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U.S. Army Unmanned Aircraft Systems (UAS)a historical perspective to identifying and understanding stakeholder relationships

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U.S. ARMY UNMANNED AIRCRAFT SYSTEMS (UAS)—A HISTORICAL PERSPECTIVE TO IDENTIFYING AND UNDERSTANDING STAKEHOLDER RELATIONSHIPS

By: Donald R. Lowe,
Holly B. Story, and
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June 2014

Advisor: Richard B. Doyle

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13. ABSTRACT (maximum 200 words)

This research is intended to advance understanding of relationships between unmanned aircraft systems (UAS) stakeholders and programs to allow the Army to increase efficiencies and reduce costs. It was found that the Army had never completed a formal UAS stakeholder identification and analysis. Internal and external stakeholders are identified here and fall within categories of Army executive program leadership (e.g., Program Executive Office for Aviation), Army and service components (active, Guard, reserve forces), senior Army leadership (e.g., Headquarters, Department of Army), other federal and non-federal government entities (e.g., Congress), commercial interests (e.g., industry and academia), and other interested parties, such as the American people. An analysis of relationships affecting these stakeholders was conducted, including organizational beliefs and cultures, management of resources, policies and law and future UAS enhancements planned by the Army and industry partners. The most important problems found were inter-service and inter-branch disputes that shape UAS policies and procedures, forecasting for future UAS growth while managing costs and finding more efficient, less redundant ways to use current UAS capabilities, and safe integration into the national airspace system. This stakeholder analysis allows the Army to leverage the support of others for funding, resources, intellectual property, lessons learned and cooperation.

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN PROGRAM MANAGEMENT

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ABSTRACT

This research is intended to advance understanding of relationships between unmanned aircraft systems (UAS) stakeholders and programs to allow the Army to increase efficiencies and reduce costs. It was found that the Army had never completed a formal UAS stakeholder identification and analysis. Internal and external stakeholders are identified here and fall within categories of Army executive program leadership (e.g., Program Executive Office for Aviation), Army and service components (active, Guard, reserve forces), senior Army leadership (e.g., Headquarters, Department of Army), other federal and non-federal government entities (e.g., Congress), commercial interests (e.g., industry and academia), and other interested parties, such as the American people. An analysis of relationships affecting these stakeholders was conducted, including organizational beliefs and cultures, management of resources, policies and law and future UAS enhancements planned by the Army and industry partners. The most important problems found were inter-service and inter-branch disputes that shape UAS policies and procedures, forecasting for future UAS growth while managing costs and finding more efficient, less redundant ways to use current UAS capabilities, and safe integration into the national airspace system. This stakeholder analysis allows the Army to leverage the support of others for funding, resources, intellectual property, lessons learned and cooperation.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAS	Armed aerial scout
AATD	Aviation Applied Technology Directorate
ABO	Army Budget Office
AMRDEC	Air and Missile Research, Development, and Engineering Center
ARCIC	Army Capabilities Integration Center
ARL	Army Research Laboratory
ARNG	Army National Guard
ASA (AL&T)	Assistant Secretary of the Army for Acquisition, Logistics & Technology
ATO	Army technology objective
BCT	Brigade combat team
BDA	Battle damage assessment
BLOS	Beyond line of sight
BTT	Basic training target
CBP	U.S. Customs and Border Patrol
CBRNE	Chemical, biological, radiological, nuclear, high yield explosive
CDID	Capabilities Development Integration Directorate
CNPC	Command and non-payload control
COA	Certificate of authorization
COE	Center of excellence
CONOP	Concept of operations
CONUS	Contiguous United States
CQI	Chartered Quality Institute
CRUSER	Consortium for Robotics and Unmanned Systems Education and Research
CSO	Combat systems officer
CSP	Common sensor payload
CTA	Collaborative Technology Alliance
C2	Command and control
DAR	Designated airworthiness representative

DARPA	Defense Advanced Research Projects Agency
DASA (R&T)	Deputy Assistant Secretary of the Army for Research and Technology
DER	Designated engineering representative
DHS	Department of Homeland Security
DOD	Department of Defense
DOTMLPF	Doctrine, organization, training, materiel, leadership and education, personnel, facilities
DS	Direct support
EMRP	Extended range multipurpose
ERAST	Environmental research aircraft & sensor technology
EW	Electronic warfare
FAA	Federal Aviation Administration
FPASS	Force Protection Airborne Surveillance System
GAO	U.S. Government Accountability Office
GCS	Ground control station
GPS	Global Positioning System
GS	Ground/general support
HQDA	Headquarters, Department of the Army
HSI	Human systems integration
ICBM	Intercontinental ballistic missile
IED	Improvised explosive device
IEWS	Intelligence, electronic warfare and sensors
ISR	Intelligence, surveillance, and reconnaissance
IT&E	Integrated test and evaluation
JFACC	Joint Force Air Component Command
JPO	Joint Program Office
LOS	Line of sight
LRIP	Low rate initial production
LVC	Live virtual constructive
MAST	Micro-autonomous systems and technology
MUM-T	Manned-unmanned teaming

NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEXTGEN	Next Generation Air Transportation System
NOAA	National Oceanic and Atmospheric Administration
OCO	Overseas contingency operations
OIF	Operation Iraqi Freedom
OEF	Operation Enduring Freedom
OND	Operation New Dawn
OSD	Office of the Secretary of Defense
OSGCS	One system ground control station
OSRVT	One system remote video terminal
PdM	Product manager
PEO	Program Executive Office
PM	Program manager
POR	Program of record
PUMA	Pointer Upgraded Mission Ability
QDR	Quadrennial Defense Review
RATO	Rocket assisted take off
RC	Radio controlled
RDECOM	U.S. Army Research, Development, and Engineering Command
RSTA	Reconnaissance, surveillance, target acquisition
RUS	Robotics, sensors for unmanned systems
SAA	Separation assurance/sense and avoid
SATCOM	Satellite communications
SECDEF	Secretary of Defense
SOCOM	Special Operations Command
S&T	Science and technology
TCAS	Traffic alert and collision avoidance system
TCM	U.S. Army Training and Doctrine Command Capability Manager
TRADOC	U.S. Army Training and Doctrine Command
TTP	Tactics, techniques, procedures
UAS	Unmanned aircraft system

UASTB	UAS Training Battalion
UAV	Unmanned aerial vehicle
UGCS	Unmanned Ground Control Station
UNEP/GPA	United Nations Environment Programme/Global Programme of Action
UPT	Undergraduate Pilot Training
U.S.	United States
USA	United States Army
USAF	United States Air Force
USD	Undersecretary of Defense
USGS	United States Geological Survey
USMC	United States Marine Corps
USN	United States Navy
UW	Unmanned warfare
WWI	World War I
WWII	World War II

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I.   HISTORY AND EVOLUTION OF U.S. ARMY UNMANNED AIRCRAFT SYSTEMS

A.   HISTORY

Rare is the technology that can change the face of warfare. In the first half of the past century, tanks and planes transformed how the world fought its battles. The fifty years that followed were dominated by nuclear warheads and ICBMs, weapons of such horrible power that they gave birth to new doctrines to keep countries from ever using them. The advent of the armed drone upended this calculus: War was possible exactly because it seemed so free of risk. Mazzetti, 2013, p. 100.

1.   Unmanned Aerial Vehicles: 1840–1930

Unmanned aerial vehicles (UAVs) have a long history of use going back over 150 years with the first recorded use of UAVs in 1849. That year Austria launched pilotless balloons fitted with bombs against the city of Venice. Although these bombs were largely ineffective, it was a precursor for things to come (On This Day, 2011). The next recorded use of UAVs was during the American Civil War when balloons were, again, unsuccessfully used to drop bombs over the enemy. This was followed by the United States (U.S.) using a kite to take aerial surveillance of the enemy in 1898 during the Spanish American War. The use of the kite's camera was successful and often referred to as the first known "aerial reconnaissance" (Scheve, 2014).

The use of the pilotless aircraft/UAVs that are the ancestors of today's UAVs began with "aerial torpedoes" or what are now called "cruise missiles" (Goebel, 2013). Although it was not used in any significant capacity, this technology was first available during World War I (WWI) in the form of the Hewitt-Sperry Automatic Airplane (Scheve, 2014). The technology that made this possible was Elmer Sperry's automatic gyroscopic stabilizer, a revolutionary device first used in the ship industry but latter adapted for use in airplanes (Scheve, 2014). In 1916, Elmer Sperry and his son joined forces with Peter Hewitt, a radio communication expert, with the sole purpose of designing what became known as the Hewitt-Sperry Automatic Airplane. The trio is credited with countless aviation first achievements such as the first open air wind tunnel,

an aircraft strapped to the top of an automobile, and also the first heavier-than-air unmanned vehicle to fly in controlled flight, accomplished in 1918. After WWI, with Hewitt and Sperry showing little to moderate success using a non-radio controlled aerial torpedo, the U.S. Navy (USN) took over control of the Hewitt-Sperry Automatic Airplane program and continued to sponsor similar programs with relative success until interest in the programs lapsed in 1925 ("Hewitt-Sperry Automatic Airplane," 2013).

2. Unmanned Aerial Vehicles/Targets: 1930–1950

Beginning in the 1930s, Great Britain and the U.S. again began to experiment with UAVs, though this time the majority of research took the form of radio controlled aircraft. According to Greg Goebel of Vectors,

> In 1931, the British developed the Fairey 'Queen' radio-controlled (RC) target from the Fairey IIIF floatplane, building a batch of three, and in 1935 followed up this experiment by producing larger numbers of another RC target, the 'DH.82B Queen Bee,' derived from the de Havilland Tiger Moth biplane trainer. Through some convoluted path, the name of 'Queen Bee' is said to have led to the use of the term 'drone' for remote-controlled aircraft. Goebel, 2013, p. 1.1.

Most of the research and use of UAVs in the U.S. at this time and through World War II (WWII) revolved around radio controlled targets in the form of attack sized and full sized obsolete aircraft fitted with radio control hardware. In Operation Aphrodite, the U.S. even experimented with remotely piloted B-17 aircraft that were stripped down and fully loaded with explosives. Unfortunately the program was deemed "dangerous, expensive and unsuccessful" during 15 documented flights, and the program was abandoned ("Operation Aphrodite," 2014).

Large scale production of UAVs first began in the late 1930s with a company founded by Reginald Denny called Radioplane. The Radioplane Corporation made countless variations of remote controlled aircraft such as the RP-1, RP-2, RP-3, RP-4 (OQ-1), RP-5 (OQ-2), OQ-3, and many more. As seen in the Figure 1 photograph and Table 1 specifications, these aircraft were very simple but were effective target practice for anti-aircraft weapons (Goebel, 2013).

Figure 1.   Radioplane OQ-2A (from Goebel, 2013, p. 1.0)

```
RADIOPLANE OQ-2:
_____   _____   _____

spec                    metric                  english
_____   _____   _____

wingspan                3.73 meters             12 feet 3 inches
length                  2.65 meters             8 feet 8 inches
takeoff weight          47.2 kilograms          104 pounds

maximum speed           137 KPH                 85 MPH / 74 KT
service ceiling         2,440 meters            8,000 feet
endurance               70 minutes

launch scheme           Conventional runway takeoff.
recovery scheme         Parachute or runway landing.
guidance system         Radio control.
_____   _____   _____
```

Table 1.   Radioplane OQ-2A Specifications (from Goebel, 2013, p. 1.1)

Radioplane followed the success of the OQ-2 family of UAV targets with the OQ-19A and OQ-19B in the 1940s. These basic training targets (BTT) evolved essentially unchanged through the 1960s and continued in their role as targets for training. In the 1960s the Army adapted a standardized designation system and the surviving "OQ" designated BTTs became known as MQM-33s. The MQM-36 (shown in Figure 2) was in service through the remainder of the century and over 73,000 were built to the specifications in Table 2 by Radioplane and later (after a buyout of Radioplane) Northrop Ventura (Goebel, 2013).

3

Figure 2.   MQM-36 Shelduck (from "Radioplane BTT," 2014)

```
RADIOPLANE MQM-36 SHELDUCK:
_____   _____   _____

spec                       metric                english
_____   _____   _____

wingspan                   3.5 meters            11 feet 6 inches
length                     3.85 meters           12 feet 8 inches
height                     0.76 meters           2 feet 6 inches
empty weight               123 kilograms         271 pounds
launch weight              163 kilograms         360 pounds

maximum speed              370 KPH               230 MPH / 200 KT
service ceiling            7,000 meters          23,000 feet
endurance                  1 hour

launch scheme             RATO booster or bungee catapult.
recovery scheme           Parachute.
guidance system           Radio control.
_____   _____   _____
```

Table 2.   MQM-36 Shelduck Specifications (from Goebel, 2013, p. 1.2)

3.   Unmanned Aerial Vehicles/Targets: 1950–1970

During the late 1950s and early 1960s, increasing speeds of enemy assets brought about two new families of UAVs, jet powered and rocket powered UAVs. Looking for more threat representative targets, the U.S. military began performing research into Mach 1 and Mach 2 UAVs that could be used for training anti-aircraft crews. Early research and prototypes such as the Northrop Ventura Q-1 utilized turbojet engines, whereas later UAVs such as the Northrop Ventura "AQM-38" utilized solid rocket engines. The AQM-

4

38 and later blocks were used by the U.S. Army (USA) to train Nike anti-aircraft missile crews and others through the 1970s. Mach 2 UAV targets consisted of several prototypes such as the turbojet powered Northrop Ventura AQM-35 and the ram-jet powered Lockheed AQM-60 that never made it into full scale production, but did provide essential data for other supersonic manned aircraft. Later, the North American Company built a Mach 2 UAV target (specifications shown in Table 3) called the MQM-42A Redhead/Roadrunner (seen in Figure 3) in modest numbers for the training of Hawk Surface to Air Missile Training (Goebel, 2013).
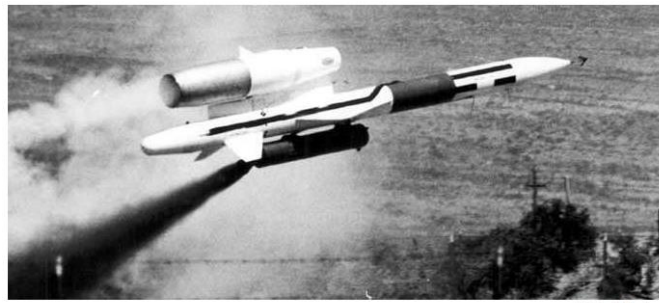
Photo: U.S. Army

Figure 3.   MQM-42A Redhead/Roadrunner (from Parsch, 2007)

Length	7.57 m (24 ft 10 in)
Wingspan	1.90 m (6 ft 3 in)
Diameter	30 cm (12 in)
Weight	400 kg (900 lb)
Speed	> Mach 2
Ceiling	18000 m (60000 ft)
Range	400 km (250 miles)
Propulsion	Booster: Rocketdyne solid-fuel rocket; 26.7 kN (6000 lb) Sustainer: Marquardt MA-74 ramjet

Table 3.   MQM-42A Specifications (from Parsch, 2007)

4.   Unmanned Aerial Targets: 1970–Present

Modern target UAVs/drones, such as the BQM-74C Chukar III seen in Figure 4, have become much more sophisticated than the early radio controlled and auto pilot units. Target technology has advanced dramatically from the early drones. According to Greg Goebel:

> Early target drones were not much more sophisticated than hobbyist's radio controlled (RC) model airplanes. The only payload they could handle was a towed target sleeve. In time, target drones became more sophisticated, carrying countermeasures, scoring devices, active or passive radar enhancement devices, and tow targets, and would also acquire more sophisticated programmable guidance systems.

> Modern target drones are usually launched by aircraft; or off a rail using solid-fuel rocket assisted takeoff (RATO) boosters; or hydraulic, electromagnetic, or pneumatic catapult. Very small target drones can be launched by an elastic bungee catapult. Few target drones have landing gear, and so they are generally recovered by parachute or, in some cases, by a skid landing. Goebel, 2013, p. 2.0.

BQM-74C CHUKAR III (NORTHROP GRUMMAN)

Figure 4.   Modern Target: BQM-74C Chukar III (from Goebel, 2013, p. 2.0)

5.   Unmanned Aerial Vehicles: 1960–2003

In the late 1960s and early 1970s, the success of UAVs as targets led to the realization that modifying UAVs for reconnaissance missions could be very beneficial for the United States. Multiple shoot downs of manned American spy planes and the

subsequent capture of several pilots/crewman was a topic of serious concern for the U.S. government during the Cold War era. The progression involved not only design and use of supersonic/stealth reconnaissance airplanes such as the SR-71 Blackbird and the F-117 Nighthawk, but also reconnaissance UAVs (Goebel, 2013).

In the early 1960s the U.S. Air Force (USAF) began secret research into modifying the Ryan Model 136 Firefly to reduce radar signatures, improve navigation and reconnaissance equipment, and increase fuel capacity (Schwing, 2007a). What happened next is best summarized by Lieutenant Colonel Richard Schwing in his U.S. Army War College Research Project on UAVs:

> The Ryan Model 147 "Lightning Bug" UAV was born, successfully completing testing in 1962. By 1964, a large number of Lightning Bugs were serving with distinction in Southeast Asia. Between 1964 and 1975, Lightning Bugs flew 3,435 sorties in the Vietnam War. The Bugs proved extremely versatile, flying low and high level reconnaissance, electronic warfare, and leaflet dropping missions. Following another shoot down of a manned aircraft, this time an EC-121 airborne command and control aircraft, the Air Force turned to the UAV to fill the gap. Another version of the Bug was developed to fulfill the airborne electronic intelligence mission; it flew 268 sorties from 1970 to 1973. The Lightning Bug was a milestone UAV that proved its worth in Southeast Asia, and successfully overcame the many technological hurdles experienced in previous UAV development. Schwing, 2007, p. 5.

In short, the Lightning Bug/Firefly was very successful and served in countless capacities as well as several theaters such as Communist China, North Vietnam, and North Korea during the 1960s and 1970s. In all, 578 Lightning Bugs/Fireflies were lost with "over half shot down and the rest lost in various accidents" (Goebel, 2013). The Ryan Firefly story does not end there. The 1970s brought research into highly maneuverable versions of the Ryan model 147 as well as versions with active jamming gears as well as improved chaff dispensers. An unknown number of the Ryans were even delivered to the Israelis in the early 1970s, later to see action in the Yom Kipper war in a reconnaissance role. The Israeli Ryans continued to see action until the mid-1990s (Goebel, 2013).

In spite of huge gains in UAV development, UAV research and use came to a halt due to the restructuring of USAF roles and missions. The USAF transferred ownership of UAVs, like the Ryan Firebee depicted in Figure 5 and Table 4 below, from the Strategic Air Command to the Tactical Air Command, where UAVs had to compete with manned combat systems, and ultimately lost.

Essentially all Ryan Fireflies/Lightning Bugs were grounded and committed to storage in 1979 (Schwing, 2007). Once again the story does not end there. Five modified Ryans such as the one shown in Figure 5, with extended ranges (see specifications in Table 4) were used once again on a one way mission to lay chaff corridors during the beginning of Operation Iraqi Freedom (OIF) in 2003, effectively ending the known use of Ryan Firefly/Lightning Bug/Firebees in an operational context (Goebel, 2013).

Figure 5.   Ryan Firebee UAV BQM-34F (from "Ryan Firebee," 2014)

```
_____

SUMMARY TABLE OF MODEL 147 DRONES:
_____

147A        Initial variant, minor mod of Firebee with stretched fuselage.
147C        147A update, no-contrail system, 4.6 meter (15 foot) wingspan.
147D        Modified 147C to "sniff" SAM proximity fuze emissions.

147B        First high-altitude variant, 8.2 meter (27 foot) wingspan.
147G        147B update, fuselage stretch, no-contrail system, new engine.
147H        Optimized high-altitude drone, 9.8 meter (32 foot) wingspan.
147T        Improved 147H with more powerful engine.

147E        147B with 147C SAM "sniffer" payload.
147F        One-off 147B mod to test SA-2 countermeasures.
147J        Fast-track mod of 147B for low-altitude reconnaissance.
147TE       ELINT version of 147T, used in Korea.
147TF       Improved 147TE with external tanks.

147N        Expendable decoy derived directly from Firebee.
147NA       Chaff dispenser variant.
147NC       Chaff / leaflet dispenser variant.
147NC(M1)   Low-level version of 147NC.
147NX       Expendable decoy with secondary reconnaissance capability.

147NP       Fast-track low-altitude drone derived from 147A.
147NRE      Night reconnaissance modification of 147NP.
147NQ       Radio-controlled version of 147NP.

147SA       Optimized low-altitude 147, Firebee wings, stretched fuselage.
147SB       147S variant with multiple-altitude control system.
147SRE      Night reconnaissance 147S with infrared strobe, Doppler radar.
147SC       Improved Doppler navigation system, largest number produced.
147SC/TV    147SC with TV camera.
147SK       Naval 147SC with 4.6 meter (15 foot) wingspan and RATO launch.
147SD       147SC with improved navigational system, external tanks.
147SDL      147SD with LORAN guidance backup.
_____
```

Table 4.   Complete Listing of Ryan 147 Drone Models (from Goebel, 2013, p. 3.7)

The last UAV to be discussed from the 1990s era is the Pioneer drone (see Figure 6). The Pioneer was originally an Israel developed UAV called the "Scout" and built by Mazlat. According to unconfirmed accounts, U.S. Marine Corps (USMC) General P.X. Kelly was in Lebanon investigating a car bombing outside the USMC barracks when the Israelis showed him video of a Scout with cross hairs locked on his head, after which he immediately became a believer in UAV technology. A USN competition for a UAV led to the selection of the AAI Pioneer, an improved version of the Israeli's Scout (see specifications in Table 5). The Pioneer would go on to be used in the Gulf War, Operation Enduring Freedom (OEF), and Operation Iraqi Freedom (OIF) very successfully. It would be the basis for many UAVs to come (Goebel, 2013).

