Utilizing Model Based System Engineering to look at the Infantry Squad as a SoS architecture

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

David Chau
U.S. Army RDECOM, ARDEC
Picatinny Arsenal, NJ 07806-5000
(973)724-3266; david.k.chau2.civ@mail.mil

Dana Perriello
U.S. Army RDECOM, ARDEC
Picatinny Arsenal, NJ 07806-5000
(973)724-9937; dana.e.perriello.civ@mail.mil

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

B.L.U.F. & Agenda

Bottom Line Up Front

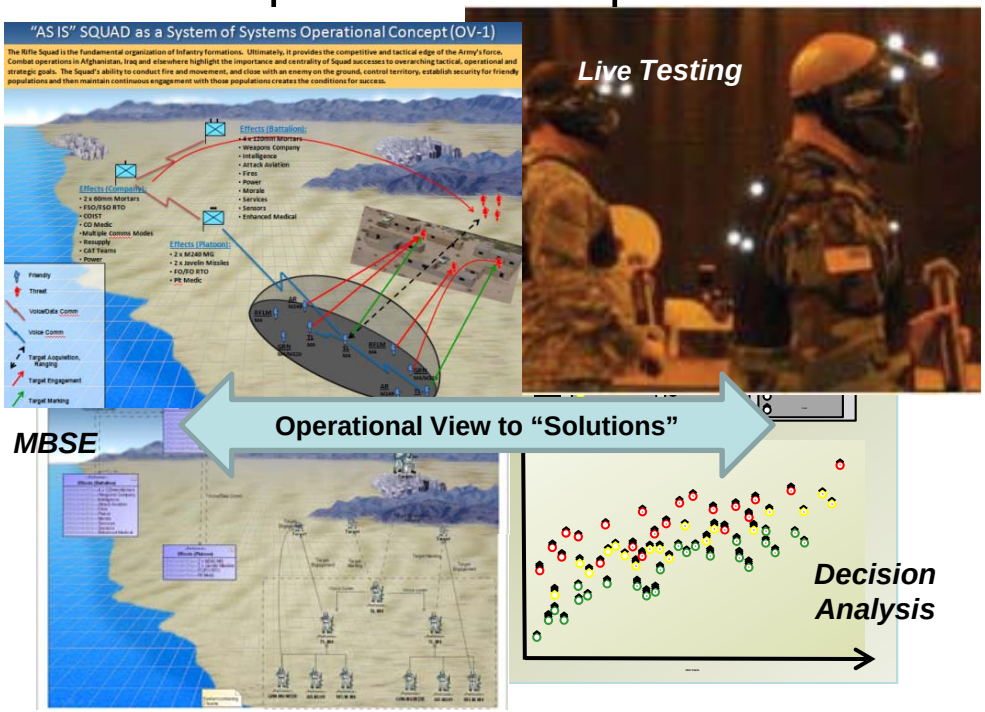
MBSE can be utilized to assess the Squad as a Systems of Systems Architecture, and as a collective Formation, to support capability portfolio assessments to enable Overmatch.

Agenda

- Overview
- MBSE Methodology & Tools
- The Squad as a System
  - Squad Requirements & Architecture
  - Integrated Modeling and Simulation
  - Decision Analysis
- Proof of concept results
- Conclusion
- Question & Answer

Overview

Squad SoS Perspective



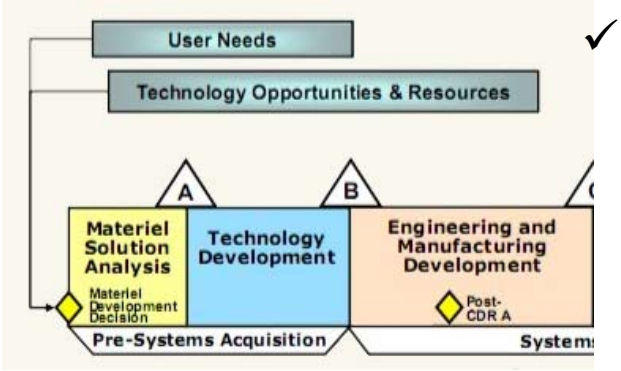
Squad SE Methodology that defines SoS Tradespace and Integrates DOTMLPF Solutions

- Use Model Based SE to model the Squad as a formation, a system of systems, rather than individual materiel & non-materiel solutions

- Apply Systems Engineering methodology & Model Based tools to assess and evaluate capability improvements to a Squad that will provide decision makers with increased insight into the effectiveness of their options

