

U.S. Army Evaluation Center



ATEC



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# MANPRINT for MBT&E

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# Outline

- T&E Policy Revisions
- Mission Based Test & Evaluation
- MANPRINT for MBT&E
- Future Work
- Why MANPRINT for MBT&E?



# T&E Policy Revisions

## OSD T&E Policy Revision Memo, 2007

- Measure improvements to mission capability and operational support based on user needs
- Evaluate in the mission context and expressed in terms of the operational significance of test results
- Understand the strengths and weaknesses of a system and its components and the effect on operational capabilities and limitations
- Compare against current mission capabilities

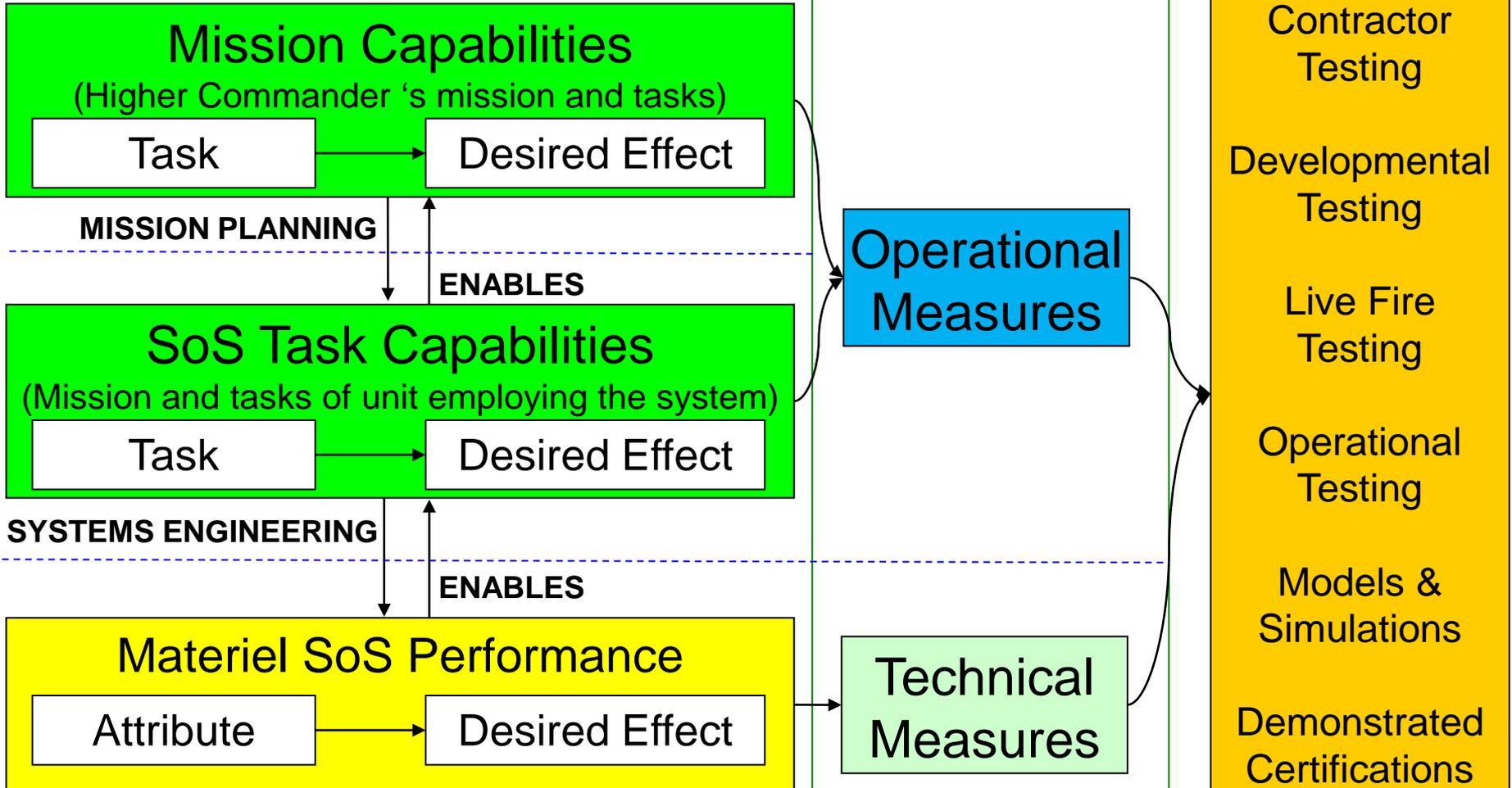
"...to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price." (DoD Directive 5000.1)