Figure 6.   RQ-2 Pioneer over Iraq (from "AAI RQ-2 Pioneer," 2014)

```
MAZLAT / AAI RQ-2A PIONEER:
_____     _____     _____

spec                   metric               english
_____     _____     _____

wingspan               5.15 meters          16 feet 11 inches
length                 4.26 meters          14 feet
height                 1 meter              3 feet 3 inches
payload                45 kilograms         100 pounds
launch weight          190 kilograms        419 pounds

maximum speed          185 KPH              115 MPH / 100 KT
service ceiling        4,575 meters         15,000 feet
endurance              > 6 hours

launch scheme          RATO, pneumatic catapult, or runway.
recovery scheme        Net or runway landing with hook.
payload                Day / night imager.
guidance system        Programmable with radio control backup.
_____     _____     _____
```

Table 5.   RQ-2A Pioneer Specifications (from Goebel, 2013, p. 4.3)

B. TECHNICAL SPECIFICATIONS OF MODERN DAY ARMY UNMANNED AIRCRAFT

OEF and OIF marked the first time the world had witnessed the widespread use of UAVs. During the first decade of the twenty-first century, the Department of Defense (DOD) experienced unparalleled growth in unmanned systems. From 2002 to 2008, the total number of unmanned aircraft increased from 167 to well over 6,000 (Goebel, 2013). While most modern news coverage of "drones" and UAVs is related to the CIA or USAF-flown armed UAVs such as the Predator and Reaper, the focus of this research is UAVs from the U.S. Army Unmanned Aircraft Systems (UAS) Program Office.

Prior to OEF and OIF, technology limited the use of UAVs to very specific missions. As discussed previously, these missions were mainly preprogrammed autonomous flight to a point and then a return to "home." These flights were often failures because the UAVs could not be easily controlled remotely, if at all, and often crashed or were shot down before delivering reconnaissance data (no data uplink). Several technological improvements during the 1980s and 1990s have made remotely piloted vehicles technically feasible and militarily relevant:

- Improved speed and security of communications channels allowed for real time video feeds and push from remote pilots.

- Global Positioning System (GPS) and later the Secure GPS allowed for navigation anywhere in the world

- Commercially available automated approach and takeoff systems as well as autopilot addressed disorientation issues associated with pilots landing via a video feed.

The Army UAS Family of Systems (see Figure 7) is composed of four levels: corps level, division level, brigade level, and battalion/below level. Each of these levels has a dedicated mission and generally speaking, each level or "tier" is defined by range and air time limit.
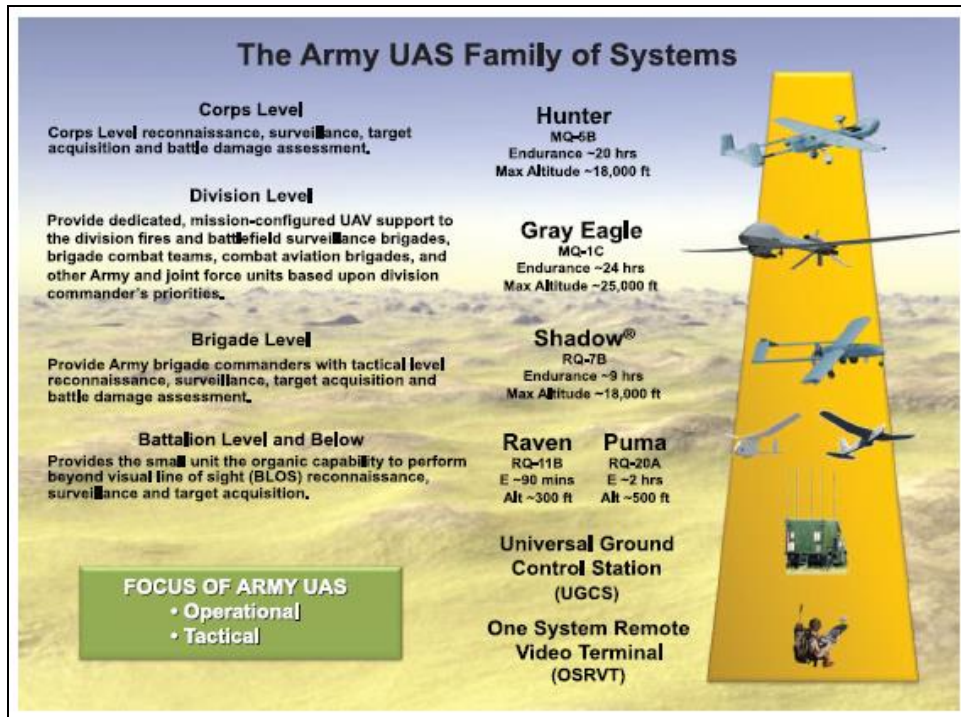
Figure 7.   Army Family of Systems (from Spigelmire & Baxter, 2013, p. 56)

1.   Corps Level

The corps level assets are primarily used for "reconnaissance, surveillance, target acquisition (RSTA), and battle damage assessment (BDA)," although versions have also been armed and used in combat (Spigelmire & Baxter, 2013). The MQ-5B Hunter II is the single member of the corps level class. With twin tail booms and a tripod landing gear, the Hunter looks very similar to the Pioneer; however, it consisted of twin engines in series and was approximately 75 percent larger. An interesting note was that the Hunters twin engines had a very uncommon architecture in that they were in series; with one engine on the rear pushing and the other on the front pulling. The Hunter's original low rate initial production (LRIP) contract was placed in 1993, but due to multiple problems with the system it was eventually cancelled. The previously purchased assets were put into service in several operational missions and even saw duty in the spring of 2003 in the U.S. invasion of Iraq. Continued reliability problems, insufficient range/payload, and requirements for more automation, especially during takeoff and landing, forced a new version of the Hunter. That version was coined the MQ-5B Hunter,

flying for the first time in 2005. The MQ-5B was given a much more capable avionics suit, more powerful engines, dual weapons pylons on opposing wings, and an electro optic turret. Also worth noting is that the MQ-5B was the first production version Hunter to be weaponized. Early versions had been prototyped to accept weapons but the MQ-5B was designed with a weapons payload in mind.

The MQ-5B Hunter has been extremely successful and even though termination of the system has been considered multiple times it continues to fly today (see Figure 8).
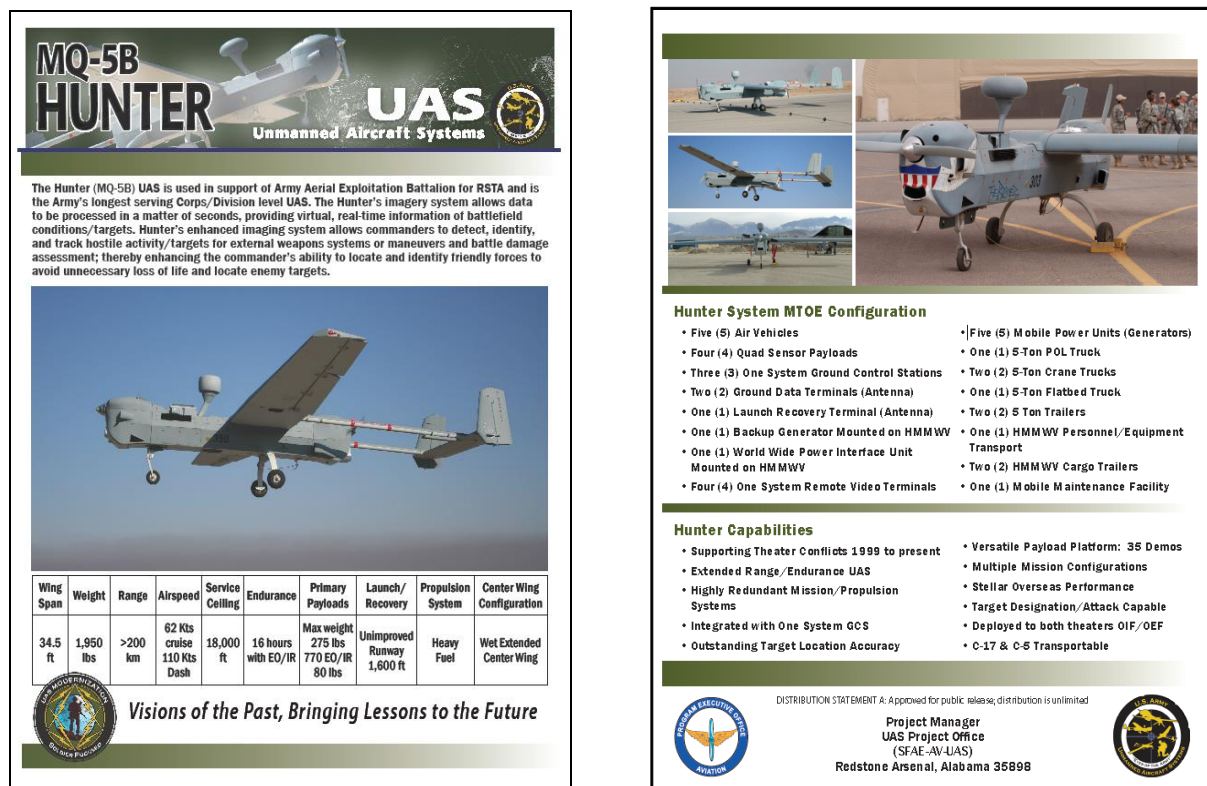
Figure 8.   MQ-5B Hunter Fact Sheet (from Project Manager for Unmanned Aircraft Systems [PM UAS], n.d.-a)

2.   Division Level

Division level assets are used to "provide dedicated, mission-configured UAV support to the division fires and battlefield surveillance brigades, brigade combat teams,

combat aviation brigades, and other Army and joint force units based upon division commander's priorities" (Spigelmire & Baxter, 2013). The single division level Army UAS asset started life in 2005 as the extended range multipurpose (ERMP) UAS. In 2008 the ERMP started initial operational test and evaluation and was in theater, in Iraq, within months. The ERMP was commonly referred to as the "Sky Warrior," but the Army eventually settled on the MQ-1C Gray Eagle (see Figure 9). The Gray Eagle is essentially a USAF predator with a modified power plant and enlarged wingspan to account for the heavier engine. In order to meet Army fuel requirements, the modified power plant is a Thierlert engine that runs on JP-8. This Thierlert engine makes more power, has better fuel efficiency, and is more reliable than the Predator's rotary engine. The introduction of the MQ-1C has ignited a turf war between the USAF and the USA over control of the Predator like assets, but ultimately the Army was successful in maintaining control of this air support asset (Goebel, 2013).

Figure 9.   MQ-1C Gray Eagle Fact Sheet (from PM UAS, n.d.-b)

3. Brigade Level

Brigade level UAS assets are used to "provide Army brigade commanders with tactical level RSTA and BDA" (Spigelmire & Baxter, 2013). Currently there is a single brigade level asset, the RQ-7B Shadow; however, upgraded versions of the Shadow and new completion are in the works.

As shown in Figure 10, the Shadow is obviously a direct successor to the AAI Pioneer and is essentially just a more refined and modernized version (Goebel, 2013). Except for heat and sand induced engine failures, the Shadow served very well during OIF and OEF. The next generation Shadow, the M2, supposedly will also feature a heavy fuel, JP8, engine that should eliminate engine problems while giving the Shadow the ability to be weaponized should the Army decide to do so.

Figure 10.   RQ-7B Shadow Fact Sheet (from PM UAS, n.d.-c)

4. Battalion Level and Below

Battalion level and below assets currently consists of the RQ-11B Raven and RQ-20A Puma. These UAVs "provide the small unit the organic capability to perform beyond visual line of sight (BLOS) reconnaissance, surveillance and target acquisition" (Goebel, 2013). According to UAS information, each system employs a secure digital link and they also share the same control station. Each has been designed to be compatible with the One System Remote Video Terminal (OSRVT) and VUIT-II.

The RQ-11B AeroVironment Raven, as seen in Figure 11, is a hand launched aircraft designed to support battalion and lower maneuver elements with real-time imagery during day or night. Found throughout the Army in maneuver and support units, the Raven's ancestor, the FQM-151A Pointer was double the Raven's size and was originally fielded during the First Gulf War. An upgraded version of the Pointer became the modern PUMA (Goebel, 2013).

Figure 11.   RQ-11B Raven Fact Sheet (from PM UAS, n.d.-d)

At first glance, the RQ-20A Pointer Upgraded Mission Ability (PUMA) (see Figure 12) appears virtually unchanged from the Pointer, but the PUMA has upgrades for better endurance, as well as significant upgrades to the camera and infrared imager system. The avionics within the PUMA were borrowed from the AeroVironment asset, Raven. Even though the PUMA is twice the size of its sibling the Raven, the PUMA was also hand launched. Unlike the Raven, however, its larger size delivers twice the endurance that makes it better suited for demanding environments and operations. The PUMA is typically used for route clearance missions as well as brigade combat teams.

Figure 12.   RQ-20 PUMA Fact Sheet (from PM UAS, n.d.-e)

5.   Common Systems Integration

An important aspect and rarely discussed portion of UAS is the ground support equipment required for all assets. The Army began an ambitious program in the early

2000s to move to a universal ground control station (UGCS) (see Figure 13) as well as an OSRVT (see Figure 14). The original purpose was to enable an open architecture where multiple aircraft could be flown from a single ground control element and through a common data link. An extremely important added benefit, however, is that these assets have taken the data produced by UAVs and elevated its usefulness exponentially by allowing, not only the users, but warfighters across the battlefield access to the video and telemetry of UAVs. The Army One System approach was a significant achievement in integration of the fight.

Figure 13.   Universal Ground Control Station Sheet (from PM UAS, n.d.-f)

Figure 14.   One System Remote Video Terminal Sheet (from PM UAS, n.d.-g)

C.   OPERATIONAL USAGE OF ARMY UNMANNED AIRCRAFT SYTEMS

Operational usage of the Army UAS systems is detailed within the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* and summarized below:

1.   Movement and Maneuver

UAS support the commander by giving him lethal and non-lethal capabilities quickly and accurately (U.S. Army Unmanned Aircraft System (UAS) Roadmap 2010–2035, n.d.).

2.   Intelligence

UAS is a critical component in providing timely and pertinent intelligence, surveillance, and reconnaissance (ISR) data to the soldiers. In the future, UAS will have more onboard data processing capability which will reduce battlefield bandwidth as well as improving the value of transmitted information (U.S. Army UAS Roadmap, n.d.).

3. Fires

UAS systems are increasingly weaponized and therefore can provide soldiers quick and effective threat reduction. UAS systems also provide warfighters various other abilities such as laser designation, target recognition, damage assessment, mortars and artillery support and even electronic warfare (EW) missions (U.S. Army UAS Roadmap, n.d.).

4. Protection

The ever increasing loiter time of UAS assets allows for better protection for permanent military assets as well as improved support of troop movements, operations, and even chemical, biological, radiological, nuclear, high yield explosives (CBRNE) detection (U.S. Army UAS Roadmap, n.d.).

5. Sustainment

As the autonomous functions of UAS improve, so do the possibilities for future uses. Current Army plans include using UAS in the future to support battlefield logistics such as medical evacuation, medical equipment, repair parts, maintenance parts, etc (U.S. Army UAS Roadmap, n.d.).

6. Command and Control

Improved electronics payloads in UAS improve command and control (C2) by giving relays for warfighters outside line of sight (LOS) communication as well as in times of degraded satellite communications (U.S. Army UAS Roadmap, n.d.).

Army UAS systems are segregated into tiers/echelons based upon their range and mission duration. The longest of these is defined as corps level and the shortest is the battalion level and below. Below are the concept of operations (CONOPs) stated in the *U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035* for each of the echelons:

- **Division level and higher (to include corps level)**

  Range : >200km　　　　Duration: >16 hours or more

  CONOPs: The Gray Eagle and the Hunter both provide direct support and ground support with the ability to carry multiple payloads and strike

capabilities in support of division and higher-level operations. Future CONOPs may utilize division level UAS to support sustainment and battlefield logistics through intra-theater lift airland, airlife, or airdrop.

- **Brigade level**

  Range: <125 km   Duration: 5-10 hours

  CONOPs: The Shadow provides reconnaissance, surveillance, and C2 support. This improves the warfighter's target acquisition, situational awareness (SA), BDA, and extends communication reach to LOS range. Future CONOPs may utilize brigade level UAS to support sustainment with varying forms of battlefield deliveries/retrievals.

- **Battalion level and below**

  Range: <25 km   Duration: 1-2 hours

  CONOPs: The Raven and PUMA operate below the coordinating altitude, area used by helicopters or airplanes, and are generally utilized prior to or during maneuvers to provide real-time, organic reconnaissance and surveillance capability. Typical support includes SA, security, target acquisition, and BDA. Future plans for battalion level and below include roles such as signals intelligence, EW, all weather sensing, weapons deliver, tailored or high priority relay, psychological operations support, supply delivery, and covert reconnaissance. Increasing levels of miniaturization will play a role in the ever increasing abilities of micro and nano-size UAVs.

D.   SUMMARY

Unmanned aircraft systems have improved significantly since the days of "aerial torpedoes." The past 20 years have revealed unparalleled growth in operational usage, production, and capabilities. Current UAS are becoming increasingly niche oriented systems. The days of a single UAV doing all the UAS missions are past. Micro-UAS give soldiers street to street superiority. Battalion level and below UAS gives soldiers the ability to monitor larger city sized areas. Brigade and up UAS are capable of a multitude of missions and almost continuous coverage of the battlefield. These incredible machines are capable of offensive and defensive operations to protect the warfighter as well as the ability to deter enemies with lethal and non-lethal armaments. The possible future uses of UAS are impossible to predict. The ever increasing autonomy, loiter time, payload capacity, etc. make for endless possibilities.

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II. U.S. ARMY UNMANNED AIRCRAFT SYSTEMS STAKEHOLDERS

> Think in terms of creating value for all of our stakeholders simultaneously. All stakeholders are interdependent and connected…you have to develop a feeling for who your stakeholders are and figure out how to make them all winners. Mackey, 2013.

It is clear from these words that although John Mackey, Co-founder and Chief Executive Officer of Whole Foods, Inc., is not a military leader and very likely has little to nothing vested in the U.S. Army's unmanned aircraft systems (UAS), he understands the importance of "stakeholders" and the Army can learn from his insights. In a recent article, Mackey (2013) stated that there are all kinds of intelligence, but the one that helped him most was systems intelligence, what he calls "SyQ." He explains, "It refers to the ability to see the big picture, how different parts of a system interconnect. With a high SyQ, you can see the impact that a decision has on all stakeholders" (Mackey, 2013). He goes on to provide a simple-to-understand example of the impact of not understanding stakeholders:

> Remember when auto-industry executives wanted to get loans from Washington and flew there on their private jets? They never considered how that would look to voters--who just happen to be key stakeholders when you want a government loan. That's a systems-intelligence failure. Mackey, 2013.

The Army cannot afford such a failure by not understanding its UAS stakeholders. The first, and most obvious, step to understanding the interrelationships and interdependencies among UAS stakeholders and Army UAS programs is to identify the Army UAS stakeholders. Before we can do this, it is important to understand what a stakeholder is, why stakeholders are important, how to identify an entity as a stakeholder, what analysis must be done to understand relative and useful stakeholder behavior, and how to involve and manage the stakeholders to ensure higher probability of success.

A.   STAKEHOLDER DEFINITION

What is a "stakeholder?" The *Merriam-Webster Dictionary's* definition (Stakeholder, n.d.-b) is:

- A person entrusted with the stakes of bettors
- One that has a stake in an enterprise
- One who is involved in, or affected by, a course of action

BusinessDictionary.com defines a stakeholder as "A person, group, or organization that has interest or concern in an organization" (Stakeholder, n.d.-a).

What these common, by the book, definitions do not take into account, and what Army leaders and managers often fail to take into consideration when properly identifying and engaging stakeholders, is that stakeholders include any entity that is likely to be affected, either negatively or positively, by the project or program in question and can therefore affect the outcome of the project or program, either negatively or positively.

For Army UAS we will define a stakeholder as any person, group, or organization (foreign or domestic) that has interest in or concern with Army UAS and whose direct or indirect involvement with UAS can affect, either negatively or positively, the outcome of the program.

B.   STAKEHOLDER IMPORTANCE

Why are stakeholders so important? Simply put, no organization, project or program can accomplish its goals and missions in isolation. Without the support of other groups, individuals, and communities for things like money, personnel, intellectual property, communication of past experiences, cooperation that leads to better integration, and political support, a program runs a greater risk of failure.

Understanding the Army UAS stakeholders and what their relationships and interdependencies are will help the Army's leadership to satisfy the desires and objectives of high-influence stakeholders, to address the concerns and negative impacts of other stakeholders, and is essential to running an effective organization. Properly managing the

Army's key UAS stakeholders, especially in the current economic climate, can only serve to improve organizational relationships, increase efficiency, cut costs, and ensure that the expectations and impacts of all stakeholders are addressed.

