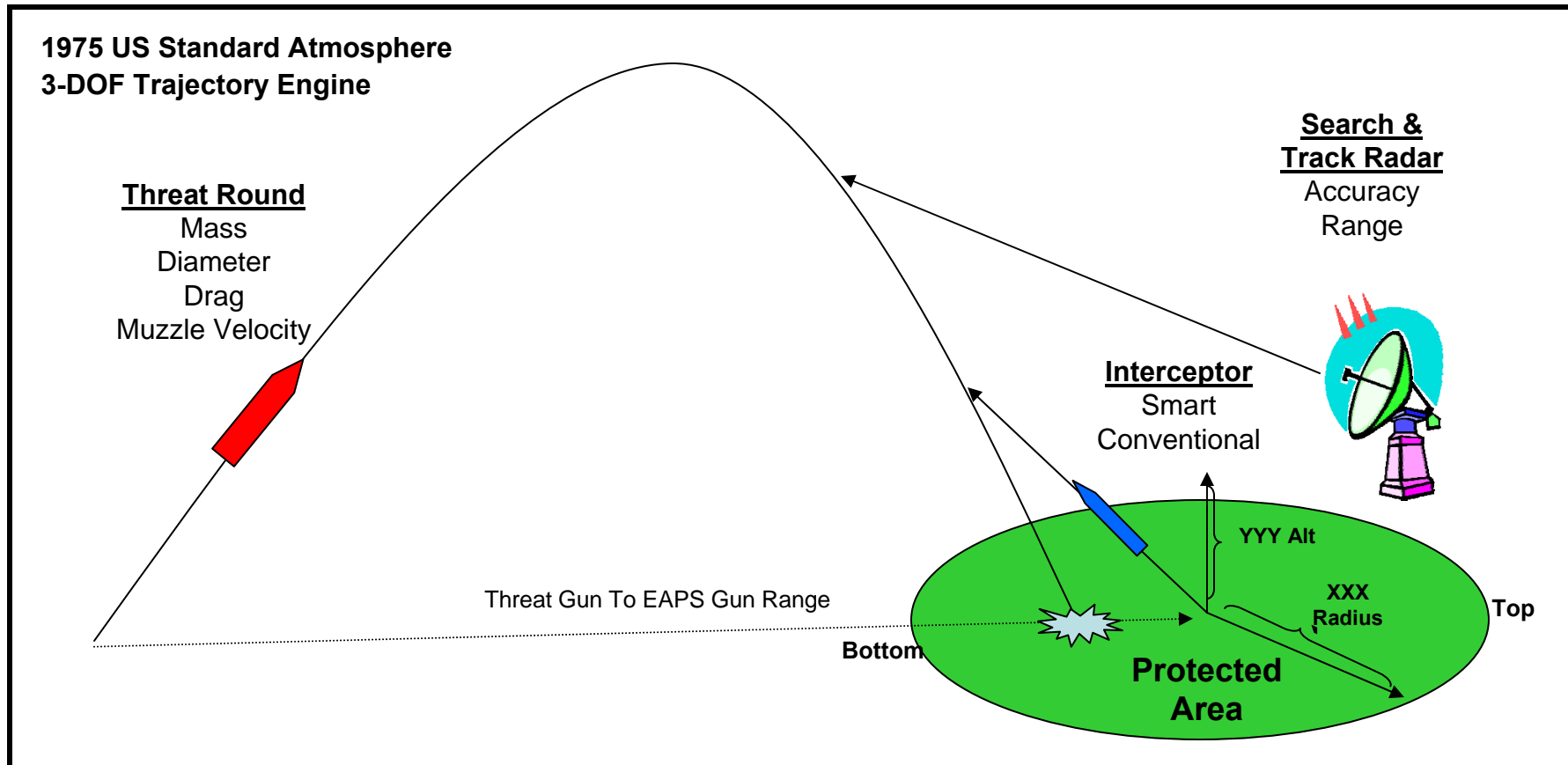
- Early detection: Acoustics (*needs prove out of utility*).
- Acquisition and Tracking Radars: **PTS**, Phalanx, etc. (*compare to each other*).
- Guidance: Unguided, **Command Guidance**, Lock on Before Launch, Autonomous (*needs Phit analysis*).
- Fuzing: Proximity – RF or Optical/ IR, Time, **Command Detonate**, Direct Hit KE.
- Warhead: **multi-EFP**, Canister with Multi-KE Rods or Tungsten Balls, Focused, **Preformed Fragments**, KE bullets, frangible KE (*needs lethality, fragment size, weight, velocity tradeoff study*).
- Weapon systems: 20mm (Phalanx-type), **50mm** (Bush III, Skyshield types), 70mm, 82mm Scorpion.



