

Systems Evaluation of Unmanned Aircraft Systems



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Agenda

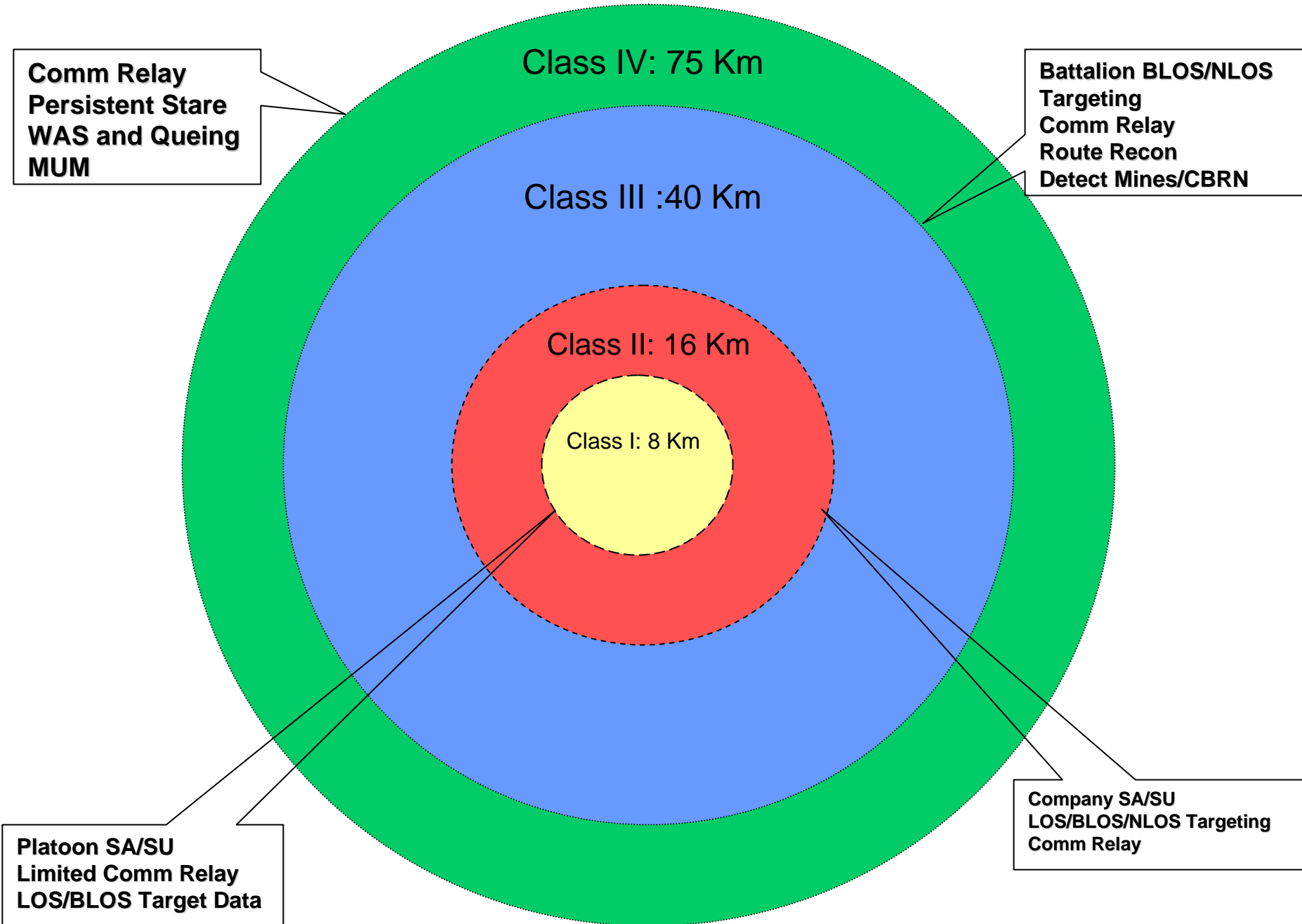
- Overview of Current UAS missions
- Case study: Small UAS Evaluation
 - OPEVAL
 - OT
 - Lessons Learned
 - Doctrine Changes

URGENT!