There are many benefits to stakeholder involvement and consideration throughout the life of a program. First, stakeholder involvement leads to informed decision-making, as stakeholders often possess a range and wealth of ideas, experiences and expertise that motivate the development of alternative solutions that can benefit the program (United Nations Environment Programme/Global Programme of Action [UNEP/GPA], 2004). Next, early identification, involvement, and consensus of stakeholders reduce the likelihood of conflicts that could otherwise harm the implementation and success of the program (UNEP/GPA, 2004). Third, stakeholder involvement contributes to the transparency of public and private actions, building trust between the government and civil society, leading to long-term collaborative relationships (UNEP/GPA, 2004).

C. STAKEHOLDER ANALYSIS

Identifying and analyzing a program's stakeholders should not be a one-time activity. The program will continuously evolve and so will the views, interests and importance of various stakeholders as time goes on.

Stakeholder analysis involves four basic steps: identify key stakeholders; assess stakeholder interests and impacts; assess stakeholder influence and importance; and outline a stakeholder participation plan (UNEP/GPA, 2004). These steps and the key questions to address each are referenced below.

In the course of our research we found no evidence to support that a formal identification and analysis of Army UAS stakeholders has ever been conducted. Most Army UAS briefings include a limited, and somewhat typical, understanding of stakeholders and appear to only include those stakeholders that serve to have a positive and immediate/direct impact on the program.

In order to get at the strategic and economic impacts that stakeholders have on Army UAS we found that we had to develop an all-inclusive list of Army UAS stakeholders. Information and conclusions that we provide in later chapters of this study

might provide insights as to why the Army should conduct a comprehensive, formal stakeholder analysis for Army UAS.

1. Step 1: Identification of Key Stakeholders

As indicated in the definition section previously, stakeholders include any person, group, or organization that has interest or concern in Army UAS and who is likely to affect, or be affected by (either negatively or positively) the Army UAS Program.

When identifying the key stakeholders of the Army's UAS Program, there are many considerations. First, who are the expected beneficiaries of the program? Next, are there vulnerable groups who might be permanently or adversely impacted by the program? Who are the supporters and opponents of the program and are their viewpoints understood? Finally, what are the relationships among the stakeholders that could impact the program (UNEP/GPA, 2004)?

Generally, a distinction is made between two kinds of stakeholders - the primary, internal stakeholders and the secondary, external stakeholders (Sharma, 2008). The primary (or internal as we will refer to them) stakeholders are the stakeholders who are directly affected, either positively or negatively, by the project. Secondary (or external as we will refer to them) stakeholders are those entities that play some intermediary role and may have an important effect on the UAS Program's outcome (UNEP/GPA, 2004).

Internal stakeholders include government organizations and program offices that are developing and building UAS capabilities for the Army and the intended users and immediate beneficiaries of Army UAS capabilities (Sharma, 2008). The Army has narrowly defined its UAS stakeholder community, seen in Figure 15, focusing primarily on internal stakeholders that would fall into the shareholder and employee categories discussed later in the chapter.
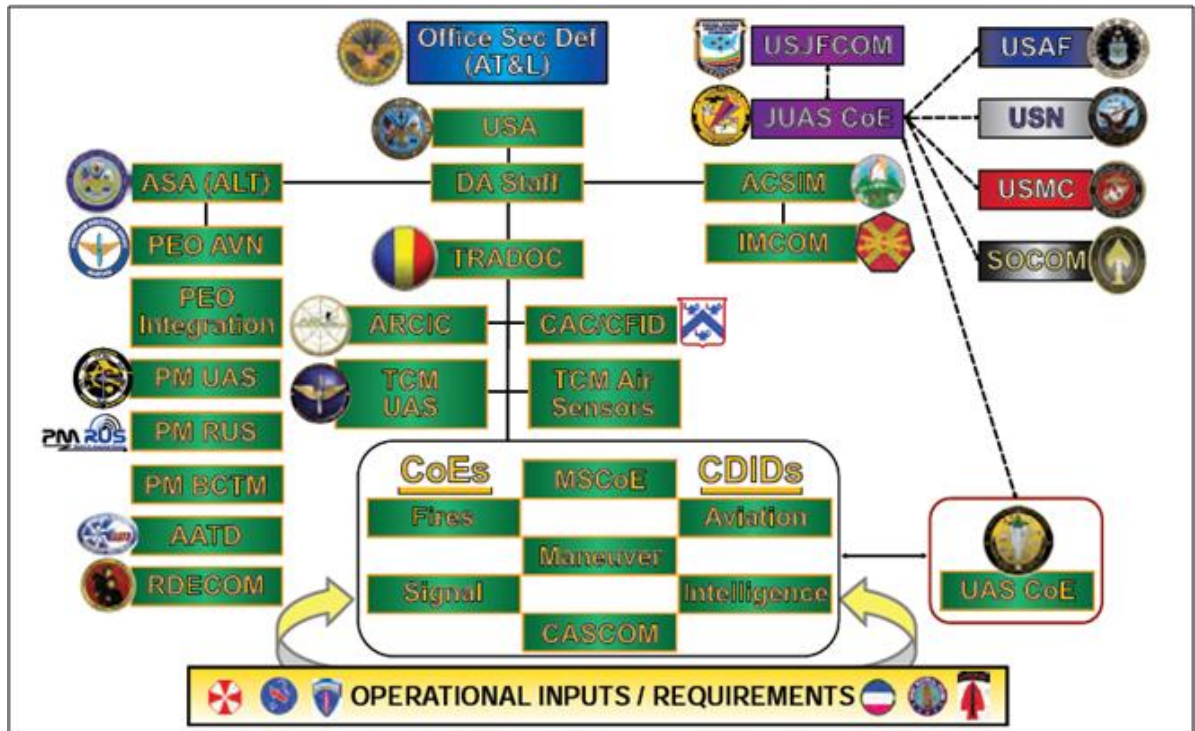
Figure 15.   Army UAS stakeholders (U.S. Army UAS Roadmap, n.d., p. 130)

Before identifying actual stakeholders later in this section, we will first break down stakeholders generically in order to be able to better understand what internal and external stakeholders need to be considered in more detail and with more fidelity for the Army UAS program's success. Stakeholders can be further broken down and broadly separated into five stakeholder categories: shareholders; customers; employees; suppliers; and society (Chartered Quality Institute [CQI], 2014).

Shareholders include investors, owners, partners, directors, people owning shares or stock, banks and anyone having a financial stake in a given business (CQI, 2014). For our federal government-centric program, shareholders include Congress, the Office of the Secretary of Defense (OSD), the Army Staff, the Army's Budget Office (ABO), Executive Science and Technology (S&T) and Program Leadership as they provide resources and financial support in return for increasing value in their investment. Conversely, shareholders may withdraw their support if the actual or projected financial return is no longer profitable. In this case, they could choose to stop government funding or divert resources to other programs. Shareholders put up the capital to get the program

off the ground and are therefore of prime importance during program start up and execution, but once operational it is customers that keep the business going (CQI, 2014).

Customers include clients, purchasers, consumers and end users (CQI, 2014). For the Army's UAS program, customers would be the end users, the service men and women who employ the capabilities, and all of the organizations that take the needs of the end users and translate them into requirements for further exploration and development. Examples of such organizations would be the Army centers of excellence (COE) and the U.S. Army Training and Doctrine Command (TRADOC.) Without customers there is no requirement and without a valid requirement there is no UAS program; customers are therefore the most important stakeholders following the start-up of a program (CQI, 2014).

Employees include temporary and permanent staff and managers (CQI, 2014). In the context of Army UAS, employees would consist of the program management organizations, capability managers, and personnel that take the specified requirements of the customers and translate them into representative capabilities that address critical Army needs.

Suppliers include manufactures, service providers, consultants and contract labor (CQI, 2014). For Army UAS this would consist primarily of the private industrial base that supports the DOD in the robotics, aerospace, and aviation sectors. Suppliers provide products and services in return for payment on time, repeat orders and respect but who may refuse to supply or cease supply if the terms and conditions of sale are not honored or they believe they are being mistreated. Next to customers, suppliers are next in importance as an organization depends upon them for goods and service to succeed. In the case of UAS, without suppliers, production will fall behind and critical parts and materials that make up the physical UAS capabilities will not be available (CQI, 2014).

Society includes the people local communities, the global community and the various organizations set up to govern, police and regulate the population and its interrelationships (CQI, 2014). Society provides a license to operate in return for benefits to the community as a whole and a respect for ethical values, people and the environment

but can censure the organization's activities through protest and pressure groups and ultimately regulatory bodies if these activities are believed to be detrimental to the community. Society as a whole gains economic benefit from organizations but also wants protection from unjust, unethical, irresponsible and illegal acts by organizations (CQI, 2014). Society is a stakeholder group that is easily overlooked, but plays a huge part in the success of Army UAS. Privacy and safety concerns are of the utmost concern for this group. In the context of Army UAS, society might consist of local communities outside of locations being considered for UAS testing and experimentation, as people might believe that UAS flying in such close proximity to their personal property and interests could infringe upon their privacy and place the safety of their families at risk.

Any organization or program that ignores any one of the stakeholder categories does so at its own risk, as all must be considered and each plays a part in the success, or demise, of a program. There must be a balance of cooperation and consideration amongst all stakeholders with a full understanding that there will be conflict between the various stakeholders from time to time as their wants and priorities evolve.

We found many generic references to Army UAS stakeholders in our research, but found no single list that encompassed all Army UAS stakeholders as we have defined them in this study. Table 6 depicts what we, through research of various documents and sources throughout this paper, identified as a comprehensive list of stakeholders in the Army's UAS community.

US Army Unmanned Aircraft System (UAS) Stakeholders			
		Definition	**Stakeholder**	**Provides**
Internal Stakeholders	**Tier 1**	Stakeholders most directly involved with setting program vision and goals for overall program leadership and management. Direct involvement is needed to lead, manage and champion the program. (e.g., Executive Program Leadership, Program Management)	Program Executive Office (PEO) Aviation	Air & Missile Research, Development & Engineering Center (AMRDEC); PM UAS
			Program Manager(PM) UAS	Unmanned Aircraft Systems
			PEO Intelligence, Electronic Warfare and Sensors (IEWS)	Product Manager (PdM) Robotics, Sensors for Unmanned Systems (RUS)
			Product Manager (PdM) RUS	Robotics & Sensors for Unmanned Systems
			TRADOC Capability Manager (TCM) UAS	Coordination of DOTMLPF in support of Army UAS
	Tier 2	Stakeholders most directly impacted by changes resulting from the program. Direct involvement and/or buy-in is needed for the program to succeed. (e.g., Program Customers, Related Programs)	U.S. Army and other services(active, reserve, Guard forces)	UAS Requirements, Urgent Needs fullfilled by UAS, Operators, Training Facilities
	Tier 3	Stakeholders not directly related to the program, but may have general interest in the program's outcome. (e.g., Senior Agency Leadership, Army Workforce)	Headquarter, Department of the Army (HQDA)	UAS Guidance to the S&T & Combat Development Communities; Funding; Resources
			Army Science & Technology (S&T) Community	Align investments w/Army missions & capability needs
			Army Acquisition Community	Develop/acquire/field/support/sustain
			Army Capabilities Development Community	Intelligence, Signal, Maneuver, Fires, Maneuver Support, Sustainment COEs and CDIDs

		Definition	**Stakeholder**	**Role**
External Stakeholders	**Tier 4**	External government stakeholders with direct interest in the program. (e.g., Oversight Groups, Related Programs)	Congress	Regulations, Policy, Guidance; Funding; Political Backing
			OSD	Acquisition oversight for DOD UAS & associated subsystems; Funding; Resources
			DHS	US Customs & Border Protection
			USGS	Proof-of-concept w/ DOD systems; operator training; Certificate of Authorization
			NASA	Lead UAS Integration in the NAS
			NOAA	Monitor Global Environment
			FAA	Integrate UAS in the NAS Safely
	Tier 5	Commercial interests that may be directly impacted by the program or have general interest in the program's outcome. (e.g., Suppliers, Contractors, Special Groups)	Consortia, Coalitions & Academia	Innovative solutions to shape strategy for UAS development & production; utilize the commercialization of patented technologies from DoD labs
			Industry and Commercial Vendors	Innovation & Development, Manufacturing, program support, sustainment contracts
	Tier 6	Other stakeholders with general interest in the program. (e.g., General Public, Foreign entities)	American Public	Swaying of Public Opinion; Votes & Acceptance
			Enemies & Adversaries	Intelligence regarding Counter-UAS capabilities; Tactics, Techniques, and Procedures (TTP)

Table 6.   Comprehensive list of Army UAS stakeholders (after Sharma, 2008, p. 3)

a.   TIER 1: Program Executive and Management

The primary Army office that works with UAS is the Program Executive Office (PEO) for Aviation's UAS Project Management (PM) Office (PM UAS). The mission of PM UAS is to provide the U.S. and its allies world class UAS that are interoperable with Army, joint and coalition partners and that are made affordable through excellence in program management (Program Executive Office [PEO] Aviation, n.d.). It provides a total Army perspective for the life cycle management of the Army's unmanned aircraft system program, including development, acquisition, testing, systems integration, product improvements, production, fielding, and logistical support. PM UAS directly supports the core mission of Army UAS to provide tactical commanders near-real time, highly accurate, reconnaissance, surveillance and target acquisition (RSTA). This mission includes weaponization, communications relays, specialty payloads and linkage to manned aircraft (PEO Aviation, n.d.).

Although UAS capability has grown quickly within the Army, PM UAS is keeping pace with demands while making crucial upgrades and advancements in UAS technology. When OIF began in March 2003, there were only three systems (13 aircraft) deployed in support of combat operations. With U.S. combat forces no longer present in Iraq, UAS support was redirected to Afghanistan and elsewhere in the region. Today, there are hundreds of systems and thousands of aircraft providing 24/7 support to theater operations and wartime missions. As of February 2012, Army UAS had flown 1.46 million total hours, 90 percent of which were in support of OIF and Operation New Dawn (OND)/OEF (Shelton, 2012).

PM UAS currently manages four programs of record (POR): Gray Eagle, Shadow®, Raven, and most recently, the OSRVT (Shelton, 2012). Additionally, PM UAS works in conjunction with counterparts in the user community and with Army senior leadership to rapidly field UAS technology to the Warfighter to address emerging requirements and operational needs for the deployed commanders (Shelton, 2012). Examples of other programs and technologies PM UAS works with are the MQ-5B Hunter, RQ-20A Puma, and Sky Warrior Alpha.

Program Executive Office for Intelligence, Electronic Warfare, and Sensors (PEO IEW&S) is another key stakeholder. As part of the PEO IEW&S, the product manager (PdM) for robotic and unmanned sensors (PdM RUS) falls under the program manager for night vision reconnaissance surveillance and target acquisition (PM NV/RSTA) (Kreider, 2013a). The mission of PdM RUS is to develop, produce, field, and sustain Army and DOD multi-purpose RSTA sensors and sensor systems for unmanned and unattended air and ground applications in support of the twenty-first century warfighter (Program Executive Office for Intelligence, Electronic Warfare, and Sensors [PEO IEW&S], 2013).

A primary project currently being worked by PdM RUS is the Common Sensor Payload (CSP). CSP is the primary payload for all Army UAS (Kreider, 2013b). The CSP provides common command and control across platforms, longer endurance, better situational awareness of the battlespace, increased survivability, and near-real time imagery for detection and classification of targets and threats (Colucci, 2008). CSP provides the Army with operational, logistic, and economic benefits as payloads will share common parts lowering training and maintenance requirements thus lower costs over the life of the system (Colucci, 2008).

Co-located at Fort Rucker with the PM UAS is the TRADOC capability manager for unmanned aircraft systems (TCM UAS). TCM UAS performs as the Army's centralized and overall coordinator for all combat and training development and user activities associated with Army UAS (U.S. Army Aviation Center of Excellence [USAACE], 2013). TCM UAS coordinates work on doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) integration in support of the Army's UAS to ensure success throughout the operational environment. TCM UAS executes its mission by coordinating DOTMLPF development to ensure these key areas remain integrated and support operational requirements. TCM UAS is responsible to integrate all unmanned aircraft "system of systems" components to include unmanned aircraft, mission equipment, payloads, communication architectures, display and control elements, the human element, and life cycle logistics (USAACE, 2013).

In the earlier days of Army UAS, the separation of TCMs and PEOs responsible for UAS aircraft, ground stations and sensors/payloads slowed integration and capability development (Spigelmire & Baxter, 2013e). When the USAACE and TCM UAS absorbed the Army UAS COE, the Army UAS Roadmap document became the responsibility of the TCM UAS and program personnel and those responsible for capability development were more closely linked. The *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035*, now found at the USAACE website, outlines how the U.S. Army will develop, organize and employ UAS from 2010 to 2035 across the full spectrum of military operations (USAACE, 2013).

b.   TIER 2: U.S. Army, National Guard and Other U.S. Forces

Current robotics capabilities are primarily controlled by remote operators, and have been showcased in recent military conflicts for applications such as aerial reconnaissance, searching caves, and disposing of unexploded ordinance (Mait & Sadler, 2013). It is anticipated that the Army's use of autonomous platforms will only increase in the future. Tier 2 consists predominantly of the operational users of the capabilities, the people who rely on the capability for mission success.

Army UAS support a full spectrum of U.S. and allied operations. Maneuver units such as infantry, scout, aviation, artillery, as well as intelligence and medical units benefit from the availability and overall effectiveness of UAS. Missions include but are not limited to intelligence, surveillance and reconnaissance (ISR), BDA, target acquisition, persistent stare for around-the-clock lethal and non-lethal operations, convoy protection and anti-ambush improvised explosive device (IED) emplacement (Shelton, 2012). Reflecting the hard-won lessons of combat, the 2010 *Quadrennial Defense Review* (QDR) reinforced the expansion of the UAS program both implicitly and explicitly with a commitment to excelling in current conflicts and a call for expansion of UAS ISR (Department of Defense [DOD], 2010).

Supporting the technology is a doctrine that embraces the participation, availability and flexibility of the UAS. By formalizing UAS as part of the Aviation Branch, the Army has integrated UAS into the planning, execution and after-action

processes at all echelons. The linchpin to this integration has been making UAS organic to brigade combat teams (BCT), rather than attachments or add-on forces (Institute of Land Warfare, 2010).

Ground control and data dissemination are the foundation of the Army UAS mission and fleet; the link between potential and reality, between sensor and shooter and key to this link are the One System Ground Control Station (OSGCS) and One System Remote Viewing Terminal (OSVRT). The two systems link the operator, the airframe and the ground commander together in a seamless manner through a near-universal interface (Institute of Land Warfare, 2010).

UAS continue to revolutionize the way the Army fights. The Army has been successful in introducing UAS from corps level down to the platoon. In 2003, the Army deployed 13 aircraft for OIF and now 10 years later, about 1,200 unmanned medium and large aircraft are deployed to the field. This number increases significantly when small UAS are included. Just counting medium and large platforms, the Army has more UAS than the USN and USAF combined, and collectively Army UAS have flown almost two million deployed hours (Spigelmire & Baxter, 2013).

U.S. Army installations currently with a UAS/UAV mission include Fort Huachuca, Arizona, Fort Eustis, Virginia, Fort Benning, Georgia, Aberdeen Proving Ground, Maryland, Redstone Arsenal, Alabama, Fort Knox, Kentucky, Fort Gordon, Georgia, Fort Sill, Oklahoma, Fort Leonard Wood, Missouri, Fort Lee, Virginia, Fort Rucker, Alabama, and Picatinny Arsenal, New Jersey. Other Army installations with organizations having, or planning to have by 2015, active UAS operational and deployed missions include Fort Lewis, Washington, Fort Hood, Texas, Fort Carson, Colorado, Fort Drum, New York, Fort Benning, Georgia, Fort Riley, Kansas, Fort Campbell, Kentucky, Fort Bragg, North Carolina, and Fort Stewart, Georgia, and Fort Wainright, Alaska (Gallagher, 2012).

So is there a flip side to the Army as a stakeholder? On the one hand, UAS is extremely beneficial to users from all branches of the Army, but it is not unheard of to have "in-fighting" over who owns the capability. Does the aviation community vs.

Intelligence Community have proponency for the mission? Who should pilot UAS, the officer ranks or the enlisted ranks? Who puts in for and receives funding for UAS? All of these questions are valid when trying to understand the Army users as stakeholders.

Another prime beneficiary of Army UAS is the National Guard. The Army National Guard (ARNG) has over 40 percent of the Army's total authorized inventory of rotary wing aircraft and UAS. In addition to being essential elements of the Army's aviation war fighting capability, these aviation and UAS assets also comprise one of the National Guard's "essential-10" capabilities that provide critical support to the 54 states and territories so that it can quickly and effectively respond to emergencies and natural or man-made disasters within the homeland. The ARNG provides the total Army with 30 of 80 tactical UAS platoons ("Shadow"), plus the same percentage of small UAS assets ("Raven"). When not mobilized, the ARNG aviation units are the most available and fastest responding aviation elements for critical first response missions in the homeland, where they are controlled by the states and ordered out by the governor (Army National Guard, 2011).

