US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Modeling and Simulation for Mission-Based Test and Evaluation (MBT&E)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Purpose

The purpose of this presentation is to provide background on MBT&E, supporting tools, and modeling and simulation (M&S) applications.

Bottom line up front: M&S used in testing need to expand the linkages between materiel attributes and operational capabilities for MBT&E.

Outline

- Why and what is MBT&E?
- Approaches to organizing an effective M&S program for MBT&E
- M&S issues
- What are we doing to solve the issues?
- Summary
- Points of contact

Why was MBT&E developed?

- Drive operational mission context into all test and evaluation (T&E).
- Develop a T&E methodology that fully addresses recent acquisition initiatives.
- Provide "feedback" directly to the joint capabilities integration and development system (JCIDS) in terms of the war fighter's mission.
- Enable robust and systematic system-of-systems T&E.

Director, Operational Test and Evaluation – *"The evaluation of operational effectiveness [and system performance] is linked to* ***mission accomplishment****."*[1]

1. Memorandum, OSD DOT&E, subject: Reporting of Operational Test and Evaluation Results, 6 Jan 10.

What is MBT&E?

Mission-Based Test and Evaluation

is a methodology that focuses T&E on the **capabilities** provided to the warfighter. It provides a ***framework*** and ***procedure*** to:

- **link materiel system attributes to the operational capabilities;**
- **examine the SoS required** to enable the operational capability; and
- examine synergistic use of all **available data sources.**

Courtesy of Chris Wilcox, Army Evaluation Center, ATEC

Approaches to organize an effective M&S program

- Tools for test and evaluation planning
  - The test and evaluation support tool and example repository (TESTER)
  - Model-based systems engineering with Vitech CORE
- Models and simulations to augment costs of testing
  - OneSAF (semi-automated forces)
  - Infantry Warrior Simulation (IWARS)
  - Combined Arms Analysis Tool for the 21st Century (COMBAT XXI)
  - System of Systems Survivability Simulation (S4)
  - CORE

Critical to an effective M&S program is to understand model purpose, requirements, timelines, and limitations.

TESTER: Online MBT&E

Users
- Army Evaluation Center (AEC) Evaluators
- AEC System Team (AST) Members
  - Operational Test Command (OTC)
  - Developmental Test Command (DTC)
  - Analysts
  - Modeling & Simulation Representatives
- Other Stakeholders
  - Program Manager
  - Training & Doctrine Command (TRADOC)
  - Test Centers

Access System via CAC Login

List of Current Systems is provided by an Army Online Database

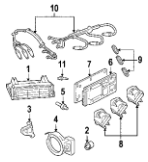
TESTER Process and Functions

Collect Source Documentation

Identify Issues & Standards
- Key Performance Parameters
- Key System Attributes
- Critical Operational Issues
- Etc.

Define Missions & Tasks

Identify Components & Functions



- Fire
- Protect
- Maneuver
- Sense
- Etc.

Link Components & Functions to Missions & Tasks

Develop Measures

Capture Design of Experiments

Factor	Factor Level	Data Source	P/S	Control Technique
Terrain	Flat	LUT	P	Held Constant
	Rolling	OneSAF	P	Tactically Varied
Light Level	Full Sun	LUT	P	Uncontrolled
		OneSAF	S	Held Constant
	Night	LUT	P	Held Constant
Weather	Rain	OneSAF	P	Systematically Varied
	Dust	OneSAF	P	Random Assignment

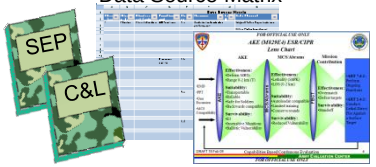
Identify Data Requirements

What data will need to be collected from test to answer measures.

Identify Data Sources

Develop Reports

Data Source Matrix



Reports can be generated to:
- Enable System Evaluations
- Assist in Test Planning
- Facilitate Design of Experiments planning and execution
- Ensure all needed data is collected for system evaluation

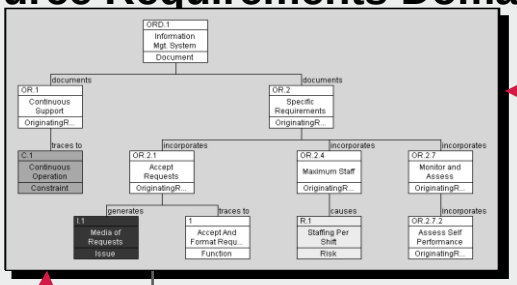
TESTER will streamline MBT&E System Evaluations and facilitate collaboration among distributed System Teams and other stakeholders.