EAPS.F FORTRAN Gun Simulation



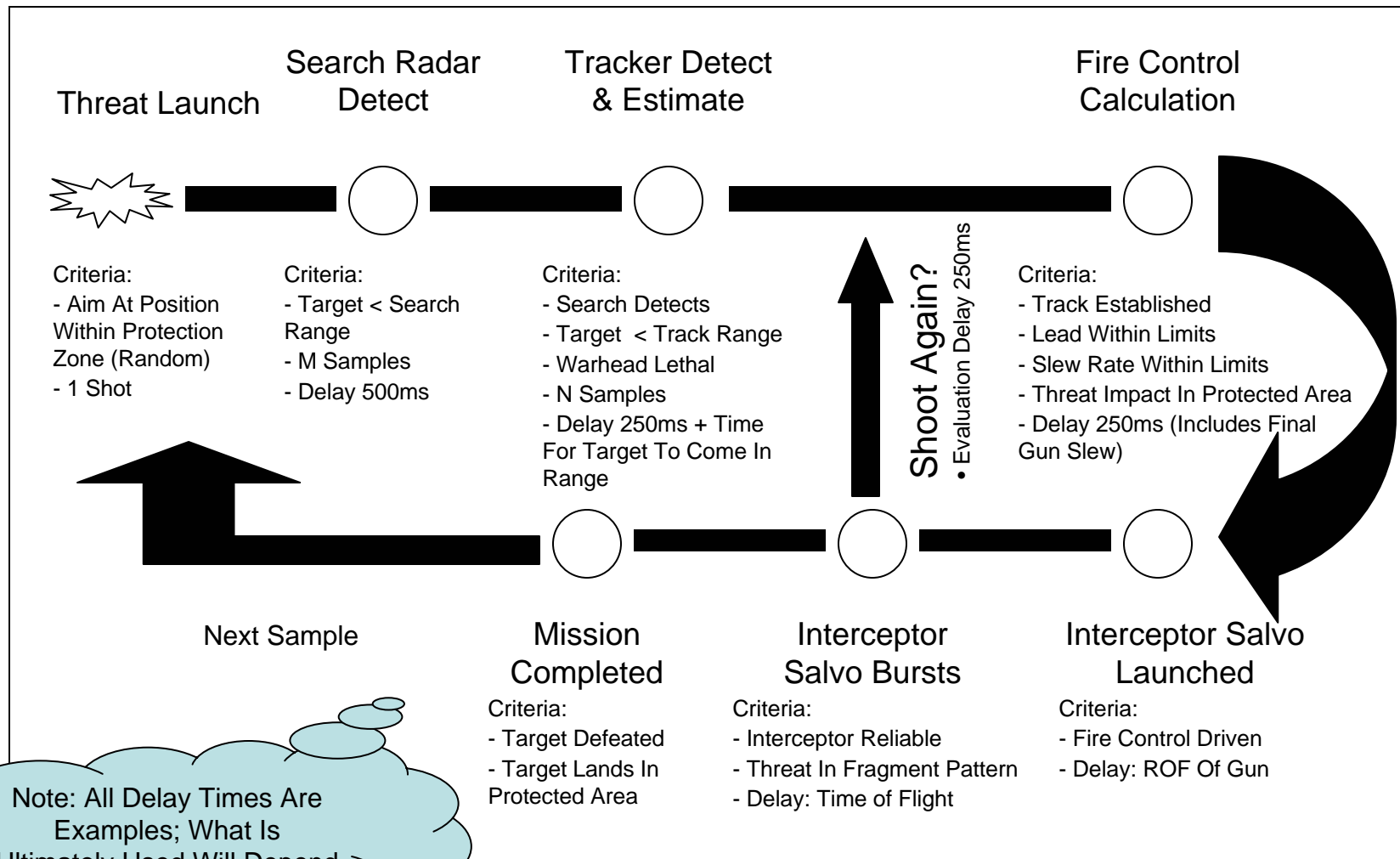
Basic Idea Is To Model The Event Timeline, Accuracy, & Lethality In Explicit Detail



Simulation Models A One (Or Many) On One Engagement Of Incoming Threat Round With EAPS Gun (Acoustics, Radar, Fire Control, Gun, Bullet)