Systems Engineering Process

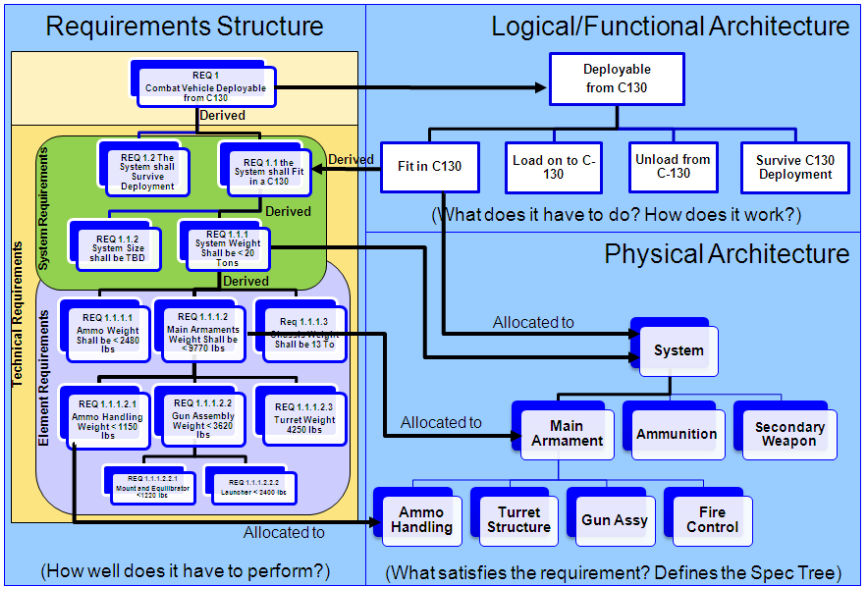
Requirements Definition



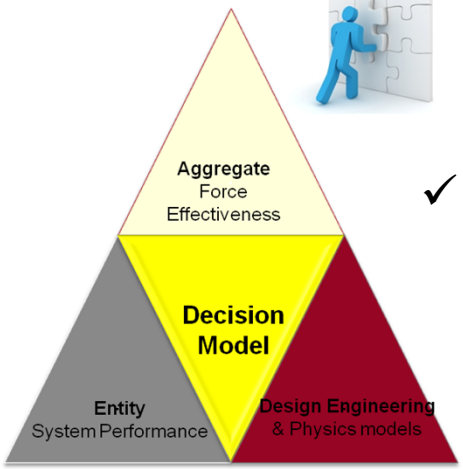
✓

Systems Architecting

✓



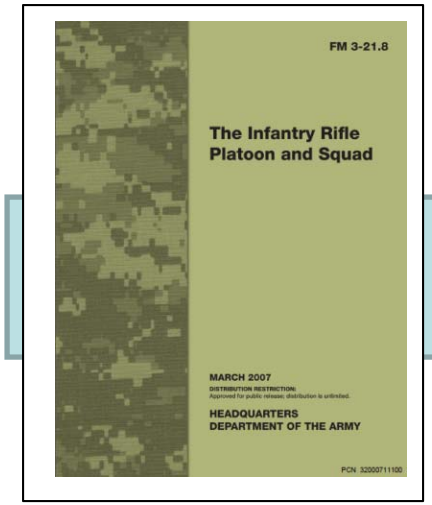
Decision Analysis



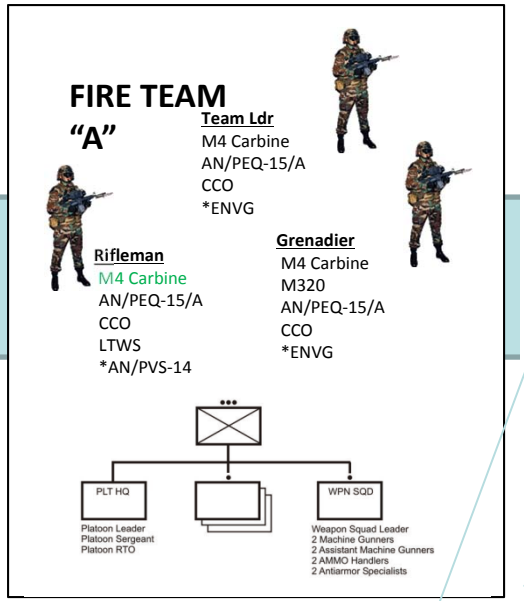
✓

Baseline Squad Architecture

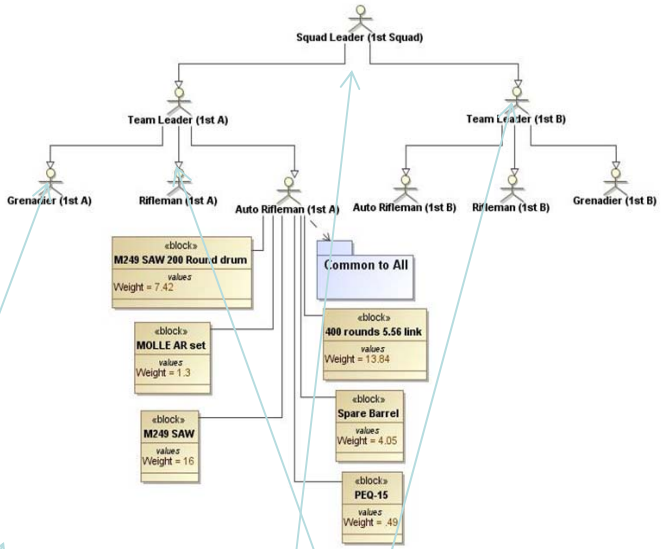
Mission/Requirements (TRADOC)



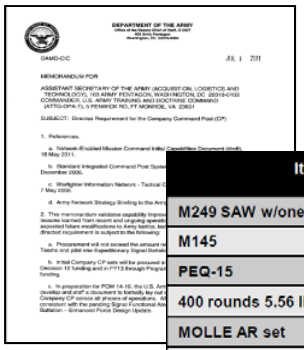
Soldier Architecture



Physical Architecture



Input to Analyses



Item	Weight
M249 SAW w/one 200 round drum	23.42
M145	1.51
PEQ-15	
400 rounds 5.56 link	
MOLLE AR set	1.3
Spare Barrel	4.05
Total	44.61
+ Common Equipment	140.72
+ Common + Cold Weather	147.34

Soldier Equipment

- Lethal/Non-Lethal
  - 40mm HE/DP
  - 40mm PARA
  - 40mm SMK
  - 40mm STAR
  - 5.56 Ammo Linked
  - Flashbang
  - M67 Grenade
- PPE
- Training Package
- Weapon Pckg
  - Relations
  - AN/PAS-13 (TWS II Tech insert) LW
  - M145 MGO
  - M249
  - M320

Leadership & Training

- Leadership Package
  - Relations
  - Advanced Leaders Course
  - Initial Entry Training (IMT/OSUT)
  - Ranger School
  - Small Unit Leader Course
  - Soldier Self Development (SSD) I
  - Soldier Self Development (SSD) II
  - Warrior Leaders Course
- Lethal/Non-Lethal
- PPE
- Training Package
  - Relations
  - ASAT
  - FORSCOM/CENTCOM PD Checklist

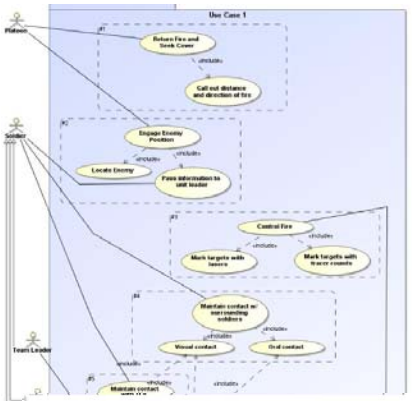
Squad MTOE Attributes - Baseline

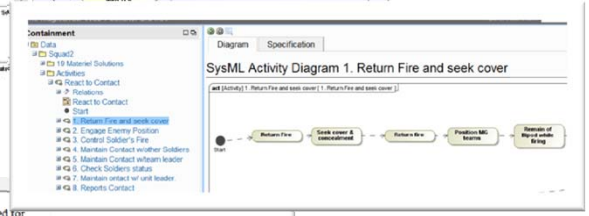
Integrated MBSE

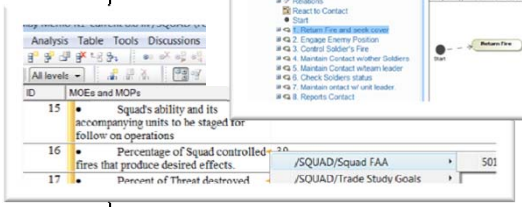
Operational Context

New Capability/S&T (M,L,T)

Squad Baseline

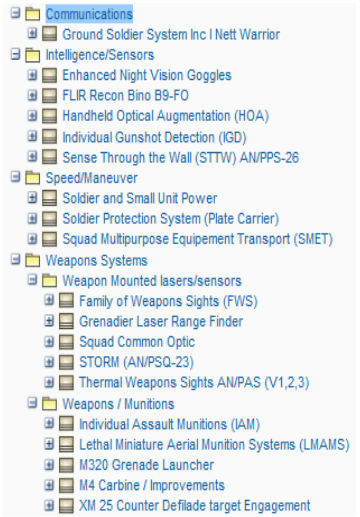






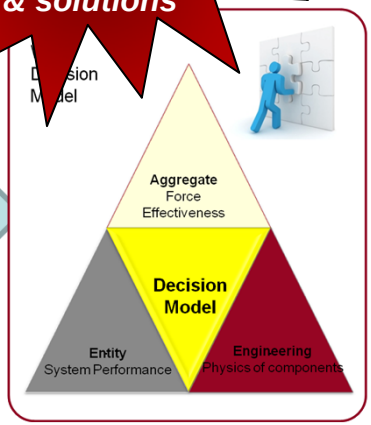
Use Cases

Operational Requirements
MFE/MOE/MOPs



Tradespace Analysis

Optimized investments & solutions



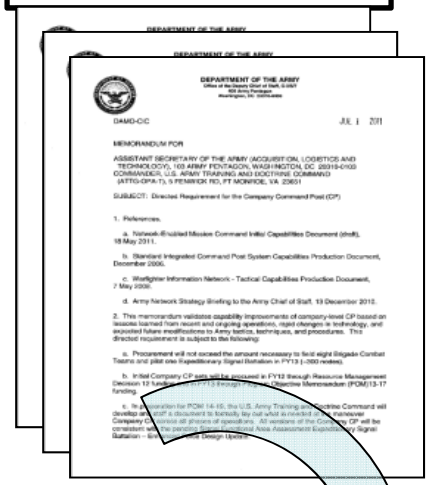
Integrated DOTMLPF Decision Framework …from Requirements to Concepts to Solutions

Integrated M&S/Analysis Environment
Live, Virtual, & Constructive

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

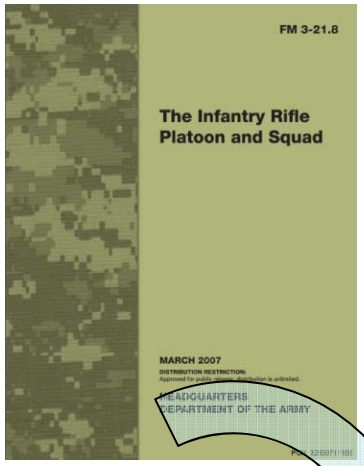
Understanding User Needs
"SE with Models"

