



Extending a Missions and Means Framework (MMF) Demonstration to Vulnerability/Lethality Data Production

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Objective



To present the data production process for the 2005 MMF demonstration and how lessons learned can be applied in the future.



Outline



- **MMF: *What's different***
- **Demonstration Models and Data**
- **Data Development Process**
- **Status**
- **Implications**



MMF Demonstration: What's Different?



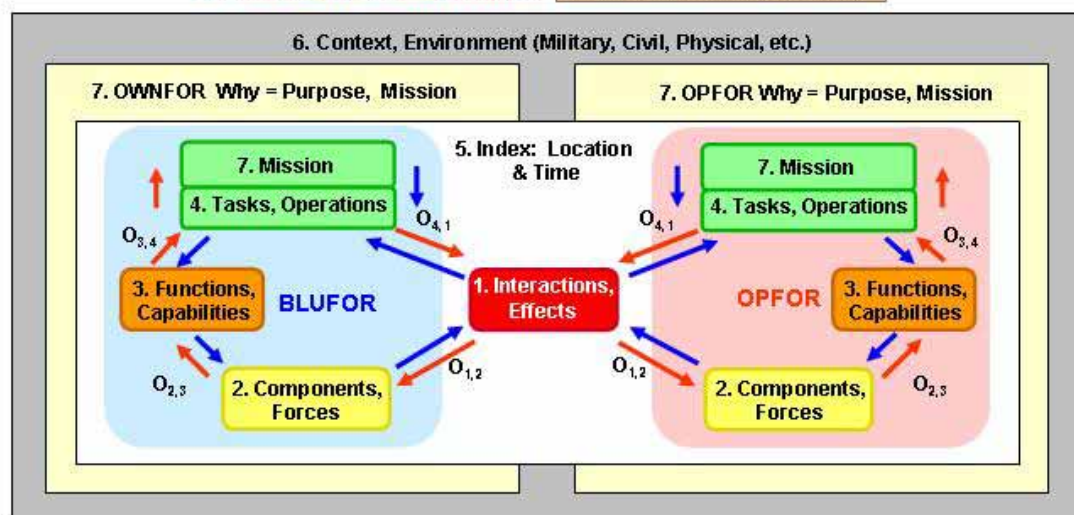
- Direct application of war fighter tasks.
- Demonstration of network-centric effects that features SoS-level fault trees

Degraded Capability States (DCS) at both platform and component levels

Dynamic effects of vulnerability, reliability, repair, ...

