Unmanned Aerial Systems:

What We've Learned Through Experimentation

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The Joint and Army Experimentation Division (JAED) of the U.S. Army Training and Doctrine Command's (TRADOC's) Army Capabilities Integration Center (ARCIC) is responsible for conducting experiments to prepare the Army for the future and supervises numerous battle laboratories and experimentation and analysis elements at TRADOC Centers of Excellence as they execute experiments. The Mission Command Battle Laboratory at Fort Leavenworth, Kan., Maneuver Battle Laboratory (MBL) at Fort Benning, Ga., Fires Battle Laboratory at Fort Sill, Okla., Intelligence Experimentation and Analysis Element at Fort Huachuca, Ariz., and the Aviation Experimentation and Analysis Element at Fort Rucker, Ala., have conducted numerous simulation-supported experiments that have examined unmanned aircraft system (UAS) employment.

In addition to the simulation-supported experiments, MBL also conducted an annual live force-on-force/constructive simulation experiment — the Air Assault Expeditionary Force (AAEF)/Army Expeditionary Warrior Experiment (AEWE) — since 2004. During AAEF/AEWE, A Company, 1st Battalion, 29th Infantry Regiment, also known as the Experimentation Force (EXFOR) "… conducts experimentation of emerging technologies (in order to) provide Soldier assessment and feedback of systems/capabilities under consideration for acquisition/fielding to the force."[1] Among the emerging technologies each year are UAS, which the EXFOR Soldiers pilot during tactical operations against an opposing force (OPFOR) that is also equipped with UAS.

The U.S. Army Aviation Center of Excellence's UAS Center of Excellence (CoE) at Fort Rucker outlined how the Army plans to develop and organize UAS in its report *"Eyes of the Army" — U.S. Army Roadmap for Unmanned Aircraft Systems 2010-2035*. According to the roadmap, a UAS is comprised of an unmanned aircraft (UA), a payload (sensor, weapon, communications, etc.), a human element (the crew), a control element (system to launch, control, and land), a display (how/where a sensor payload information is displayed), communications architecture (hardware/software used to send data between control element, the aircraft, and the display) and life-cycle logistics (equipment needed to move, launch, recover, and maintain the UAS). Within this roadmap, the UAS COE has categorized Army UAS in accordance with the Department of Defense's five identified groupings of UAS (see Figure 1).

During experimentation efforts over the past 10 years, analysts identified critical information that enabled the Army to develop a UAS strategy for operations in Iraq and Afghanistan as well as future operations. Additionally,

Figure 1 — UAS Categories and Current Systems[2]

UAS Category	Max Gross Takeoff Weight	Normal Operating Altitude (Feet)	Airspeed	Current U.S. Army UAS in operation
Group 1	<20 lbs	<1,200 Above Ground Level (AGL)	<100 Knots	RQ-11B Raven
Group 2	21-55 lbs	<3,500 AGL	<250 Knots	No Current System
Group 3	<1,320 lbs	<18,000 Mean Sea Level (MSL)		RQ-7B Shadow
Group 4	> 1,320 lbs		Any Airspeed	MQ-5B, MQ-1C
Group 5		>18,000 MSL		No Current System

observations from Soldiers, UAS technology providers, experiment control/support personnel, and OPFOR members provided important insights into the desired characteristics of UAS; tactics, techniques, and procedures (TTPs) for UAS employment; and the proper mix of UAS to support tactical operations from platoon to division.

UAS Desired Characteristics

Over the course of several campaigns of experimentation, the experiment community of practice (COP) identified characteristics that should be common to all UAS, regardless of size, category, or echelonment. While not all inclusive, these characteristics include detectability, ease of control, location identification, and ability to complete required mission set.

A UA conducting operations must be difficult to detect so the enemy doesn't know it is being observed. If the enemy detects a UA, they can hide or worse — portray false actions in an attempt to deceive. UA are most often detected because they were seen or heard. Any UA should be silent to anyone on the ground while it is conducting operations at its operating altitude. Additionally, a UA should not be observable from the ground while at its operating altitude, which in some cases will restrict operations to periods of limited visibility. One solution is having a UA that can operate offset from the objective with the ability to observe the objective from that distance. If a UA can be seen or heard while conducting operations, its value is reduced and it should not be employed.