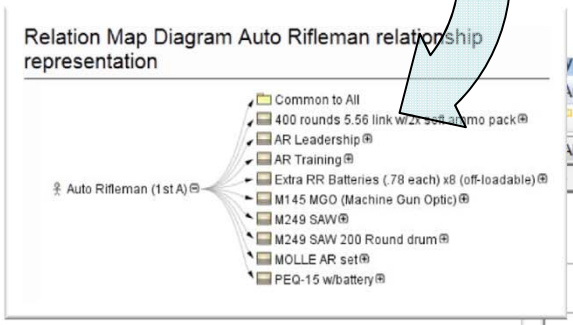
Soldier Load Baseline

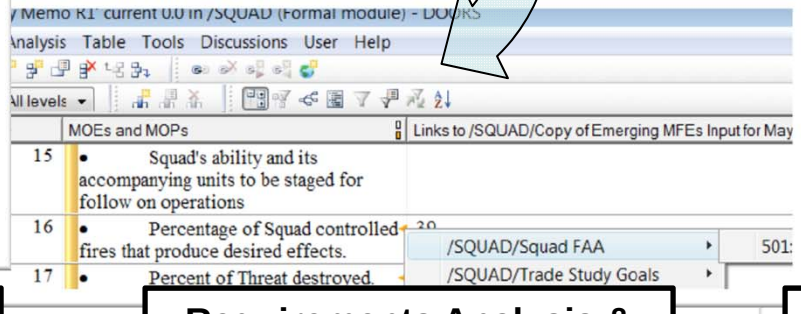


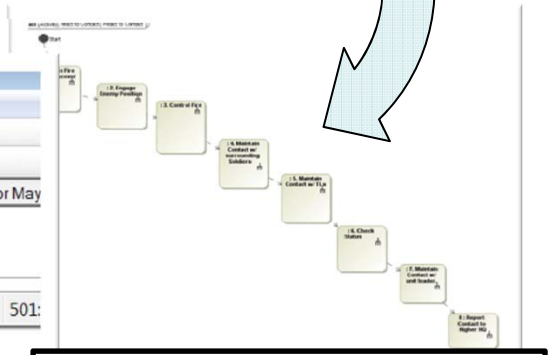
Squad CBA Gaps & MOE/MOPs

CONOPS







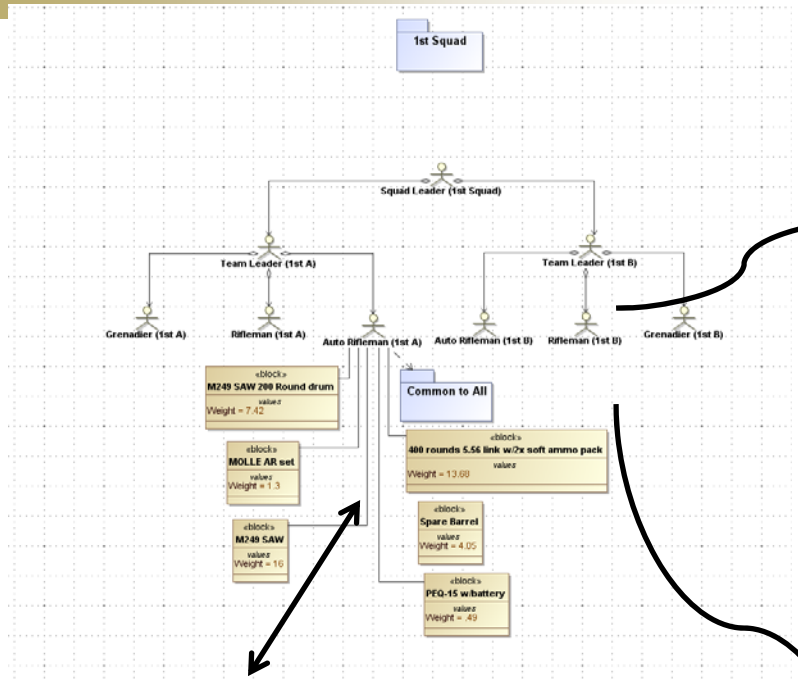


Structural Architecture (SysML)

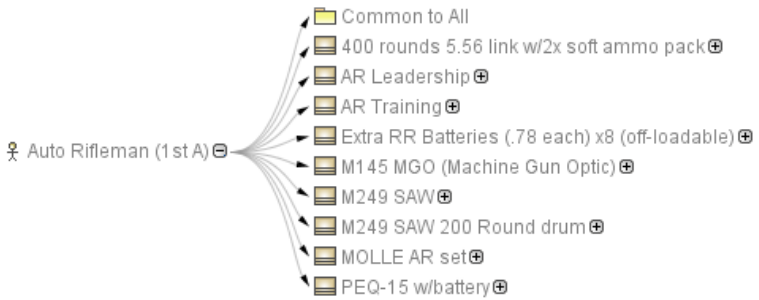
Requirements Analysis & Management Tool

Behavioral Architecture (SysML)

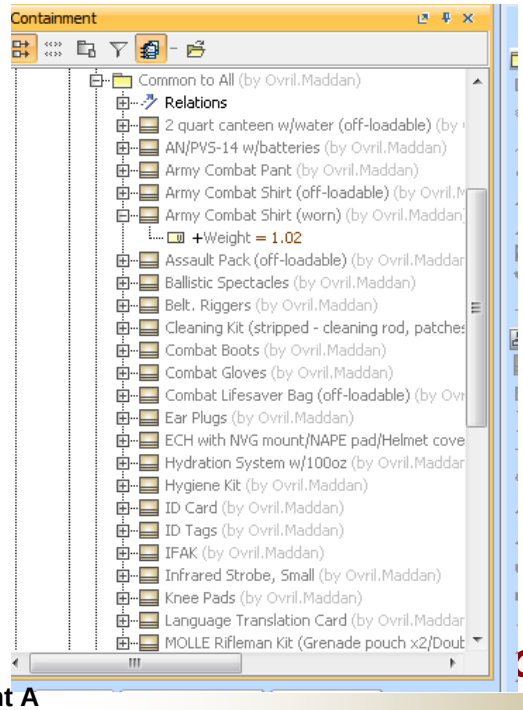
Squad Formation Physical Architecture (BDD)



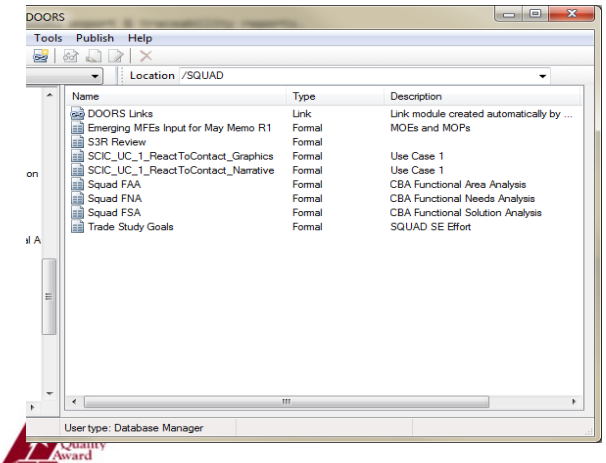
Squad Position Physical Allocation



SysML Containment Tree (MTOE)