Alternative courses of action

11 Fundamental Elements: Seven Levels, Four Operators





MMF Data: *What's Different?*



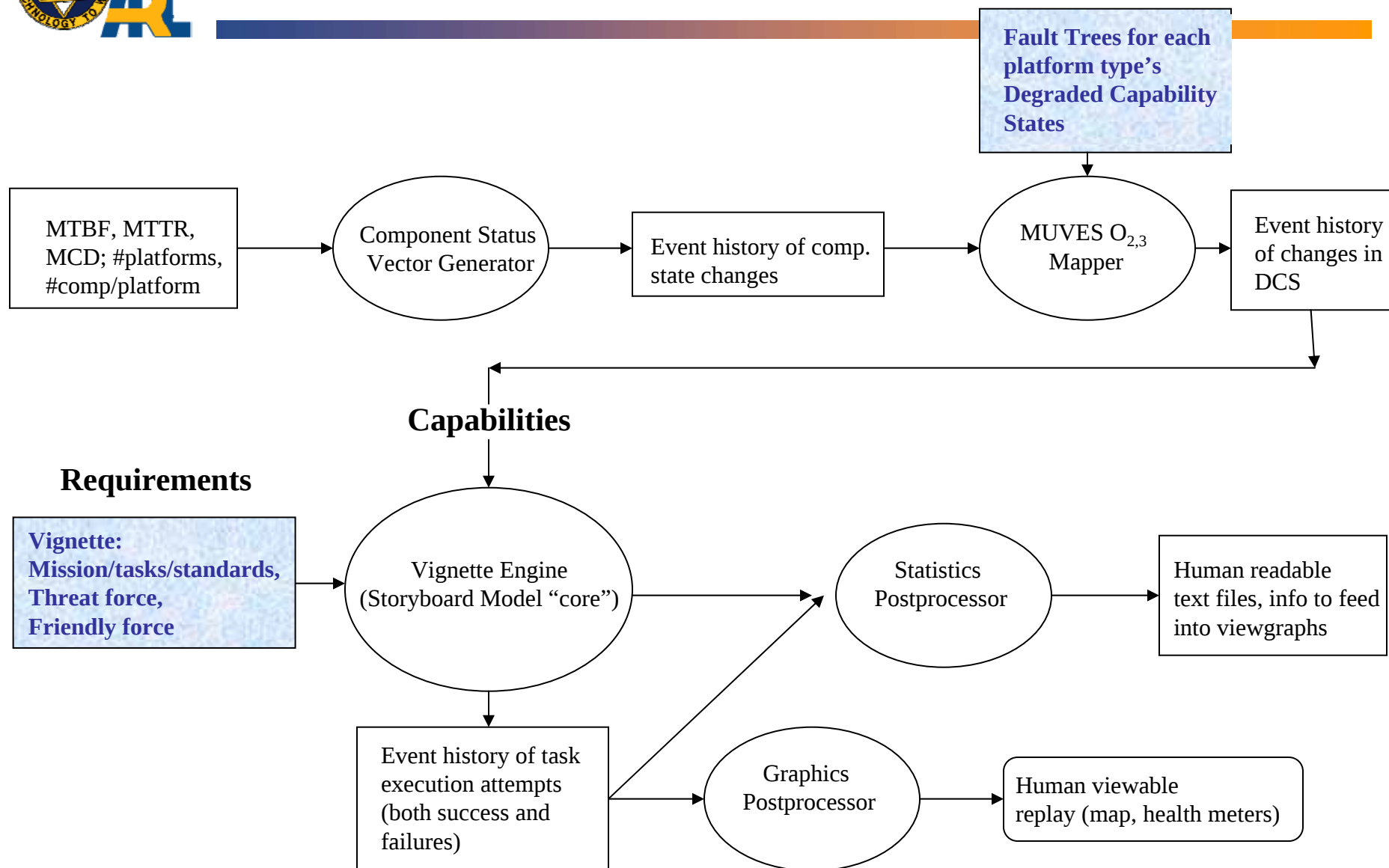
Traditionally

- System developer, user and evaluator determine a Damage Assessment List of critical Line-Replaceable-Units (LRU).
- A conclave is formed to assign a weighting to each LRU representing the loss to mission effectiveness across all scenarios and environment conditions.
- Limiting metrics; mobility, firepower, communications and catastrophic.
- Developmental test information was not incorporated into V/L modeling.

What's NEW

- Data development is directly correlated to the Army Universal Task List (AUTL), Joint Universal Task List (UJTL) or Lead System Integrator tasks.
- Expanded metrics support a robust system representation required for a system of systems evaluation and training.
- A closer communication between the modeling, testing and soldier community.

What's missing is metric validation via developmental testing.





Data Development Process: Overview



1. Determine platform engineered capability elements (engineer/design contractor).
2. Perform criticality analysis and develop system fault trees (engineer/analyst).
3. Determine semantic and design constraints (engineer/analyst).
4. Develop the DCS partially ordered set (Poset) given the constraints (analyst).
5. Determine the appropriate tasks typical for platform (AUTL/UJTL).
6. Determine the required DCS for each tasks and color code acceptability (TRADOC System Manager).
7. Bin the platform poset by tier and acceptability.
8. Calculate the probability of available capability at 3 levels (red, amber, green) for each platform task per threat (analyst).

Process requires closer communications between the modeling, analysis, testing, and training communities.