UASs are needed in the Battle Field Missions

- Need in OEF/OIF to perform Recon Surveil. Target Acq. Missions at platoon level: RAVEN, DRAGON FLY
 - Look for insurgent activity and provide target info to fire support
 - Use in PSY OPS
- Retrofit with BAT munitions and use to deliver lethal and accurate force: HUNTER VIPER STRIKE
- Use as persistent stare asset, for wide area surveillance at high altitudes and target acquisition, company level –WARRIOR A, GLOBAL HAWK, REAPER
- Use as signal relay platforms for connecting to GIG –ERMP, SHADOW, ER/MP, FCS Class IV (FIRE SCOUT)
- Man Un Manned (MUM) Teaming to use as a forward asset to provide target information to AH-64 – ERMP, HUNTER
- EOD and surveillance: use ahead of convoys for looking at road details up close, platoon level – g-MAV, FCS CLASS I UAS

ARMY UAS PROGRAMS



Overall Evaluation Approach: Start with ...how is the USER employing the UAS?

- Concept of Operations
- Operation and Organization
- Operational Mode Summary/Mission Profile
- Capability Development Document (Requirements)
- Critical Operational Issues (and Criteria)
- Development of MOEs/MOPs/MOSs
- Design of OT to include END TO END mission accomplishment

Case Study: RAVEN UMR and Small UAS POR In Support of Combat Missions





Purpose

- Discuss Means to Assess Capabilities and Limitations on Raven UAS Shipped for Rapid Deployment to Operations Enduring Freedom/Iraqi Freedom (OEF/OIF)
- Assess Enhancements in Close Combat Missions Using Small Unmanned Aircraft Systems (SUAS)

Data Sources

- RAVEN: Responses from Commanders and Raven operators in OEF/OIF
- SUAS: Production Qualification Testing, Airborne Testing and Initial Operational Testing

SUAS Test and Evaluation

- Evaluate SUAS Effectiveness, Suitability and Survivability
- Analyze Changes in Army Doctrine Relevant to Using the SUAS

Raven UAS Description

Small all-electric UAS

- Endurance ~ 60 minutes (90 minutes total)
- Range (radio line of sight) ~ 10 Km
- Airspeed ~ 40 knots cruise – 52 knots maximum
- Provides real-time daylight color video or IR and coordinate information and position of AV
- Fully autonomous waypoint navigation, automatic altitude and heading reporting



Raven Capabilities/Limitations

Enhances Situational Awareness

- Reconnaissance

- Convoy escort – Recognize vehicles, or detect personnel activity next to a road
- Point and route reconnaissance, cover sectors of urban areas while patrols go house to house

- Surveillance

- Cordon and search operations – loiter over building(s) of interest
- Perimeter defense – detect and get closer look at vehicles

- Target Acquisition

- Use Raven coordinates to narrow target location and ID



Raven Capabilities/Limitations

- **Operators Report Raven is Simple to Assemble, Program, Launch and Recover**
 - AV parts press in place without tools – ready in 5 minutes
 - Navigation Waypoints Programmed using MGRS
 - No Need for a Runway – Small Operations/Logistics Footprint
 - Damage to the Air Vehicle Occurs Mainly During Launch and Recovery
- **Challenges in Airspace Coordination and Frequency De-confliction**
 - Extensive Planning and Mission Requests on Par with Manned Aircraft Missions
- **Susceptibility to Visual and Audible Detection**
 - Ravens are Difficult to See and Avoid Due to Small Size – Mix with Manned Aircraft
 - Less Noise than larger UASs

SUAS System Description

System Description

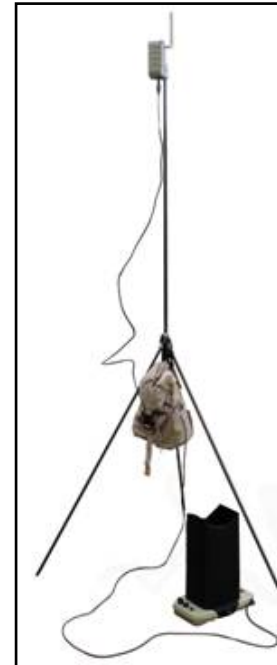
- Modified Raven - Improved Visible Daylight Side View Camera and IR + Laser Pointer
- Ground Control Station and Remote Video Terminal are Interchangeable
- Raven Air Vehicle Remains Unchanged
- Center Field of View Coordinates to Target



Hand-held Video/Controller



Air Vehicle (three each)