Requirements Management



Translating CONOPS to Materiel Developers

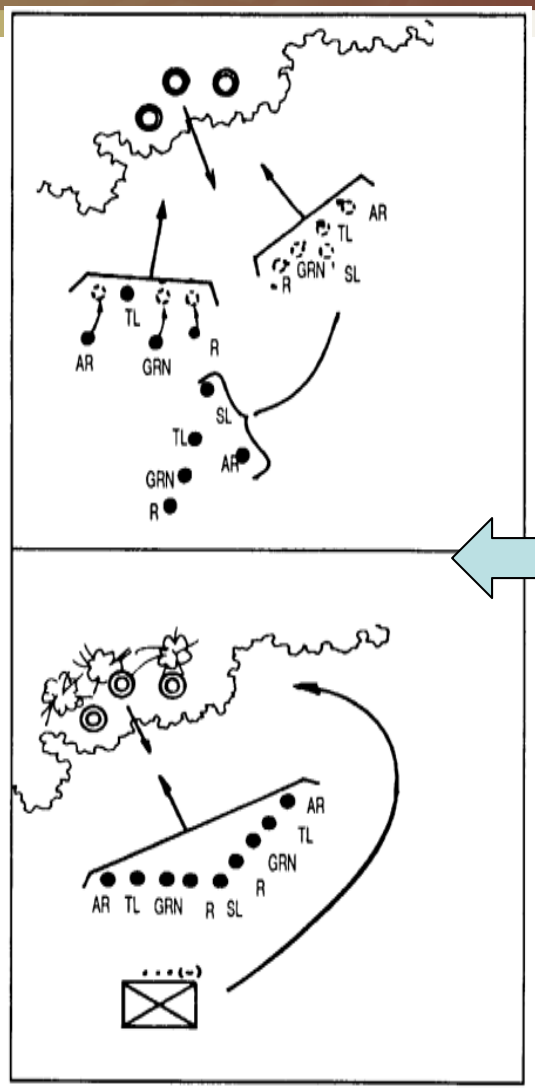
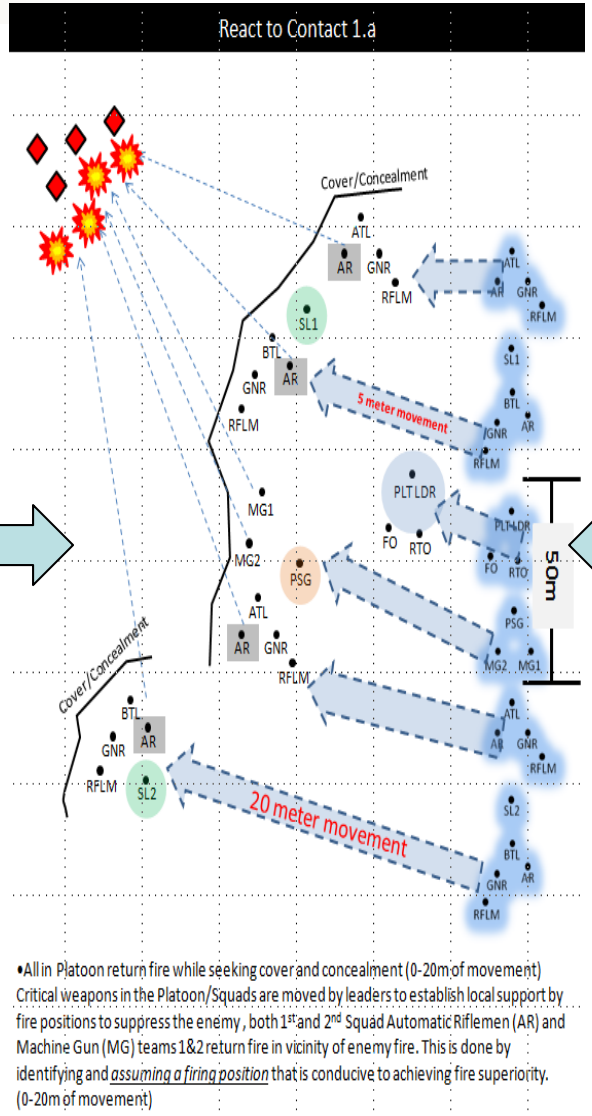
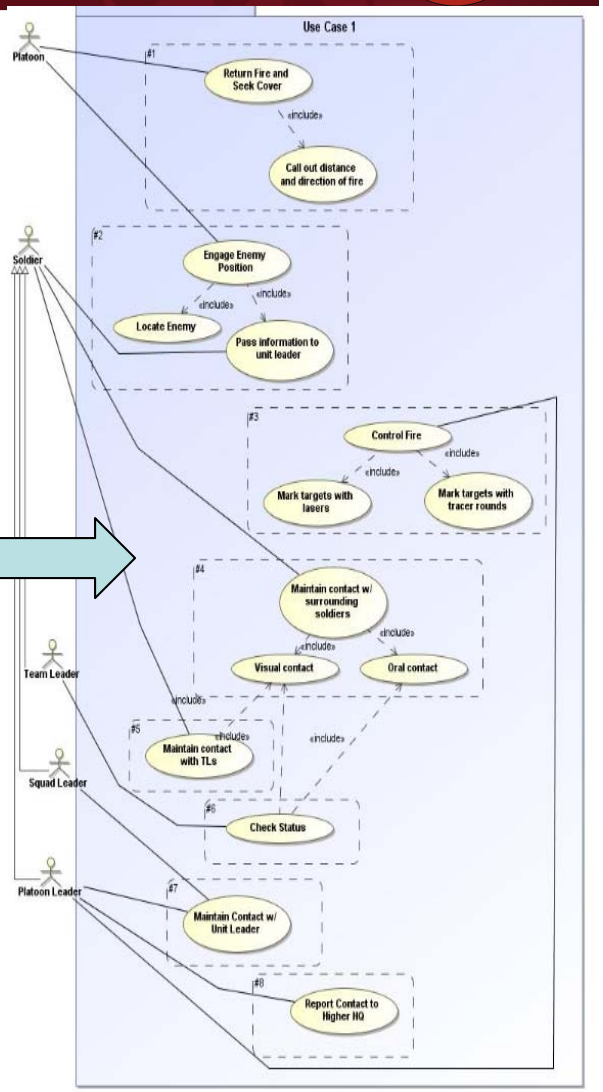


Figure 4-4. React to contact.

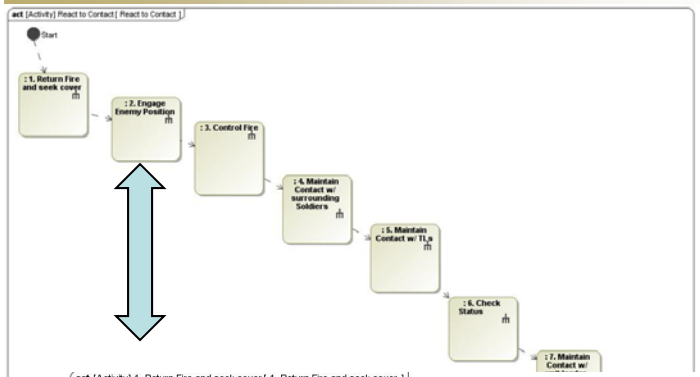


•All in Platoon return fire while seeking cover and concealment (0-20m of movement) Critical weapons in the Platoon/Squads are moved by leaders to establish local support by fire positions to suppress the enemy, both 1st and 2nd Squad Automatic Riflemen (AR) and Machine Gun (MG) teams 1&2 return fire in vicinity of enemy fire. This is done by identifying and *assuming a firing position* that is conducive to achieving fire superiority. (0-20m of movement)