Degraded Capability States: Basic Elements



**C2V
(2)**



**NLOS
(6)**



**ARV-RISTA
(3)**



**Class-II UAV
(3)**

Mobility (5)

- M0 No Mobility Degradation
- M1* Reduced Maximum Speed
- M2 Reduced Maneuverability
- M3* Stop After T Minutes
- M4 Reduced Acceleration
- M5 Total Immobilization

Firepower (12)

- F0 No Firepower Degradation
- F1 Lost Ability To Fire Buttoned Up Main
- F2 Degraded Delivery Accuracy of Main
- F3 Degraded Initial Rate of Fire of Main
- F4 Degraded Subsequent Rate of Fire of Main
- F5 Degraded Maximum Range Main
- F6 Lost Reload Capability
- F7 Total Loss of Firepower Main
- F8 Lost Ability to Fire Buttoned Up Secondary
- F9 Degraded Delivery Accuracy of Secondary
- F10 Degraded Initial Rate of Fire of Secondary
- F11 Degraded Subsequent Rate of Fire of Secondary
- F12 Total Loss of Firepower Secondary

Communication (8)

- X0 No Communication Degradation
- X1 Reduced Range
- X2* Lost Line-of-Sight (LOS) Data (ex. JTRS)
- X3* Lost LOS Voice
- X4* Lost Non-LOS Data (ex. SATCOM)
- X5 Lost NLOS Voice
- X6 Lost Internal Communications
- X7 Lost External Communications
- X8 Lost All Communications

Survivability (6)

- S0 No Survivability Degradation
- S1 Lost NBC Protection
- S2 Lost Ability to Deploy Obscurants
- S3 Lost Silent Watch Capability
- S4 Lost Active Protection System
- S5 Lost Threat Warning Capability
- S6 Lost Fire Suppression Capability

Target Acquisition (3)

- A0 No Acquisition Degradation
- A1 Lost Daylight Sights
- A2 Lost Night Sights
- A3 Lost Range Finder

Surveillance (4)

- Z0 No Surveillance Degradation
- Z1 Lost Primary Sensor
- Z2 Lost Secondary Sensor
- Z3 Lost Tertiary Sensor
- Z4 Lost All Surveillance

Crew (7)

- C0 No Crewmember Incapacitated
- C1 Commander Incapacitated
- C2 Squad Leader Incapacitated
- C3 Driver Incapacitated
- C4 Operator 1 Incapacitated
- C5 Operator 2 Incapacitated
- C6 Gunner Incapacitated
- C7 Loader Incapacitated

Passengers (1)

- P0 No Passengers Incapacitated
- P1 Passengers Incapacitated

Other (3)

- O1 Lost Situational Awareness
- O2 Lost Unmanned System Control
- O3 Lost Automated C²

Catastrophic Loss (1)

- K0 No Catastrophic Loss
- K1 Lost Every Capability

* assigned degradation factor according to the variation in components affecting speed or bandwidth.



Data Development Process:

Determine Engineered Capabilities



<u>Category</u>	<u>Description</u>	<u>ARV</u> <u>(RSV)</u>	<u>UAV</u>	<u>C2V</u>	<u>NLOS-C</u>
Mobility					
m1	reduced_maximum_speed	x	x	x	x
m2	reduced_maneuverability	x	x	x	x
m3	stop_after_t_minutes (leaks)	x	x	x	x
m5	total_immobilization	x	x	x	x
Firepower					
f1	lost_ability_to_fire_buttoned_up_main	x		x	
f2	degraded_delivery_accuracy_main				x
f3	degraded_initial_rate_of_fire_main				x
f4	degraded_subsequent_rate_of_fire_main				x
f7	total_loss_of_firepower_main	mg		mg	howitzer
f12	lost_secondary_armament				x
Communications					
x2	lost_external_data	x	x	x	x
x3	lost_external_voice			x	x
x6	lost_internal_comms			x	x
x8	lost_all_commo			x	x