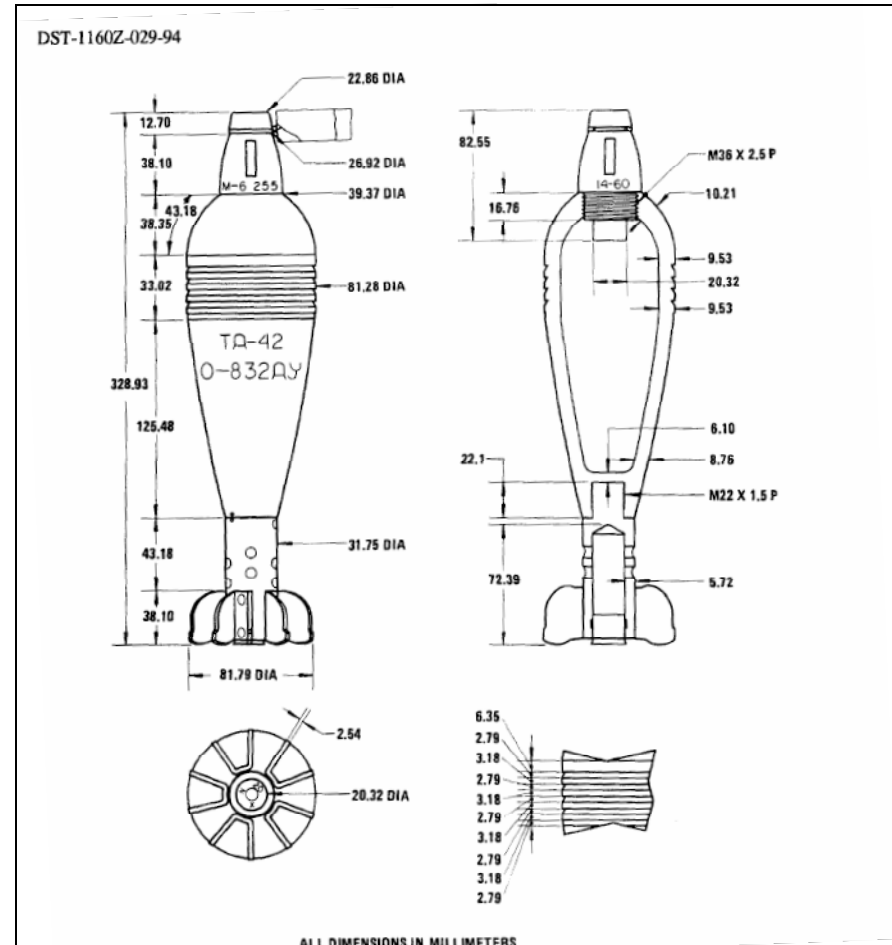
Flow of EAPS Gun Mission



Note: All Delay Times Are Examples; What Is Ultimately Used Will Depend On System Architecture

Example: Mortar Round

- Target Is Described By The Following Data Set
 - Aerodynamic Drag Data
 - Associated Mach Numbers
 - Radius of Round (m)
 - Weight of Round (lbs)
 - Launch Velocity (mps): Number of Zones, Velocity For Every Zone
 - Location of Launcher (m)
 - Length of Warhead
 - Explosive Fill
 - Thickness of Casing (mm)
 - RCS (DBSM)
- Trajectory Data To Insure Flight Characteristics Match Other Models



Rapid Fire- Hit to Kill 1

- C-RAM Type Engagement
- 20-30mm Caliber
- High Rate of Fire
- KE or HEPD Kill
- Lowest Cost Ammo
- High Expenditure Rate
- Issues: Collateral Damage and Cost



Precision Fire- Burst to Kill 2

- 35-82mm Caliber
- Low- Mod Rate of Fire
- Advanced Warhead
- Prox/Advanced Fuzing
- Moderate Cost Ammo
- Issues: Adequate Ph and Lethality



Precision Fire- Guide to Hit 3

- 30-35mm Caliber
- Low- Moderate Rate of Fire
- Command Guided Course Correction
- KE Kill
- No Warhead, Fuze or S&A
- High Cost Ammo
- Issues: Burst Size, Cost and SD



Precision Fire- Guide to Burst 4

- 50-82mm Caliber
- Low Rate of Fire
- Command Guided Course Correction
- Advanced Warhead
- Prox/Advanced Fuzing
- High Cost Ammo
- Issues: Cost, Complexity, Size



All Engagement Options Evaluated

KE/ Shaped Charge w/ Impact Fuze 1

- C-RAM Type Engagement
- 20mm or Larger
- Hit to Kill
- For KE Kill:
 - >50 gm, 1800 mps to get High Order?
 - >24 gm, 800 mps to get Breakup?
- Min Size Shaped Charge?
- Must Include Self Destruct



KE Preforms w/ Time Fuze 2

- Burst to Kill Engagement
- Probably Addressing Breakup Kill
- Preformed Tungsten Cylinders or Spheres
- Large Frags Required (10-20 gm?)
- Focused Forward Cone
- Minimum Caliber: 35 or 50 mm?



Blast Frag w/ Proximity Fuze 3

- Burst to Kill Engagement
- High Order Det or Breakup Kill?
- Prescored or Preformed Frags?
- MEFP or Mult SC Concepts?
- Large Frags Required (10-20 gm?)
- Spherical vs Focused Pattern?
- Forward Frag or Side Frag Pattern?