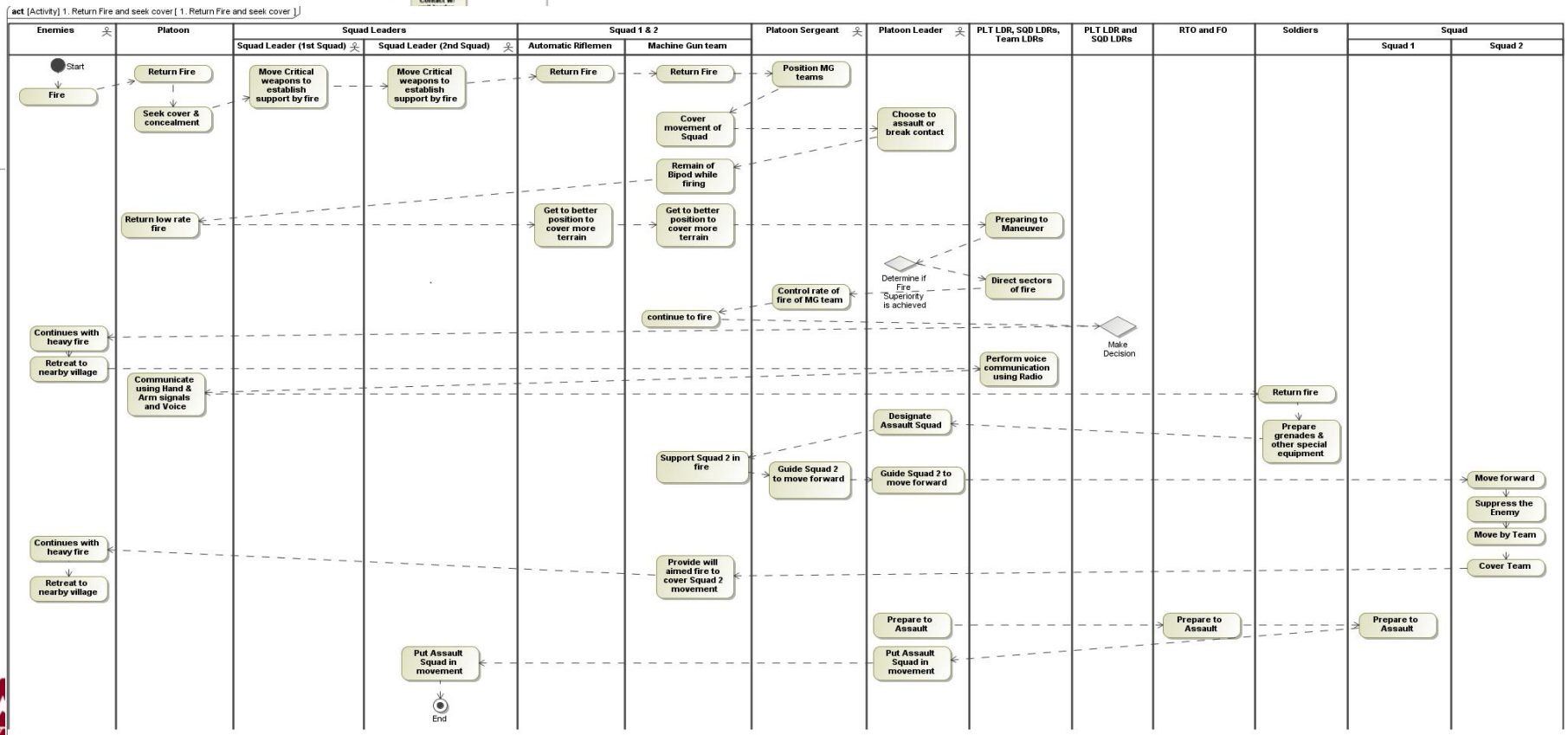


TRADOC MCoE | **NSRDEC SCIC** | **ARDEC SED**

Use Case: React to Contact

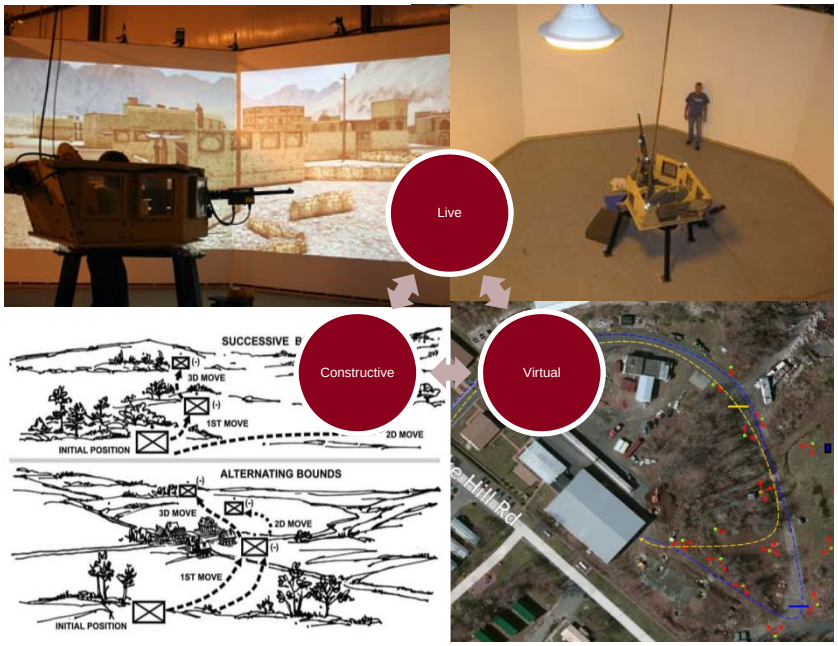


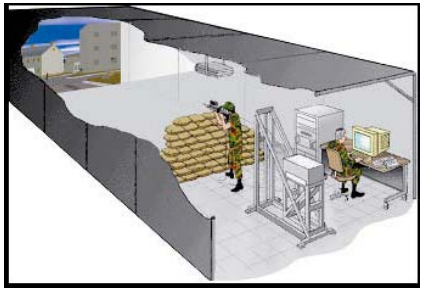
- Use Cases & IWARS Simulations
- Translate Use Cases (Narratives, Tasks, Graphics) into MBSE models
- Traceability to Requirements, MOEs, CONOPS
- Facilitate M&S development and execution



Soldier System Integration

- Early Focus on Soldier-System Integration in the design life cycle
- “Soldier in the Loop” evaluations to augment M&S
- Provide human empirical data to better inform the SE process including requirements, design considerations, and Trade Studies





