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RQ-2 Pioneer: The Flawed System that Redefined US Unmanned Aviation

by

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One of the greatest challenges military commanders face in the planning and execution of warfare is minimizing the fog of war. That gray area in which there is a knowledge gap of what the adversary is going to do at a given time or place, or how ones' own forces will react to a given scenario during a campaign. The great military strategist Carl Von Clausewitz, in his work *On War*, described this phenomenon as an uncertainty that is present in three quarters of the factors on which action in war is based, and as such results in war being a realm of chances.[1] In an effort to mitigate this uncertainty, commanders have historically relied on intelligence collection as one of the primary means for establishing better battlefield situation awareness. Through intelligence collection, commanders can gain a wealth of information to include: disposition of enemy forces, enemy force activity, indications and warning of impending enemy attack, terrain analyses, and battle damage assessments (BDA) after attack operations have occurred. Although the battlefield of the twenty-first century includes an extensive array of intelligence, surveillance and reconnaissance (ISR) capabilities ranging from national space based systems, to theater level collection aircraft and human intelligence sources, the remotely piloted aircraft (RPA) is currently king.

The ability of these RPA systems to provide near real time (NRT) intelligence around the clock on various named areas of interest to commanders around the world—at the tactical, operational and strategic levels of war—has drastically changed, and in most cases minimized, the impact fog of war has on the planning and execution of military operations. The success these systems have had in over ten years of fighting the global war on terrorism has been remarkable, and has championed a movement throughout the Department of Defense (DoD) to increase the number of combat air patrols (CAP) in theater to 65 by the year 2015; a greater than ten-fold increase in RPA CAPs since the war began in October 2001.[2] Although much of this increase in ISR can be attributed to current counter insurgency (COIN) and counter terrorism efforts the US is conducting in Afghanistan, Pakistan, Iraq, and the Horn of Africa, the RPA has proven to be a critical force multiplier of U.S. combat capability dating back to the Vietnam War where the USAF used one of its first systems, the AQM-134 Lightning Bug. But despite the successes achieved by the AQM-134 in the conflict, a general lack of interest in the program after the war resulted in budget cuts that ultimately led the system to its retirement, and found US military interest in RPAs virtually non-existent until they were used again in Operations Desert Shield and Desert Storm.[3] As such, the origins of the RPA evolution we see today in American warfare arguably dates back to the US Navy acquisition of the RQ-2 Pioneer in the mid-80s. In over two decades of operational use in various contingencies around the world, the RQ-2 has conducted a myriad of ISR missions, employed different tactics techniques and procedures (TTP), and garnered many successes and lessons learned that have shaped and influenced the development and employment of RPA systems today.

System Acquisition History

In the 1980s, US military involvement in various contingency operations highlighted the potential benefits of reinvigorating an RPA program that it had stepped away from in the aftermath of Vietnam. Among the many lessons learned from its operations in Grenada, Lebanon and Libya, US military leadership identified a need for an on-call, inexpensive, unmanned, over-the-horizon targeting, reconnaissance and BDA platform to facilitate increased situational awareness for local commanders.[4] Having lost two aircraft over Lebanon in December of 1983—at the hands of Syrian surface to air missile systems stationed in country—the US Secretary of the Navy had a particular interest in seeking an alternative ISR capability that would lower the risk to combat aviators flying tactical reconnaissance missions near potentially hostile territory.[5] A study conducted on his behalf revealed that Israel had an established capability with their Mastiff RPA program that accomplished the same tactical ISR missions the US was using manned aircraft for.[6] In 1985, the Navy decided to purchase several Mastiff RPAs from Israeli Aircraft Industries (IAI) to evaluate the potential utility of the system for the service.[7] But upon further system evaluation, they found the Mastiff had several limitations to include a daylight only video sensor package, and limited range and endurance.[8] The Navy wanted a system that would give them longer loiter time with the added flexibility of being able to operate day or night.