All Warhead and Fuzing
Options Evaluated



Gun System Candidates



System	Cal (mm)	Firing Rate (spm)	Muzzle Vel (mps)	Projectile Mass (gm)	Comments
Phalanx	20	4500	1030	99	C-RAM System
GAU-12	25	4200	1097	186	25mm Gatling Gun
Goalkeeper	30	4200	1080	362	Production CIWS System
Mk44	30/40	200	1020 (1000)	378 (740)	30/40mm Precision Gun
Bush III	35/50	250	1050 (1375)	750 (1051)	35/50mm Precision Gun
Skyshield	35	1000	1050	750	Production Air Defense Sys
Bush IV	40 Bofors	160	1100	975	Bigger 40 than Super 40
Bofors 57	57	220	1030	2400	Naval Gun System
XM274	75	70	1100	5220	Army Developed Gun System
Scorpion	82	120	277	3230	Foreign Mortar System



Trade Study Results - Req PR: Characterization of Trade Space



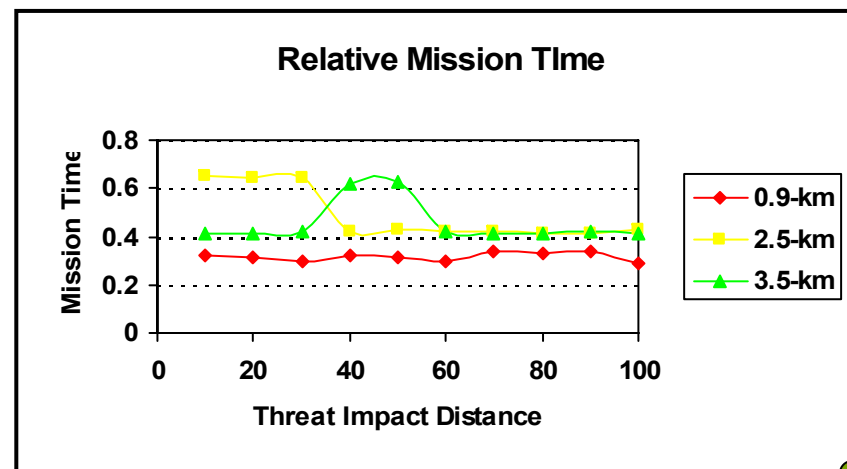
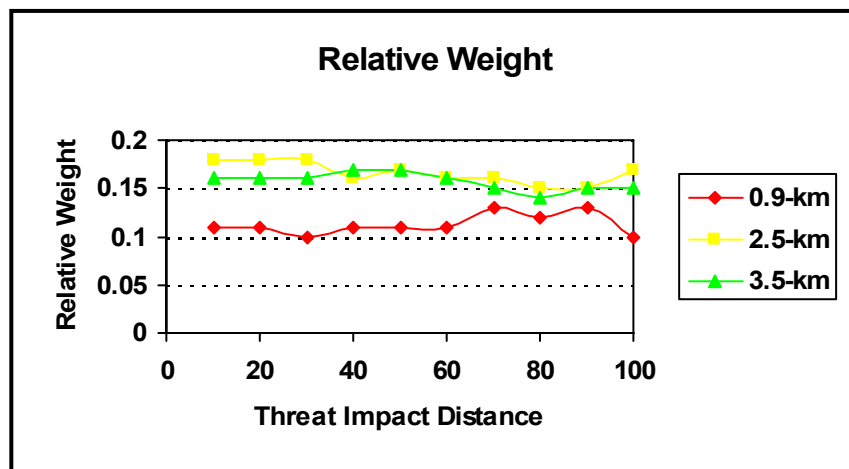
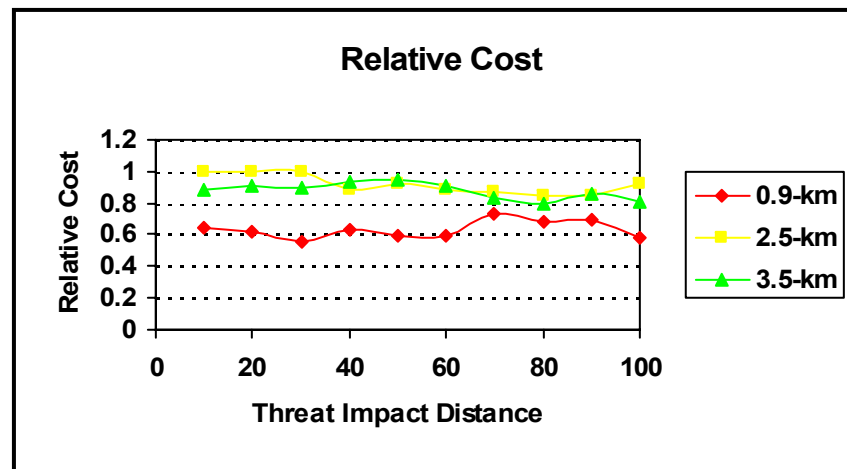
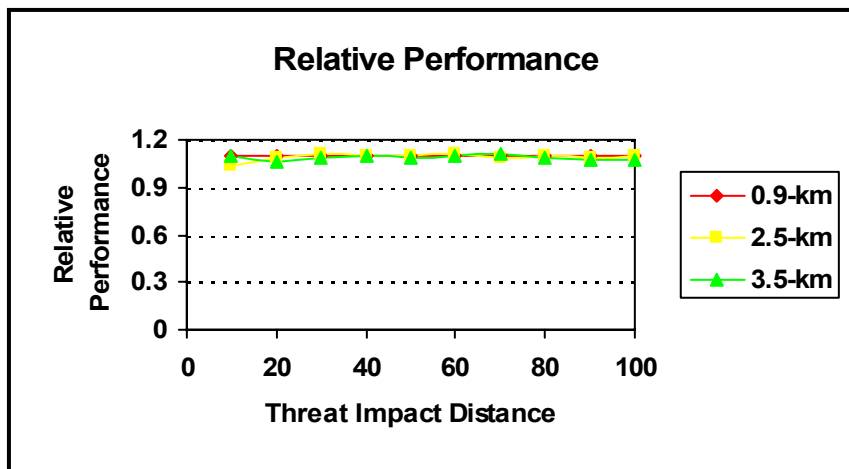
Warhead	Guidance	20mm 100% lbs.	25mm 101% lbs.	35mm 730% lbs.	50mm 1020% lbs.	75mm 5061% lbs	82mm 6893% lbs
KE-Sabot	No	PR~30% 100% Shots	PR~40% 35% Shots	ROF Too Low	Similar To Smaller Calibers ROF Too Low		Velocity Too Low
	Yes	Too Small		PR ~60% 5-9% Shots	ROF Issues		