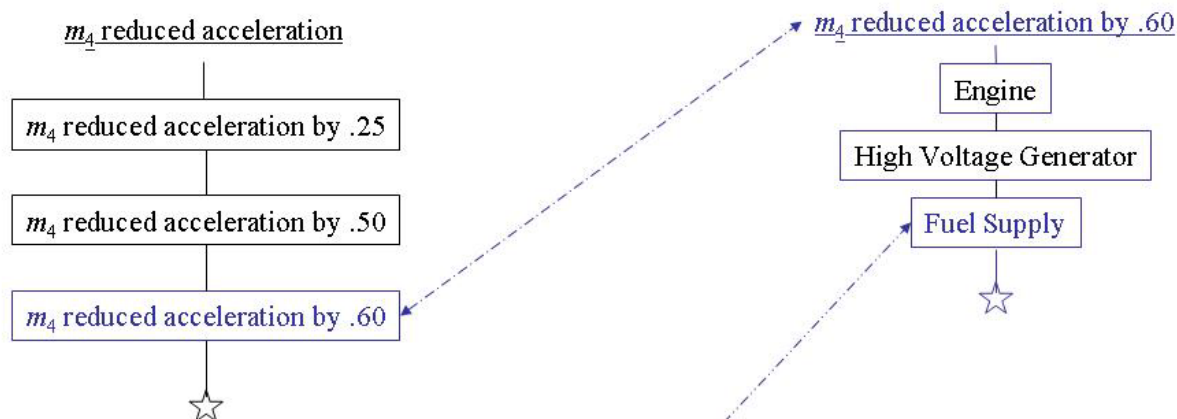


Data Development Process:

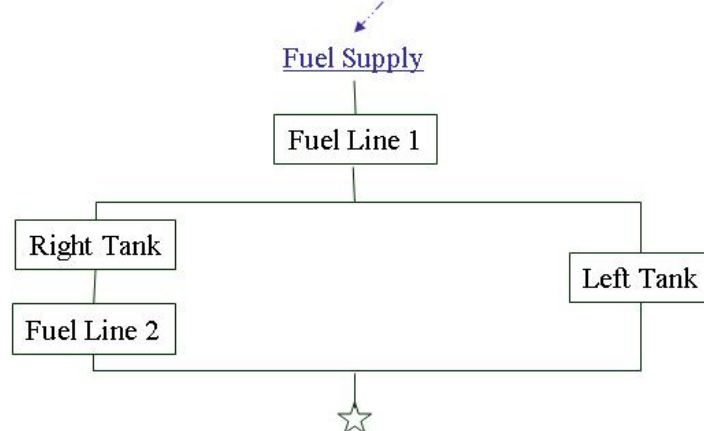
Criticality Analysis and DCS Fault Tree Development



Series fault tree structure



Series and Parallel fault tree structure



NLOS-C mobility is increased by hybrid electric technology.



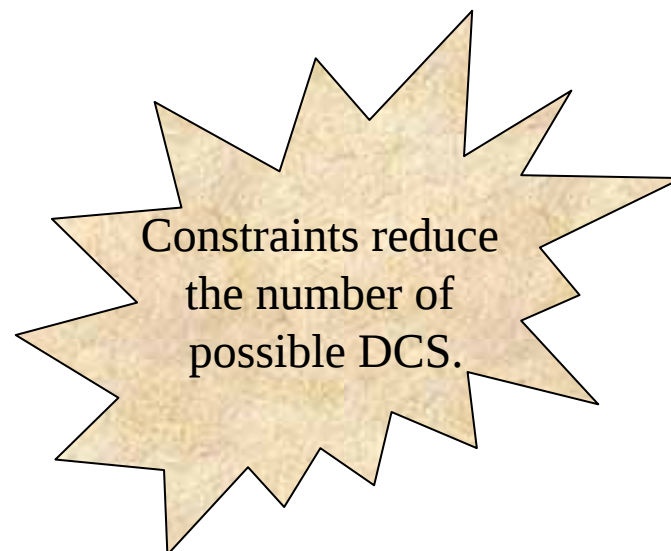
Data Development Process:

Determine Constraints



- SEMANTIC constraints imply loss by definition.
i.e., if x_7 then x_1 , x_2 , x_3 , x_4 and x_5 .
- DESIGN constraints imply loss of capability by the engineered component relation.
i.e., if x_2 then x_3

ID	COMMUNICATION CAPABILITY
X_0	No Communication Degradation
X_1	Reduced Range
X_2	Lost Line-of-Sight (LOS) Data
X_3	Lost LOS Voice
X_4	Lost Non-LOS Data
X_5	Lost NLOS Voice
X_6	Lost Internal Communications
X_7	Lost External Communications
X_8	Lost All Communications





Data Development Process:

Develop Partially Ordered Sets



Of the $2^5 = 32$ subsets of $\{m_1, m_2, m_3, m_4, m_5\}$, the constraint preclude all but these 16:

tier 0

$\{ \}$

tier 1

$\{ M1 \}$

$\{ M2 \}$

$\{ M3 \}$

$\{ M4 \}$

tier 2

$\{ M1 M2 \}$

$\{ M1 M3 \}$

$\{ M2 M3 \}$

$\{ M1 M4 \}$

$\{ M2 M4 \}$

$\{ M3 M4 \}$

tier 3

$\{ M1 M2 M3 \}$

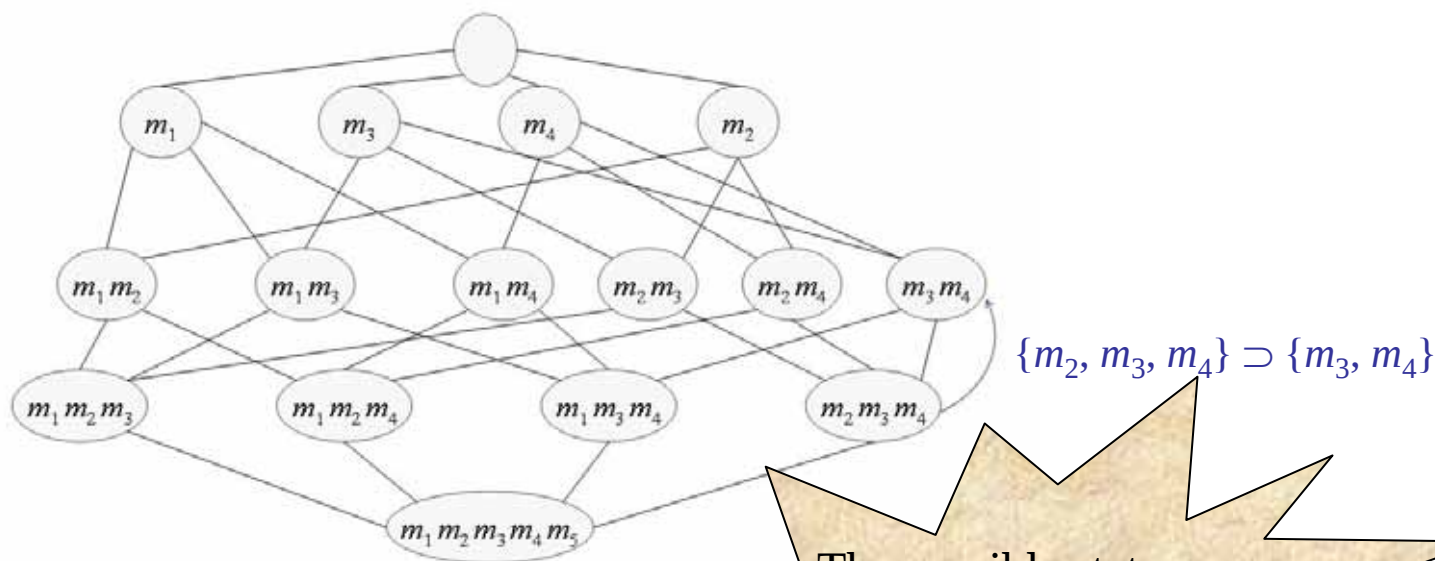
$\{ M1 M2 M4 \}$

$\{ M1 M3 M4 \}$

$\{ M2 M3 M4 \}$

tier 4

$\{ M1 M2 M3 M4 M5 \}$



16 states in 5 tiers

The possible states
ordered
bottom-to-top
by set containment

How the NLOS-C mobility states compare for capability.