Not only do the Active Army, Reserve and Guard forces have stake in UAS, but so do the joint and other services and forces. Why are other services and many allied forces with UAS capabilities stakeholders in Army UAS? Other services can both be a benefit and an obstacle for Army UAS. Of course we all benefit when our UAS capabilities are interoperable and when the information we exchange and share helps to either further our programs or save the lives of our troops, but what about when it comes time to protect funds or proponency? Who owns UAS? Is it the Army? Is it the Navy or Air Force? It is similar to the situation with space assets. The Air Force and Army both have space efforts and rely on space to accomplish their missions, but when it comes to certain topics pertaining to space (space control, for example), both try to lay claim to the mission area and both are competing for scarce resources. UAS is similar in some respects due to stereotypes that exist between the two services. For example, fixed wing assets that fly above a certain altitude "should" belong to the Air Force because it is trained and equipped to fly fixed wing aircraft and they know how to operate in National Airspace. The Army, on the other hand, is thought to be better equipped to fly rotary

wing aircraft at lower altitudes. In other words, the Air Force "should" fly planes and the Army "should" fly helicopters.

    c.   *TIER 3: Army Leadership and Science and Technology, Acquisition, and Capabilities Development Communities*

Headquarters, Department of the Army (HQDA) provides guidance to the S&T materiel development community and the TRADOC combat development community on priorities and needs for annual adjustments to the Army S&T portfolio, including proposals for new Army technology objective (ATO) programs which are the highest priority S&T efforts designated by HQDA (Killion & Nash, 2007). This guidance is signed jointly by the Deputy Assistant Secretary of the Army for Research and Technology (DASA(R&T)), the Assistant Deputy Chiefs of Staff, G-3/5/7, and the Deputy Chief of Staff, G-8, Director for Force Development. It supports objectives in the Army Modernization Plan and the Defense Research and Engineering Director's strategy (Killion & Nash, 2007). HQDA also provides funding via ABO to the various organizations to fund UAS efforts.

Another tier 3 stakeholder is the Army science and technology (S&T) community. Army leaders are vital in specifying and articulating requirements to the S&T community in order to develop and field UAS systems that are interoperable. For example, regardless of the airframe, UAS video and data are delivered to command posts, vehicles and individual soldiers via the OSRVT (Spigelmire & Baxter, 2013g). Additionally, as proven in theater, delivering information from UAS directly to Apache and Kiowa helicopters, referred to as manned-unmanned (MUM) teaming, is a battlefield combat multiplier (Spigelmire & Baxter, 2013). These vital capabilities were born from within the S&T community.

S&T investments are aligned with Army missions and capability needs (Killion & Nash, 2007). TRADOC represents soldiers in the S&T process and its combat developers inform the S&T community of needs in terms of capability gaps and technology shortfalls identified through three Army Capabilities Integration Center (ARCIC) processes: current gap analysis, capability needs assessments and technology shortfall

analysis (Killion & Nash, 2007). TRADOC endorses and validates that the S&T program is pursuing technologies that are relevant to satisfying capabilities needed in the current and future forces (Killion & Nash, 2007). Two of the primary organizations within the S&T community to carry out its UAS endeavors are the Army Research Laboratory (ARL) and the Aviation Applied Technology Directorate (AATD).

The ARL of the U.S. Army Research, Development and Engineering Command (RDECOM) is the Army's corporate laboratory. Its mission is to provide innovative science, technology, and analyses to enable full spectrum operations (Mait & Sadler, 2013). ARL's research continuum focuses on basic and applied research and survivability, lethality and human factors analysis (Mait & Sadler, 2013). ARL conducts research internally and collaboratively with industry and academia through a single investigator program supported by the Army Research Office, through two collaborative technology alliances (CTA) (the Robotics CTA2 and the Micro-Autonomous Systems and Technology (MAST) CTA3), through the Defense Advanced Research Projects Agency (DARPA) and other government agencies, and through small contracts (Mait & Sadler, 2013).

ARL's internal research focuses on human-machine interaction, the development of air and ground platforms, increasing the functionality of backpack-sized ground platforms (e.g., increasing their ability to navigate and sense, and increasing their capacity for distributed networking and cognition), and developing technologies for small-scale mobility, sensors, and power contracts (Mait & Sadler, 2013). The Robotics CTA (RCTA) is concerned primarily with increasing the capacity for autonomous behavior for large platforms, e.g., unmanned vehicles and backpack-sized platforms, and the MAST CTA, with developing palm-sized autonomous platforms contracts. An important issue addressed by all programs is enabling cooperative behavior between robots and with humans (Mait & Sadler, 2013).

The mission of the AATD is to transition critical technologies that enhance and sustain Army Aviation as the premiere land force aviation component in the world (U.S. Army Research, Development, and Engineering Command [RDECOM], n.d.). The executing strategy is to: (1) develop, demonstrate, and apply critical technologies that

enhance the capability, affordability, readiness and safety of DOD aviation systems; (2) provide quality and timely engineering services and rapid prototyping support to Army PEOs, U.S. Special Operations Command (SOCOM), and other customers; and (3) support worldwide contingency operations through the expedited fabrication, application, and support of innovative material solutions. AATD's four main divisions include Platform Technology, Power Systems, Rapid Prototyping and Systems Integration (RDECOM, n.d.).

One of the major outcomes of the stakeholder relationship between the AATD and the PM UAS office is the manned-unmanned teaming capability (MUM-T). Advancements in the interoperability profile development continue to strengthen MUM-T capability that allows the manned aircraft pilot to guide and direct unmanned aircraft 10–15 kilometers ahead, maintaining a greater standoff distance from enemy combatants. MUM-T creates the opportunity for greater lethality from Army aviation assets at a greatly reduced risk to the manned aircraft pilot, since current UAS payloads include laser designators and HELLFIRE® II missiles as well as standard ISR payloads (Shelton, 2012).

Also under tier 3 falls the Army acquisition community. The mission of the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT)) is to provide soldiers a decisive advantage in any mission by developing, acquiring, fielding, and sustaining the world's best equipment and services and leveraging technologies and capabilities to meet current and future Army needs (Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology, 2014).

Within the Army's concept development community, there are several centers of excellence (COE) and capability development integration directorates (CDID) throughout the Army to address how UAS will doctrinally factor into, and integrate with, the major functions performed on the battlefield in order to successfully execute Army operations and accomplish military objectives. These functions include aviation, intelligence, signal, maneuver, fires, maneuver support, and sustainment. The predominant outputs from the COE and CDID stakeholders which affect Army UAS are training, doctrine and tactics, techniques, and procedures (TTP).

All of the different COEs provide a different approach. The Intelligence COE at Fort Huachuca, Arizona provides UAS training and simulation. It is home to the Army's only unmanned aircraft systems (UAV/UAS) training center (Fort Huachuca (U.S. Army), n.d.). The Signals COE is responsible for integration of space and signal capabilities. The Maneuver COE at Fort Benning, Georgia is concerned with unmanned aircraft and armed aerial scout (UA/AAS) integration. The Fires COE focuses on UAS effects integration. The Maneuver Support COE relies on UAS for mine detection capability. Finally, the Sustainment COE is responsible for UAS sustainment issues (U.S. Army UAS Roadmap, n.d.).

d. TIER 4: Non-Army/External Government Stakeholders

In tier 4 are several non-Army, external entities that have some stake in Army UAS. They include Congress, the Office of the Secretary of Defense (OSD), Department of Homeland Security, and many others we will discuss in this section.

(1) Congress. The Congressional Unmanned Systems Caucus educates members of Congress and the public on the strategic, tactical, and scientific value of unmanned systems. Members are committed to the growth and expansion of UAS. Congress develops laws, policies, and guidance to ensure acceptable, safe and sensible use of UAS. Through policies and budget, Congress promotes a larger, more robust unmanned system capability, a stronger industrial base, more jobs and a better U.S. economy (Congressional Unmanned Systems Caucus, 2014).

(2) The Office of the Secretary of Defense (OSD). Within OSD, the Unmanned Warfare & Intelligence, Surveillance, and Reconnaissance (UW&ISR), Strategic and Tactical Systems in the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) and the Office of the Assistant Secretary of Defense for Acquisition lead acquisition oversight for DOD UAS and associated subsystems including control stations, sensors and communications-links within the Office of USD(AT&L). In addition to leading the OSD UAS Task Force (providing oversight for maritime and terrestrial unmanned programs), UW&ISR serves on special committees to address issues with unmanned capabilities. Major programs include the following:

- RQ-4B Global Hawk UAS
- Multi Platform Radar Technology Insertion Program (MP-RTIP)
- MQ-4C Triton UAS
- NATO Alliance Ground Sensor (AGS)
- MQ-9A Reaper UAS
- MQ-1B Predator UAS
- MQ-8C Fire Scout Vertical Takeoff UAV (VTUAV)
- RQ-7B Shadow UAS
- OSRVT & Remote Operated Video Enhanced Receivers
- MQ-1C Gray Eagle UAS
- Unmanned Combat Air System Demonstration

(3)   Department of Homeland Security (DHS). The U.S. Customs and Border Patrol (CBP) falls under DHS and the purpose of its UAS program is to provide reconnaissance, surveillance, targeting, and acquisition (RSTA) capabilities across all CBP areas of responsibility. DHS's UAS are intended as a command, control, communication, intelligence, surveillance, and reconnaissance capability to complement crewed aircraft and watercraft, and ground interdiction agents (Department of Homeland Security [DHS], 2012).

CBP began UAS operations in fiscal year (FY) 2004 with a pilot study conducted by the Office of Border Patrol to determine the feasibility of using UASs in the southwest border region and the pilot study proved the UAS was successful in providing RSTA and actionable intelligence to Border Patrol ground agents. Additionally, CBP works with the DOD and has conducted efforts with the U.S. Army to test new technologies and to share lessons learned (DHS, 2012).

(4)   U.S. Geological Survey. The goal of the U.S. Geological Survey's (USGS) National Unmanned Aircraft Systems (UAS) Project Office is to support the integration of UAS technology into the process employed by USGS scientists to support informed decision making across the Department of the Interior (U.S. Geological Survey [USGS], n.d.). This integration will directly benefit the nation by creating the opportunity

for USGS and its partners to gain access to an increased level of persistent monitoring of earth surface processes (forest health conditions, monitoring wildfires, earthquake zones, invasive species, etc. (USGS, n.d.).

The USGS (2014) is working closely with the National Oceanic and Atmospheric Administration (NOAA), DOD, DHS, National Aeronautics and Space Administration (NASA), industry and academia to utilize UAS technology where there is overlap in mission sets. USGS acquired Raven and T-Hawk small UAS systems (valued at nearly $15M) from the DOD to conduct proof-of-concept projects, have initiated UAS operator training, and submitted numerous Certificate of Authorization (COA) requests to the Federal Aviation Administration (FAA) (USGS, n.d.). USGS' UAS provide an affordable solution for "eyes in the sky" as they do not have the budget to maintain a fleet of aircraft, obtain commercial satellite imagery or to supplement their current aviation units with more cost effective aircraft for specific missions. There is very little maintenance costs associated with the systems and DOD has provided an ample supply of replacement parts (USGS, n.d.).

(5)   The National Oceanic and Atmospheric Administration (NOAA). NOAA's UAS Program also has stake in UAS. UAS can revolutionize NOAA's ability to monitor and understand the global environment (National Oceanic and Atmospheric Administration [NOAA], n.d.). There is a key information gap today between instruments on earth's surface and on satellites, a gap that UAS can bridge (NOAA, n.d.). UAS can also collect data from dangerous or remote areas, such as the poles, oceans, wildlands, volcanic islands, and wildfires, enabling better data and observations to improve understanding and forecasts, save lives, property, and resources, advancing NOAA's mission goals (NOAA, n.d.). NOAA's UAS program and efforts work draws on the experience and knowledge of its industry, academic, and government partners. Together they apply technologies used in national defense, including high and low altitude UAS (PUMA, Skywisp, and Global Hawk) communication technologies, and instruments to benefit the global environment (NOAA, n.d.).

(6)   National Aeronautics and Space Administration (NASA). NASA is another example of an organization that the Army UAS community must work with.

Before unpiloted or remotely piloted aircraft can safely operate in the same airspace as other, piloted aircraft, robotic aircraft and their operators will need to demonstrate a high level of operational robustness and the ability to "sense and avoid" other air traffic (National Aeronautics and Space Administration [NASA], n.d.). NASA's Dryden Flight Research Center at Edwards Air Force Base, Calif., is leading a project designed to help integrate UAS into the world around us (NASA, n.d.). The UAS Integration in the National Airspace System (NAS) project, or UAS in the NAS, will contribute capabilities designed to reduce technical barriers related to safety and operational challenges associated with enabling routine UAS access to the NAS (NASA, n.d.).

NASA's communications experts have flight-tested a prototype radio as part of the agency's contributions toward fully integrating civil and commercial UAS in the NAS. The radio is one of the first steps to provide the critical communications link for UAS pilots on the ground to safely and securely operate their remotely piloted vehicles in flight even though they are many miles—if not continents or oceans—apart (Banke, 2013) Built under a cooperative agreement between NASA and Rockwell Collins in Iowa, the current prototype radio is a platform to test operations at certain frequencies with specific radio waveforms that are unique to its particular task, in this case, command and control of a remotely piloted vehicle (Banke, 2013).

To further explore ways to tackle the unique challenges of integrating UAS in the NAS NASA has launched the Unmanned Aircraft Systems Airspace Operations Challenge (UAS AOC), focused on developing key technologies that will make UAS integration into the NAS possible (NASA, n.d.).

(7) Federal Aviation Administration (FAA). At the forefront of integrating UAS into the NAS is the FAA. UAS must be integrated into a National Airspace System (NAS) that is evolving from ground-based navigation aids to a GPS-based system. Safe integration of UAS involves gaining a better understanding of operational issues, such as training requirements, operational specifications and technology considerations (Federal Aviation Administration [FAA], 2014). In 2012, the FAA established the UAS Integration Office to provide a one-stop portal for civil and public use of UAS in U.S. airspace, to develop a comprehensive plan to integrate and establish operational and

certification requirements for UAS, and to oversee and coordinate UAS research and development (FAA, 2014). The FAA Modernization and Reform Act of 2012 directed the FAA to establish a program to integrate UAS into the National Airspace System at six test ranges (FAA, 2013) . After months of deliberation over 25 applications, the FAA announced the selection of the six sites on December 30, 2013 (Jansen, 2013a). In selecting the six test site operators, the FAA considered geography, climate, location of ground infrastructure, research needs, airspace use, safety, aviation experience and risk (FAA, 2013a). The FAA will not contribute financially to the research, but will assist the test site operators in setting up a safe testing environment (Jansen, 2013a). The six sites will be briefly discussed in the next section on commercial interests.

e. TIER 5 Commercial Interests in Army UAS

State UAS coalitions, consortia and academia are one example of entities that hold commercial interests in Army UAS. As Figure 16 shows, there are more states than not with a vested interest in UAS evidenced by enactment of legislation and adoption of resolutions. To have a large UAS footprint, a state must provide resources from military, public, and private sectors, as all are required for success. One way to form this type of alliance is through a consortium or a coalition to develop the UAS industry—from concept, design, and prototype development to experimental flight, production, and manufacturing (Center for Innovation, 2012). The formation of a UAS consortium (of which there are several across the US) is an opportunity for partnerships across a broad spectrum of stakeholders, and it can be any number of configurations (Center for Innovation, 2012). For example purposes, we will highlight a state coalition that is falls within a geographic area with a large Army presence and stated UAS mission. We will also address the six UAS test sites selected recently by the FAA as well as one non-test site UAS consortium and a recent joint Army/university effort. Finally, we will look at UAS industry and partners.
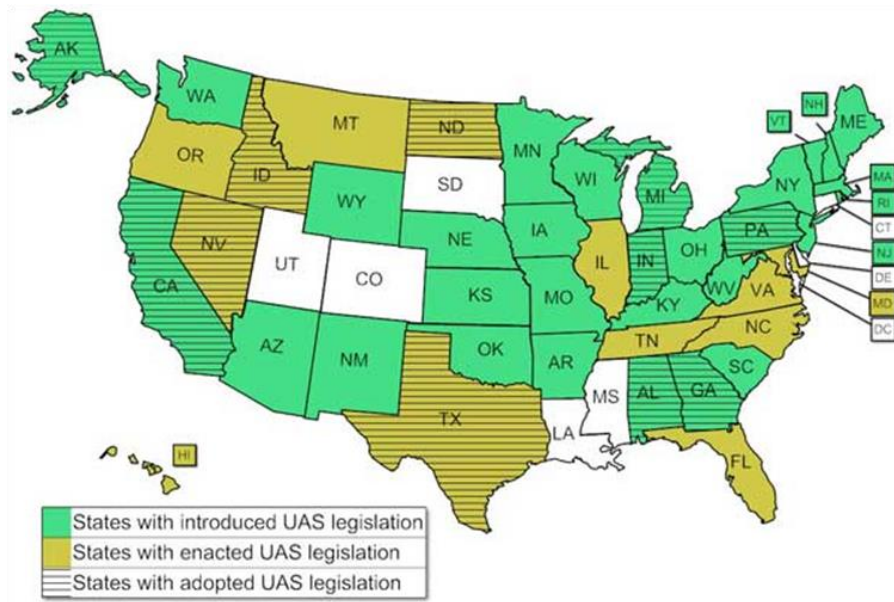
Figure 16.   States with UAS legislation and action (from National Conference of State Legislatures, n.d.)

(1)   The Colorado UAS Coalition. The Colorado UAS Coalition, spearheaded by the University of Colorado Boulder, representing and leading the Colorado UAS Team (a public-private consortium of over 100 Colorado state UAS stakeholders), put forward a unified application to make Colorado home to one of the six future FAA test sites. Senator Mark Udall, Senator Michael Bennet, Governor John Hickenlooper and five of Colorado's members of the U.S. House of Representatives strongly backed this coalition and its application for FAA site selection (Udall, 2013).

Although its application for FAA site selection was not chosen, the Colorado UAS Coalition will remain active in UAS activities. Colorado is already a significant hub for national space activity, with several key military commands and organizations and three space-related Air Force bases located in the Front Range region. Together, these installations employ thousands of military personnel engaged in aeronautics, aviation and space research, testing, and training operations. With the collaboration of the military, high-caliber academic and research institutions, and hundreds of private companies, Colorado has the industrial base in place to facilitate UAS research, development, and testing (Udall, 2013).

Establishing Colorado as a hub for UAS operations stands to bolster the state's economy. Colorado's aerospace industry directly employs close to 25,000 private sector workers, with an average salary of $120,310. It also supports approximately 30,000 military personnel. A 2013 study by the Association for Unmanned Vehicle Systems International reports that the integration of UAS into U.S. National Airspace Systems will create almost 1,200 new jobs in Colorado during the first three years (Udall, 2013).

(2)   FAA-selected Test Sites. The FAA-selected test site operators also have the potential to impact and/or to be impacted by decisions made regarding Army UAS. The six test sites chosen by the FAA in December of 2013 key elements in helping the FAA to meet the goal of sharing the skies by the end of 2015. Additional benefit to the test sites is their anticipated ability to spark and attract economic development (Jansen, 2013). The sites will be active participants in what is expected to be an industry worth billions of dollars. The Association for Unmanned Vehicle Systems International has projected that the industry will create 100,000 jobs and will generate $82 billion in economic activity in the decade after the aircraft are allowed in general airspace (Jansen, 2013). From the FAA's press release (2013), the six test sites ultimately chosen are outlined below.

- *The University of Alaska* was chosen for its diverse set of test site range locations in seven climatic zones as well as a geographic diversity with test ranges in Hawaii and Oregon. The University plans to develop of a set of standards for unmanned aircraft categories, state monitoring and navigation, and safety standards for UAS operations.

- *The State of Nevada* will concentrate on UAS standards and operations, operator standards and certification, and evolution of air traffic control procedures as UAS are integrated into civil environment. Nevada's location further adds to geographic and climatic diversity.

- *New York's Griffiss International Airport* plans to work on developing test and evaluation as well as verification and validation processes under FAA safety oversight. Their research will focus on sense and avoid capabilities and integrating UAS into highly congested airspace.

- *North Dakota Department of Commerce* plans to develop UAS airworthiness data, validate high reliability link technology, and conduct human factors research. North Dakota is the only site that offers a test range in the Temperate (continental) climate zone and includes a variety of different airspace to benefit multiple users.

- *Texas A&M University, Corpus Christi* plans to develop system safety requirements as well as protocols and procedures for airworthiness testing. The University contributes to geographic and climactic diversity.

- *Virginia Polytechnic Institute and State University (Virginia Tech)* plans to conduct UAS failure mode testing and to identify and evaluate operational and technical risks areas. This proposal includes test site range locations in both Virginia and New Jersey.

Each test site operator will manage the site in a manner that will give access to parties interested in using the site (FAA, 2013). This could be of benefit to the future of Army UAS if it chooses to interact with this stakeholder as the Army could leverage resources that the commercial entity has and garner lessons learned on technologies and capabilities of interest to both parties such as sense and avoid technology, safety, pilot training and certification, and test and evaluation.

(3) Universities and Academia. Universities across America can also influence Army UAS. One such example is the University of Alabama, Huntsville. The future of unmanned aircraft systems is the focus of an agreement between the University of Alabama–Huntsville (UAH) and the Army. The university and the Army's Unmanned Aircraft Systems Program Management Office operate under a memorandum of understanding to explore opportunities for collaboration to promote the development of the next generation of unmanned aircraft systems ("Army's unmanned aircraft systems agreement," 2013). It is also intended to further the education of young engineers specializing in unmanned aircraft systems matriculating at the undergraduate and graduate levels that might one day go to work on behalf of UAS within the UAS community ("Army's Unmanned Aircraft Systems Agreement," 2013).