LVC Simulated Testing

Distributed M/S & Decision Analysis Environment

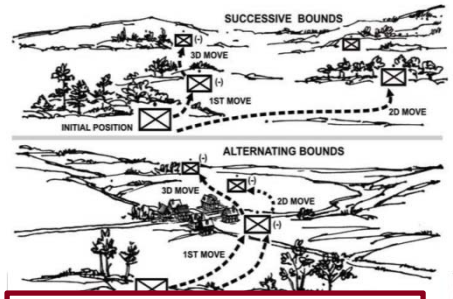
"Gaming" Soldier in the loop

Multiple model & simulation tools

Data Collection Plan

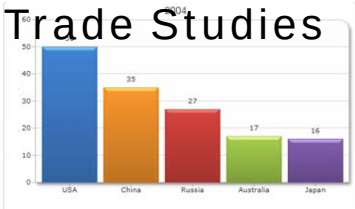
Weapon Fire
Location 123
Speed
56789

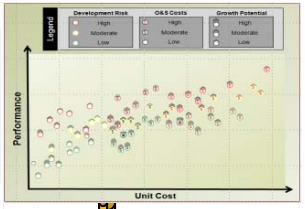
DB



Soldier in the Loop

System Analysis & SE Trade Studies



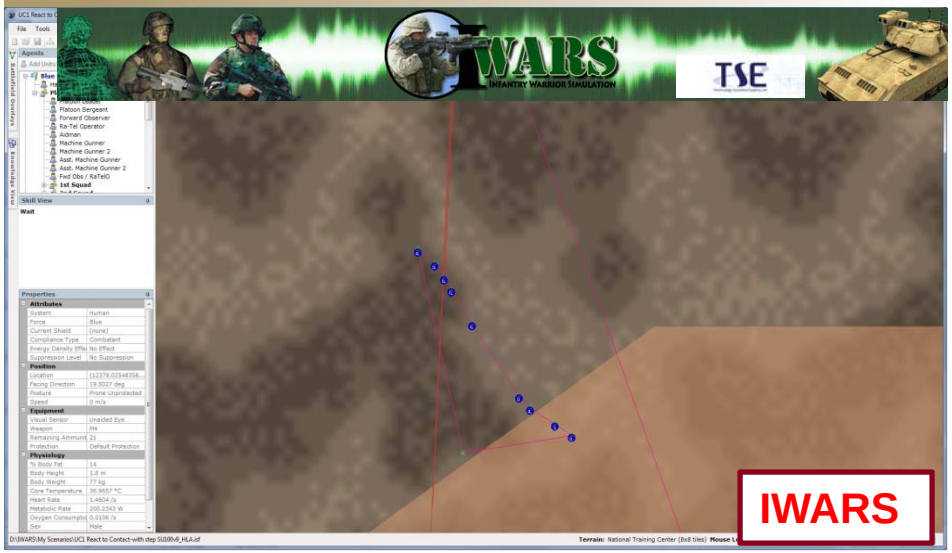


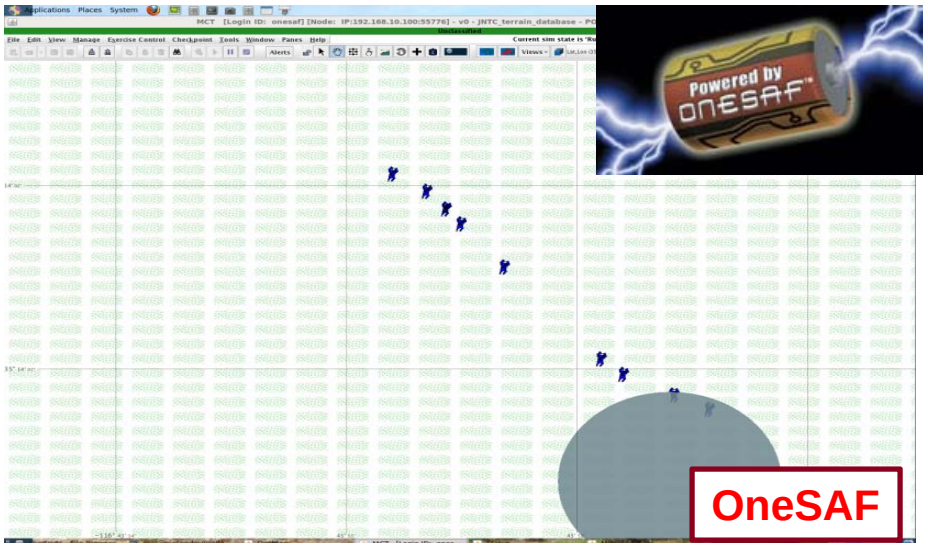
Integrated M/S to derive system data, drives decision analysis

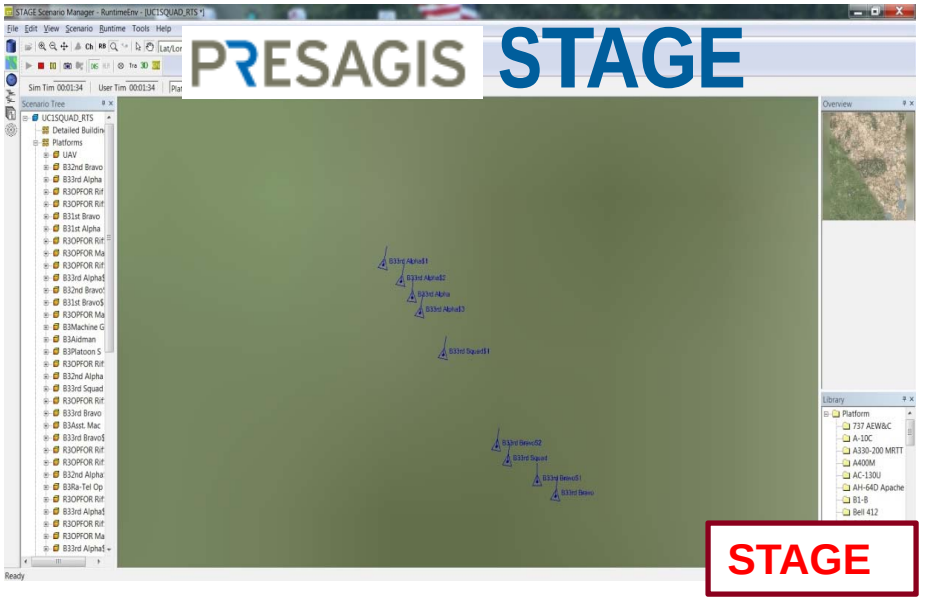
Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Integrated Modeling & Simulation





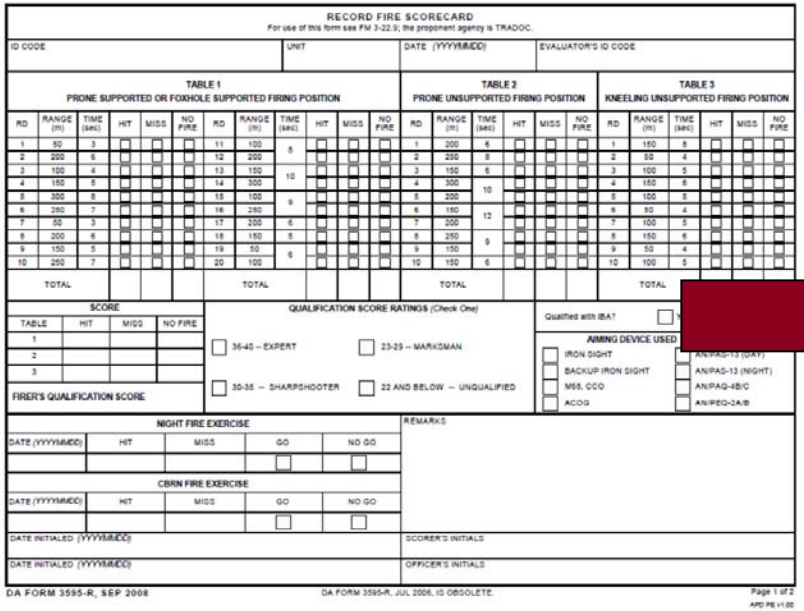


2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Training Qualification Scenario

M4 Fire Score Card



RECORD FIRE SCORECARD

For use of this form see FM 3-22.9; the proponent agency is TRADOC.

ID CODE | UNIT | DATE (YYYYMMDD) | EVALUATOR'S ID CODE

TABLE 1 — PRONE SUPPORTED OR FOXHOLE SUPPORTED FIRING POSITION

RD	RANGE (m)	TIME (sec)	HIT	MISS	NO FIRE	RD	RANGE (m)	TIME (sec)	HIT	MISS	NO FIRE
1	50	3				11	100	8			
2	200	6				12	200				
3	100	4				13	150	10			
4	150	5				14	300				
5	300	8				15	100	9			
6	250	7				16	250				
7	50	3				17	200	6			
8	200	6				18	150	5			
9	150	5				19	50	6			
10	250	7				20	100				
TOTAL						TOTAL					

TABLE 2 — PRONE UNSUPPORTED FIRING POSITION

RD	RANGE (m)	TIME (sec)	HIT	MISS	NO FIRE
1	200	6			
2	250	8			
3	150	6			
4	300	10			
5	200				
6	150	12			
7	300				
8	250	9			
9	150				
10	150	6			
TOTAL					

TABLE 3 — KNEELING UNSUPPORTED FIRING POSITION

RD	RANGE (m)	TIME (sec)	HIT	MISS	NO FIRE
1	150	8			
2	50	4			
3	100	5			
4	150	6			
5	100	5			
6	50	4			
7	100	5			
8	150	6			
9	50	4			
10	100	5			
TOTAL					

SCORE

TABLE	HIT	MISS	NO FIRE
1			
2			
3			

FIRER'S QUALIFICATION SCORE

QUALIFICATION SCORE RATINGS (Check One)