Data Development Process:

Determine Appropriate Tasks



<u>Battlefield Operating System</u>	<u>Sub-Class</u>
INTELLIGENCE	Manned Ground System
	Unmanned Ground System
	Manned Air System
	Unmanned Air System
MANEUVER	Direct Fire
	Infantry Fighting Vehicle/Armored Personnel Carrier
	Air Attack
FIRE SUPPORT	Indirect Fire
	Unmanned Ground System
AIR DEFENSE	
MOBILITY/COUNTERMOBILITY/SURVIVABILITY	Manned Ground System
COMBAT SERVICE SUPPORT (CSS)	Fuel Truck
	Ammo Truck
	Air Utility
	Medical/Evacuation
	Personnel Carrier
COMMAND AND CONTROL (C2)	

Chapter 1 ART 1.0: The Intelligence Battlefield Operating System

ART 1.3.3 CONDUCT TACTICAL RECONNAISSANCE

ART 1.3.3.1 CONDUCT A ZONE RECONNAISSANCE

ART 1.3.3.2 CONDUCT AN AREA RECONNAISSANCE

ART 1.3.3.3 CONDUCT A

ART 1.3.3.4 CONDUCT

ART 1.3.3.5 CONDUCT PATROL

ART 1.3.4 CONDUCT SURVEILLANCE

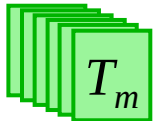
This is a new frontier for the V/L M&S community!

Requires (approval or) buy-in from the user community.



Data Development Process: Platform Tasks to Capability Matrix*



	 TASKS Current tasks determine which states are adequate.	Min Performing Task	MOBILITY (ART 2.2)					
			m0	m1	m2	m3	m4	m5
02:00-03:40, 03:51-04:17	ART 2.2 *LSI A1.2 Conduct Tactical Maneuver ART 2.2	126	m0	m1	m2	m3	m4	m5
		0.25	(m1 + m2)					
03:41-03:51, 04:20-10:00	ART 2.5 LSI A1.5.2 Occupy an Attack/Assault Position ART 2.5.2	350	m0	m1	m2	m3	m4	m5
		0.68						
03:41-03:51, 04:15-04:25	ART 3.3 *ART 3.3.1.1 Conduct Surface to Surface Attack	20						
		0.04						
03:47-03:52, 04:22-04:27, 04:38-04:43	ART 3.3 MTP 06-5-A008 Conduct Fire Missions	15						
		0.03						

Total minutes working tasks for NLOS-C in vignette =

511

* MMF Demonstration

93% of the NLOS-C mission required some mobility.