A UAS can have every feature you want, but if the control element is too burdensome, the UAS is of little worth. All UAS have some sort of ground control system (GCS), be it a small tablet for a Group 1 UAS to multiple control trailers for a Group 5 UAS. While a vehicle-mounted GCS may be appropriate for a company in an armored brigade combat team (ABCT) or a Stryker brigade combat team (SBCT), it would be unsuitable for an Infantry brigade combat team (IBCT). Additionally, if a UAS requires an entire rucksack for the control element and life-cycle logistics (batteries, spare parts, etc.), then it is inappropriate for an IBCT as well. The control element must be appropriate for the type of unit and echelon of employment.

Soldiers operating UAS during AEWE have identified the need to have both active flight control (they physically fly the UA) and waypoint movement control (they pre-program the route) methods of employment and the ability to shift between them at will without losing capability during the transition.

Soldiers also have observed that many of the optical sensors Group 1 UAS do not have an electro-optical (EO) or infrared (IR) sensor payload that provides enough fidelity. There are many quality UAs produced today so the Army should concentrate on payloads. Having common payload characteristics allows a UA company to build the UA, while another company that builds quality payloads can develop payloads that satisfy the requirement of the overall UAS.

Photo by Angela Depuydt

Experimentation Force Soldiers operate an unmanned aerial system during the Army Expeditionary Warrior Experiment at Fort Benning on 16 January 2013.

One very important requirement for a UAS is its ability to perform the mission required by that echelon of employment (platoon-division). Modern UAS can conduct numerous mission profiles including surveillance, reconnaissance, communications relay, attack, etc. However, not all UAS are able to perform every mission profile and at each echelon of employment, but the UAS must perform the mission profile the unit needs. Systems supporting target acquisition must have the ability to identify targets with enough fidelity to allow engagement with indirect fire systems. UAS conducting reconnaissance missions unable to provide the location of what it is observed is not effective. Units conducting night operations must have UAS with the ability to "see" in limited visibility (with infrared, synthetic aperture radar, etc.). When selecting UAS for each echelon, the Army must carefully consider the requirement of the echelon and the particular type unit; ABCT requirements are different than IBCT requirements.

Every UAS in the Army inventory should have the ability to identify locations. A UAS should display the UA location and should also have an indication of the direction it is observing so those doing analysis can determine locations. Some UAS require the fidelity to have the location of what the UAS is observing, like UAS supporting a fires battalion. A UAS without any ability to provide locations provides minimal information.

Photo courtesy of PEO Aviation

Current Army UAS include the MQ-1C Gray Eagle, RZ-7B Shadow, MQ-5B Hunter, RQ-11B Raven, and RQ-20A Puma.

UAS Tactics, Techniques, and Procedures (TTPs)

Extensive and recurring experimentation has resulted in the capture of some TTPs for UAS employment. Soldiers operating the systems, leaders of units supported by the UAS, UAS technical providers, experiment control personnel, analysts, and OPFOR Soldiers and commanders generated these TTPs.

The requirement to secure the UAS launch/recovery location and the operators at the GCS is very important. For Group 1 UAS, it is best to have the operators move with their unit and launch from the unit's location, thus ensuring residual security. Group 2 and larger UAS require some sort of open area to launch and recover; the larger the UAS, the larger the launch/recovery area. For any UAS launch/recover operations away from the unit's location, the unit will require dedicated security as the UAS crew will be consumed with air operations.

All UAS operations, regardless of payload, are an operational decision, so employment decisions need to be made by the commander or his operational representative. Many UAS can carry different payloads. The MQ-1C Gray Eagle Extended-Range Multi-Purpose (ERMP) UAS that supports divisions can be configured for surveillance, communications support, and as an attack platform. The division G6 will want the platform for communications relay while the G2 will want to get as many platforms as he can for reconnaissance and surveillance. As the representative of the division commander, the G3 or chief of staff decides the ERMP missions. This decision is usually best decided in an UAS board or in a meeting, where all interested parties can present their case before the decision is made.