# MBT&E Framework

## MISSION AND SYSTEM

## EVALUATED BY

## TESTED BY





## MANPRINT for MBT&E

A methodology that focuses T&E on the evaluation of the Warfighter as a system-of-systems. It leverages the existing MBT&E framework by providing a procedure to:

- develop evaluation measures to **assess Warfighter performance as a function of operational capabilities and system attributes**

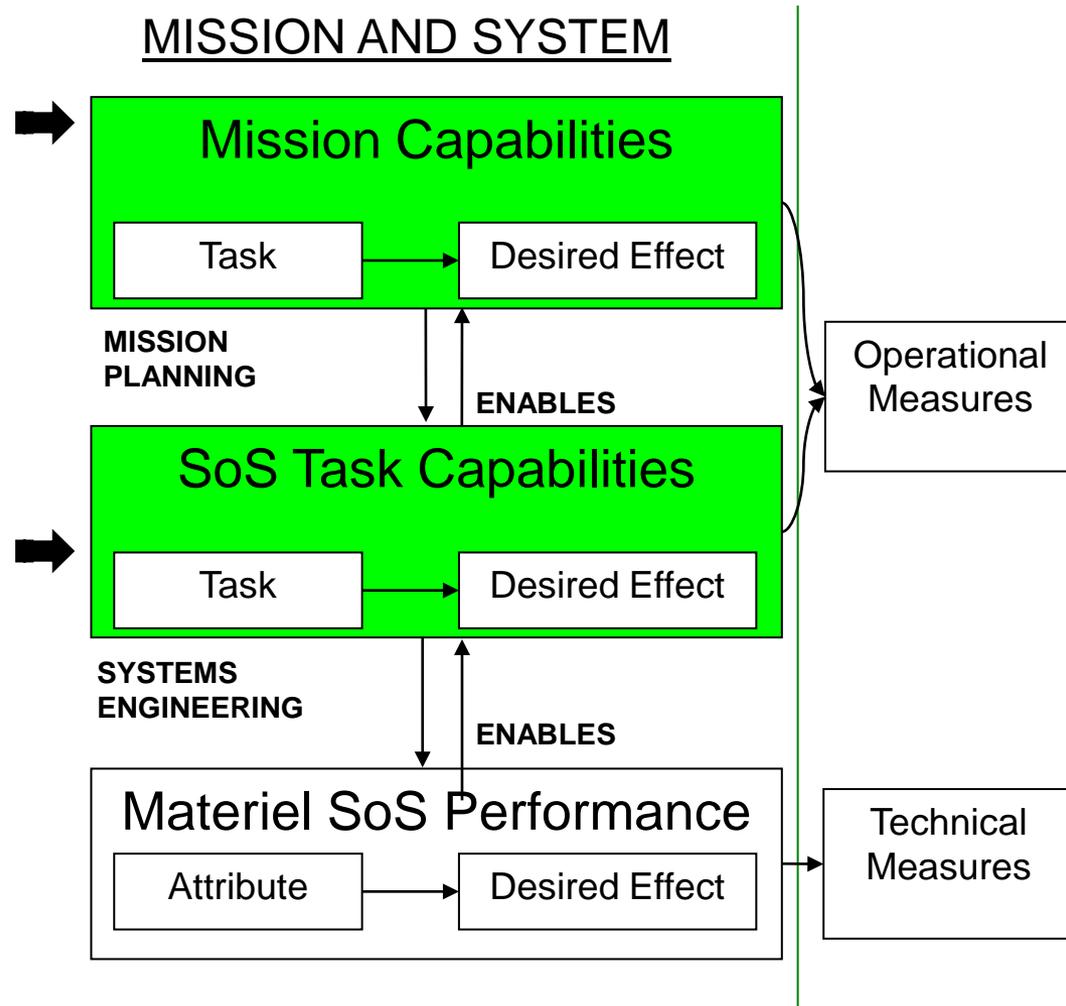
# Primary Steps in MANPRINT for MBT&E

## Understand the Human as a System

- Roles & responsibilities within a systems architecture
- Information requirements to complete missions
- Training requirements
- Overload indicators
- Performance attributes