Army Proven
Battle Ready

Courtesy of Jamie Pilar, Army Evaluation Center, ATEC

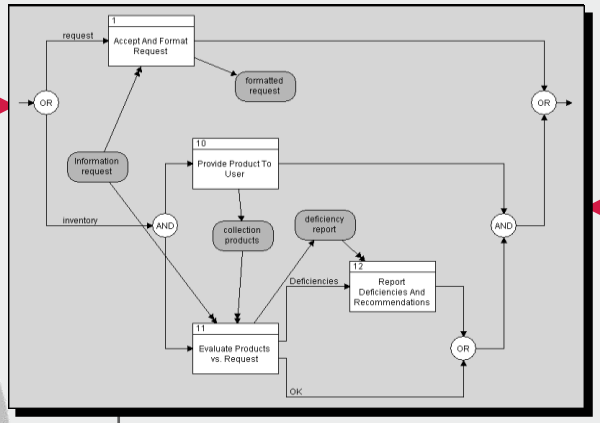
Systems Engineering with CORE

Source Requirements Domain



Originating requirements trace to behavior

Behavior Domain



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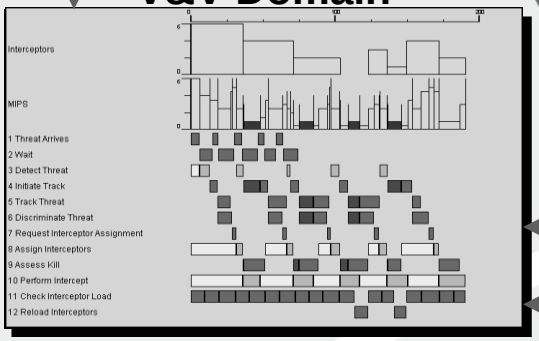
The CORE System Engineering Repository

Behavior is allocated to physical components

V&V Domain



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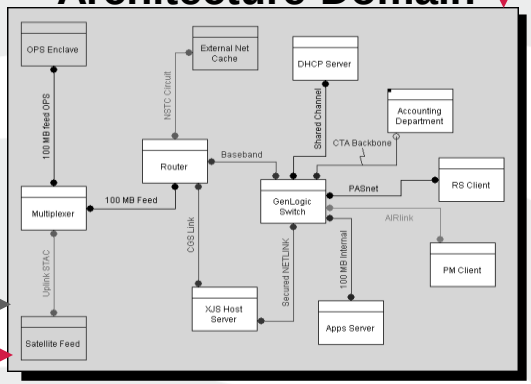
Architecture Domain



Originating requirements trace to physical components

Utilizing a layered approach to progressively clarify and elaborate all four domains concurrently ensures consistency and completeness.

M&S issues

The MBT&E strategy presents several issues in the application of modeling and simulation (M&S) to augment testing limitations and associated costs:

- The vulnerability/lethality (V/L) data and usage of that data in traditional M&S does not meet the requirements for MBT&E.
  - Historically, V/L data were generated by multiplying an *average* combat utility value to a loss-of-function (LoF) probability (i.e., how well the system can perform its mobility [M] or firepower [F] functions).
  - In Army M&S, the LoF values are then applied to all possible combat scenarios*.
- MBT&E aligns system **components** and **functions** to a specified tactical mission at a higher resolution than M/F LoF.
  - The approach then evaluates **system capability** requirements of a mission in addition to technical performance parameters.
- **M&S used in testing need to expand the linkages between materiel attributes and operational capabilities.**

* Deitz, Paul H., and Starks, Michael W., "The Generation, Use, and Misuse of "PKs" in Vulnerability/Lethality Analyses", U.S. Army Research Laboratory, APG, MD., ARL-TR-1640, MAR 1998.