Various military schools may also offer expertise and knowledge that will influence Army UAS. The Naval Postgraduate School's Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) provides a collaborative environment and community of interest for the advancement of unmanned systems education and research endeavors across the Navy, Marine Corps and Department of Defense (Stein, n.d.). One of CRUSER's goals is to link engineers and technical personnel developing UAS capabilities with stakeholders and participants dealing with the cultural, ethical, political and societal issues and concerns related to unmanned

systems (Buettner, n.d.). Although CRUSER is primarily focused on Navy, much of their information, research, and experimentation results are shared and exchanged with other DOD and UAS stakeholders. Two examples of efforts important to the Army are the development of counter-UAV that specifically threaten other UAVs (such as an expendable "hunter-killer" UAV) and development of a UAS employed in non-kinetic operations to disable enemy assets (such as jamming or spoofing operations) (Buettner, n.d.).

(4)   UAS Industry and Manufacturing Partners. Industry is the final entity we will discuss under tier 5 stakeholders. There are several U.S. industries that deal with unmanned aircraft systems, namely aerospace, robotics, and aviation, which are also highly vested stakeholders for Army UAS. A number of U.S. firms currently manufacture UAS for military and civil government operations. According to Forecast International, total UAS spending will increase over the next decade. Of the total, 46 percent of spending will be on the air vehicles themselves followed by 38 percent of spending on payloads and the remainder on ground control equipment (Harrison, 2013).

Interest in UAS has grown dramatically during the conflicts in Afghanistan and Iraq. Demand for the capabilities they bring has exceeded the supply (Office of the Under Secretary of Defense Acquisition, Technology & Logistics [OSD AT&L], 2011). Predator and Global Hawk provide constant imagery and are now virtually indispensable to combatant commanders in theater (OSD AT&L, 2011).

Over the last decade, business development of UAS has been left to smaller, independent, startup companies as large aerospace primes see little profit in the typically small, inexpensive and short production UASs (OSD AT&L, 2011). Industry thrives based on the innovation brought to it by these small independent firms. In order to move their ideas into reality, however, these small firms typically enter into strategic alliances with a larger prime integrator or are bought out (OSD AT&L, 2011). Working through a prime integrator allows the smaller companies to continue to do the innovation and creativity that they do best without the problems associated with learning how to build and develop a fully integrated system (OSD AT&L, 2011). Mergers and acquisitions will

continue and further consolidation within the UAS industry is expected as the UAS demand continues to expand and larger programs develop.

Also, the larger than originally anticipated UAS fleet is creating a greater demand and opportunity for industry to support infrastructure such as training, services, maintenance, and data management (Harrison, 2013). What remains unknown is whether the Army is prepared to adequately support the increased inventory as assets are brought back to the U.S. following wartime operations. In an effort to help address this concern, in September 2013, the Army awarded Wyle, Inc. an $18.5 million, three-year task order supporting the Army's PM UAS in Huntsville, AL ("Wyle Wins $18.5 Million," 2013). Wyle will provide engineering, analysis and testing to identify approaches for reliability and supportability improvements ("Wyle Wins $18.5 Million," 2013). This research and development work will include aircraft associated support and production systems as well as vulnerability studies leading to increased equipment reliability and a reduction in support costs ("Wyle Wins $18.5 Million," 2013). This requirement stemmed from a perception that fielded UAS and the equipment used to support them are aging faster than originally expected due to extremely high use in the Afghanistan and Iraq war zones. Reliability, maintainability, quality, supportability and interoperability issues have become more apparent because of the high use ("Wyle Wins $18.5 Million," 2013).

U.S. manufacturers with the largest share of the global UAS market include General Atomics (20.4 percent), Northrop Grumman (18.9 percent), Boeing (1.5 percent), and Textron (which bought out AAI) (1.2 percent) (Harrison, 2013). Other U.S. companies such as AeroVironment, Raytheon, Elbit Systems and Wyle also help to shape the world of Army UAS. The Association for Unmanned Vehicle Systems International (AUVSI), an advocacy organization that promotes unmanned and robotic systems, had more than 500 corporate members in 2011, representing a significant number of U.S. companies with a stake in UAS manufacturing activities (Harrison, 2013).

Despite the boom, the unmanned aircraft industry is still trying work through restrictive rules and policies that will keep their designs grounded until 2015 at the earliest (Parsons, 2013). While drones have been proven effective as a weapon of war, they have been used for that purpose predominantly over areas of the world with little or

no commercial air traffic (Parsons, 2013). In order to properly train future UAS operators to fly safely, efficiently, and effectively, it is necessary for Army training programs to include access to the National Airspace System (NAS). Until Army UAS has the ability to effectively "sense and avoid" other air traffic, it is unlikely that they will be able to convince the FAA and the American people that they can operate outside of very restricted, and often unrealistic, military environments.

f.   TIER 6: Other Stakeholders with General Interest

The American people are the largest group of stakeholders having a general interest in UAS. Without the support of their constituents, it is unlikely that elected officials will approve funding for UAS. UAV/UAS, drones, and robots have been common in the headlines around the U.S. lately. People are concerned about UAS presence and use within our NAS, within our borders as well as on the deadly effects that UAS have had on thousands of innocent civilians in foreign countries.

Privacy advocates with the American Civil Liberties Union and other organizations have expressed concern about the operation of unmanned aerial systems by government agencies (Gallagher, 2012). The fear is that any UAS operator could accidently or purposefully tread on individuals' privacy by allowing persistent wide-scale surveillance (Gallagher, 2012). There have been stories in the news of late highlighting blatant abuse of authority and access to spy on someone that has no bearing on any military or national security mission. When people begin to fear that their civil liberties are threatened, they get upset and voice their displeasure and distrust which makes it difficult sometimes for newer technologies to find acceptance. The American people are accepting enough of UAS when they are deployed and not immediately affecting them, but here on U.S. soil, many are in opposition.

Enemies, adversaries and forces opposing the U.S. also have stake in UAS. You might ask why we would include enemies and opposing forces such as Al Qaeda and the Taliban as "stakeholders" in Army UAS. We noted earlier that by definition a stakeholder can affect a program either positively or negatively. We would maintain that our enemies can both positively and negatively affect Army UAS. As one famous quote attributed to

both Sun Tzu and Niccolò Machiavelli says, "Keep your friends close, and your enemies closer." In other words, know the enemy, learn from him, how he will react, what his "stake" is in Army UAS. In understanding the effect Army UAS has on an adversary and how it affects his behavior, the Army will develop more effective capabilities and will develop better TTP to use and protect them. If an enemy is capable of detecting, destroying or degrading Army UAS capabilities, he has negatively impacted the outcome of the program. If an enemy is capable of convincing the world that UAS kill thousands of innocent people, this has a negative impact on the program.

Al-Qaeda's leadership has assigned cells of engineers to find ways to shoot down, jam or remotely hijack U.S. drones, hoping to exploit the technological vulnerabilities of a weapons system that has inflicted huge losses upon the terrorist network as well as killing an estimated 3,000 people over last decade (Whitlock & Gellman, 2013). U.S. intelligence officials have closely tracked the group's persistent efforts to develop a counter-drone strategy since 2010 (Whitlock & Gellman, 2013). Furthermore, details of al-Qaeda's attempts (since 2006) to fight back against the drone campaign are contained in a top-secret intelligence report, *Threats to Unmanned Aerial Vehicles* provided to the *Washington Post* by Edward Snowden, the fugitive former National Security Agency contractor (Whitlock & Gellman, 2013).

U.S. UAS strikes have forced al-Qaeda operatives and other militants to take extreme measures to limit their movements in Pakistan, Afghanistan, Yemen, Somalia and other places (Whitlock & Gellman, 2013). Although most around the world would argue that this is a good thing, there is a flip side. Drone attacks have taken a heavy toll on foreign civilians, generating a bitter popular backlash against U.S. policies toward those countries (Whitlock & Gellman, 2013).

With so much information available to our enemies through open-source information, leaked sensitive/classified information, or reverse-engineering, the likelihood of any one of our enemies recruiting operatives with the right skill-sets, training and education to develop and produce effective counter-UAS capabilities continues to grow and with that so must the Army's ability to address, adapt and

overcome. Clearly, understanding this particular "stakeholder" can only serve to help the Army develop and deploy UAS to counter the enemy.

2. Step 2: Assess Stakeholder Interests and the Potential Impact of the Project on these Interest

Once the relevant stakeholders have been identified, their interest in the project can be considered and weighed. It is important to realize when assessing the interests of the different stakeholders that some stakeholders may have hidden, multiple or contradictory aims and interests (UNEP/GPA, 2004).

To assess the interests of the identified stakeholders it is important to understand the stakeholder's expectations and perceived benefits. Further, if the stakeholder is able and willing to mobilize resources for the project, what are they and to what extent? Finally, if the stakeholder's interests conflict with the project goals, this must be identified and addressed early to avoid potential strife in the project (UNEP/GPA, 2004).

3. Step 3: Assess Stakeholder Influence and Importance

The third step involves assessing the influence and importance of the identified stakeholders. Influence refers to the formal or informal power that a stakeholder has over a project. Importance relates to the level of active stakeholder involvement needed to achieve project objectives. Stakeholders who are important are those that benefit from the project or whose objectives overlap (positively or negatively) with the objectives of the project. Some stakeholders who are very important might have very little influence and vice versa (UNEP/GPA, 2004).

To assess stakeholder importance and influence it is necessary to understand not only how organized the stakeholders are, but the span of formal and informal control they have over decision making, resources, strategies, and their business and personal connections. This understanding will aid in assessing the political, social and economic power and status of the stakeholders and importance of each to the success of the project (UNEP/GPA, 2004).

4.   Step 4: Outline a Stakeholder Participation Strategy

Based on responses in the previous three steps, planning and consideration as to how to best involve and address the different stakeholders can be accomplished. Involvement of stakeholders should be planned according to their interests, importance, and influence. There are many ways to view stakeholder involvement and participation throughout a project's evolution.

The primary focus of stakeholder engagement efforts and resources should be on stakeholders exhibiting a high degree of influence. Stakeholders of high influence and low support, or "High Influence Challengers," could be converted to "Champions" or the project management team could plan countermeasures to neutralize potentially harmful actions that could negatively impact the project. High Influence Champions are those stakeholders from whom positive energy can be harnessed to further program objectives and build a strong foundation for support (Sharma, 2008).

For low influence stakeholders it is important to maintain awareness of any actions that could harm the program if they are Challengers and to maintain a positive relationship if they are Champions. Little energy and emphasis should be placed on converting them or increasing their influence (Sharma, 2008).

D.   SUMMARY

An Army UAS stakeholder is any person, group, or organization (foreign or domestic) that has interest in or concern with Army UAS and whose direct or indirect involvement with UAS can affect, either negatively or positively, the outcome of the program.

The Army has never done a formal stakeholder identification and analysis for Army UAS. With only a narrow current understanding of stakeholders, the Army does not adequately leverage the support of others for things like funding, resources, intellectual property, lessons learned, and cooperation that lead to better integration, political and popular support, and better odds of accomplishing goals and missions.

In this chapter, we identified a comprehensive list of both internal and external UAS Stakeholders for consideration. To truly benefit from a relationship with and/or understanding of the key stakeholders, the Army would need to take the action one step further and assess the interests, influence and importance of each stakeholder and the impact they have on Army UAS and how they could better incorporate them into a participation strategy.

In the next chapter, we will examine some strategic and economic relationships that exist between key stakeholders and Army UAS and their potentially positive and negative implications.

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III. FACTORS THAT AFFECT ARMY UAS STAKEHOLDER RELATIONSHIPS

In Chapter II, we defined a stakeholder as any person, group, or organization (foreign or domestic) that has interest in or concern with Army UAS and whose direct or indirect involvement with UAS can affect, either negatively or positively, the outcome of the program. Some factors impacting Army UAS are more challenging to manage than others. There are varying degrees to which such factors can be controlled, but understanding the factors can only help the Army to deal with the effects. In this chapter we will discuss some recurring factors that affect Army UAS stakeholder relationships.

A. ORGANIZATIONAL CULTURES AND VALUES

Not all Army UAS stakeholders we identified in our previous chapter will necessarily share the same concerns or have unified opinions or priorities. Depending on the topic in which they have a "stake," stakeholders can serve to help or hinder Army UAS.

In his work *Organizational Culture and Leadership*, Edgar H. Schein offered a definition of what he called "an empirically based abstraction" (Desson & Clouthier, 2010):

> Organizational culture is a shared pattern of basic assumptions learned by a group as it solves its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems. Desson & Clouthier, 2010.

This definition applies to organizations of virtually every kind—families, social clubs, work groups, companies, governments, and nations (Desson & Clouthier, 2010). Each organization eventually develops its own set of implied and understood beliefs and practices which often become "gospel truth." It is not easy to explain exactly what the cultural characteristics of a particular group are, but its members understand and conform instinctively to its implied expectations (Desson & Clouthier, 2010).

The Army, and more specifically, Army UAS, is no different. The use of UAS by the Army provides potential for improved situational awareness, intelligence, and fire power with little risk to U.S. soldiers. The application of UAS capabilities, however, poses issues such as inter-service disputes over their control, debates over how to organize and integrate them, and how to process and disseminate collected intelligence data (Blom, 2010). Army UAS stakeholders have certain expectations of UAS that are based on implied, but often unstated opinions, beliefs, and history. We discussed briefly in Chapter II the perception that the Air Force "should" fly planes and the Army "should" fly helicopters, but there are other examples, such as that "UAS are intelligence assets vs. aviation assets," that there should always be a human in the loop versus autonomously operated aircraft, and that UAS pilots "should" be officers vs. enlisted personnel. Each of these scenarios highlights both the positive and negative sides to Army UAS stakeholder relationships.

There are two distinct priorities that appear to be at the root of any of these observed opinions and beliefs. One is competition for funding and the other is competition for ownership of missions that have associated funding lines. The Army has expressed concern that Army UAS costs must come down and that the Army must retain control of its UAS operations (Magnuson, 2013). These two priorities cause the most strife, as there appears to be a continual battle for both funding and control of UAS.

In the next four sections we will outline different scenarios where Army UAS stakeholders may share the same concerns on one hand, but on the other, may find that differing opinions and priorities can adversely affect the UAS program.

1.   Army Versus Air Force

Advocates of airpower have disputed its role in war since the 1920s (Blom, 2010). The debate has always focused on whether airpower, of which UAS are a modern day form, should be applied tactically or strategically (Blom, 2010). Perceptions as to which service, Army or Air Force, plays the tactical role and which plays the strategic role are based on the vastly different missions of the two services. The Air Force collects intelligence and conducts reconnaissance and surveillance for strategic missions. The

Army does the same, but in more tactical scenarios (Magnuson, 2013). The long-standing battle between the Air Force and the Army over close air support and air mobility was a classic mission conflict in which both services agreed on the need for the capabilities, but disagreed on procurement responsibility and authority. The Air Force sought to deprioritize these missions in favor of air superiority and strategic bombing. As a result, the inter-service conflicts almost certainly reduced the effectiveness of U.S. ground-air collaboration in Vietnam (Farley, 2010).

The debate unfolds much the same for unmanned aircraft. The Air Force claims that it can cover most missions (strategic and tactical) with its current inventory of UAS and that for both the Air Force and Army to have systems that basically do the same thing is wasteful duplicity (Magnuson, 2013). The Army, however, argues that to have a quick reaction capability as conditions change on the battlefield, they cannot afford to put in a "request" to another service for a UAS to support its troops (Magnuson, 2013).

The Army has been battling the Air Force for decades to gain and maintain control of its own unmanned aircraft systems and programs. The most recent turf battle between the Army and the Air Force over who should operate unmanned systems tactically over battlefields was fought and won by the Army in the latter half of the previous decade. As a result, the Army has subsequently controlled its own fleet of UAS in wartime environments. Due to a bleak budget climate and a trend to downsize and consolidate within the Department of Defense (DOD), however, the old debate on control is resurfacing and change appears imminent (Magnuson, 2013).

It is not difficult to understand when looking at the Army's Gray Eagle and the Air Force's Reaper and Predator, which are all very similar aircraft, why one would determine that it is likely more efficient and less expensive to let the Air Force do all of the flying (Magnuson, 2013). Potential redundancy of effort across services has been an issue for decades.

In the mid to late 1980s, there was a congressional effort to address inefficiencies, waste and duplicative UAS efforts across the individual services. From 1986 to 1988, the House and Senate Armed Services Committees and the Senate Appropriations Committee

questioned the effectiveness of each service maintaining its own UAV program (Blom, 2010). As a result, DOD was required to produce a report outlining its plan to minimize waste in its services' UAV programs. In 1988, DOD published its first annual "Master Plan for UAV Development," which represented one of the first policy statements by DOD regarding unmanned aircraft systems (Blom, 2010). Additionally, in an effort to promote interoperability and commonality among unmanned systems, Congress transferred all fiscal year 1988 UAV funding from each of the services into a Joint Program Office (JPO) that would centrally manage all research, development and procurement of UAVs until 1994 (Blom, 2010).

More recently, to address redundancies in service UAS capabilities, the Deputy Secretary of Defense directed that the Army and Air Force acquire a single air vehicle in lieu of operating both a Predator and ERMP fleet, making all three of the Army's UAS programs joint systems (Kappenman, 2008). The premise for this mandate is that adopting a more joint approach provides "significant" cost and schedule savings for DOD's unmanned systems programs (Liang, 2013).

Although this premise is simple enough on the surface, it may not be desirable for the Army. We previously discussed the Army's perception that it must organically control its assets in order to adequately support troops on the ground. Commanders on the ground require real-time, dedicated combat information without lengthy processes. Army UAS is tailored to provide that dedicated tactical RSTA, and other battlefield enablers such as communications relay and MUM teaming (Kappenman, 2008). While it is true that Air Force systems are capable of providing such support, their employment is geared at the strategic levels and their priorities are therefore not always on the current ground fight which is the Army's priority. Troops in contact with the enemy cannot afford to wait for a UAS request to move through the division staff, the corps staff, and the Joint Force Air Component Command (JFACC) staff/leadership, and then, if approved, wait for the asset to travel en route to the ground forces (Kappenman, 2008). Competing service priorities necessitate the Army maintaining its own organic UAS capability to achieve mission success on the ground.

2. Army Aviation Versus Army Intelligence

Another battle for control exists between the Army's aviation and intelligence communities. Control of electronic surveillance assets and sensors such as the UH-60 and now UAS has gone back and forth between Army aviation and military intelligence units through many wars (Blom, 2010).

Capabilities of Army UAS have evolved from a theater intelligence asset to primarily tactical roles such as surveillance, reconnaissance, attack, targeting, communications relay, convoy over-watch, and cooperative target engagement through manned and unmanned (MUM) teaming. The Army is employing UAS as an extension of the tactical commander's eyes to find, fix, follow, facilitate, and finish targets. Army UAS missions are integrated into the maneuver commander's mission planning, at the start, as a combat multiplier in the contemporary operational environment (Kappenman, 2008).

Army commanders need UAS to do more than just support strategic intelligence, surveillance, and reconnaissance (ISR), which is a process, not a mission. Army commanders require UAS that execute tactical reconnaissance, surveillance, and target acquisition (RSTA) in direct support of their ground maneuver mission (Kappenman, 2008). In this sense, UAS serve as both an aviation and intelligence asset.

But who is responsible for the UAS—what type of mission it flies and the data which it collects? Is it the aviation community or is it the Intelligence Community? It appears that both branches have responsibility, but it is not clear how each will be equitably resourced to carry out the responsibilities as budgets and manpower shrink. For the time being, intelligence and aviation communities have devised ways to resolve "ownership" issues through cooperative arrangements. One such arrangement addresses UAS training.

To address the Army's UAS training requirements, the Unmanned Aircraft Systems Training Battalion (UASTB) was activated on April 19, 2006 during the transition of authority for UAS training from the U.S. Army Intelligence Center to the U.S. Army Aviation Center of Excellence. On June 14, 2011, UASTB was designated

2nd Battalion, 13th Aviation Regiment. Second Battalion, a tenant organization at Fort Huachuca, Arizona, operates the largest UAS training center in the world, training approximately 2,000 soldiers, marines and foreign military students annually with over 125,000 square feet of training space, four hangars and three runways. Programs of instruction at the Fort Huachuca "school house" include Shadow UAS Repairer, Hunter UAS Repairer, UAS Operator Common Core, 1500 UAS Warrant Officer Technician, and the UAS Unit Commander and Staff Officer Course (PEO Aviation, n.d.).

This cooperative organizational tenant relationship shows the aviation and Intelligence Community's willingness to attempt to work together to ensure that, while one branch of the Army is equipped to fly and maintain the aircraft, they are equally committed to understanding how their missions impact the Intelligence Community and must continue to nurture that relationship for Army UAS to function as a cohesive program.

3.   Manned Aircraft Systems Versus Unmanned Aircraft Systems

Today's force has a mix of both manned and unmanned aircraft systems. By combining advanced sensors, tactical RSTA, MUM teaming of UAS, attack and reconnaissance helicopters, and air assault aviation assets, the Army has been able to maximize combat power and employ lethal and nonlethal effects to deny the enemy a permissive environment to operate. MUM engagements have been instrumental in deterring future IED emplacement by providing the insurgency a hostile environment in which to operate (Kappenman, 2008).