HE-Nat	No	PR~30% 100% Shots	Not Done	Not Done – Appears to Have Low Promise Results Similar to KE Sabot			
	Yes	Too Small					
HE-PFF	No	Too Small			Not Done	PR >100% ~1.5% Shots	PR~10% 1% Shots
	Yes	<div style="border: 1px solid black; background-color: green; padding: 5px; display: inline-block;"> What Works 100% PR </div>			Not Done	PR>100% ~0.75% Shots	Not Done
CE-Unitary	No	Not Done – Appears to Have Low Promise Results should be similar to KE Sabot					Too Slow Likely To Be Ineffective
	Yes						
HE-EFP	No	Too Small			Not Done – Appears to Have Moderate Promise Results Should Be Similar To HE-PFF		
	Yes						
KE-Subs	No	Too Small		PR~20% 10-15% Shots	PR~60% ~7% Shots	PR~60% ~2% Shots	Too Slow Likely To Be Ineffective
	Yes	<div style="border: 1px solid black; background-color: green; padding: 5px; display: inline-block;"> Approach Cost/Kill: <66% Weight/Kill: 28.3% Time/Kill: ~40% </div>		Too Small	PR~100% ~2.5% Shots	PR~90% ~2% Shots	<div style="border: 1px solid black; border-radius: 50%; padding: 5px; display: inline-block;"> Logistic Burden Too High </div>
CE-Subs	No	Not Done – Appears To Be Too Small (Insufficient Number Of Submunitions)					Not Done – May Have Some Promise In Larger Calibers
	Yes						