Ground Control Station



Remote Video Terminal

SUAS Test and Evaluation

- **SUAS is the Army Acquisition Program of record and Fielding of the Upgraded Raven**
- **Test and Evaluation Strategy**
 - **Effectiveness**
 - Answer Critical Operational Issue (COI) *“Does the SUAS Enhance the Combat Effectiveness of a Small Unit?”*
 - Leads to Comparative Analysis of Close Combat Missions with and Without the SUAS
 - Force on Force Test Examines Use of the SUAS During Attacks, Raids, Convoy Escort, and Observation of Known Areas of Interest
 - Evaluates Technical Requirements the System Must Meet (Range to Target, Interoperability, and Capability to Detect/Recognize Vehicles and Personnel)
 - Data Obtained from Initial Operational Test (IOT)

SUAS Test and Evaluation

- **Test and Evaluation Strategy (Continued)**

- **Suitability/Survivability**

- Answers Critical Operational Issue *“Does the SUAS Support the Small Unit’s Sustained Operational Requirements?”*
- Required Reliability Testing, Portability, Transportability, Airborne Capability MANPRINT, and Supportability Assessments
- System Reliability Data Obtained From Production Qualification Testing, and IOT
- Portability Assessed through dismounted operations During IOT
- During the Logistics/MANPRINT Demonstration Verified/Validated Technical Manuals, Training, Assembly/Disassembly, Preventive Maintenance Checks and Services (PMCS), MOPP IV and Cold Weather Tasks
- Electromagnetic Environmental Effects (E3) Data Collected from Production Qualification Testing
- System Susceptibility to Acoustic Signature obtained from Developmental Test and IOT

Approach to Evaluating Effectiveness

- **Initial Operational Test (IOT)**

- Mission Matrix Consists of 21 Infantry Company Level Close Combat missions
- Nine Pairs of Comparison Missions with and without the SUAS
- Three to Meet Data Requirements According to the OMS/MP and for the Purpose of RAM

MISSION	Daytime		Nighttime	
	With SUAS	Without SUAS	With SUAS	Without SUAS
Conduct a Convoy Escort (ARTEP 71-2-2320)	1	1	1	1
Conduct an Attack by Fire (ARTEP 71-2-0219)	1 and (1)	1	1	1
Conduct a Raid (ARTEP 71-2-0308)	1 and (1)	1	2 and (1)	2
Defend a Battle Position (ARTEP 71-2 2603)	1	1	1	1

Approach to Evaluating Effectiveness

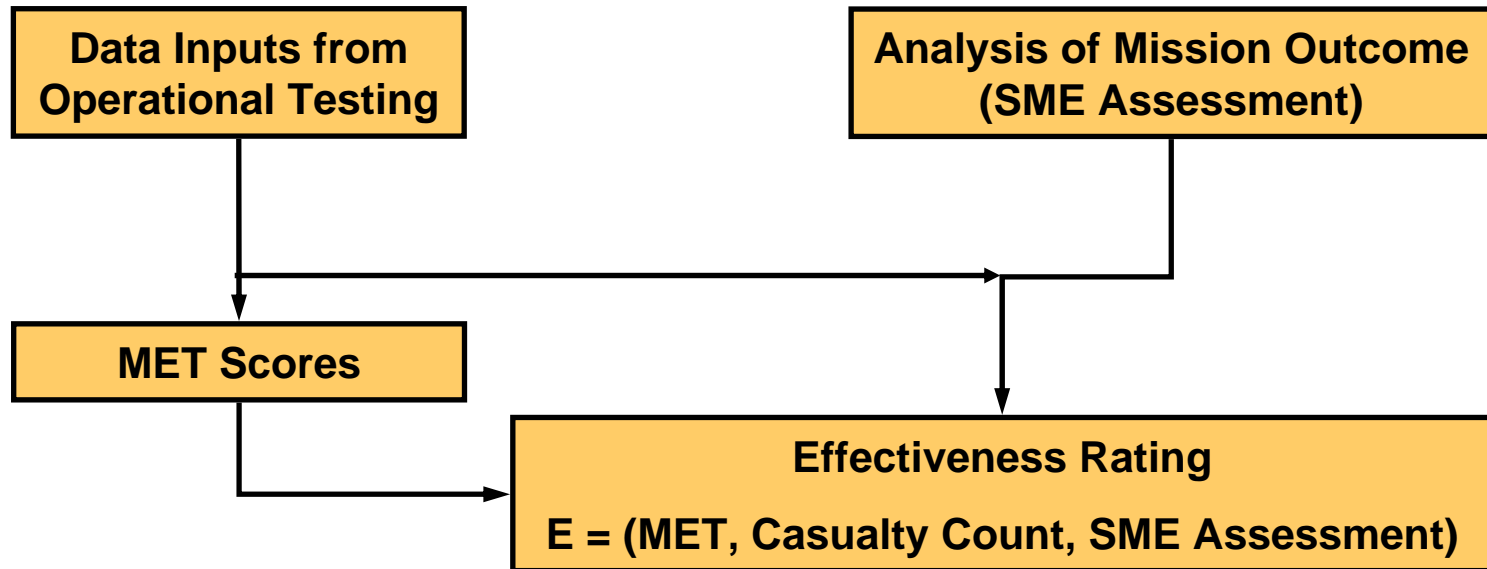
- **Comparative Test With and Without the SUAS Required Using a Robust OPFOR and Cluttered Environment to Challenge the Test Unit**
- **Mission Effectiveness Templates (MET) and Assessment of Mission Outcome by Subject Matter Experts**
 - METs use Timeliness, Accuracy, and Unit Resources as Attributes to Objectively Score Missions With and Without the SUAS
 - ARTEP MTPs Assessed by O/Cs to Observe Accomplishment of Task Steps
 - The Entire Mission is Timed by Distinct tasks, SALUTE Reports are Recorded and Actions the Unit Takes to Complete the Mission
 - SMEs Individually Assess the Mission as it Unfolds in the Battlefield and Based on Mission Outcome Determine Mission Success and Commander's Intent