## Understand the Effect of Human-System Interactions on Human Cognitive Performance

- Situational Awareness
- Speed of Decision Making
- Workload



# MANPRINT for MBT&E Framework Example – Unmanned Aerial System

Adapted from Apicella, Wyant, & Wilcox 2009

## Mission / Tasks

### Attack, Raid, Defend, Security

### Perform Intelligence, Surveillance, and Reconnaissance (ART 2.3)

#### Conduct Reconnaissance (ART 2.3.3)

#### Support to Situational Understanding (ART 2.2)

#### Conduct Tactical Maneuver (ART 1.2)

System		System Functions	Arrive in Area of Operations (AO)	Detect and Locate Surface Targets (ART 3.2)	Intel Support to Targeting (ART 2.4.1)	Evaluate the Threat (ART 2.2.1.3)	Determine Threat Courses of Action (ART 2.2.1.4)	Conduct an Area Reconnaissance (ART 2.3.3.3)	Navigate from One Point to Another (ART 1.2.10)	
System of Systems	UAS	Airframe	Navigate to AO	1. Time to Arrival in AO 2. Navigation Accuracy 3. Control Latency						
			Execute search pattern	Time on Station					Time to Complete Maneuver	
		Communication Equipment	Send/receive video			% Video Sent/Received				
			Send/receive image(s)			% Image(s) Sent/Received				
		Sensor	Detect target		1. % Targets Detected 2. Detection Range		1. Frame Refresh Rate 2. Screen Resolution			
			Locate target		Location Accuracy					
	Identify target				% Targets Identified					
	Operator / Maintainer	Control	Prepare UAS for takeoff	Time to Prepare System for Operation		Altitude Accuracy			Time to Complete Maneuver	
			Input / update way points	1. Time to Input Waypoints 2. Waypoint Accuracy				1. Response Time to Change/Adjust Existing Route 2. Response Accuracy		
			Monitor UAS vital signs (oil/gas/altitude/pitch/yaw)					1. Response Time to System Warning Indicator(s) 2. Response Accuracy 3. Information Usability (readable, interpretable, visible)		
			Monitor METT-TC factors					1. Altitude Accuracy 2. Day/Night Payload Accuracy		
			Trouble shoot UAS warning indicators					Response Accuracy		
			Track Target						1. Time to Complete Maneuver 2. Ability to Provide Constant Location of Moving Target 3. Time to Decide to Track Target 4. Ability to Crossque Other ISR Assets	
			Prepare UAS for landing	1. Time to Input Waypoints 2. Waypoint Accuracy						
		Establish/maintain local SA	Monitor command net (comms)				1. Timeliness to Provide Situation Report (SITREP) 2. SITREP Accuracy 3. SITREP Completeness 4. Timeliness of Answering CCIR/PIR	1. Mental Workload Availability to Respond/Perform to Add'l Tasking 2. Threat Behavior Accuracy (SITREP)		Mental Workload Availability to Control the System and Adjust/Correct Maneuvers Based on Add'l Tasking/Requirements
				Evaluate battlespace factors	Monitor UAS video feed					Sensor-feed Usability (readable, interpretable)
		Collect info/intel	Manipulate operator control unit (camera operation - pan/tilt/zoom)		1. Ease-of-use of OCU 2. Knowledge of Physical Location of UAS Relative to Physical Environment					
		Process info/intel	Detect target	Locate target		1. % Targets Detected 2. Detection Range				
				Identify target		Location Accuracy		% Targets Identified		
				Decide to share info/intel based on CCIR				1. Timeliness to update individual SA 2. SA Accuracy 3. SA Completeness 4. Timeliness of Answering CCIR/PIR	Timeliness of Answering CCIR/PIR	1. Timeliness to update SA 2. SA Accuracy 3. SA Completeness
Disseminate info/intel		Send/Receive info		Availability of Network to Send						