The life-cycle logistics of any UAS has a great effect on UAS operations and the unit it supports. Every UAS requires power, be it batteries or fossil fuel to operate, and the unit has to have the ability to manage fuel. How will an airborne IBCT obtain batteries for its UAS immediately after conducting an airborne assault? UAS should be durable with the ability to quickly and easily repair broken parts. UAS require maintenance and parts to maintain operations, and units must prepare for this. While UAS operations require different logistics, the unit supply system is capable of providing this when leaders plan for it.

UAS mission planning improves operations and provides security for the unit. Each unit, from platoon to division, has different groups of UAS, and planners need to ensure that units have continuous UAS coverage. UAS mission planning must ensure that while one UA is in the air conducting its mission, another is ready to launch to replace it before the original UA lands. Additionally, the replacement UA is prepared to launch in case the original UA has to terminate its mission early. Route planning is an important part of UAS mission planning. Good route planning enhances airspace command and control (AC2). Units should not fly directly to and from the target area because the enemy can observe the direction the UA is flying and either follow the UA back to its launch location or predict the location using the flight direction and a map reconnaissance. Another mission planning tactic is to avoid what is called "echelonment" of UAS. Units should avoid flying the brigade UAS, followed by the battalion UAS, the company UAS, and finally the platoon UAS in an orchestrated procession of systems. While continuous UAS coverage of an enemy position may fix an enemy that is trying not to be seen, commanders need to be careful not to give away their plan with an echelonment of UAS.

Managing the UAS-congested airspace over the battlefield has been and continues to be a difficult task, especially below BCT level. Division and BCTs have staff sections with the personnel and equipment to provide some positive airspace control. Below BCT level, the airspace should be controlled with procedural airspace control, but the Army requires more experimentation and training to achieve an acceptable level of control.

UAS Unit Recommendation

Based on years of experimentation with UAS in live, virtual, and constructive events, the following are recommendations for particular UAS support for the different echelons of maneuver units from squad to division.

The lowest level that should have organic UAS is the platoon. Squads should not have personnel dedicated to UAS operations; if they require UAS support, the platoon should provide it. Platoons should have two Group 1 UAS. These UAS should be vertical take off and landing (VTOL) and only require electro-optical (EO) and infrared (IR) sensor payloads. They should have 45-minute endurance. They should have a tablet-based GCS that is also the display. They should operate with the platoon and receive residual security from being with the platoon. Some examples of platoon UAS that satisfy these recommendations include the Sky Watch Huginn X1, Airrobot AR100B, and gas micro-air vehicle (gMAV) small UAS.

Companies in an ABCT, SBCT, and IBCT should have a dedicated UAS section at the company level that works closely with the company intelligence support team (CoIST) to provide UAS support and basic AC2. Company-level UAS support is different based on the type of BCT due to factors such as mission and mobility. The ABCT and SBCT company UAS section should have two hand-launched Group 1 UAS with two aircraft each (for a total of four aircraft) supported by a vehicle for life-cycle logistics, control element, and communications architecture. Company UAS

Photo by Cheryl Rodewig

An EXFOR Soldier demonstrates the Airrobot UAS during the Army Expeditionary Warrior Experiment at Fort Benning in December 2008.

payloads should include an EO and IR sensor as well as a communications-relay payload. These UAS should have a one-hour endurance. The display should be visible in the GCS but also visible in the CoIST and/or the commander's vehicle. The UAS could collocate with the company mortars (both have similar requirements for locating positions), and this combined element could secure itself. If it operates independently, it will require a security element. Some examples of company UAS that satisfy these recommendations include the RQ-11B Raven, Skylark Block I UAS, and Desert Hawk Extended Endurance & Range UAS.

The companies in an IBCT (including airborne and air assault) do not have the mobility of other BCT companies, so their UAS sections need to be different. The company UAS section of an IBCT should have two VTOL Group 1 UAS (similar to the platoon-level UAS) and one hand-launched Group 1 UAS (similar to the A/SBCT companies). These UAS should have the same payloads and display options as previously mentioned. While the IBCT company UAS section should have a vehicle, they should be trained and prepared to operate dismounted for extended periods. Like their heavier "brothers," they should operate with the company mortars.