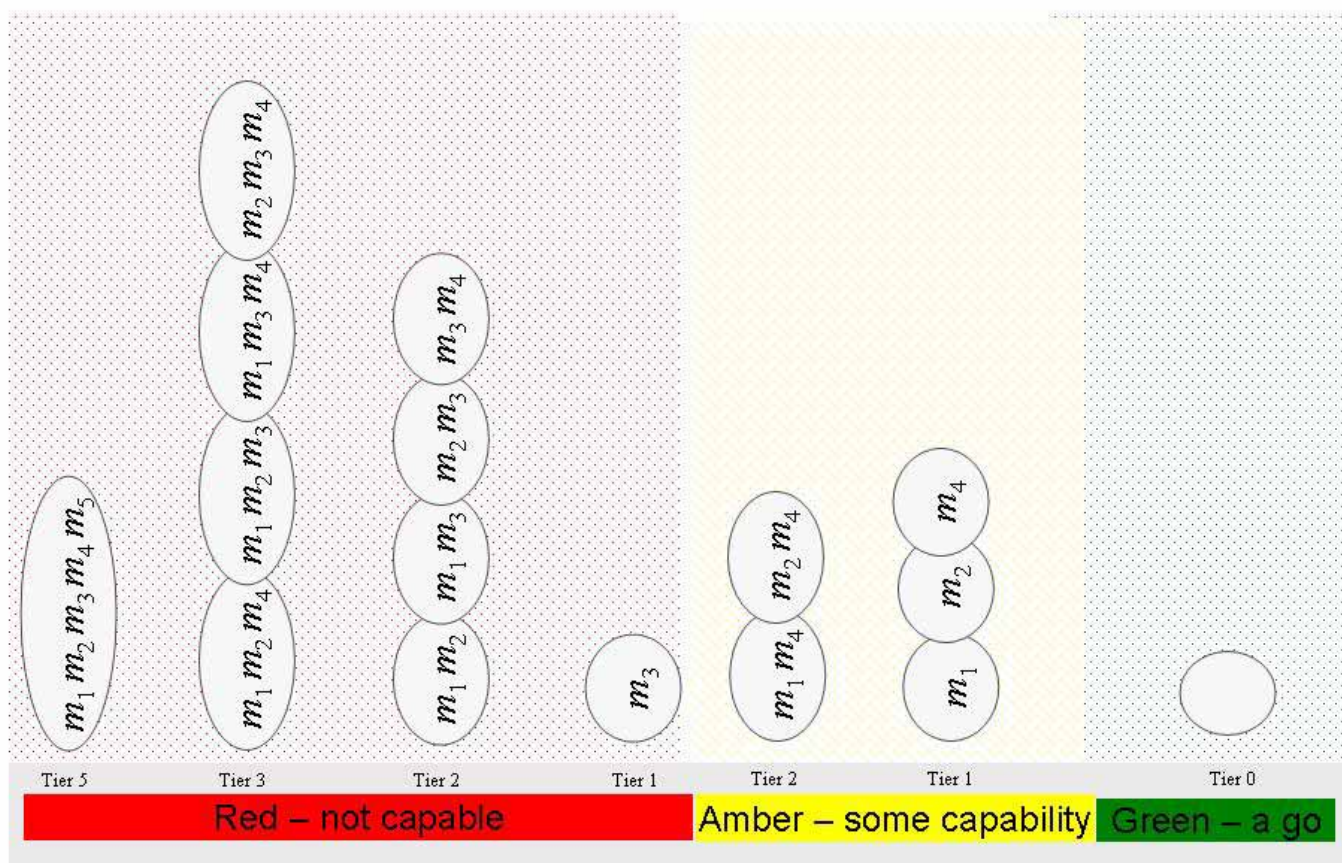


Data Development Process:

Bin poset for Each Task



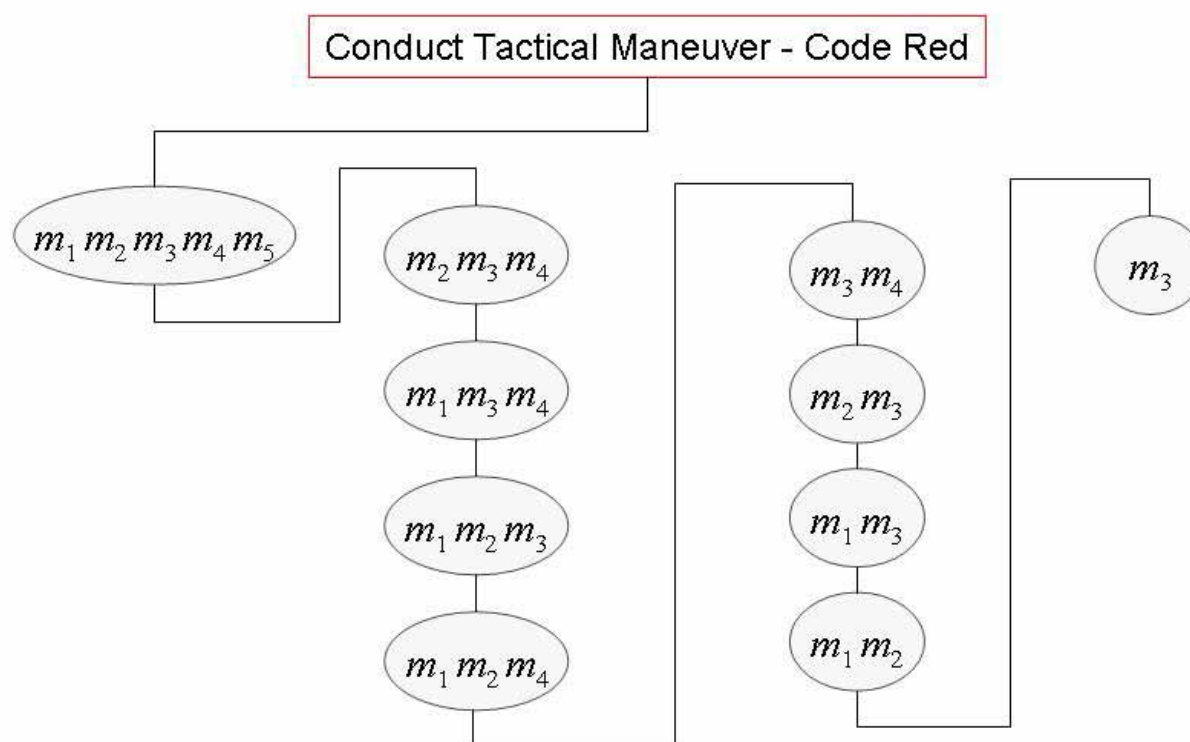
For task ART 2.2 LSI A1.2 Conduct Tactical Maneuver *.



* MMF Demonstration



Data Development Process: *Task-based Fault Tree Development*





Data Development Process: Calculate Probability of Degradation



TASK	Threat A		
	R	A	G
ART 2.2 Conduct Tactical Maneuver	.11	.15	.74
ART 2.5.2 Occupy Attack/Assault Position	.13	.14	.73
ART 3.3.1.1 Conduct Surface to Surface Attack	.21	.15	.64
MTP 06-5-A008 Conduct Fire Missions	.21	.15	.64
Mission Health Average	.17	.15	.68

Ballistic vulnerability
as it relates to
mission tasks.

Ballistic vulnerability
as it relates to
platform capability.

Capability	Threat A		
	R	A	G
Mobility	.20	.08	.72
Communications	.01	.04	.95
Crew	.00	.03	.97
Catastrophic	.04	N/A	N/A



Data Development Status



- **Battlefield Operating Systems (BOS) have been mapped to platform subclasses, individual platforms in those classes, and associated tasks; database of this information is under development.**
- **ARL will be visiting Combined Arms Command (CAC) and the Futures Center to foster collaboration (BOS and AUTL/UJTL to platform assignment).**
- **There are plans to collaborate with TRADOC schools.**
- **ARL is developing MMF data for select Current Force systems.**
- **Several related M&S tools are under development to improve input development and results analysis.**

The T&E community can leverage from these activities.



Implications



- **AUTL used for MMF can be used to support Operational Testing, i.e., what the system is supposed to do.**
- **Information from Developmental Testing can be incorporated into V/L modeling and validate Degraded Capability States.**
- **The same V/L modeling can be used to provide pre-shot predictions and support post-shot analysis during LFT&E.**
- **Low level tasks derived from an authoritative source such as the AUTL could be incorporated into Force-Level scenario development.**
- **The V/L data that supports the Force-level modeling could also be based on the same AUTL.**

System evaluation would have an auditable trail while reducing inconsistency and risk.