By December of 1985, IAI completed development of their next generation RPA, the RQ-2 Pioneer. Building off of the accumulated battlefield and technical lessons learned from their Scout and Mastiff programs, IAI developed a more capable system that the US Navy decided to purchase for beta testing in January 1986.[9] By July of that year, initial system delivery of eight Pioneer vehicles occurred and by December the Navy deployed its first Pioneers on board the USS Iowa battleship.[10] In July of 1987, three additional systems were delivered to the US Marine Corps for operational use on board LHA-class vessels and other land-based units, to include a training unit.[11] The Navy ultimately purchased nine Pioneer systems, each with eight air vehicles, for a total cost of $87.7 million.[12] By March of 1990, the US Army also purchased the system to further enhance its ISR capabilities.[13] And in 1991, the companies of IAI and AAI merged to become Pioneer UAV Incorporated; a company that would market the Pioneer to the US Navy.[14] Since its procurement in 1986, the Pioneer has supported ship borne operations on the USS Iowa, Mississippi, Wisconsin, New Jersey, and Landing Platform Dock (LPD) class vessels.[15]

System Specifications

Figure 1. RQ-2 Pioneer

The RQ-2 Pioneer is approximately 14 feet long with a wing span of over 16 feet. It has a maximum take-off load of 450 pounds (RQ-2B variant), and is powered by a 29 horsepower pusher-propeller driven, 2-stroke, twin cylinder, rear mounted engine allowing it to fly at a cruising speed of 92 miles per hour and an employment altitude of 15,000 feet. With approximately 70 pounds of fuel on board, the Pioneer is capable of achieving a mission loiter time up to 6 and a half hours. The flexibility provided in the launch and recovery aspects of the vehicle, allows for both land and sea based operations. On land the system can be launched utilizing a wheeled take-off, a catapult from a pneumatically operated twin rail launcher, or rocket-assisted using the EX 125 Mod 2 jettisonable JATO booster. When launching from naval vessels, the Pioneer vehicle is launched using the rocket assist method to provide the necessary propulsion for take-off from the ship deck. The Pioneer can land on runways using a wheeled landing with a tail hook to catch arresting cables, or by flying into a catch net attached to an energy absorbing system when landing on ships.[16]

Guidance and control of the Pioneer is accomplished through the IAI developed Ground Control Station (GCS)-2000 or the more modernized mission planning and control station (MPCS). These control stations allow operators to remotely fly the Pioneer up to 100 nautical miles away from the GCS or MPCS via C-band datalink. This allows the Pioneer to conduct various ISR missions in and around enemy territory while posing little to no threat to its operators flying the vehicle. Finally, a separate planning and control station (PCS) allows the Pioneer to be controlled by the launch and recovery element, while freeing up the GCS or MPCS to conduct other battlefield assignments. Within the GCS are electronic compartments known as pilot, observer, and tracking bays that will normally house two operators to support system employment. Datalink integrity is provided via a separate Tracking Communications Unit (TCU) that provides the primary jam-resistant C-band datalink to the Pioneer, while a back-up datalink capability is also available via ultra-high frequency (UHF).[17]

The RQ-2 is also capable of carrying a variety of payloads to satisfy different mission requirements. From a sensor perspective, it can be configured with TV, forward looking infrared (FLIR), or dual-sensor electro-optical/infrared (EO/IR) packages. This gives warfighters the flexibility to tailor the Pioneer sensor package for a variety of ISR mission requirements ranging from route reconnaissance and target acquisition to post-strike BDA. The TV or EO sensor is suitable for daytime operations, and provides a high-resolution video, while the FLIR or IR sensor provides a day or night capability that establishes a high resolution video from heat signatures that objects in the air, sea, or ground are emitting.

The dual-sensor EO/IR ball provides the most capability to the warfighter, as it provides a balance to the strengths and weaknesses of each system. The EO sensor is optimally used during the day, and even though the IR sensor can be used day or night, it is susceptible to degradation due to thermal crossover or IR blooming. Joint Publication (JP) 3-09.3 defines thermal crossover as, "the natural phenomenon that normally occurs twice daily when temperature conditions are such that there is a loss of contrast between two adjacent objects on infrared imagery."[18] For example, a tank in the open desert that has not been used for an extended amount of time will, at certain times of the day, have the same surface temperature as the ground it is sitting on giving the illusion that the tank is not there when observed through an IR sensor. In contrast, IR blooming is that initial "white out" effect that occurs when the sensor is observing a significant explosive detonation on the ground, perhaps from an air strike or large improvised explosive device. This can cause the sensor to temporarily loose visibility of points of interest on the ground that it may be tracking.