# MANPRINT for MBT&E Framework Example – Unmanned Aerial System

## Identify Human System Attributes through:

- Mission CONOPS
- Army Field Manuals
- Environment

MANPRINT for MBT&E Framework Example – Unmanned Aerial System		Mission / Tasks								
		Attack, Raid, Defend, Security								
		Perform Intelligence, Surveillance, and Reconnaissance (ART 2.3)								
		Conduct Reconnaissance (ART 2.3.3)				Support to Situational Understanding (ART 2.2)			Conduct Tactical Maneuver (ART 1.2)	
System Attributes		System Functions		Arrive in Area of Operations (AO)	Detect and Locate Surface Targets (ART 3.2)	Intel Support to Targeting (ART 2.4.1)	Evaluate the Threat (ART 2.2.1.3)	Determine Threat Courses of Action (ART 2.2.1.4)	Conduct an Area Reconnaissance (ART 2.3.3.3)	Navigate from One Point to Another (ART 1.2.10)
Operator / Maintainer	Control	Prepare UAS for takeoff	Time to Prepare System for Operation	Altitude Accuracy					1. Response Time to Change/Adjust Existing Route	Time to Complete Maneuver
		Input / update way points	Time to Input Waypoints						System Warning Indicator(s) 2. Gas/Oil Indicator Accuracy 3. Information Usability (readable, interpretable, visible) 4. Presence of System Vitals	
		Monitor UAS vital signs (1) gas/altitude/pitch/yaw)							1. Altitude Accuracy 2. Day/Night Payload Accuracy	
		Monitor METT-TC factors							Response Accuracy	1. Time to Complete Maneuver 2. Ability to Provide Constant Location of Moving Target 3. Time to Decide to Track Target 4. Ability to Crossquery Other ISR Assets
		Track Target								
	Establish/maintain local SA	Prepare UAS for landing	1. Time to Input Waypoints 2. Waypoint Accuracy							Mental Workload Availability to Control the System and Adjust/Correct Maneuvers Based on Add'l Tasking/Requirements
	Evaluate battlespace factors	Monitor command net (comm)								
	Collect info/intel	Monitor UAS video feed							Sensor-feed Usability (readable, interpretable)	
	Process info/intel	Manipulate operator control camera operation - pan								
		Select target								
		Locate target								
		Identify target								
		Decide to share info/intel based on CTR								
	Disseminate info/intel	Send/Receive info		Availability/Network to Send Info					1. Timeliness to update individual SA 2. SA Accuracy 3. SA Completeness 4. Timeliness of Answering CCTR/PIR	1. Timeliness to update SA 2. SA Accuracy 3. SA Completeness

**Mission:** Information, Surveillance, and Reconnaissance (ISR)  
Mission Threads for Attack, Raid, Defend, and Security

### Tasks :

1. Perform ISR (ART 2.3)
2. Conduct Reconnaissance (ART 2.3.3)
3. Support to Situational Understanding (ART 2.2)
4. Conduct Tactical Maneuver (ART 1.2)

### Human System Attributes

- Control
- Establish / Maintain Local Situational Awareness
- Evaluate Battlespace Factors
- Collect Information / Intelligence
- Process Information / Intelligence
- Disseminate Information / Intelligence

# MANPRINT for MBT&E Framework Example – Unmanned Aerial System

## Identify Human System Functions by:

- CONOPS for System Use & Employment
- Obs of Current Force Tactics, Techniques and Procedures (TTPs)
- Task Analyses
- SME interviews

		Mission / Tasks								
		Attack, Raid, Defend, Security								
		Perform Intelligence, Surveillance, and Reconnaissance (ART 2.3)								
		Conduct Reconnaissance (ART 2.3.3)			Support to Situational Understanding (ART 2.2)		Conduct Tactical Maneuver (ART 1.2)			
		Arrive in Area of Operations (AO)	Detect and Locate Surface Targets (ART 3.2)	Intel Support to Targeting (ART 2.4.1)	Evaluate the Threat (ART 2.2.1.3)	Determine Threat Courses of Action (ART 2.2.1.4)	Conduct an Area Reconnaissance (ART 2.3.3.3)	Navigate from One Point to Another (ART 1.2.10)		
System	System Functions									
Operator / Maintainer	Control	Prepare UAS for takeoff	Time to Prepare System for Operation		Altitude Accuracy			Time to Complete Maneuver		
		Input / update way points	Time to Input Waypoints				1. Response Time to Change/Adjust Existing Route			
		Monitor UAS vital signs (oil/gas/altitude/pitch/yaw)	Waypoint Accuracy				2. Response Accuracy			
		Monitor METT-TC factors					1. Response Time to System Warning Indicators			
		Trouble shoot UAS warning indicators					2. Gas/Oil Indicator Accuracy			
		Track Target					3. Information Usability (readable, interpretable, etc.)			
	Establish/maintain local SA	Prepare UAS for landing	Time to Input Waypoints				4. Presence of System Vitals			
		Monitor command net (comms)	Waypoint Accuracy				1. Altitude Accuracy		1. Time to Complete Maneuver	
		Evaluate battlespace factors					Response Accuracy		2. Ability to Provide Constant Location of Moving Target	
		Collect info/intel							3. Time to Decide to Track Target	
		Process info/intel	Detect target							4. Ability to Crosscorrelate Other ISR Assets
			Locate target							
Identify target										
Disseminate info/intel	Decide to share info/intel based on CCIR									
	Send/Receive info	Availability of Network to Send								