Fuze Risk Too High

Logistic Burden Too High



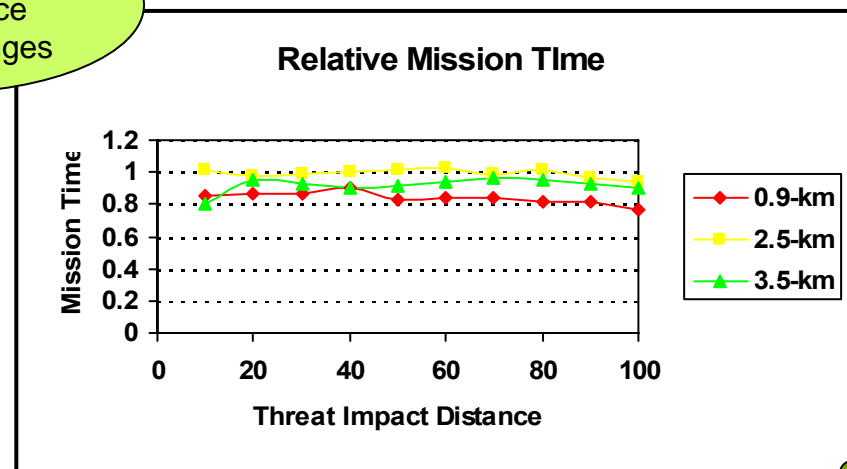
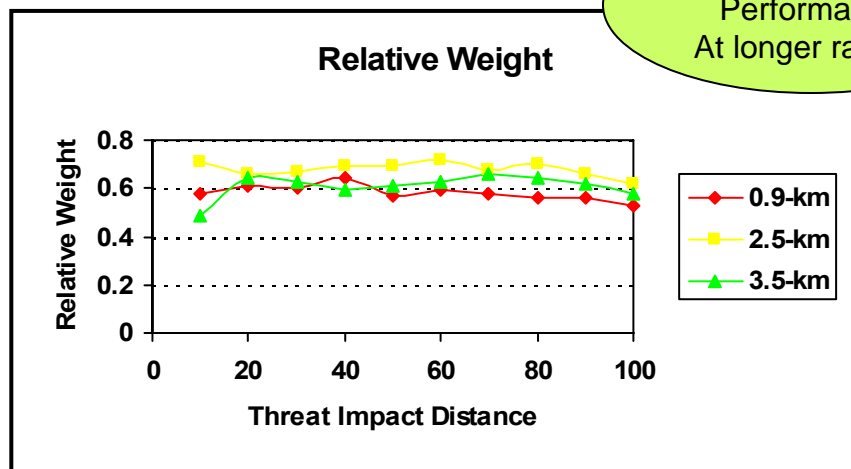
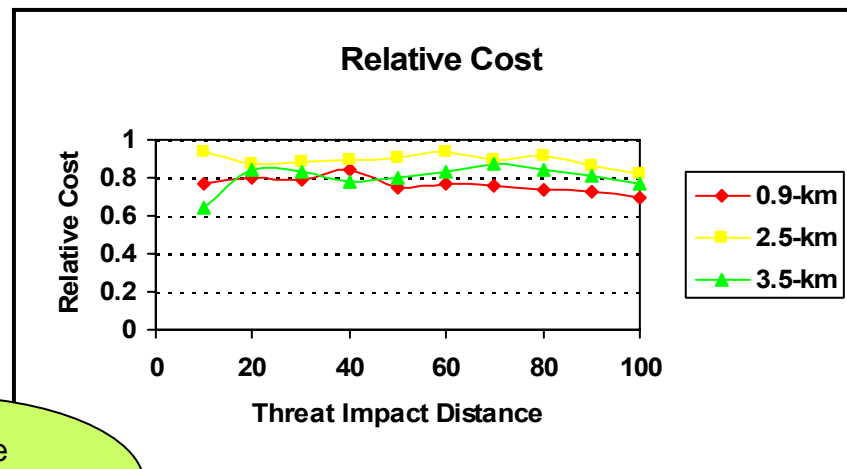
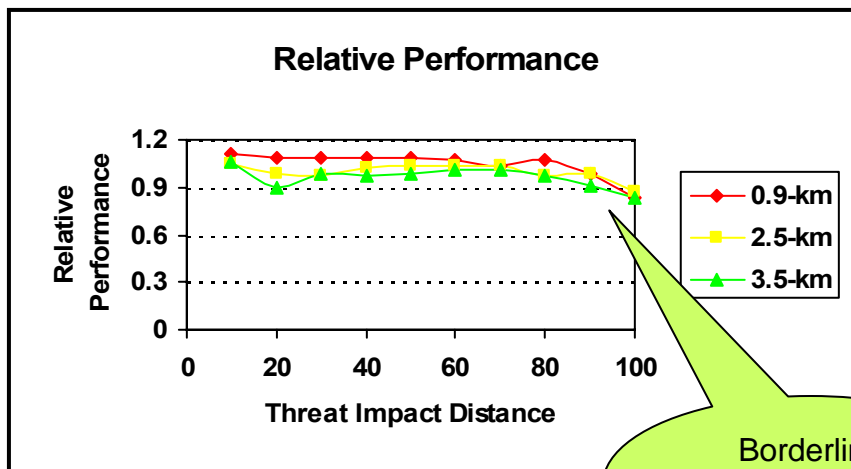
Cost, Weight and Time Analysis: 50mm FF Guided vs 82mm Mortar



System Meets All Objectives: Performance, Cost, Weight, and Mission Time Are Improvements Over Requirements



Cost, Weight and Time Analysis: 75mm FF Guided vs 82mm Mortar



Borderline Performance At longer ranges

System Meets Almost All Objectives: Performance (Out to 90% Of Threat Impact Range), Cost, Weight, and Mission Time Are Improvements Over Requirements