All three sensor packages provide a NRT video feed to the GCS or MPCS via datalink that allows the user to see whatever the sensor ball is currently looking at on the ground whether that is troops, military equipment, urban areas, or coastal areas of interest. This same data feed can also be transmitted to users at the tactical, operational and strategic level through a remote receiving station, providing the warfighter with intelligence data day or night.[19]

Additionally, the Pioneer can carry electronic warfare (EW), electronic counter-measure (ECM), and decoy package to provide self-protection, jamming or spoofing capability against enemy integrated air defense networks. This gives the Pioneer a combination of both offensive and defensive measures that can be used against enemy surface-to-air-missile site target acquisition and target tracking radar or early warning radar systems. Moreover, as a communications relay node, the Pioneer can also directly support very-high frequency (VHF) and UHF communications between friendly ground and air forces that may be hindered from communicating with one another due to terrain masking or distance limitations.

Finally, and perhaps most important, is the laser designator and spotter capability the Pioneer possesses. The laser designator allows the Pioneer to "buddy lase" a target for aircraft that are dropping laser guided bombs (LGB). The guidance control unit on the LGBs will acquire the laser path from the Pioneer and follow it to the designated target on the ground. This capability allows for highly precise attacks on targets and minimizes the potential for collateral damage. The spotter capability allows the Pioneer to highlight target location to friendly forces; a capability that the US Navy originally used for direct support to naval gunfire.

As a deployable package, the system can contain five to eight Pioneer air vehicles with up to nine configurable sensor payloads for both TV and FLIR capability. Additionally, the standard deployment package will contain one GCS or MPCS, one PCS, one TCU, up to four remote receiving stations, a pneumatic or rocket-assisted launcher, command and datalinks, runway and deck arrester gear, recovery net and stabilized antenna for sea based operations and any additional support equipment.[20]

Overcoming System Limitations

Despite the many capabilities provided by the Pioneer, the system does possess several limitations that the US military has had to deal with over the course of its 25 years of service in the inventory. Many have noted that the Navy's decision to purchase a non-developmental RPA from the Israelis is the main culprit in a series of growing pains the program has had to overcome. IAI advertised the Pioneer program as being a ship-based capable system, but the US Navy did not adequately examine this aspect of the program when making its procurement decision.[21] In fact, at the time of procurement, the Pioneer had never been employed from a ship, and IAI had no supporting data to show that the system could be used at sea.[22] As a result, the Pioneer experienced several crashes during its initial system deployment due electromagnetic interference between the ships other onboard systems and the Pioneer's GCS causing a loss of datalink. Additionally, the vehicle's engine size proved insufficient for ship-based operations and would regularly overstress causing further aircraft losses.[23] Finally, the issue of recovering the RQ-2 on Navy ships with the net system proved to be an extremely daunting task and major limiting factor for using the system at sea.

The Marine Corps was also unhappy with the initial performance of the Pioneer. Former Commandant of the US Marine Corps, General Charles Krulak identified numerous shortfalls with the system noting, "First, the Pioneer does not have an automatic take-off, landing, or mission execution capability that has led to high accident rate. Second, since the UAV telemetry is calculated at a GCS that is incapable of integrated data dissemination, we lose the ability to pass this information quickly to the units that need it. Third, because it lacks weatherproofed avionics and has no Synthetic Aperture Radar (SAR) capability, the Pioneer is useless in bad weather."[24] Ultimately, these limitations forced the Navy to spend over $50 million in system upgrades—more than 50 percent of the original program procurement cost—to get the Pioneer to meet minimum operational requirements.[25] Moreover, the Pioneer's limited endurance and range proved to be another shortfall to the warfighter who was always seeking intelligence support in a fluid combat environment. However, even though the Pioneer clearly did not meet US military requirements when procured in 1986, the systems evolution and performance in over two decades of supporting contingency operations was successful, and paved the way for the future of US RPA employment.