### Human System Functions

#### I. Control

1. Prepare UAS for Takeoff (i.e. PMCS)
2. Input / update way points
3. Monitor UAS vital signs (i.e. oil/gas/altitude/etc...)
4. Monitor METT-TC factors
5. Trouble shoot UAS flight/control warning indicators
6. Prepare UAS for landing

#### II. Establish Maintain Local SA

1. Monitor command net

#### III. Evaluate battlespace factors

1. Monitor UAS video feed

#### IV. Collect Info/Intel

1. Manipulate operator control unit (i.e. camera operations – pan/tilt/zoom)



# MANPRINT for MBT&E Framework Example – Unmanned Aerial System

			Mission / Tasks						
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Operator / Maintainer	Control	Prepare UAS for takeoff	Time to Prepare System for Operation		Altitude Accuracy				Time to Complete Maneuver
		Input / update way points	1. Time to Input Waypoints 2. Waypoint Accuracy					1. Response Time to Change/Adjust Existing Route 2. Response Accuracy	
		Monitor UAS vital signs (oil/gas/altitude/pitch/yaw)						1. Response Time to System Warning Indicator(s) 2. Response Accuracy 3. Information Usability (readable, interpretable, visible)	
		Monitor METT-TC factors						1. Altitude Accuracy 2. Day/Night Payload Accuracy	
		Trouble shoot UAS warning indicators						Response Accuracy	
		Track Target							1. Time to Complete Maneuver 2. Ability to Provide Constant Location of Moving Target 3. Time to Decide to Track Target 4. Ability to Crosscue Other ISR Assets
	Prepare UAS for landing	1. Time to Input Waypoints 2. Waypoint Accuracy							
	Establish/maintain local SA	Monitor command net (comms)			1. Timeliness to Provide Situation Report (SITREP) 2. SITREP Accuracy 3. SITREP Completeness 4. Timeliness of Answering CCIR/PIR	1. Mental Workload Availability to Respond/Perform to Add'l Tasking 2. Threat Behavior Accuracy (SITREP)			Mental Workload Availability to Control the System and Adjust/Correct Maneuvers Based on Add'l Tasking/Requirements
	Evaluate battlespace factors	Monitor UAS video feed						Sensor-feed Usability (readable, interpretable)	
	Collect info/intel	Manipulate operator control unit (camera operation - pan/tilt/zoom)		1. Ease-of-use of OCU 2. Knowledge of Physical Location of UAS Relative to Physical Environment					
Process info/intel	Detect target		1. % Targets Detected 2. Detection Range						
	Locate target		Location Accuracy						
	Identify target			% Targets Identified					
Disseminate info/intel	Decide to share info/intel based on CCIR				1. Timeliness to update individual SA 2. SA Accuracy 3. SA Completeness 4. Timeliness of Answering CCIR/PIR	Timeliness of Answering CCIR/PIR		1. Timeliness to update SA 2. SA Accuracy 3. SA Completeness	
	Send/Receive info		Availability of Network to Send Info						

## Cell Entries Determined By:

- MANPRINT Regulation (AR 602-2)
- Mission/Scenario Characteristics
- Environment / Task Condition
- Threat Condition
- Commander's Critical Information / Priority Requirements
- Threat/Adversary Characteristics
- Personnel Capabilities



# MANPRINT for MBT&E Framework Example – Unmanned Aerial System

Mission / Tasks  
 Attack, Raid, Defend, Security  
 Perform Intelligence, Surveillance, and Reconnaissance (ART 2.3)

Conduct Reconnaissance (ART 2.3.3)      Support to Situational Understanding (ART 2.2)      Conduct Tactical Maneuver (ART 1.2)