Used M&S To Determine Technical Approach To EAPS

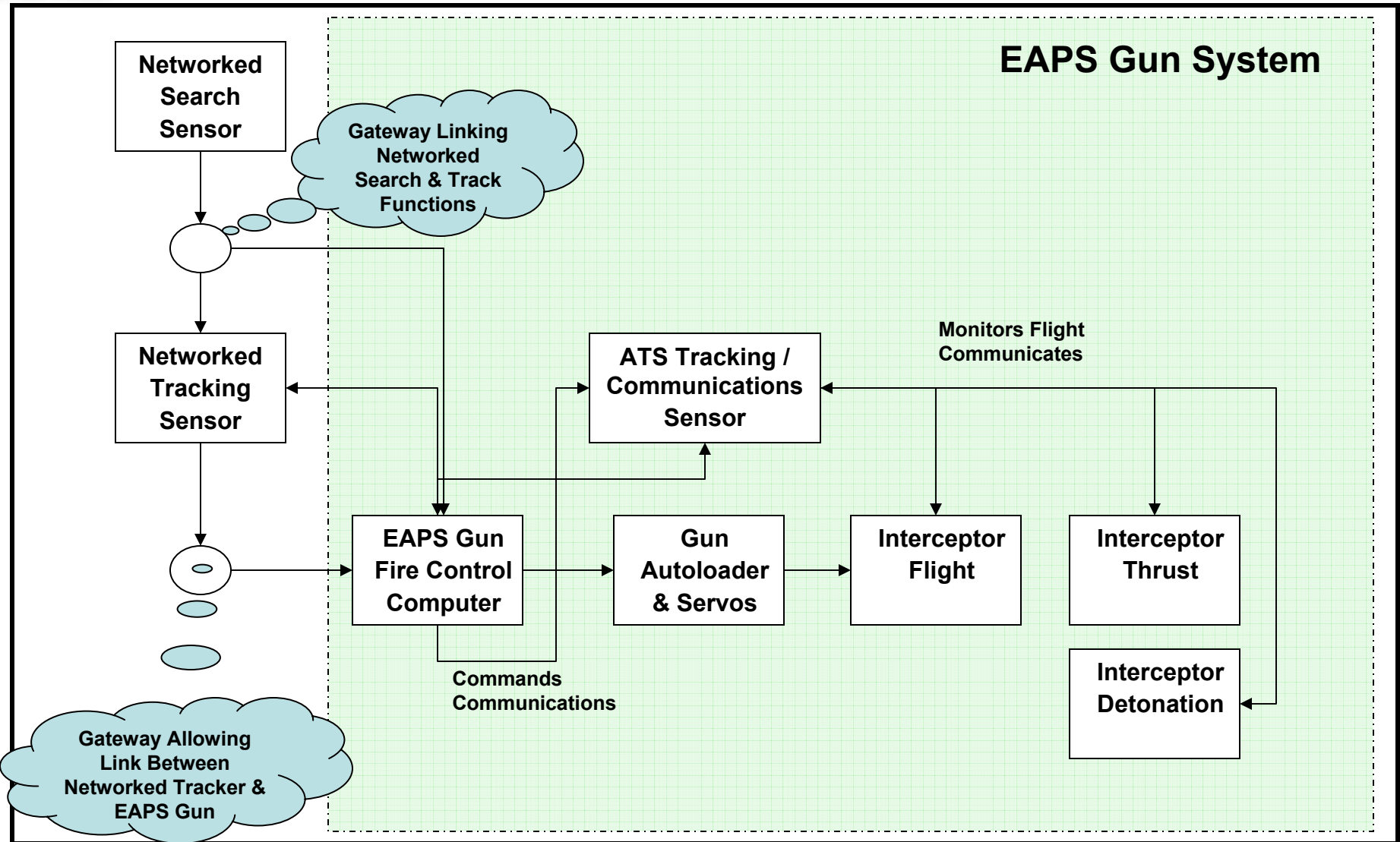


- Recommended Development of A Demonstrator Incorporating:
 - External Surveillance Radar With At Least Phalanx Range Capability
 - PTS/ATS Fire Control Radar For Tracking And Communication Link
 - 50mm Bushmaster III/IV Gun Capable of Achieving High Muzzle Velocity
 - Interceptor Using Course Correction Technology From MAST STO (Single Thruster, Guidance Instruments)
 - Transceiver Compatible With PTS/ATS Radar
 - Command Fuzed Forward Fragmenting Warhead Using Multiple EFP (or , Back Ups, Reactive Fragments or Preformed Tungsten Fragments with Boost)

Launched EAPS Gun and Interceptor Development Using These Rough Guidelines As Most Likely Technical Approach To Meet C-RAM Intercept Needs