The teaming of manned platforms with UAS is fast becoming the standard in the Army rather than the exception. MUM teaming extends the shooter's eyes on target by linking UAS sensors to the manned platforms (Kappenman, 2008). It is still questionable, however, how manned-unmanned teaming will be applied and what effects it will have on acquisitions (Magnuson, 2013).

There are those who think unmanned systems could completely replace armed aerial scout (AAS) helicopters, but others believe a soldier in a manned aircraft must always be in the loop (Magnuson, 2013). Regardless, evidence shows that MUM teaming

is beneficial and potentially a game-changing tactic. MUM teaming is a potential cost-saving move as the Army will not need to purchase as many costly armed aerial scout helicopters (Magnuson, 2013). It is also a life-saving measure, as it takes a human pilot out of certain dangerous situations.

Creating a doctrinal template better integrating unmanned aircraft into the Full Spectrum Combat Aviation Brigade is one method on the table to maximize the potential of MUM teaming (Gould, 2013). Helicopters are generally the better choice when troops are on the ground as human pilots can bring intuition and contextualize action on the battlefield (Gould, 2013). Visible helicopters deter insurgents from attacking, thereby building trust with the local population, and according to Gould (2013), "attack aviation assets can help establish security for key engagements, and then leave the immediate area during the actual meeting, thereby avoiding an overbearing presence."

For missions that require stealth and longevity, unmanned aircraft are better because unmanned aircraft are less detectable, harder to hit with small arms, have better sensors, loiter longer and more slowly, and can "provide a real-time feed to operation centers at some fraction of the cost (in terms of risk, dollars and manpower) of rotary wing assets" (Gould, 2013). It is still debatable, however, whether the use of unmanned strikes reduces or increases civilian casualties and it is generally believed that using unmanned assets and helicopters in tandem to reduce collateral damage is a preferred method of operations (Gould, 2013).

For manned and unmanned aircraft to operate in harmony better communication is needed between operators and commanders on the ground as well as integration of air and ground operations, as operators of both types of aircraft must know whether a ground commander they are supporting is clearing an area of insurgents or trying to win over the population (Gould, 2013).

There is also an argument that by increasing the acquisition of UAS, funds might be diverted from manned aircraft programs and that the technical expertise to build such manned aircraft will erode due to a concentration solely on unmanned aircraft (Gertler, 2012).

4.   Enlisted Versus Officer UAS Operators

Does the status of "manned" or "unmanned" have any bearing on how a UAS should be flown? Integrating unmanned aircraft into a force structure that has been dominated by manned aircraft is naturally challenging and poses both control (of aviator status) and cost issues.

Although the Air Force and the Army operate similar versions of MQ-1 aircraft, their approaches to manning them are very different. Both services seem effective despite their dissimilar approaches to personnel management, but is one more cost-effective than the other (Hasik & Coerr, 2011)?

The Air Force organizes all its MQ-1B Predators and MQ-9 Reapers into a single formation, the 432nd Wing, based at Creech Air Force Base in Nevada. The 432nd is composed of two groups, one for operations (flying) and another for maintenance. As of late 2010, the 432nd had approximately 140 Predators and 35 Reapers. This centralization of assets and personnel matches the service's foundational view of the importance of centralized control of military aviation, a corporate viewpoint dating to the 1930s and 1940s (Hasik & Coerr, 2011).

The Army approaches the organizational question quite differently. The ground force ethos of the Army has generally valued decentralized execution—and more so in recent years, as the counterinsurgency experience in Iraq and Afghanistan has thrust more responsibility upon captains and corporals. Since losing the Predator mission to the Air Force in the early 1990s, the Army has chafed at its lack of direct control. Thus, the Army is parceling out its drones as it has long done with its manned helicopter fleet. The aviation brigade of each division is receiving a single company of 12 MQ-1Cs, at a rate of about three companies standing up annually (Hasik & Coerr, 2011).

Automation has been perhaps the most widely discussed difference in the Air Force and Army approaches. While the original MQ-1B was not designed for automated takeoffs and landings, the MQ-1C has been completely autonomous. Full automation of

these functions would mean that no pilots would need to deploy to overseas wars, allowing for completely centralized management of aircrews stateside (Hasik & Coerr, 2011).

Rank and experience are the next obvious differences in approach. As is widely known and remarked upon, the Air Force's drone pilots initially came entirely from officer ranks and from the cockpits of manned aircraft. The Army's pilots, however, have always been enlisted soldiers, and generally without prior flight experience. In the past decade, however, the Air Force has altered its approach as its demand for drone pilots has increased and availability of commissioned officer pilots has decreased. First, it began placing pilots straight from undergraduate pilot training (UPT) into Predator squadrons. Later, it began training a corps of "combat systems officers" (CSOs)—drone pilots of officer rank, but with merely civilian instrumented pilot ratings. Despite the service's initial misgivings, the Air Force Research Laboratory's research indicated that CSOs and UPT graduates have "performed nearly as well as the much more experienced pilots currently selected for Predator training" (Hasik & Coerr, 2011).

Location is a third and dramatic difference. The Air Force bases its crews stateside. The Army, however, bases its crews at the airfield from which its Gray Eagles fly in the war zone. Remote basing of combat troops may induce emotional stress without physical risk and there is some reason to believe that face-to-face planning, briefing and debriefing has some value, particularly when teaming with ground troops and manned aircraft pilots. It does not appear, however, that one manning approach or the other is the driving difference in cost between the Air Force and the Army's MQ-1 fleets (Hasik & Coerr, 2011).

The significant difference in costs between the approaches is in staffing. In the Army, there are either 115 or 128 troops in each company of twelve authorized aircraft, which means that there are either 9.58 or 10.67 people assigned to each authorized aircraft. For the Air Force, 1,500 troops for a wing of 220 authorized aircraft means 6.82 people are assigned per aircraft. If the Air Force figure is rounded to seven people per aircraft, and the Army's figure to ten, it shows that the Army is using approximately three

more people per aircraft in its approach. This policy would cost roughly $300,000 more annually per aircraft than the Air Force approach (Hasik & Coerr, 2011).

Considering that the long-term plan for the Army is to expand its MQ-1 inventory to at least 120 aircraft, the Army could save in excess of $36M annually simply by updating its current staffing approach to model the Air Force approach of more centralized staffing with fewer, more highly skilled personnel. This approach is actually more suited to the Army's full reliance on unrated, enlisted pilots (Hasik & Coerr, 2011). A 2011 Congressional Budget Office report on policy options for UAS suggested that the Army could save $1.3 billion, through the forecast end of U.S. involvement in Afghanistan and Iraq, by adopting the Air Force's approach to remote-split operations of MQ-1 Gray Eagles. In this approach, individual division commanders would be given operational control of the aircraft from a central fleet, but they would be operated from the U.S. or other secure (remote) locations (Congressional Budget Office, 2011).

In light of the Army's preference for local control, one option it might consider is consolidation of UAS units at select locations where they can be managed separately from manned aircraft units. This consolidation would force the Army to review its current staffing and basing and could not only save the Army money, but could better posture the Army to transition from a forward deployed status and into the NAS (Hasik & Coerr, 2011).

The FAA and other airspace control authorities are reluctant to allow unmanned aircraft to fly within their national airspaces without rated pilots in control. Additionally, the Army will face the problem of where it can fly the UAS. Operating UAS from a single location in a sparsely populated state may be more readily accomplished than flying from a dozen bases all around the United States.

B.   RESOURCES

In the first portion of this chapter we examined key areas where culture, values, opinions, and beliefs shape the way the Army views certain stakeholders. These types of interactions also impact how the Army manages resources to better utilize and support integration into national airspace, bandwidth and frequency usage and allocation,

contracted efforts, funding, basing and infrastructure, and training. In this section we will look at some of the resource issues and the changes that the Army may face in addressing them.

1. Bandwidth and Frequencies

UAS cannot perform command, control and dissemination of information without reliable communications. Frequency and bandwidth availability, link security, and network infrastructure are critical to support missions (Department of Defense, n.d.). There are two primary concerns when looking at bandwidth and frequencies – availability and security. Overcrowding of the bandwidth and frequency spectrum is already a concern for the Army and DOD at large, but it is of particular concern to the Army UAS community because of the challenges it faces in ensuring that enough bandwidth is protected for UAS expansion (Judson, 2013b). It is estimated that one Global Hawk requires five times more bandwidth than the U.S. military used in the 1991 Gulf War (Uberti, 2012). The Army, one of the major users of bandwidth in Iraq and Afghanistan, is accustomed to having what it needs, when it needs it, but this expectation becomes more unrealistic as time goes on. The demand for bandwidth from both military and commercial consumers grows at a rate that cannot be met by current military and commercial satellite capabilities, especially as the regions of the world that the military currently operates in, or is projected to operate in, become more reliant on bandwidth for day-to-day life.

In addition to a shrinking spectrum due to increased civil use of bandwidth and spectrum, the DOD has begun to sell frequencies to industry in order to offset budget cuts and deficits. This practice is of concern to the Army because there appears to be no evidence that DOD is preserving enough of its bandwidth to effectively operate its network-centric future (Judson, 2013b). The Army of the future will need greater amounts of bandwidth for a wide variety of systems, including UAS (Judson, 2013b). As the Army fields more unmanned systems with more sensors and communications systems, there will be increased amounts of data collected and disseminated globally. To have such global reach takes large amounts of bandwidth and frequencies, which is

costly. A bandwidth spectrum study may be useful to the Army to assess what bandwidth will be available and how much will be required to support Army UAS in the future. With this assessment, the Army will be able to better plan for how to obtain the levels of bandwidth and frequency they require to support increased operations in a more cost effective way.

Another concern is the security of the communications links that UAS depend upon and the safeguarding of data that is collected, stored and disseminated globally. Many of the commercial satellites that the Army relies on can downlink to ground stations that are in countries outside of where they operate. This means that there may be little site and satellite security available and limited defensive measures accessible for commercial vendors to safeguard the non-military sites and satellites that the Army relies upon (Uberti, 2012).

2.   Contracted Support for Logistics and Maintenance

In looking at the future of Army UAS from a cost perspective, the Army will have to assess whether it makes sense to continue using contractor support for its logistics matters and maintenance of its UAS fleet (Judson, 2013b). In the first portion of this chapter we suggested that the Army has developed a culture of over-reliance on contracted support from a narrow pool of contractors. This was not a huge issue for the Army during a time of extended conflict in Iraq and Afghanistan because there was funding devoted to the war and a deep pool of contractors available, freeing the military to fight the war. As the wartime environment and its associated funding continue to shrink, the Army will have to better manage costs. It must examine whether maintenance and support for UAS should be done through contractor logistics or whether the Army should develop an organic military capability to perform that type of maintenance (Judson, 2013b). If contracted logistics is continued, the Army will need to be vigilant in promoting competition for this work in order to keep costs low. Whether the Army chooses to continue contracted support or to grow an organic military capability, it must be budget conscious.

3. UAS Funding

We stated earlier in this chapter that controlling costs would be a major goal for Army UAS. Although future years spending plans allow for flexibility and continued growth in the UAS Segment, the DOD's total research, procurement and sustainment costs are small compared to the spending projected on manned systems. In order to control UAS costs, the Army intends to stand pat with four basic unmanned aerial vehicle models (Magnuson, 2013). Aside from completing its fleet of new Gray Eagle medium-altitude, long-endurance drones, there are no new Army unmanned aircraft under development (Magnuson, 2013). Most of the Army's UAS funding will go to enhancements, refreshes, and upgrades such as expanded fuel capacity, upgraded engines, weaponization and on-board sense-and-avoid technology so that the Army's aircraft can safely fly and train in the national airspace.

Despite the absence of new UAS development efforts, healthy competition should keep the UAS industry's appetite whet and the costs of contracting and procurement low. All improved payloads, sensors and weaponization will be open for competition, which should drive down costs (Magnuson, 2013). Vendors who want to compete to place their products aboard the Army's larger UAS are going to have to live within their bounds as the Army cannot afford to reconfigure aircraft to accommodate new and unique payloads (Magnuson, 2013). Vendors who want to compete for work associated with the smaller aircraft will have ample opportunity as these systems will undergo more frequent refresh of technology associated with smaller system improvements at a rapid rate (Magnuson, 2013).

4. UAS Training

In order to support the rapid growth in UAS, the Army is challenged to train sufficient numbers of personnel to operate and maintain their inventory and to provide sufficient access to airspace and training ranges to adequately train personnel (Department of Defense [DOD], 2012). Integrating unmanned aircraft system capabilities, regardless of the service operating them, into the operations of troops on the ground, especially ground maneuver forces, is the most critical drone-related training

issue the Pentagon faces. To address the training shortfall, the Pentagon has tailored its upcoming training plan to focus on UAS capabilities and operational results ("DOD: Better Training," 2013).

With the three main objectives of commonality, capability and availability, the training plan recommends expanding joint UAS training and operational standards to increase the effectiveness of both collective and joint training, as well as further developing related operational doctrine ("DOD: Better Training," 2013). The plan also lays out the best way to integrate UAS operations into service specific curricula. But because this type of integration will take time, the department will start to work on "interim alternatives" with the services to train commanders and staff for the employment of large UAS in support of the combatant commander ("DOD: Better Training," 2013).

Further complicating DOD's ability to address a training plan for an integrated UAS operational architecture is an increase in UAS training requirements that will continue in the near future due to expanding inventories and the sustained high demand for UAS-provided capabilities globally. One training area that needs more attention is manned and unmanned teaming for close air support. The training plan recommends ways to develop joint doctrine to support collective training and operations into a "live-virtual, constructive and gaming construct" ("DOD: Better Training," 2013).

UAS training for the Army will be further complicated by the fact that much of the training up to this point was "on the job" training conducted in forward deployed areas where there were few flight restrictions to limit airspace and the area of operations did not have to be replicated in any way to make the training experience realistic. With UAS capabilities and operators returning to the states, training in an operationally relevant environment with few restrictions will be a challenge due to the geographical disbursement of units and training areas that do not have substantial area and terrain to replicate areas that UAS may need to operate.

C. LAWS, REGULATIONS AND POLICIES

1. Acquisition Policy

A method to alleviate inter-service redundancy and waste across UAS programs is to implement and enforce an open systems approach from the early stages of UAS development. An open systems approach would allow components of the unmanned aircraft system to be replaced or refreshed with new, improved components from a variety of suppliers (Government Accountability Office [GAO], 2013). There are many benefits to Army UAS adhering to the open systems approach. Not only might there be lower lifecycle costs and faster ability to modify, repair and upgrade the capability, but the approach would also encourage competition which further drives down costs (GAO, 2013). While DOD "has cited a preference for acquiring open systems in its policy since 1994 and each of the services have since issued open systems policies," the U.S. Government Accountability Office (GAO) found that:

> The Army and Air Force have been slow to make their UAS systems open, particularly from the start of development. It appears that the Army's over-reliance on proprietary components of its systems and support of original prime contractors has caused it to miss an opportunity to increase innovative ideas and save money. GAO, 2013.

GAO argues that the only way to drive the acquisition community to actually use the open systems approach is through policies and leadership (GAO, 2013d). According to Liang (2013):

> Strong leadership is needed 'to overcome preferences for acquiring proprietary systems'…while DOD's Better Buying Power initiative requires programs to outline an approach, the Office of the Secretary of Defense (OSD) does not have adequate insight of the extent to which an open systems approach is being used by individual weapon acquisition programs.

This appears to allow the services to continue developing and acquiring UAS tailored to their individual service wants, needs, and missions, not taking into consideration what would be best for the entire DOD. Without adequate knowledge of policy implementation and program office expertise, DOD cannot have reasonable assurance that an open systems approach is being implemented effectively by the

services. Until it takes action to overcome these challenges, DOD will likely continue to invest in costly proprietary systems (Liang, 2013).

GAO provided four recommendations for the Secretary of Defense (SECDEF) to administer as directives to improve DOD's implementation of an open systems approach for UAS and other weapon acquisition programs, as well as its visibility of open systems implementation and program office expertise (GAO, 2013). The first of these was that the SECDEF direct the secretaries of the Air Force and Army to implement their open systems policies by including an open systems approach in their acquisition strategies (GAO, 2013). The second recommendation was that the SECDEF direct the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) to define appropriate metrics to track programs' implementation of an open systems approach (GAO, 2013). The third recommendation was that the SECDEF direct the secretaries of the Air Force, Army, and Navy to require Air Force, Army, and Navy acquisition programs to include open systems metrics developed by the USD(AT&L) in their systems engineering plans, track progress in meeting these metrics, and report their progress to the USD(AT&L) at key acquisition milestones (GAO, 2013). The fourth recommendation was that the SECDEF direct the Secretaries of the Air Force, Army, and Navy to assess their service-level and program office capabilities relating to an open systems approach and work with the Deputy Assistant Secretary of Defense for Systems Engineering to develop short-term and long-term strategies to address any capability gaps identified (GAO, 2013).

2. UAS Integration into the National Airspace System

Operating Army UAS in the National Airspace System (NAS) was not a major concern for the Army until recent years. In the past, training areas were sufficient for the relatively low number of UAS available and more operational testing and training could be conducted in theaters of operations where airspace was easily accessible and not as congested. An increase in demand has resulted in a large number of UAS capable of a wide range of missions (DOD, 2012). This larger number of fielded systems also means a stronger demand for access within the NAS to test new systems, train operators, and

conduct CONUS-based missions (DOD, 2012). Now that UAS are returning to the U.S., more coordination and deconfliction will be needed between the Army and the Federal Aviation Administration (FAA) which could significantly impact the Army's ability to meet its requirements.

In 2012, the 112th Congress passed House Resolution 658, FAA Modernization and Reform Act of 2012. Under Section 332 of the bill, Congress addressed the integration of unmanned aircraft systems into the national airspace system. PM UAS is leading the Army's effort to fly UAS in civil airspace by developing a ground-based, sense-and-avoid system that will allow UAS to fly safely within the NAS. Last year, the Army demonstrated, for the Federal Aviation Administration, a system using ground radar that characterized the airspace and provided situational awareness of commercial aircraft coming into the area of operations for UAS, enabling the UAS to land safely while the commercial aircraft passed through.

D. FUTURE ENHANCEMENTS AND IMPROVEMENTS TO UAS

While the Army has no plans to buy new types of unmanned aircraft systems in the near future, it continues to look at improving the effectiveness and efficiency of its unmanned aircraft systems by looking at commonality, interoperability and modularity as "three key things to focus on" (Judson, 2013a). At the same time, the Army will closely scan the industrial sectors for such technological advances as improved sensors, information-processing capabilities, and payloads ("Army Working," 2013).

The Army is looking at improvements to the Gray Eagle (Judson, 2013a). According to the PM UAS, Colonel Timothy Baxter,

> The Army is very interested in expeditionary right now, so we are taking a hard look at our footprint and signature on the Gray Eagle program to identify those things we can do within the existing program of record to assist both our general purpose forces and our [special operations] forces in reducing footprint and signature. Judson, 2013a.

One example is a "roll-on-roll-off" capability allowing the Gray Eagle to be deployed on short notice with a goal of trying to get the minimum amount of ground control equipment and ground control stations and aircraft deployed very quickly to

provide initial capability in advance of placing other equipment in theater. One proposed concept is a smaller control system, such as a portable or mobile ground control station or a mobile ground control station (Judson, 2013a).

Additionally, now that the Gray Eagle is being fielded to aerial exploitation battalions, giving the aircraft a Ka-band satellite link would open up the envelope for additional payloads. Gray Eagle is equipped with a standard electro-optical/infrared camera and synthetic aperture radar, but there is a plan to provide a tactical signals intelligence payload to the aircraft in the future, according to Colonel Baxter (Judson, 2013a).

To support additional payloads, the Army wants to embrace more of a universal interface that would allow the system's operators to plug-and-play capabilities "very quickly" and meet the needs of the aerial exploitation battalions. A more "app-based" universal interface "would significantly reduce the cost associated with incorporating on our systems," and would streamline airworthiness certifications, Colonel Baxter noted (Judson, 2013a).

Colonel Baxter further told reporters on 4 February 2013 that efforts to revisit the service's unmanned platforms would almost certainly include "a return to mobile-type operations" as opposed to operating UAS mainly from large forward operating bases (FOBs) (Wasserbly, 2013). He says, "We've been kind of FOB-centric in Iraq and Afghanistan over the past 10 years or so, so really instilling an expeditionary or mobile operations mind-set with our UAS is going to be our focus as we develop our strategic plans for the future and our five-year plan for product improvements across the board" (Wasserbly, 2013). Accordingly, the UAS project office "has been aggressively pushing unmanned aircraft system stakeholders to really do a critical review of our UAS base philosophies within the Army" (Wasserbly, 2013).

E. SUMMARY

Not all Army UAS stakeholders will necessarily share the same concerns or have unified opinions or priorities. Depending on the topic in which they have a "stake," stakeholders can serve to help or hinder Army UAS.

In the first section of this chapter, we identified four relationships where organizational beliefs and cultures shape the way the Army executes its UAS programs. The application of UAS capabilities poses issues such as inter-service disputes over their control, debates over how to organize and integrate them, and how to process and disseminate collected intelligence data (Blom, 2010). A sometimes adversarial stakeholder relationship exists between the Army and the Air Force with regard to mission control and funding to support those missions. Further, there is an internal Army struggle between the aviation and intelligence communities due to a perception that aviators fly and intelligence analysts produce intelligence. Additionally, manned and unmanned aircraft both play an important role in military operations. Sometimes they operate separately and sometimes side by side and there are advantages to operating in both ways. Finally, whether the aircraft is piloted by an enlisted soldier or an officer has impacts on manning, cost and potentially to future integration into the NAS.