System	System Functions	Arrive in Area of Operations (AO)	Detect and Locate Surface Targets (ART 3.2)	Intel Support to Targeting (ART 2.4.1)	Evaluate the Threat (ART 2.2.1.3)	Determine Threat Courses of Action (ART 2.2.1.4)	Conduct an Area Reconnaissance (ART 2.3.3.3)	Navigate from One Point to Another (ART 1.2.10)
	Prepare UAS for takeoff	Time to Prepare System for Operation		Altitude Accuracy				Time to Complete maneuver
	Input / update way points	1. Time to Input Waypoints						Response Time to Change/Adjust Existing Route Response Accuracy
Control	Monitor UAS vital signs (oil/gas/altitude/pitch/yaw)						1. Response Time to System Warning Indicator(s) 2. Response accuracy 3. Information Usability (readable, interpretable, visible)	
	Monitor METT-TC factors							Altitude Accuracy Day/Night Payload Accuracy
	Trouble shoot UAS warning indicators							Response Accuracy
<b>Army Task - Conduct an Area Reconnaissance (ART 2.3.3.3)</b> <b>System Function – Monitor UAS vital signs (oil/gas/altitude/etc...)</b>								
<b>Measures of Performance (Cell Entries)</b>								
1. Response time to warning indicator(s) 2. Response accuracy to warning indicators 3. Degree of information usability (readable, interpretable, visible)								
Operator / Maintainer	Monitor UAS video feed							Sensor-feed Usability (readable, interpretable)
Essential/maintain	Manipulate operator control unit (camera operation - pan/tilt/zoom)		1. Ease-of-use of OCU 2. Knowledge of Physical Location of UAS Relative to Physical Environment					
Evaluate battlespace factors	Detect target		1. % Targets Detected 2. Detection Range					
	Locate target		Location Accuracy					
	Identify target			% Targets Identified				
Process info/intel	Decide to share info/intel based on CCR				1. Timeliness to update individual SA 2. SA Accuracy 3. SA Completeness 4. Timeliness of Answering CCR/PIR	Timeliness of Answering CCR/PIR		1. Timeliness to update SA 2. SA Accuracy 3. SA Completeness
Disseminate info/intel	Send/Receive info		Availability of Network to Send					



- Cell Entries Determined By:**
- MANPRINT Regulation (AR 602-2)
  - Mission/Scenario Characteristics
  - Environment / Task Condition
  - Threat Condition
  - Commander's Critical Information / Priority Requirements
  - Threat/Adversary Characteristics
  - Personnel Capabilities

# Why MANPRINT for MBT&E?

- Answers the senior decision maker "So What" question
- Considers contributing factors affecting mission outcome
- Increases the sensitivity of measures and metrics



# MANPRINT in DT/OT

- Survey Instruments

- Static
- Intermittent

I am satisfied with Widget A.

Strongly disagree  Disagree  Neither agree nor disagree  Agree  Strongly agree

- Field Test Observations & Data Collection

- Data quality dependent on data collector KSAs
- Access to operators / maintainers

- Modeling & Simulation

- Model-Test-Model
- Data granularity



# Future Work

The Human Contribution to System Performance can be expressed in terms of:

Ref: Adapted from the US Army Logistics Management College - MANPRINT Reference Book, pg 1-10, OV-19

$P_s$  is some function of  $(P_h)$ ,  $(P_e)$ , and  $(E)$

Equipment Performance is explained, in part, by  $(A_o)$ .

Could Human Performance be explained, in part, by  $(A_h)$ ?

- Human performance is determined with the assumption that the warfighter is available (**physical, cognitive, ...**) 100% of the time.
- Future efforts will consider performance when the warfighter is available **less than 100%** of the time.

- $P_s$  = System Performance
- $P_h$  = Human Performance
- $P_e$  = Equipment Performance
- $E$  = Environment
- $A_o$  = Operational Availability
- $A_h$  = **Human Availability**

... Initial meeting held with AEC, ARL and AMSAA on 11 March 2010 to define  $A_h$  and its attributes  
Results of initial meeting will be briefed to G-1 and AEC & ARL management



## Why discuss MANPRINT for MBT&E?

- Leverages current ATEC MBT&E methodology to fully addresses recent acquisition initiatives. (Example: Section 231 Report).
- Provides a means to conduct evaluations and report results about the end-to-end operational effectiveness of a system.
- Enables more robust and systemic human-in-the-loop system-of-systems T&E.

*“We will continue to examine and challenge our most basic institutional assumptions, organizational structure paradigms, policies, and procedures to better serve the Army.”*