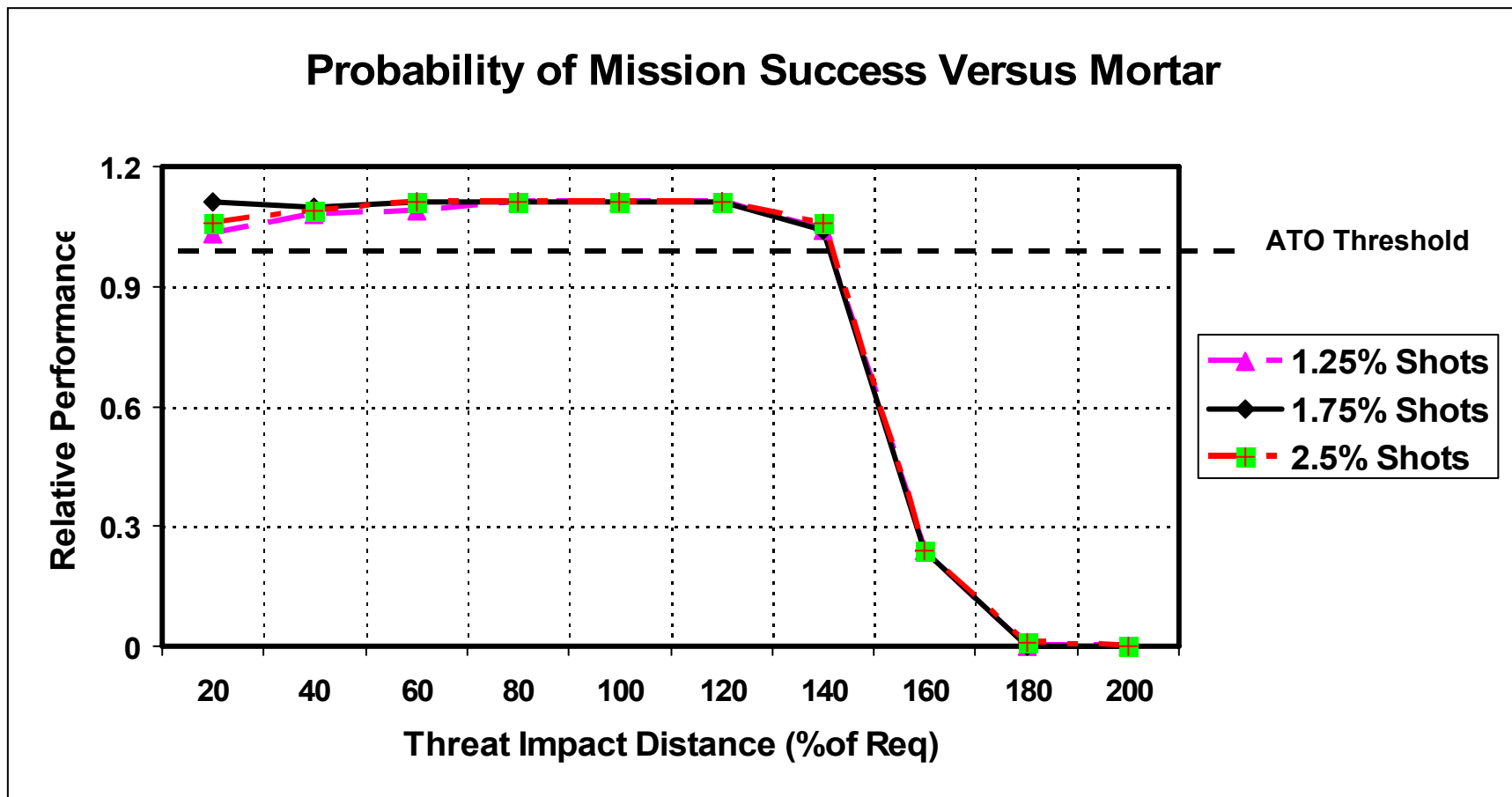


EAPS Gun Architecture





Probability of Mission Success Versus Mortar Threat



Exceeds ATO Performance Threshold With 1.25% Shots Out To 140%



Gun System Requirements (ATO Objectives)



Requirement	EAPS ATO	Approach To EAPS Requirement
Pk	\geq RPK	>RPK Vs Threats 1.25 to 2.5% Shots (MEFP Design)
Kill Range	\geq 100%	>120% Ground Range
Stowed Kills	X	1X to 2X
Cost/ Kill	<\$T	45% to 90%K of T Based On DTUPC
Multiple Near Simultaneous Threats	-	Up to 8 Targets Within One Quadrant
Fratricide/ Collateral Damage	Minimize Potential	Probability of Collateral Hit Low
Transportability	TBD	C5A, C17
Mobility	Mobile, 360 Hemispherical	Meets With 20-Ton Class Vehicle

Meets All Specified Goals For EAPS Gun