ARTEP=Army Training And Evaluation Program

SALUTE=Size Activity Location Unit Time Equipment

MTP=Mission Training Plan

Approach to Evaluating Effectiveness



CC = Casualty count factor; $CC = R - 2(B + NC)$

R: % OPFOR killed or captured

B: % BLUFOR killed or captured

NC: % NON COMB. killed or captured

Approach to Evaluating Effectiveness (Mission Effectiveness Templates)

Timeliness (30%) (T)	Score	100	0	Actual	
Planning (40%)					
Mission Planning Time (20%)		30	240	_____	X 0.024 =
Time to Initial SALUTE Report (80%)		20	240	_____	X 0.096 =
Execution (60%)					
Mission Execution Time (LD) (100%)		30	240	_____	X 0.180 =
Accuracy (50%) (A)					
Battalion PIRs (30%)					
Number of PIRs Detected* (50%)		Detections	0	_____	X 0.100 =
Number of PIRs Recognized (50%)		Recognitions	0	_____	X 0.100 =
Planning (40%)					
Man-sized Object Detections (50%)		Detections	0	_____	X 0.100 =
Locations (20%)		Recognitions	0	_____	X 0.040 =
Vehicle Recognitions (30%)		Recognitions	0	_____	X 0.060 =
Execution (30%)					
Man-sized Object Detections (50%)		Detections	0	_____	X 0.100 =
Locations (20%)		Recognitions	0	_____	X 0.040 =
Vehicle Recognitions (30%)		Recognitions	0	_____	X 0.060 =

PIR= Priority Information Requirements

Approach to Evaluating Effectiveness (Mission Effectiveness Templates)

Company Resources (20%) (R)	Score	100	0		Actual
Planning (40%)					
Personnel (50%)		2	15	_____	X 0.040 =
Vehicles (50%)		0	2	_____	X 0.040 =
Execution (60%)					
Personnel (50%)		2	15	_____	X 0.060 =
Vehicles (50%)		0	2	_____	X 0.060 =

$$\text{MET Score} = T + A + R$$

- Total Scores Without SUAS Compared to Total Scores With SUAS Using a t-distribution Paired Samples Test and Wilcoxon Signed Rank Test

Approach to Evaluating Effectiveness

Results of Mission Effectiveness Template Scores by Mission			
		With SUAS	Without SUAS
Attack	Day	34.9	34.1
	Night	35.4	19.8
Raid	Day	43.0 (0 score)	24.2
		47.9	41.9
	Night	23.4 (0 score)	36.3
Convoy Escort	Day	40.5	46.7 (0 score)
	Night	41.5	42.4 (0 score)
Defense (Observe NAI)	Night	38.4	20.2

Note: Scores highlighted in red have a zero rating due to an unsuccessful mission outcome

Statistical Analysis Using a Paired Samples Test and Wilcoxon Signed Ranks Test			
Paired Samples Test		Wilcoxon Sign-Rank Test	
t-Ratio	0.777403		
Degrees of Freedom	7	Test Statistic	5
Prob $p > t $	0.4624	Prob $p > z $	0.547
Prob $p > t$	0.2312	Prob $p > z$	0.273