CG, ATEC Commander’s Priorities for FY 10-15

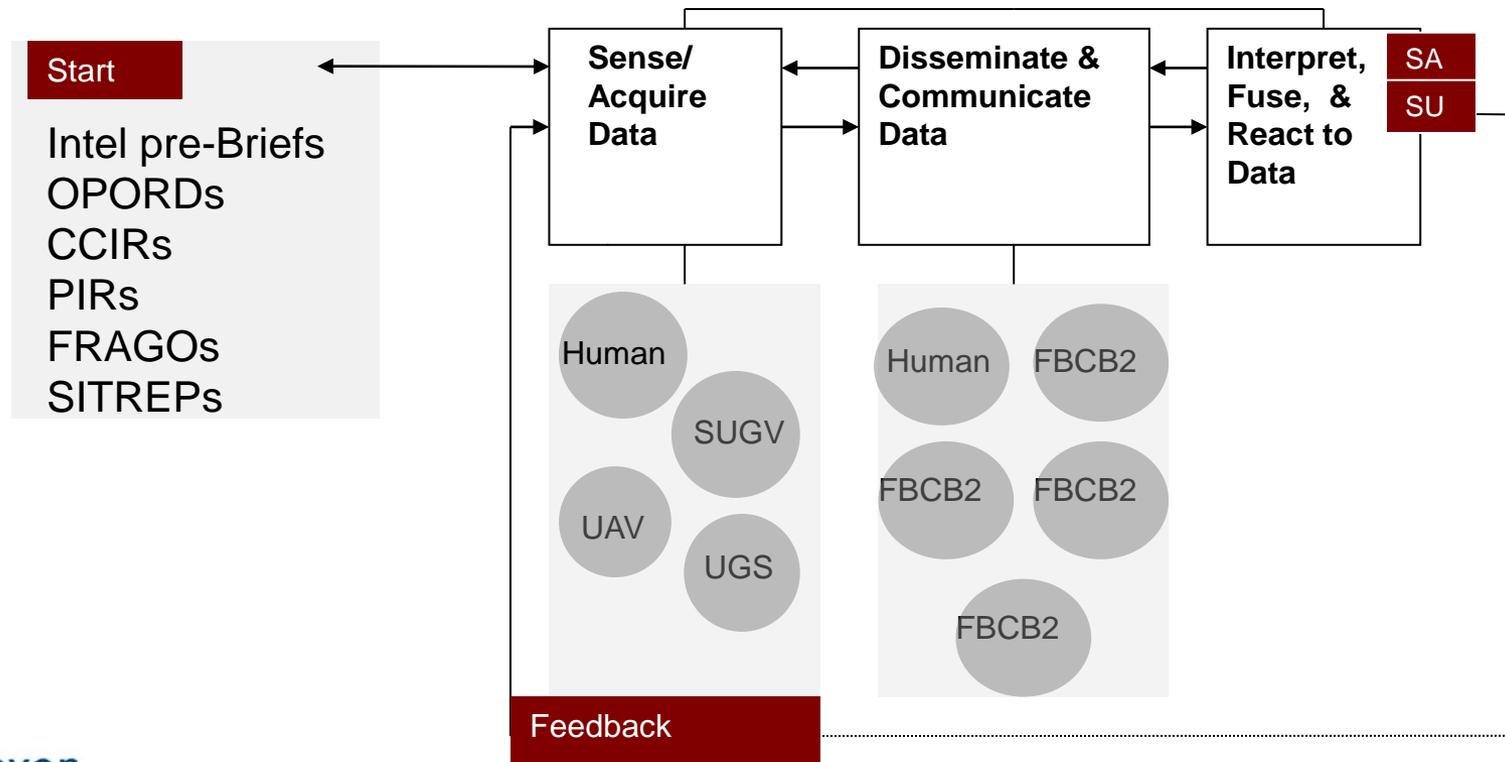


# Backup

# Understanding the Human as a System

**Situational Awareness:** Soldiers knowledge of battlespace events/activities from direct observation or indirect observation. SA is not the information on a machine. (FM-3)

**Situational Understanding:** Key leader(s) interpretation of battlefield events and ability to use information from command to make timely, accurate, and decisive decisions (FM-3)





# Operational Test Example:

## SA & SU Evaluation

BTN Commander	<b>Survey Instruments</b> <ul style="list-style-type: none"> <li>• When: End -of-Increment AAR or Structured Interview</li> <li>• What: 6-pt Likert Scale</li> <li>• Purpose: Assess overall unit mission accomplishment</li> </ul>
CO Commander	<b>FBCB2 System Data</b> <ul style="list-style-type: none"> <li>• In-bound/Out-bound SA message entity data</li> <li>• Soldier Spot Reports</li> </ul>
Platoon Leader	
Squad Leader	
NIK Operator / Maintainer	
UAS Operator / Maintainer	<b>Survey Instruments</b> <ul style="list-style-type: none"> <li>• When: End-of-Mission</li> <li>• What: Fill in the blank</li> <li>• Purpose: Assess Soldier knowledge of battlespace events (friendly / enemy)</li> <li>• Date Elements: <ul style="list-style-type: none"> <li>-Size                      -Activity</li> <li>-Location                -Equipment</li> <li>-HVT details</li> </ul> </li> </ul>
SUGV Operator - Maintainer	
UGS Operator - Maintainer	
OPFOR	

### Data Sources to Support SA / SU Analyses

- Operation Orders (OPRDs)
- Fragmentary Orders (FRAGOs)
- Commander's Critical Information Requirements (CCIRs)
- Priority Information Requirements (PIRs)
- Mission / Scenario Descriptions

### Time Stamped Network Data from C2 System

- OPFOR Entity and Position Reports
- Blue Entity and Position Reports
- Sensor Entity Reports
- Soldier generated messages - SITREP and Spot Reports (e.g. Free Text)



# Operational Test Example: SA & SU MOEs & MOPs

**MOE:** The ability of System X to achieve SA/SU

**MOP:** SA Accuracy – The percent of correct knowledge about key mission threads, threat, and additional battlespace factors.