In the second section of this chapter, we identified several resource management factors that stakeholders consider in their relationship to Army UAS. These factors may impact how the Army manages resources to better utilize and support integration into national airspace, bandwidth and frequency usage, security and allocation, contracted efforts, funding, basing and infrastructure, and training. First, we concluded that the Army lacks the ability to adequately forecast bandwidth, frequency, and data security requirements for the future without conducting an assessment of what currently exists as opposed to what will be required for future UAS growth. Furthermore, we concluded that the Army must better manage costs and to do so will require an examination as to whether maintenance and support should be done through contractor logistics or with organic military capability. We also concluded that to cut costs, the Army will need focus more on efficiencies outside of new capability development and rely more on enhancements, modifications, and innovation to meet mission requirements. Additionally, the Army can apply staffing and basing lessons learned from the Air Force to save resources (funding, personnel, infrastructure, training, etc.). Finally, we concluded that because the Army values decentralized operations down to the individual unit and lower

levels of organization, it will be difficult to for them to change their way of thinking to a more strategic level which will impact its ability to train its UAS units.

The third section of the chapter dealt with two policies and laws that have significant impacts on Army UAS. The first is acquisition policy dealing with the open systems approach to alleviate inter-service redundancy and waste. Though this approach will have benefits for the Army in the long-term, none of its UAS programs were developed from the start according to its methodology and thus they are overly reliant on proprietary and often more costly systems. The second is the FAA Modernization and Reform Act of 2012, which addressed the integration of UAS into the NAS. There is a stronger demand now than ever for the Army to be able to test, train and operate in the NAS. If the Army does not have the ability to coordinate, deconflict and maneuver in the NAS, it could significantly impact its ability to meet mission requirements.

The final section of the chapter looks at a few of the innovative future enhancements and improvements that the Army and industry partners can cooperatively invest in during these lean fiscal years to move UAS forward. The Army will closely scan the industrial sectors for such technological advances as improved sensors, information-processing capabilities, knowledge management technologies, and advanced payloads for expanding mission sets.

In the next two chapters, we will examine two major factors that were introduced in this chapter—UAS Funding and Integration of UAS into the national airspace system.

IV. FUNDING FOR U.S. ARMY UAS PROGRAMS

The Army has been incredibly successful in introducing Unmanned Aircraft Systems (UAS) from corps level to platoon. Although still relatively new to combined arms operations, UAS are revolutionizing how the Army fights. In 2003, the Army deployed 13 aircraft for Operation Iraqi Freedom. Some 10 years later, about 1,200 unmanned medium and large aircraft are in the field. Spigelmire & Baxter, 2013, p. 55.

A. U.S. ARMY UNMANNED AIRCRAFT SYSTEM INVENTORY FY12–FY17

In the 2012 *Report to Congress on Future Unmanned Aircraft Systems Training, Operations, and Sustainability*, the DOD outlined the UAS inventory levels of all the services. This projection detailed the current budgeted inventory including the four UAS platforms operated by the Army (DOD, 2012).

The RQ-11B Raven is a battalion level and below tactical UAS that provides a small unit the organic capability to perform beyond visual line of sight (BLOS) reconnaissance, surveillance and target acquisition. Table 7 outlines current and projected inventory levels.

System Designator	FY11	FY12	FY13	FY14	FY15	FY16	FY17
RQ-11B Raven	5394	6294	6528	6717	6921	7074	7074

Table 7.   RQ-11B Raven inventory levels (from DOD, 2012)

The RQ-7B Shadow is a brigade level asset that provides brigade commanders with tactical level reconnaissance, surveillance target acquisition and battle damage assessment. Table 8 outlines current and projected inventory levels.

System Designator	FY11	FY12	FY13	FY14	FY15	FY16	FY17
RQ-7B Shadow	408	408	408	408	408	408	408

Table 8.   RQ-7B Shadow inventory levels (from DOD, 2012)

The MQ-5B, Hunter, is a corps level asset that provides reconnaissance, surveillance target acquisition and battle damage assessment. It is being replaced by the MQ-1C, Gray Eagle. As of October 2012, there were 45 MQ-5B Hunters in service. The complete phase out is anticipated to be some time in 2014. Table 9 outlines current inventory levels.

System Designator	FY11	FY12	FY13	FY14	FY15	FY16	FY17
MQ-5B Hunter	45	45	45	45	0	0	0

Table 9. MQ-5B Hunter inventory levels (from DOD, 2012)

The MQ-1C, Gray Eagle, is a division level asset that provides dedicated, mission-configured UAV support to the division fires and battlefield surveillance brigades, brigade combat teams, combat aviation brigades, and other Army and joint force units based upon division commander's priorities. Table 10 outlines current and projected inventory levels.

System Designator	FY11	FY12	FY13	FY14	FY15	FY16	FY17
MQ-1C–Gray Eagle	19	45	74	110	138	152	152

Table 10. MQ-1C Gray Eagle inventory levels (from DOD, 2012)

The Army's concept of deployment focused on equipping battalion and brigade level assets with tactical UAS platforms first while identifying larger platforms suitable for corps and division level support. The Army selected the RQ-11B, Raven, and RQ-7B, Shadow, as its tactical (operations out to 25 kilometers) and medium range UAS (operations out to 125 kilometers) and began equipping battalions and brigades. While this was going on a selection process was initiated to identify the Extended-Range Multi-Purpose (ERMP) unmanned aerial vehicle as a replacement for the MQ-5B, Hunter. The Army selected a derivative of the U.S. Air Force Predator, the MQ-C1 Gray Eagle.

B. U.S. ARMY UAS RESEARCH AND DEVELOPMENT EFFORTS

The U.S. Army has invested in the development of current UAS platforms over the last six years with significant funding outlays between FY2007 and FY2010 and again in FY2012. Table 11 shows Army funding levels from FY 2007 to FY 2014.

FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$154,937	$101,947	$104,276	$173,521	$53,641	$148,588	$204,578	$86,408

Table 11. Army UAS investment funding (in $K) (after Congressional Record–House. Division C, 2008; Congressional Record–House, 2009; H.R. Rep. No. 109-676, 2006; H.R. Rep. No. 110-434, 2007; H.R. Rep. No 112-331, 2011; H.R. Rep. No. 112-705, 2012; H.R. Rep. No. 113-76, 2013; S. Rep. No. 111-295, 2010)

1. FY 2007–FY 2008

The U.S. Army's budget submission for operational systems development of tactical unmanned aerial systems for FY07 was $154,937,000 (H.R. Rep. No. 109-676, 2006). Budget submissions specifically called out research and development for UAS weaponization, payload development and miniaturization of sensors (S. Rep. No. 109-292, 2006). Specifics from the FY07Senate report include:

- **Warrior Unmanned Aerial Vehicle [UAV] Program**

  The budget request included $46,030,000 to procure and install weapons on unmanned aerial vehicles. The funding was included in two separate budget lines, "Tactical Unmanned Aerial System" and "Weaponization of Unmanned Aerial Systems." The Army has increased the scope of the Warrior UAV program, including performance enhancements to reduce attrition and increase safety. (S. Rep. No. 109-292, 2006).

- **Unmanned Payload Concepts**

  The budget request included $38.4 million in PE 62120A, for sensors and electronic survivability. Asymmetric threats and unpredictable battlefields increase the importance of flexible response and logistics options. The committee recommended an increase of $1.5 million in PE 62120A for acceleration of concept demonstration on a remote-operated, lighter-than-air unmanned vehicle with scalable payload capabilities. (S. Rep. No. 109-292, 2006).

- **Miniaturized Sensors for Small and Tactical UAVs**

    The budget request included $23.9 million in PE 62709A for night vision technology, but included no funds for miniaturized sensors for small and tactical unmanned aerial systems (UAVs). The committee noted that among the major requirements for UAVs, were miniaturized and wide bandwidth visible, infrared and radar imaging sensors. Emphasis had been on the larger UAVs and sensor development had lagged behind vehicle development, which presented significant power, weight, and cooling challenges in adapting sensors for use in small and tactical UAVs. Therefore, the committee recommended an additional $6.0 million for miniaturized sensor development for small and tactical UAVs. (S. Rep. No. 109-292, 2006).

- **Unmanned Tactical Combat Vehicles**

    The budget request included $64.7 million in PE 63003A, for aviation advanced technology, but included no funding for a tactical unmanned combat aerial vehicle (UCAV) designed specifically for flexible launch and rapid response. Believing that the development of a survivable turbine-electric hybrid, vertical take- off and landing tactical class UCAV would introduce a self-contained, rapid response, precision strike capability for use by the tactical commander, the committee recommends an increase of $14.0 million in PE 63003A for design and fabrication of the first Excalibur tactical UCAV system. (S. Rep. No. 109-292, 2006).

- **UAV Anti-icing Technology**

    The budget request included $10.9 million in PE 64258A, for target systems development. The Department of Defense consistently lists all weather capability as a priority for operation of unmanned systems. The committee recommends an increase of $2.0 million in PE 64258A for icing and wind tunnel testing of the prototype electro-expulsive ice protection system. (S. Rep. No. 109-292, 2006).

While efforts described in FY 2007 continued, the amount of funding the Army would see for FY 2008 was less. The Army's investment for FY08 was $101,947,000 (H.R. Rep. No. 110-434, 2007). The overall decrease was due primarily to a decrease in research and development funding for the Class IV Future Combat Systems (FCS) UAS capability (H.R. Rep. No. 110-146, 2007). Aware that there were duplicative ongoing UAS development efforts within the services, the Armed Services Committee inserted language in the FY2008 National Defense Authorization Act to ensure that funding allocated for investment in UAS capabilities was not used to develop redundant capabilities.

2.   FY 2009–FY 2010

Funding levels for FY2009 stayed roughly the same as the previous FY at $104,276,000 (Congressional Record–House. Division C, 2008). In FY 2009, the House Armed Services Committee (HASC) addressed ISR issues affecting UAS. The HASC directed the Undersecretary of Defense for Acquisition, Technology and Logistics to submit a report back to Congress by March 15, 2010 on an acquisition strategy for UAS-based signals intelligence capabilities across the military services. Commonality within payloads for different UAS platforms, particularly in the area of intelligence, surveillance and reconnaissance, was a key consideration by the committee. Specially, the HASC focused on commonality across UAS capabilities in the area of ground stations for the control of UAS (H.R. Rep. No. 110-652, 2008).

House Report 110-652, Section 143 outlined the requirement for common ground stations and payloads for manned and unmanned aerial vehicles. Specifically, the section required the SECDEF to establish a policy and acquisition strategy for manned and unmanned vehicle intelligence, surveillance, and reconnaissance payloads and ground stations to achieve integrated research, development, test and evaluation, and procurement commonality (H.R. Rep. No. 110-652, 2008).

Payloads included within the policy and acquisition strategy, by vehicle class, were: signals intelligence; electro-optical; synthetic aperture radar; ground moving target indicator; conventional explosive detection; foliage penetrating radar; laser designator; chemical, biological, radiological, nuclear, explosive detection; and national airspace operations avionics and sensors (H.R. Rep. No. 110-652, 2008).

Section 143 also sought: commonality of ground systems by vehicle class; common management of vehicle and payloads; ground station interoperability standardization; open source software code; acquisition of technical data rights in accordance with Section 2320 of Title 10, United States Code; and acquisition of vehicles, payloads, and ground stations through competitive procurement (H.R. Rep. No. 110-652, 2008).

House Report 110-652 also codified the classes of UAVs as a frame of reference across the DOD and provided structure to the various acquisition activities associated with UAS. Classes of vehicles were defined as (H.R. Rep. No. 110-652, 2008):

- Tier II class: vehicles such as Silver Fox and Scan Eagle

- Tactical class: vehicles such as RQ–7

- Medium altitude class: vehicles such as MQ–1, MQ–1C, MQ–5, MQ–8, MQ–9, and Warrior Alpha

- High altitude class: vehicles such as RQ–4, RQ–4N, unmanned airship systems, Constant Hawk, Angel Fire, Special Project Aircraft, Aerial Common Sensor, EP–3, Scathe View, Compass Call, and Rivet Joint

To support the continuation of UAS research and development efforts and activities ongoing the funding level for FY 2010 was increased to $173,521,000 (House Congressional Record, 2009).

3. FY 2011 and Beyond

The sense in Congress of the importance of UAS research in the Army continued in the FY 2011 budget submission as the Senate Armed Services Committee (SASC) increased the Army R&D funding line for UAS (S. Rep. No. 111-201, 2010).

In Senate Report 111-201 (2010), a need for increased funding was called out for unmanned aerial systems research and development. The budget request included $43.5 million in PE 62211A towards applied research of aviation technologies, both manned and unmanned (S. Rep. No. 111-201, 2010).

At that time, UAS had seen dramatically increased utilization during operations, but there were shortfalls in higher performing propulsion systems and integration issues that remained to be addressed. In support of these efforts, the committee recommended an increase of $2.0 million in PE 62211A for unmanned aerial system integration. In addition, the committee recommended an increase of $8.5 million in PE 63003A for improved UAS engine development, rotorcraft corrosion reduction efforts, and improving capabilities to more rapidly insert new aviation technologies, including enhanced systems to detect hostile fire (S. Rep. No. 111-201, 2010).

The FY2013-2014 budget submission reviewed by Congress (House Armed Services Committee Report) reflected the interest and potential advantages of using open systems architecture for UAS control. Specifically, Congress encouraged the DOD to require all future UAS ground stations to comply with open architecture standards developed by the UAS Common Segment (UCS) Working Group (H.R. Rep. No. 113-102, 2013).

The Congressional Research Report on U.S. Unmanned Aerial Systems described Congressional actions regarding UAS development within the DOD. It concluded that, "At times, Congress has encouraged the development of such systems; in other instances, it has attempted to rein in or better organize the Department of Defense efforts" (Gertler, 2012).

This is evident in the legislative language in terms of commonality of ground stations and the use of open source software. The path taken by the DOD, and particularly the Army, to develop and field UAS capabilities was undertaken in less than optimal circumstances. The development of platforms and refinement of doctrine, tactics, techniques, and procedures (TTPs) took place during two major military actions. Much of the work was accomplished during real world operations. Additionally, the realignment of the Future Combat Systems Program presented challenges in terms of program continuity. Finally, fiscal realignments to pay for overseas contingency operations drove development efforts and delivery schedules.

C.   U.S. ARMY UAS PROCUREMENT

Prior to FY2010, the U.S. Army did not have a procurement line item for unmanned aerial systems. The Future Combat Systems Program included procurement funding for Army UAS platforms. The cancellation of the FCS program resulted in a transfer of UAS investment and procurement funding to Army aviation program elements. Table 12 details the procurement funding lines for the U.S. Army unmanned aerial systems since FY 2010.

Year	FY10	FY11	FY12	FY13	FY14
Amount ($K)	$266,372	$454,462	$76,239	$543,886	$447,406

Table 12. Army UAS Procurement Funding (after [Congressional Record–House, December 16, 2009], [S. Rep. No. 111-295, 2010], [H.R. Rep. No 112-331, 2011], [H.R. Rep. No. 112-705, 2012], and [Congressional Record–House, January 15, 2014])

The procurement figures account for currently deployed Army UAS platforms. The Army is in the process of replacing the MQ-5, Hunter, at the division level, with the MQ-1, Gray Eagle. The initial procurement of the MQ-1, scheduled to start in FY2012, was delayed as the procurement funding for the program was transferred to the Overseas Contingency Fund. The majority of procurement funding identified for FY2013 and FY2014 is dedicated to MQ-1 procurement.

D. FUTURE INVESTMENT AND PROCUREMENT

The *U.S. Army Unmanned Aircraft System Road Map 2010–2035* provides a detailed plan for future investment, outlining near-term, mid-term, and long-term objectives (U.S. Army UAS Roadmap, n.d.):

- In the near term, (now to 2015) identified areas for improvement include increasing platform endurance, allowing greater loiter time for ISR missions, anti-jam data links, and precision munitions.

- In the mid-term (2016–2025), the focus will be on fully integrating UAS assets into Army operations. This will include a family of UASs that can be tailored to specific missions, standard interfaces across multiple platforms, and standardized ground control systems.

- In the 2026–2035 timeframe, the Army envisions common manned and unmanned systems. The overall objective of the Army UAS program is to increase the number of tasks that can be accomplished by UAS platforms. These tasks include surveillance, armed reconnaissance, attack, sustainment/cargo and medical evacuation. Each of these broad areas includes science and technology objectives designed to produce operational solutions and will require research and development investment.

Several significant UAS material development concepts that should be applied to future science and technology efforts include (Spigelmire & Baxter, 2013):

- Controlling requirements so that airframe costs do not grow to unattritable levels.

- Multiple payloads on a single airframe—balancing the cost and significance of loss.

- Improving the ability to easily reconstitute damaged units through the development of multiclass universal products, universal operators and maintainers.

E.   SUMMARY

Over the past decade, the Army has succeeded in building a robust UAS program. They have identified four tiers of UAS capabilities and have established funding lines for research, development, test and evaluation, as well as, procurement. The adoption of the MQ-1, Gray Eagle as the ERMP platform, taking advantage of developmental efforts by the Air Force, significantly reduced the risk that would have been incurred had the Army chosen to develop an ERMP capability. Additionally, the proliferation of UAS across the Army during contingency operations, while not ideal from a program manager's perspective, provided an excellent "test-bed" for the development of operational concepts and tactics, techniques and procedures—all critically important to the successful fielding of any combat capability.

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V. UAS AND THE NATIONAL AIRSPACE SYSTEM

In order for us to get to where the UAS can become a viable, accepted part of the national airspace system, we have to make sure that sense-and-avoid is more than a given—it must be a guarantee. Without a pilot who can look and scan to the left and the right—just the way you and I do when we're backing out of a parking space—there's a perceived level of risk that the American public isn't ready for. "FAA: Drones," 2009.

A. THE NATIONAL AIRSPACE SYSTEM

The National Airspace System (NAS) of the United States is one of the most complex aviation systems in the world. It consists of thousands of people, procedures, pieces of equipment and facilities designed to enable safe and expeditious travel in the United States and over large portions of the world's oceans. In the United States, airspace is designated by class or layer, from A to G (Air Safety Institute, 2011a). These classes can, for most part, be visualized as layers within the atmosphere that require varying levels of flight control either by a pilot or air traffic control (see Figure 17).


Figure 17. Airspace at a glance (from Air Safety Institute, 2011)

B.   **NATIONAL AERONAUTICS AND SPACE ADMINISTRATION: UAS— NAS TECHNICAL INTEGRATION LEAD**

Within the Federal Aviation Administration Modernization and Reform Act of 2012 was direction to the FAA to provide a plan to integrate UAS into the NAS. Specifically, the plan would (H.R. Rep. No. 112-381, 2012):

- Define the acceptable standards for operation and certification of civil UAS

- Ensure that any civil UAS includes a sense and avoid capability

- Establish standards and requirements for the operation and pilot of civil unmanned aircraft systems, including standards and requirements for registration and licensing

- Address the best methods for enhancing technologies and subsystems necessary to achieve safe and routine operation of civil UAS in the NAS

- Provide for a phased in approach to the integration of civil UAS in the NAS and a timeline for the phased approach

- Create an airspace designation for cooperative manned and unmanned flight operations in the NAS

- Establish a process for certification, flight standards, and air traffic requirements for civil UAS at test ranges

In addition to the procedural requirements for integration of civil UAS into the NAS (certification, air traffic control procedures, etc.), Congress recognized the technical challenges associated with the integration task and directed the National Aeronautics and Space Administration (NASA) to lead the effort.

NASA identified three technical challenges that would have to be addressed to allow UAS integration into the NAS (McBride, 2013):

- Lack of validated technologies and procedures for UAS to remain appropriate distances from other aircraft for safe and routine operation in the NAS and with the Next Generation Air Transportation System (NEXTGEN) Air Traffic Services

- Lack of validated, minimum system and operational performance standards for UAS, and a lack of certification requirements and procedures for UAS

- Lack of a relevant test environment for validating concepts and technologies for UAS

NASA identified five sub-projects to address these technical challenges. The first sub-project addresses separation assurance/sense and avoid (SAA) integration. Currently an air traffic controller talks directly to a pilot in the airspace providing separation "instructions" in the event aircraft move to within a certain distance of each other. This interchange, when transferred to a UAS construct, requires the air traffic controller to talk to a UAS operator and provide separation "instructions." The main body of work in the sub-project will be to establish a concept of operations, algorithms, and tactics, techniques and procedures (TPPs). This will include decision support tools to assist in situational awareness for UAS controllers, air traffic controllers accepting recommendations from UAS operators for separation maneuvers and air traffic controllers delegating authority for separation to UAS operators (NASA's UAS NAS access project, n.d.).