- ☐ 36-40 – EXPERT
- ☐ 23-29 – MARKSMAN
- ☐ 30-35 – SHARPSHOOTER
- ☐ 22 AND BELOW – UNQUALIFIED

Qualified with IBA? ☐

AIMING DEVICE USED

- ☐ IRON SIGHT
- ☐ BACKUP IRON SIGHT
- ☐ M68, CCO
- ☐ ACOG
- ☐ AN/PAS-13 (DAY)
- ☐ AN/PAS-13 (NIGHT)
- ☐ AN/PAQ-4B/C
- ☐ AN/PEQ-2A/B

NIGHT FIRE EXERCISE

DATE (YYYYMMDD)	HIT	MISS	GO	NO GO
			☐	☐

CBRN FIRE EXERCISE

DATE (YYYYMMDD)	HIT	MISS	GO	NO GO
			☐	☐

REMARKS

DATE INITIALED (YYYYMMDD) | SCORER'S INITIALS

DATE INITIALED (YYYYMMDD) | OFFICER'S INITIALS

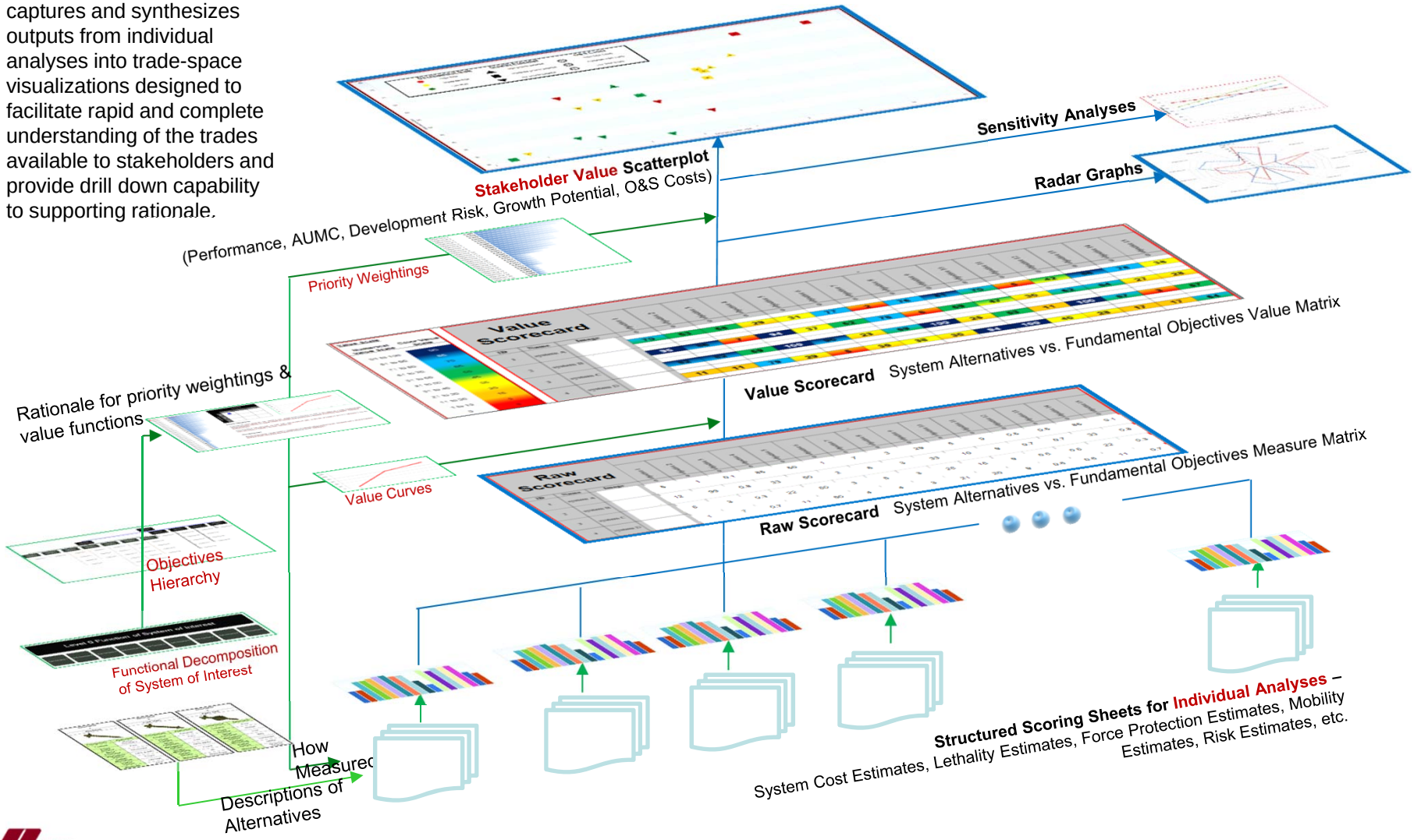
DA FORM 3595-R, SEP 2008 — DA FORM 3595-R, JUL 2006, IS OBSOLETE. — Page 1 of 2

Trained Weapons	Form 3595	Percentage Improvement Applied	Runs	Average Targets Hit	Percentage Improvement in Results
M4	<= 22	0%	42	21.1	0%
M4MM	23 - 29	24%	37	26.9	27%
M4SS	30 - 35	57%	33	35.4	68%
M4EX	36 - 40	81%	41	39.8	89%

Malcolm Baldrige National Quality Award 2007 Award Recipient

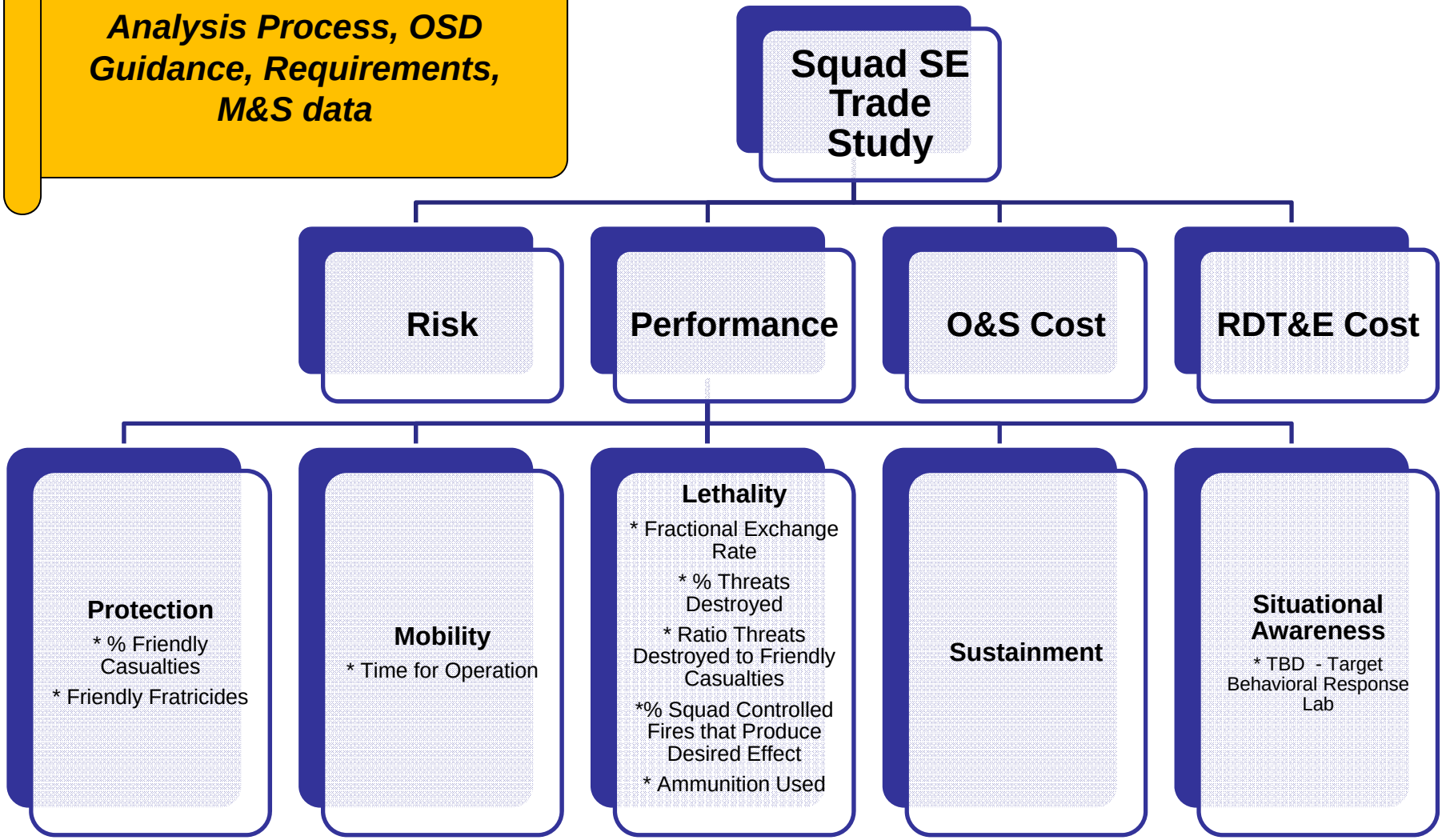
Whole System Trade Approach
Multiple Objective Decision Analysis