1. Size of threat(s)
2. Activity of threat
3. Location for threat
4. Uniform of threat
5. Time of observation
5. Equipment or obstacle type

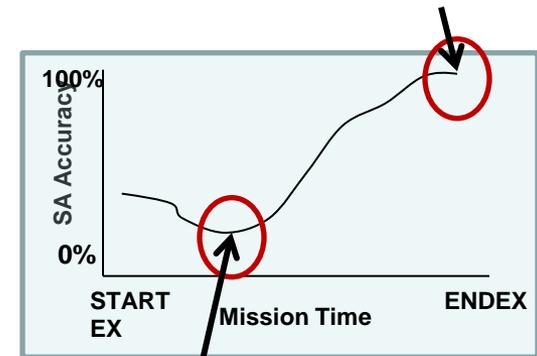
**SA Accuracy Formula:**

$$\text{SA Accuracy} = \frac{\text{Reported IBCT SA (S, A, L, U, T, E)}}{\text{Ground Truth}}$$

## Sample Results

**Graph of SA (location):**  
awareness of threat movements during Mission 1

Knowledge of where the threat was located was excellent

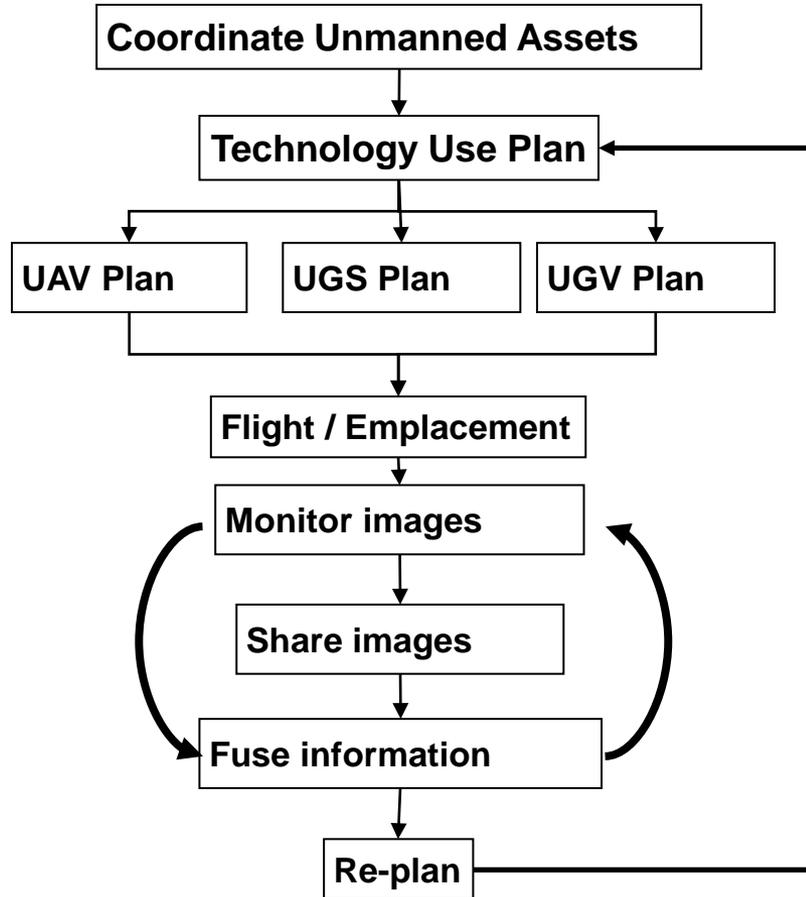


Knowledge of where the threat was located was low

**Explanation:** Unit knowledge about threat location initially degraded due to mission complexity, network lag, and/or comms; but significantly improved as the mission continued. This improvement could largely be due to the Unit's ability to use the systems to collect, process, and disseminate information quickly and accurately with minimal cost to cognitive workload.

# Understand the effect of HSI on Human Cognitive Performance

## High Level Task Analysis



## Data Collection from Net