These TTPs and concept of operation (CONOPS) issues have been addressed by the U.S. Army, and other services, in the use of small UAS during contingency operations and in field experiments. One of the first efforts in this area was an Air Force Battlelab experiment conducted in 1998 at Kunsan Air Base, Korea. The experiment, called the Force Protection Airborne Surveillance System (FPASS), was a concept demonstration to operate a UAS in the same airspace as military aircraft in close proximity to airfield operations. Since the mission of the UAS was perimeter surveillance, the goal was to fly missions 24 hours a day and to increase the number of UAS and frequency of flights during alerts and heightened force protection and security postures. Procedures were developed for separation maneuver instructions between the base air traffic control and the UAS operators. This was successfully demonstrated and the concept was subsequently employed in support of contingency operations in Iraq and Afghanistan (Perrien, n.d.).

One of the challenges associated with SAA stems from the requirement that a pilot "see and avoid" other aircraft. Consequently, SAA systems will provide operators with some level of surveillance information about aircraft operating near a UAS. The concern is that UAS operators will act on the information, with or without air traffic controller coordination. This has been observed with the Traffic Alert and Collision

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Avoidance System (TCAS) (U.S. Department of Transportation, 2011). NASA plans to assess SAA concepts through fast time and human in the loop simulation experiments. These simulations will be validated during flight testing in 2015 and 2016 (NASA's UAS NAS access project, n.d.).

The SAA requirement to operate in the NAS will likely have the most impact on military UAS operations in the United States. With increased numbers of Army UAS systems, and the withdrawal of forces from Iraq and Afghanistan, there will be a strong demand to conduct training and test new capabilities within the NAS. On 23 April 2013, Colonel (COL) Patrick Tierney, Director, Army Aviation, G-3/5/7, United States Army spoke before the House Armed Services Committee, Tactical Air and Land Forces Subcommittee, on the current and future roles for UAS in the Army. In his statement to the committee, COL Tierney stated, "After 11 years of war (UAS) have proven so valuable that they have been woven into the very fabric of both Army Aviation and Maneuver Units" (2013). The Army has a particularly difficult challenge due to the deployment concept for UAS; the Army has more than 1800 UAS embedded in maneuver units. Essentially, the Army will have UAS capabilities deployed at every army installation in the United States. The Air Force and Navy, in many cases, positioned their UAS capabilities in proximity to restricted, warning, and prohibited areas (military bombing ranges, etc.). The Army will be faced with working National Airspace System access on a much larger scale than the Air Force or Navy.

In the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035*, the Army identified goals and objectives to support the Army vision for the development of a family of UAS. These goals and objectives will serve as the Army's science and technology focus areas over the next 21 years. Goal 5 aligns with the NASA SAA sub-project—Goal 5 focuses on the development and practice of TTP that enable safe and effective operations between manned systems and UAS. The Army objectives under this goal directly address NASA's science and technology capability gap and align with NASA's efforts in this area. Objective 5-1 focuses on developing, adopting and enforcing government, international and commercial standards for UAS design, manufacturing, testing, and safe operations of UAS. Objective 5-2 cites developing and fielding UAS

that can "sense" and autonomously avoid other objects to provide a level of safety equivalent to comparable manned systems (U.S. Army UAS Roadmap, n.d.).

The alignment of NASA efforts in these areas with U.S. Army science and technology projects will be critical as both activities move forward with development. The *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* addresses near-term goals (2010–2015), mid-term goals (2016–2025) and far-term goals (2026–2035). The Army has identified as a far-term goal, "Fully compliant SAA capabilities and seamless national airspace integration" (U.S. Army UAS Roadmap, n.d.). If NASA executes its program in accordance with the FAA Modernization and Reform Act requirements, it will have a SAA solution by the end of 2017. The implementation of the SAA solution will be critical to support Army UAS training requirements, particularly at the brigade and below level for in-garrison training. Based on the extent to which the Army has integrated UAS into operations, NASA could gain a wealth of information on TTPs regarding UAS operations in congested airspace to support the SAA research.

NASA's second sub-project addresses human systems integration (HSI), specifically in the area of ground control station (GCS) operations. NASA is developing a research test bed and database to provide data and proof of concept for GCS operations. The focus of the test bed will be to address the UAS characteristics that differentiate UAS from manned aircraft and how to display airspace information without increasing workload. The goal of this sub-project is to identify and codify human factors guidelines for GCS operations in the NAS.

The *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* lays out a timeline to begin looking at development of a universal ground control station (UGCS) in the mid-term implementation plan (FY2016–FY2025). The S&T focus during this period will be on increased commonality in airframes, control stations, payloads, power sources, and cognitive aiding software. The UGCS is described as the backbone of an integrated network permitting multiple UAS operating across the area of operations. While NASA's HSI goals are described at a high level, they fall largely in line with the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* objectives. It is doubtful the S&T goals described in the document would be realized without addressing the NASA HSI

sub-project goals as well. This area provides an excellent opportunity for the Army and NASA to collaborate in a development effort. NASA's timeline notionally ends in FY2017; the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* begins to address the UGCS development and integration in FY2018. The early involvement by the Army in the NASA HSI sub-project could potentially shorten the Army's development schedule and allow scarce research and development funding to be applied to other Army UAS requirements.

The third NASA sub-project addresses communications. NASA is developing data and rationale to obtain frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS. There is currently no spectrum allocated for civil UAS. This sub-project included the development of candidate UAS command and non-payload control (CNPC) system/sub-system test equipment. This will result in a CNPC security recommendation for public and civil UAS operations in the NAS (NASA's UAS NAS access project, n.d.).

Goal 4 under the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* addresses interoperability and communications (i.e., the achievement of greater interoperability among system controls, communications, data products, data links, and payload/mission equipment packages on UAS). Objective 4.1 identifies fielding common secure communications systems for control and sensor data distribution in Beyond-Line-Of-Sight (BLOS) and Line-Of-Sight (LOS) missions. This includes the capability to prevent interception, interference, jamming and hijacking. Objective 4.2 emphasizes common payload interface standards across UAS to promote greater mission versatility (U.S. Army UAS Roadmap, n.d.).

DOD currently uses dedicated communications networks (spectrum) for UAS command and control; however, NASA's description of safe and efficient operation of UAS in the NAS must include a communication protocol that aligns with Objective 4.1. Prevention of signal interception for the purpose of hijacking, interference and jamming will certainly be a concern in the control and operation of civil UAS and an area where the Army brings technical expertise and practical experience to the problem. Additionally, Objective 4.2 aligns with NASA's goals of developing CNPC system/sub-

system test equipment. This development effort may represent an area in which the Army can capitalize on investments and the development efforts of NASA (U.S. Army UAS Roadmap, n.d.).

The fourth NASA sub-project addresses certification. NASA is developing a UAS airworthiness classification scheme to include an approach to determining airworthiness requirements applicable to all UAS digital avionics. Standards are the true enabler of interoperability. While this sub-project may be quite lengthy, due to the lack of specific data (incident, accident and reliability), NASA will investigate available hazard and risk related data. This will support development of type design criteria and best development practices for standard airworthiness certification purposes.

Under Goal 5 of the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035*, which addresses safe and efficient operations between manned systems and UAS, Objective 5.1 specifically addresses the adoption of standards to promote the development, adoption, and enforcement of government, international, and commercial standards for the design, manufacturing, testing, and safe operations of UAS (U.S. Army UAS Roadmap, n.d.).

Goal 8 of the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* addresses the Army's focus on enhancing the current logistical support process for UAS. Specifically, Objective 8.2 addresses promoting the development of engineering design to increase the reliability, availability, and maintainability of UAS to sustain warfighter needs. These areas of research and development clearly overlap and present an opportunity for collaboration between NASA and the Army. The formation of standards for design, manufacturing, testing, and safety will be crucial for future UAS platform selection by the DOD. Standards, adopted by the commercial marketplace, will lead to more reliable systems as well as more predictable platform performance envelopes. This will help to reduce the unknowns that DOD faces due to a relatively immature commercial UAS sector (U.S. Army UAS Roadmap, n.d.).

The FAA, to date, has not addressed airworthiness certificates beyond establishing procedures for issuing special airworthiness certificates in the experimental

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category or special flight permits to unmanned aircraft systems and optionally piloted aircraft. The Army can provide input to NASA in this sub-project while ensuring that current Army UAS platforms are brought up to standards.

Goal 9 and Objective 9.1 in the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* address development of an airworthiness qualification program to achieve Level 1 and Level 2 airworthiness. Level 1 is a registration certification and is the prerequisite for all other airworthiness certificates. Level 2 is an experimental certificate. Level 2 permits operation for the purpose of research and development or to show compliance with regulations. Initial flights will be confined to assigned test areas. Table 13, from NASA's Environmental Research Aircraft and Sensor Technology (ERAST) Program, provides perspective on the current path to an airworthiness certificate for a UAS in the NAS. This path mirrors the process for manned aircraft airworthiness certification and will likely be modified as a result of the NASA sub-project on certification (U.S. Army UAS Roadmap, n.d.).

Level of Certitude	Benefits and Limitations
Level 1 (2 months)—Aircraft Registration Certificate	Prerequisite for any and all airworthiness certifications
Level 2 (3 months)—Experimental Certificate	Permits operation of R&D or to show compliance with Regulations. Initial flights confined to assigned test
Level 3 (3 years)—Special Class Type Certificate	Establishes proposed initial design concept. Establishes Type Certification basis, Designated Airworthiness Representative (DAR) and Designated Engineering Representative (DER)
Level 4 (6 months)—Production Type Certificate Only	Develops production guidelines. Simpler than standard Production Certificate. Suited for limited production runs
Level 5 (6 months)—Special Airworthiness Certificate	Provides much greater operating flexibility compared with Certificate of Airworthiness
Level 6 (9 months)—Standard Airworthiness Certificate	Eliminates limitations associated with COA and Special Airworthiness Certificate. Imposes minimum number of restrictions. Permits operation under FAR Part 91
Level 7 (6 months)—Air Operating Certificate	Provides unified approach to Flight Standards, operational suitability, operator, equipment and maintenance requirements
Level 8 (3-4 years)—International Civil Aviation Organization Certification	Establishes method for certification in International Civil Aviation Organization states. Streamlined methods may be faster than U.S. certification.

Table 13.   Airworthiness Certification (from *Certification and Regulatory Approach*, n.d.)

The largest set of organized, empirical data available to NASA on incident, accident and reliability may come from the DOD, based on UAS operations over the past 13 years. Nearly all of the current platforms are maintained by contract support teams—typically the UAS designer who has a vested interest in product improvement for continued business. This data, particularly on larger platforms like the Predator, Reaper and Hunter, should be readily available.

NASA's fifth sub-project, Integrated Test and Evaluation (IT&E), will focus on validating technical solutions through a series of fast time simulations, high fidelity human in the loop simulations and integrated flight tests in a relevant environment. This will include a live virtual constructive (LVC) distributed test infrastructure. NASA

anticipates developing nodes with commercial and international partners. The LVC is envisioned to be able to link live flights with simulations.

Goal 7 in the *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* addresses testing and evaluation to ensure that, "test capabilities that support the fielding of UAS are effective, suitable and survivable" (U.S. Army UAS Roadmap, n.d.-q). Access to the IT&E environment by the Army would provide a significant test capability and would complement existing Army flight test ranges. While there is a distinction between testing civil UAS platforms and DOD UAS platforms, due to the operational nature of the DOD mission, there is certainly an opportunity to combine developmental testing with NASA at its test ranges. Using NASA test ranges for developmental testing would potentially allow the Army to defer investing in test instrumentation to support its S&T efforts and allow these funds to be reapplied to other research focus areas. The synergy achieved from collaborative testing and evaluation would benefit both parties.

C.   SUMMARY

NASA's UAS NAS Access Project addresses several significant technical challenges that align with U.S. Army S&T goals. For example, a co-development effort in the area of SAA could potentially accelerate a technical solution for Army UAS by as much as eight years. Army development efforts in the area of Ground Control Station operations are scheduled to begin in 2018. NASA is addressing the Human Systems Integration aspects of UAS control now and will continue into 2018. Additionally, the Army currently has extensive UAS HSI-related experience from recent operations in Iraq and Afghanistan that could greatly benefit NASA's efforts in this area. In the area of communications, NASA could greatly benefit from Army and DOD development programs addressing secure data links and beyond line of sight communications capabilities. UAS certification requirements for design, manufacturing and testing leading to a set of standards has far reaching implications. The current Army acquisition strategy for UAS does not include platform development. The next UAS platform procured by the Army will likely come from the commercial marketplace, making design and manufacturing standards a key consideration in platform selection. The use of the

FAA/NASA test range complex (six test sites) would potentially defray Army costs for range usage. Test ranges are expensive to instrument, operate and maintain. Collaborative testing could prove beneficial for both parties thru shared test results.

NASA and the Army have difficult technical challenges ahead. The *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* and NASA's UAS-NAS Integration goals, while notably different in some areas, are clearly synergistic in others. The Army's support of contingency operations brings a wealth of knowledge, most notably TTPs, to any UAS research endeavor. NASA brings years of aeronautical research experience and facilities that could greatly accelerate Army UAS research efforts. Both organizations could realize significant benefits from a cooperative UAS research and development partnership.

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VI. SUMMARY AND RECOMMENDATIONS

The past 20 years have revealed unparalleled growth in unmanned aircraft systems (UAS) operational usage, production, and capabilities. These incredible machines are capable of offensive and defensive operations to protect the warfighter as well as deterring enemies with lethal and non-lethal armaments. The possible future uses of UAS are difficult to predict. One thing is possible to predict, however, and that is with the drawdown of forces in Iraq and Afghanistan, as well as the ongoing reduction of military budgets, the Army is going to be forced to increase efficiency and cut costs while still striving to satisfy all UAS stakeholders. The initial step in satisfying those stakeholders is to first identify them, and then to understand the relevant interrelationships and interdependencies.

An Army UAS stakeholder is any person, group, or organization (foreign or domestic) that has interest in or concern with Army UAS and whose direct or indirect involvement with UAS can affect, either negatively or positively, the outcome of the program. Understanding the full range of Army UAS stakeholders is essential to running an effective organization as it will help the Army's leadership to satisfy the desires and objectives of high-influence stakeholders and to address the concerns and negative impacts of other stakeholders. Properly managing the Army's key UAS stakeholders can only serve to improve organizational relationships, increase efficiency, cut costs, and ensure that the expectations and impacts of all stakeholders are addressed.

The Army has never done a formal stakeholder identification and analysis for Army UAS. With only a narrow current understanding of stakeholders, the Army does not adequately leverage the support of others for things like funding, resources, intellectual property, lessons learned, and cooperation that can lead to better integration, political and popular support, and better odds of accomplishing goals and missions. Research provided within this paper identified a comprehensive list of both internal and external UAS Stakeholders for consideration. Internal stakeholders include Army executive program leadership (PEOs, TCMs, etc.), Army and other service components (active, Guard, and reserve forces), and senior Army agency leadership, Army S&T,

acquisition, and capability development communities. External stakeholders include other significant government entities (Congress, Department of Homeland Security, the National Aeronautics and Space Administration, etc.), commercial interests such as industry and academia, and generally interested parties such as the American public and adversaries. To truly benefit from a relationship with and/or understanding of the key stakeholders, the Army would need to take the action one step further and assess the interests, influence and importance of each stakeholder and the impact they have on Army UAS and how they could better incorporate them into a participation strategy.

Understanding stakeholders is just one step towards gaining efficiencies and cutting costs. Not all Army UAS stakeholders share the same concerns or have unified opinions or priorities. Depending on the topic in which the stakeholder has a "stake," stakeholders can serve to help or hinder Army UAS. In addition to thorough stakeholder analysis, it is necessary to acknowledge and understand recurring factors that affect Army UAS stakeholder relationships.

In the first portion of Chapter III, we examined key areas where culture, value, opinions, and beliefs may shape the way the Army views UAS stakeholders. Research identified four relationships where organizational beliefs and cultures shaped the way the Army executes its UAS programs. First, the application of UAS capabilities poses issues such as inter-service disputes/debates over their control, organization, integration, and how to process and disseminate collected intelligence. Second, trade space between the Army and the Air Force causes disputes with regard to mission control and/or funding. In addition, the Army has internal disputes between the aviation and intelligence communities that shape policy. Third, advantages and disadvantages exist for operating manned and unmanned aircraft separately or side by side which affect UAS policy. Finally, whether the aircraft is piloted by an enlisted soldier or an officer has impacts on manning, cost and potentially to future integration into the National Airspace System (NAS).

How the Army views certain stakeholders and interacts with them also impacts how the Army manages resources. The second section of Chapter III identified several resource management issues that the Army faces as it manages resources for integration

into national airspace, bandwidth/frequency usage, security/allocation, contracted efforts, funding, basing/infrastructure, and training. First, the Army lacks the ability to adequately forecast bandwidth, frequency, and data security requirements for the future without conducting an assessment of what currently exists as opposed to what will be required for future UAS growth. Second, the Army must better manage costs. To do so will require an examination as to whether maintenance and support should be done through contractor logistics or with organic military capability. Third, the Army will need to focus more on efficiencies outside of new capability development and rely more on enhancements, modifications, and innovation to meet mission requirements. Additionally, the Army can apply staffing and basing lessons learned from the Air Force to save resources (funding, personnel, infrastructure, training, etc.) Finally, because the Army values decentralized operations, it will be difficult for it to change its way of thinking to a more strategic level. This will impact its ability to train its UAS units.

The third section of the Chapter III dealt with two policies and laws that have significant impacts on Army UAS. The first is acquisition policy addressing the open systems approach to alleviate inter-service redundancy and waste. Though this approach will have benefits for the Army in the long-term, none of its UAS programs were developed initially with an open architecture. The Army should look to capitalize on the use of open systems architecture to reduce costs, particularly in the area of command and control systems. The second is the FAA Modernization and Reform Act of 2012 which addressed the integration of UAS into the NAS and will be summarized later in this summary.

The last section of the Chapter III looks at some innovative future enhancements and improvements in which the Army and industry partners can cooperatively invest. The Army should closely scan the industrial sectors for technological advances such as improved sensors, information-processing capabilities, knowledge management technologies, and advanced payloads for expanding mission sets. The final subject of this research delves deeper into two major factors that were introduced earlier in the paper—UAS funding and integration of UAS into the National Airspace System.

Over the last decade, the Army has succeeded in building a robust UAS program. It has identified four tiers of UAS capabilities and has established funding lines for research, development, test and evaluation, as well as procurement. The intent is to fund UAS enhancements, refreshes, and upgrades such as an expanded fuel capacity, upgraded engines, weaponization, and on-board sense-and-avoid technology so that the Army's aircraft can safely fly and train within the national airspace system. Current funding projections, if realized, will meet the Army requirements. Furthermore, the adoption of the MQ-1, Gray Eagle as the extended-range multi-purpose (ERMP) platform, taking advantage of developmental efforts by the Air Force, significantly reduced the cost risk that would have been incurred had the Army chosen to develop an ERMP capability. Additionally, the proliferation of UAS across the Army during contingency operations, while not ideal from a program manager's perspective, provided an excellent "test-bed" for the development of operational concepts and tactics, techniques and procedures—all critically important to the successful fielding of any combat capability.

One of the most significant challenges facing DOD and the Army is successful integration of UAS into the National Airspace System (NAS.) There is a stronger demand than ever for the Army to test, train, and operate in the NAS. If the Army does not have the ability to coordinate, deconflict, and maneuver in the NAS, it could significantly impact its ability to meet mission requirements. There are several opportunities for the Army to work cooperatively with other stakeholders such as NASA to successfully integrate into the NAS.

NASA's UAS NAS Access Project addresses several significant technical challenges that align with U.S. Army S&T goals. A co-development effort in the area of SAA could potentially accelerate a technical solution for Army UAS by as much as eight years. Further opportunity exists for cooperation on UAS command, control and communications. Army development efforts in the area of ground control station operations are scheduled to begin in 2018. NASA is addressing the human systems integration aspects of UAS control now and will continue into 2018. The Army has extensive UAS HSI-related experience from recent operations in Iraq and Afghanistan that could greatly benefit NASA's efforts in this area and influence the way the Army

proceeds. NASA could greatly benefit from Army and DOD development programs addressing secure data links and beyond line of sight communications capabilities.

UAS certification requirements for design, manufacturing and testing leading to a set of standards has far reaching implications. The current Army acquisition strategy for UAS does not include platform development. The next UAS platform procured by the Army will likely come from the commercial marketplace, making design and manufacturing standards a key consideration in platform selection. The use of the FAA/NASA test range complex (six test sites) would potentially defray Army costs for range usage. Test ranges are expensive to instrument, operate and maintain. Collaborative testing could prove beneficial for both parties through shared test results.

NASA and the Army have difficult technical challenges ahead. The *U.S. Army Unmanned Aircraft Systems Roadmap 2010–2035* and NASA's UAS-NAS Integration goals, while notably different in some areas, are clearly synergistic in others. The Army's support of contingency operations brings a wealth of knowledge, most notably TTPs, to any UAS research endeavor. NASA brings years of aeronautical research experience and facilities that could greatly accelerate Army UAS research efforts. Both organizations could realize significant cost, schedule and performance benefits from a cooperative UAS research and development partnership.

In summary, the Army will benefit from successful identification of its UAS stakeholders and development of an active engagement and participation plan. In understanding the interrelationships and interdependencies between stakeholders, the Army will be able to adequately leverage the support of others for funding, resources, intellectual property, lessons learned, and cooperation that leads to better integration, political and popular support, and better odds of accomplishing Army goals and missions. In the fiscally constrained environment that the DOD faces, stakeholder involvement positions the Army to be better navigate funding challenges and the difficult endeavor of integrating UAS into the NAS.

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