MBT&E metrics example: materiel system attributes

System Capabilities Assessment Process (SCAP) Functional Skeletons		
Category	System Capability	SC bin
Move		
	Travel on primary roads	
		can go max speed
		primary up to 50 mph
		primary up to 30 mph
		primary up to 10 mph
		no-go
	Travel off roads	
		can go max speed
		primary up to 50 mph
		primary up to 30 mph
		primary up to 10 mph
		no-go
	Travel cross-country	
		up to 28 mph
		up to 18 mph
		up to 5 mph
	Emplace	
	Pivot steer	
		360° / 10 sec
		no-go
	Start engine	
		fully capable
		no-go
Shoot		
	Fire standard munition	
		4 rounds / min
		1 round / min
		NOT Possible
	Fire self-defense gun	
		Fully Capable
		no-go
	Aim main gun - direct fires	
		automatic lay
		manual lay
		no-go
	Aim main gun - indirect fires	
		automatic lay
		manual lay
		no-go

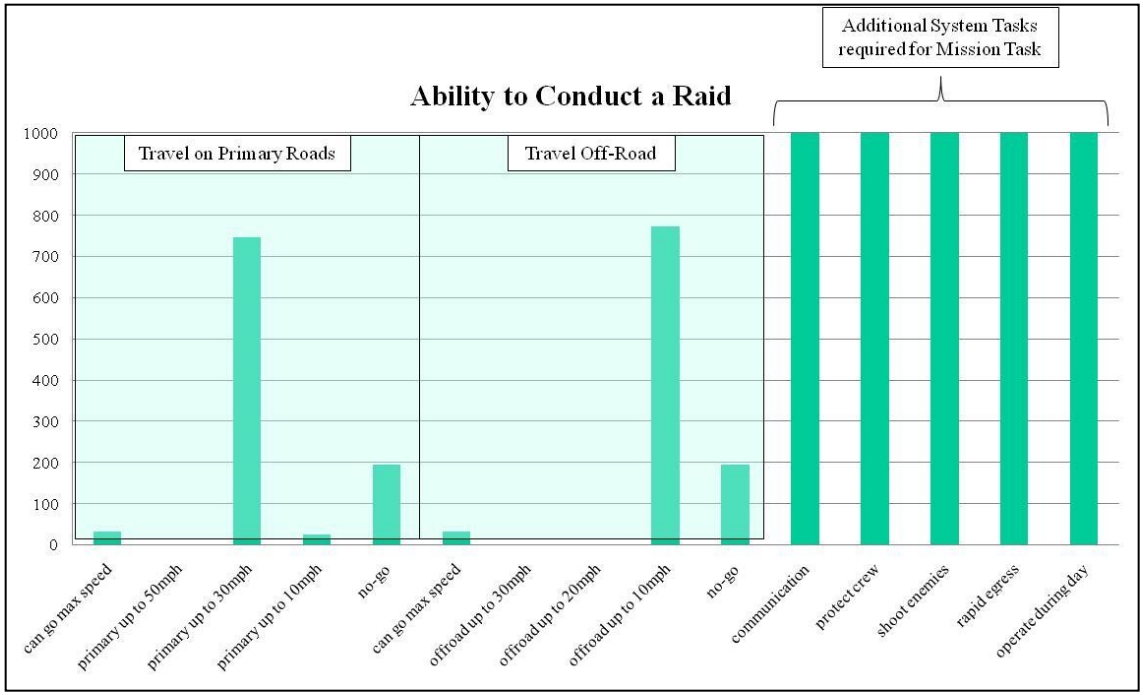
Survive		
	Protect Crew	
		protect crew from ballistic
		protect crew from CBRNE
		protect crew from rollover
	Prevent catastrophic loss	
		protect all energetic
		protect Munitions
		protect Propellant
		protect Fuel
		no-go
	Protect from NBC	
	Control fires (AFES)	
		fully capable
		no-go
	Protect from gun backblast / byproducts	
	Maintain internal enviromental conditions	
	Rapid egress	
		open all access
		bin 2
		no-go
	Prevent visible detection	
	Prevent thermal detection	
	Prevent signals detection	
Observe		
	Operate during day	
		fully capable
		no-go
	Operate during night	
		fully capable
		no-go
	Operate obscured	
		Define bins with TRADOC
	Identify location	
		GPS
		vehicle motion
		no-go
	Provide navigation	
	IFF	