Loss Exchange Ratios

Mission Type	Day/Night	Losses With SUAS				Losses Without SUAS			
		OPFOR	BLUFOR	Non-Combatants	Score	OPFOR	BLUFOR	Non-Combatants	Score
Convoy operations	Day	0%	0.0%	0.0%	55.8	88.9%	0.0%	0.0%	100.0
Convoy operations	Night	0%	0.0%	0.0%	55.8	50.0%	9.1%	0.0%	71.6
Hasty Attack	Day	35.3%	0.0%	0.0%	73.3	40.0%	9.7%	10.5%	55.5
Hasty Attack	Night	81.8%	4.1%	36.8%	55.8	0	0.0%	0.0%	55.8
Raid to capture	Day	80.0%	0.0%	15.4%	80.3	75.0%	10.5%	0.0%	82.6
Raid to capture	Day	85.7%	35.7%	0.0%	62.9	70.0%	11.1%	11.8%	67.8
Raid to capture	Night	30.8%	0.0%	0.0%	71.1	55.6%	2.6%	81.3%	0.0

Table 6. Loss exchange ratios on missions with and without the SUAS

Critical T-value= 1.943, thus no statistical significance

Approach to Evaluating Effectiveness

- **Evaluation of SUAS Effectiveness**

- SUAS Demonstrated Negligible Enhancements in Combat Effectiveness at the Company Level
- SUAS Enhanced Situational Awareness Based on Closed Set of Close Combat Mission Iterations – used to confirm course of action
- MET Scores Show No Significant Differences in Mission Outcome
- System Interoperability Proven in 95% (25 of 26) Successful Downloads from the GCS to the Laptop
- SUAS Demonstrated Insufficient Capability to be used in Call for Fire Tasks
- AV Flown Mostly at Lower Altitudes to Recognize Personnel



Approach to Evaluating Suitability/ Survivability

- **Reliability Availability and Maintainability**
 - Did Not Meet MTBOMF for sub-systems: The AV is a risk item with much lower MTBOMF than anticipated
 - Battery issues caused crashes
 - Bent motor shafts from failed launches
- **Portability**
 - Demonstrated Rucksack Portability Weight < 25 lbs to Include Single Air Vehicle
- **Capability For Airborne Operations** – Static Line and HALO Jumps Met
- **Launch and Recovery without the Need for a Runway**
 - Twenty one of 61 Launches Resulted in Failure – Attributed to Nighttime Slight Wind Conditions
 - Emphasize Operator Training on Launch Techniques –
- **Navigation, Operation and Recovery Operations – Mounted/
Dismounted**
- **Flight Endurance** – Did not Show it could Meet the 90-minute Endurance Requirement During the IOT

Approach to Evaluating Suitability/ Survivability

- **Commander/Operator Workload**
 - Emphasize Commander Participation During Collective Training - Delegate Use of the System to the XO, or FSO to Focus on Key Missions Tasks
- **System Susceptibility to Loss of Link** – demonstrated in 10 of 28 Missions
- **AV is audible at Mission Altitude** – Opposing Force (OPFOR) changed mode of operation

Changes in Army Doctrine by Integrating the SUAS

- **Doctrine – ways to a means**
 - New weapon systems can instill revisions in Army doctrine – ways to conduct combat by reducing the size of the force
- **SUAS Tradeoffs to Reduce Size of Offensive Force**
 - Traditional Offensive Operations Count on a Three to One Offensive Force
 - Cannot Violate Principles of War – mass, surprise, economy of force, maneuver
 - SUAS must demonstrate capability as a force multiplier to enhance small unit effectiveness
 - Improve sensor technology to identify individuals and the location of Improvised Explosive Devices (IED)
 - Enhance interoperability to network with other UASs and UGVs – increase sensor coverage over target
- **SUAS is a good test case for Future Combat use of small UAVs**
 - Defines the technical envelope to look forward and meet small unit Aerial RSTA needs

Conclusions

- **Raven** – Operational history shows adequate RSTA task capability in limited Close Combat Missions at the Infantry Company Level
- **SUAS incorporates minor upgrades to Raven UAS**
 - Targeting Feature is a step in the right direction – not capable now
 - Requires stable platform and sensor
- **Benefits to the Small Unit**
 - Light Infantry Unit may make better use of the SUAS than say a mechanized Infantry Unit – lack of high power sensors limit capabilities in open terrain
- **Emphasize the Need for Powerful Sensors**
 - System risk to detection offers the opposing forces advantages to change modes of operation