Decision support model captures and synthesizes outputs from individual analyses into trade-space visualizations designed to facilitate rapid and complete understanding of the trades available to stakeholders and provide drill down capability to supporting rationale.

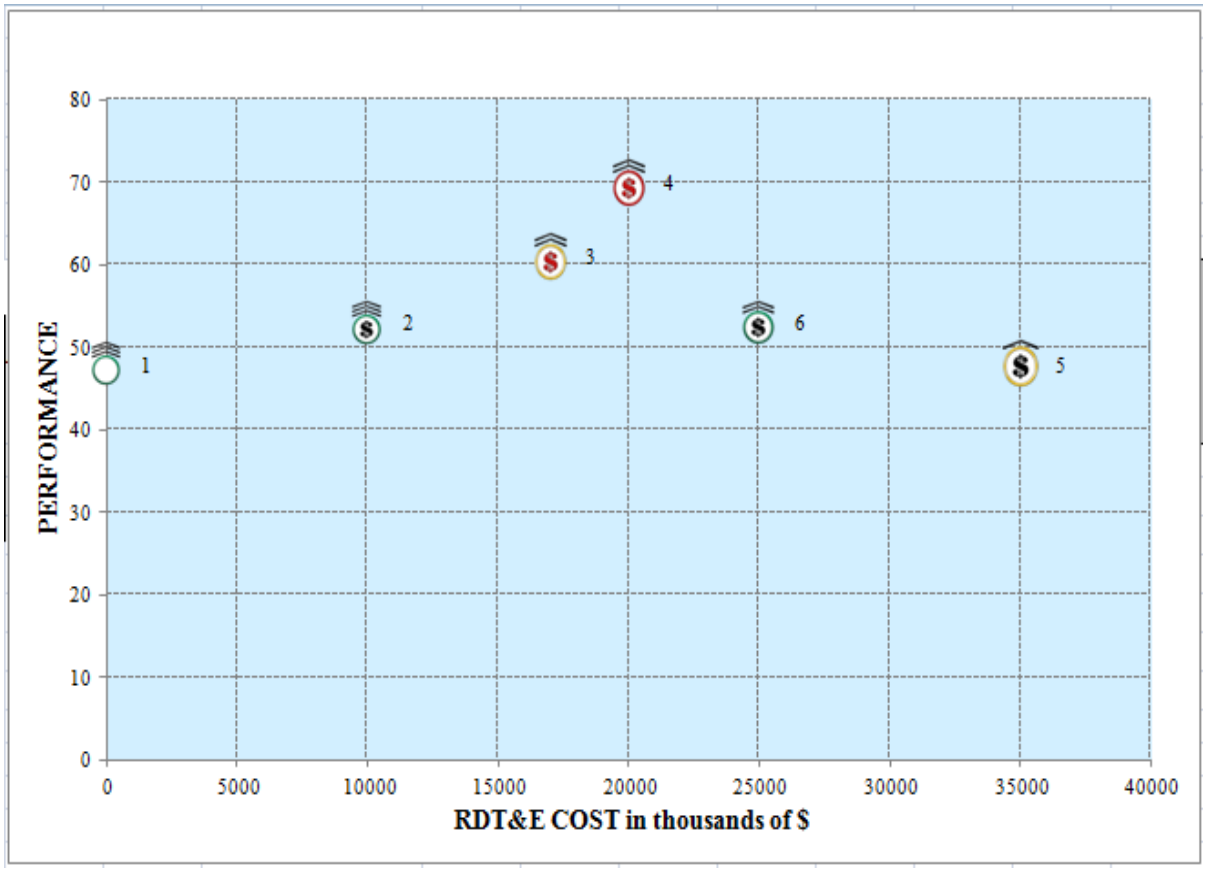


Trade Analysis Goals & Criteria

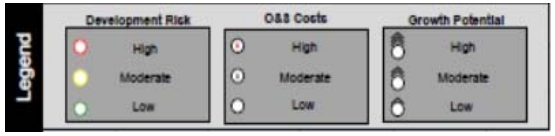
Derived based on Decision Analysis Process, OSD Guidance, Requirements, M&S data



Stakeholder Value Scatter Plot



1- Baseline - M4 Unqualified
2- M4 Marksman
3- M4 Sharpshooter
4- M4 Expert
5- Equipment Transport
6- Soldier Protection Improvemer



- Stakeholders choose the Goals they Value. Current five, based on OSD guidance.

- Decision analysis results presented to Stakeholders and Decision Makers to make informed decision.

AAMODAT
Armament Analytics Multiple Objectives Decision Analysis Tool

SE Trade Analysis Value Score Card

End-State Attractiveness Assessment Matrix			LETHALITY						PROTECTION		MOBILITY	RISK					O&S COST	RDT&E COST	GROWTH POTENTIAL
			Fractional Exchange Rate M240	Fractional Exchange Rate M4	Threats Destroyed	Squad Controlled Fires that Produce Effect	Quantity of Ammunition Used	Threats Destroyed to Friendly	Friendly Casualties	Friendly Fratricides	Time for Operations	Overall Assessment	Performance	Fielding	Funding	Requirements Documentation	O&S Cost	RDT&E Cost	Growth Potential
ID	Name	Image	0.05	0.1	0.1	0.1	0.1	0.1	0.2	0.15	0.1	0.2	0.2	0.2	0.2	0.2	1	1	1
1	Baseline - M4 Unqualified		2	100	70	11	78	4	3	90	78	100	100	100	100	100	100	100	100
2	M4 Marksman		1	100	84	15	79	10	15	86	83	81	81	81	71	100	75	80	61
3	M4 Sharpshooter		1	100	96	26	83	25	39	73	96	41	41	41	41	100	51	66	31
4	M4 Expert		1	100	100	45	87	49	59	70	100	21	21	21	21	100	26	60	1
5	Equipment Transport		1	100	71	11	78	4	1	90	78	21	61	21	21	61	41	31	46
6	Soldier Protection Improvements		2	100	81	11	73	14	25	86	75	61	61	61	61	21	68	51	66

Stakeholders provide input in development of Criteria and Priority Weighting. SMEs responsible for development of assessment for each Criteria.

Notional Proof of Concept data

Conclusion

- The Squad can be viewed as a complex System of Systems, a cohesive formation of capabilities.

- Model Based SE can facilitate:
  - A defined architecture & trade space through a common baseline model
  - Assessment across Leadership, Training and Materiel opportunities to achieve Overmatch
  - Integrated system(s) data to conduct Portfolio and SE Trade Analysis

- Proof of concept demonstrated tradeoff analyses across Materiel, Training, Leadership (DOTMLPF) that takes into account stakeholder values, including performance, risk and cost

Framework enables SE Tradeoff Analysis, a key component of the OSD Directive for Better Buying Power.