Communicate		
	Communicate short range	
		Fully capable
		data only
		analog/voice
		no-go
	Communicate long range	
	SATCOM	all crew
	Communicate intra-system	
		fully capable
	Communicate inter-system	
	Communicate to dismount	
Unique attribute		
	Ammunition reload	
	Haul vehicle	
	Provide power from slaved vehicle	

MBT&E metrics example: materiel system attributes

ARL has developed the task-system capability matrix and functional skeletons for the High Mobility Multi Wheeled Vehicle (HMMWV) and the Joint Light Tactical Vehicle (JLTV).

The challenge is to determine how Army M&S can use these new metrics to benefit the evaluator.



Model resolution and metrics

	Use/Study	Resolution	Study Timeline*	Considerations
AWARS	Analysis of Alternatives (AoA)	Division and Brigade: Entity Level	Outside MBT&E requirement	Aggregate metrics built from high resolution data
OneSAF	AoA, Training, T&E	Brigade and Below: Item Level	Years	Formal process for requirements outside ATEC control but used in OT
IWARS/ COMBAT XXI/ S4	AoA, SoSA, Many on many	Brigade and Below: Item Level	Months	AMSAA M&S cell and studies could be leveraged
Ground Wars	AoA Few on few	Platoon: Item Level	Weeks	Earlier efforts can be leveraged to provide limited capability
RTCA	Operational Assessment	Platoon: Item Level	Months	New metrics in M&S at ATEC
CORE	Engineering and Requirements	Platform: Item Level	Weeks	System characterization repository linked to requirements

- **MBT&E metrics must replace loss-of-function data**
- **Decision tables must be developed to 'act' on system attributes (remaining capability)**

* Timeline includes model development, data generation and analysis

What are we doing to solve the issues?

- SLAD is collaborating with AMSAA , ATEC and TRADOC to develop an M&S methodology for MBT&E.
- Significant actions

  1) **Establish a Language and Definition Working Group**. Purpose is to develop a lexicon for the terms/definitions used. An additional purpose would be to develop and coordinate a common framework that will support TRADOC, AMSAA, ARL and ATEC.

  2) **Develop a category/attribute template**.
  Can be done in conjunction with the language and definition working group. Purpose is to develop a universal set of attributes (and attribute levels) that sets the stage for rational of desired capabilities.

  3) **Establish a Scenario Utility Working Group**.
  Purpose is to: (a) learn what TRADOC does and how they do it when they develop scenarios; and (b) provide feedback from RD and T&E communities as to what we are looking for and how TRADOC's scenarios can support what we need.

  SLAD, in collaboration with AMSAA, will propose how MBTE metrics could be used by TRADOC models.

What are we doing to solve the issues?

SLAD met with AMSAA SMEs to discuss ideas to develop a M&S test bed for MBT&E.

One approach to a M&S development could begin with a small unit simulation for high resolution data then incrementally progress to a larger simulation for lower resolution data (i.e., aggregated MBT&E metrics).

The expected results from the experimentation would include

- methods to input MBT&E metrics,
- algorithms for data usage,
- method to aggregate MBT&E metrics for higher level M&S,
- analysis techniques, and
- recommended practices.

Considerations

- MBT&E encompasses more than LFT in support of Army acquisition.
- ATEC must render evaluations based upon system use to accomplish combat missions (Joint context)
- Technical leadership is looking for higher resolution modeling to support evaluations with goals to include
  - improve understanding of data metrics
  - incorporate consistent data development methods and usage across varying resolutions

Desired end-state is a level of consistency in the metrics for Army acquisition.

Summary

- Critical to an effective M&S program is to understand model purpose, requirements, timelines, and limitations.
- The MBT&E strategy presents several challenges in the application of M&S, test planning/execution, and the analysis of data for system evaluation.
- AEC development of TESTER will streamline MBT&E system evaluations and facilitate collaboration among distributed System Teams and other stakeholders.
- M&S used in testing need to expand the linkages between materiel attributes and operational capabilities for MBT&E.
- SLAD is collaborating with multiple agencies to help develop the methodology to make those linkages possible in M&S.

Points of contact

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