Like at company level, the IBCT battalion UAS sections need to be different then the ABCT and SBCT battalion UAS section. ABCT and SBCT battalion UAS section should consist of three Group 2 UAS each with two aircraft (for a total of six aircraft). The Army currently doesn't have a Group 2 UAS, but the U.S. Navy and the U.S. Marine Corps (USMC) are developing this capability. These Group 2 UAS should have a requirement for short launch and recovery areas; this may include catapult-launched aircraft and parachute/hook/stall and airbag recovery options. ABCT and SBCT battalion UAS payloads should include EO, IR, synthetic aperture radar (SAR), signal intelligence (SIGINT), and chemical, biological, radiological, nuclear, high-yield explosive (CBRNE) detection sensor packages, and communications packages. Battalion UAS should have a minimum of six hours of endurance. Battalion UAS displays need to be completely integrated into the network for full motion video sharing both higher and lower. These UAS will launch and recover from the battalion or BCT rear area (consider areas like combat trains or field trains), and may have to be augmented with security. Some examples of battalion UAS that satisfy these recommendations include the Scan Eagle UAS, and the Silver Fox UAS.

The UAS section of an IBCT battalion should consist of one Group 2 UAS with two aircraft (the same as above), and two Group 1 UAS with two aircraft each (for a total of four aircraft). Just like their company UAS sections, the IBCT battalion UAS section should be prepared to operate dismounted for extended periods.

Each BCT should have a UAS platoon with three Group 3 UAS, each with two aircraft (for a total of six aircraft). The launch and recovery location is large and may include unimproved and improved airfields. However, they can still be catapult launched and hook recovered. Their payload should include EO, IR, SAR, SIGINT, CBRNE sensor, and communications packages. BCT UAS should have an endurance of at least 8-10 hours. Like battalion UAS, the BCT UAS need to be completely integrated into the network for full-motion video sharing both higher and lower. The BCT UAS platoon should try to collocate with another unit for security, but if this is not possible they may require attachment of security forces. Some examples of BCT UAS that satisfy these recommendations are the RQ-7B Shadow, RQ-21A Blackjack, and Viking 400.

Photo by TSgt Christopher Gish

An airman operates a Desert Hawk unmanned aerial system.

Each combat aviation brigade (CAB) that supports a division has a UAS company to provide UAS for division operations. The company has six Group 4 UAS with two aircraft each (for a total of 12 aircraft). Their payload should include EO, IR, SAR, SIGINT, and CBRNE sensor packages like previously discussed UAS, but should also have advanced sensors. These sensors include moving target indicator (MTI), light detection and ranging (LIDAR), laser radar, and measures and signatures intelligence (MASINT). Division UAS payloads should also include communications packages, laser range finders, and laser target indicators. Like previously discussed UAS, the division UAS need to be completely integrated into the network for full motion video and other information sharing both higher and lower. Group 4 UAS require a 4,500-foot hard surface runway for launch and recovery, so they will be located on an airfield and integrated into the airfield defense plan. Some examples of division UAS that satisfy these recommendations are the MQ-1C Gray Eagle, and the MQ-1B Predator.

U.S. Navy photo

Navy and Insitu personnel lift the RQ-21A Small Tacticall Unmanned Aircraft System (STUAS) onto a launcher in preparation for flight at Naval Air Weapons Station China Lake, Calif.

The Army has come a long way in the past 25 years with the employment of UAS. UAS were successfully employed during operations Enduring Freedom and Iraqi Freedom, as well as many other operations worldwide. Even while operations were ongoing, Army experimentation was examining UAS operations to better prepare the Army of the future. Over this decade-long campaign of learning, the Army has gained valuable insights for UAS characteristics, TTPs, and employment. The Army UAS program is better prepared because of experimentation.

Notes

[1] 1st Battalion, 29th Infantry Regiment website, accessed 29 January 2014, http://www.benning.army.mil/infantry/197th/129/.

[2] U.S. Army UAS Center of Excellence, *"Eyes of the Army": US Army Roadmap for Unmanned Aircraft Systems, 2010-2035*, Fort Rucker, Ala.: U.S. Government Printing Office, 2010, http://www.rucker.army.mil/usaace/directorates/cdid/tcm-uas/index.html.

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