Operational History

Although initially procured by the Navy to conduct naval gunfire spotting, the Pioneer has supported a variety of missions throughout its storied career to include: reconnaissance, surveillance, and target acquisition (RSTA), maritime interdiction, BDA, search and rescue, sea mine detection, drug enforcement and anti-surface warfare (ASW). The system initially deployed to the Persian Gulf in 1988 where it was extremely effective in conducting over the horizon (OTH) battle ship targeting support to a reliability of nearly 100 percent. By the summer of 1995, the US was operating nine Pioneer systems across the services and had compiled over 5,000 sorties and nearly 12,000 flight hours with the program accomplishing an 85 percent sortie availability rate. The millions of dollars in upgrades the Navy invested in the program had finally paid off, and these successes continued when the Pioneer was utilized in combat.[26]

During Operations Desert Shield and Desert Storm, six operational systems, including 40 air vehicles, were deployed to the Persian Gulf to support US Army, Navy and Marine operations. Flying over 545 sorties and over 1,600 hours, the Pioneer supported combat operations of all three services and provided critical intelligence information to the warfighter.[27] It had great success in providing naval gunfire spotting support for the USS Iowa effectively destroying enemy targets and softening defenses along the Kuwaiti coastline, while also assisting in general target selection and BDA.[28] The Pioneer also proved beneficial for the Navy in conducting mine hunting operations throughout their area of operations.[29] The Marines were able to utilize the Pioneer to direct air strikes from AV-8B Harriers and conduct NRT reconnaissance in support of special operations missions, and found the system to be a viable intelligence gathering alternative to fill the gap created by the retirement of their RF-4 aircraft.[30] The Army also found great success with the Pioneer during their “left hook” maneuver into Iraq. They were able to utilize the system to help pinpoint and destroy enemy artillery pieces enabling them to maneuver into position to quickly cut-off and destroy Iraqi forces in the Kuwaiti theater of operations.[31] Additionally, the Army’s 7th Corps established new TTPs for the Pioneer, when they were able to integrate the system with AH-64 Apache by providing route reconnaissance information to the attack helicopters.[32]

But perhaps the most interesting success story of the Pioneer was the psychological effect it had on Iraqi ground forces. During the course of the campaign, Iraqi soldiers quickly realized that when they heard the buzzing sound of a Pioneer overhead it was a pretty good indication that they were about to get shelled by US warships firing their 16-inch guns at their positions.[33] This understanding actually led to an incident where a group of Iraqi soldiers on Faylaka Island surrendered to a Pioneer marking the first time in history that human soldiers surrendered to an unmanned system.[34] Although 12 vehicles were lost and another 18 damaged during the conflict, defense officials quickly recognized the successes the Pioneer achieved during the campaign.[35] Former Secretary of Defense Dick Cheney lauded the system in his report to Congress stating "the Pioneer appears to have validated the operational employment of UAVs in combat."[36] Furthermore, a post war DoD report in April 1992 noted; "The Navy Pioneer UAV system's availability exceeded expectations. Established sortie rates indicated a deployed unit could sustain 60 flight hours a month."[37]

Pioneer continued its trend of success throughout much of the 90s. In 1993, it was deployed on the USS Shreveport in support of Operation Continue Hope/UNOSOM II in Somalia. And in 1994, the Pioneer was called upon to fly missions over Bosnia in support of Operation Provide Promise. During both operations, the Pioneer continued to provide critical ISR support to the warfighter and achieved a 92.8 percent sortie effectiveness rate. In 1999, the Pioneer deployed on board the USS Ponce to provide ISR support during Operation Allied Force in Kosovo. It was during this operation that the US Air Force began full employment of its new RPA the MQ-1 Predator. Both RPAs suffered losses during the campaign (specifically four

Pioneers), but more importantly they further solidified the importance of these reconnaissance assets in future campaigns.[38]

But despite the numerous successes of the Pioneer, the Navy decided to cease operations of the program at the end of fiscal year 2002, transferring almost all of its systems under the Marine Corps.[39] The Navy decided to maintain one squadron of Pioneers—VC-6 at Patuxent river, Maryland—for test and evaluation purposes, while the Army and Marines continued operational use of the system through their 304th Military Intelligence Battalion and VMU-1 and VMU-2 squadrons respectively.[40] However, by the time US forces kicked off Operation Iraqi Freedom (OIF) in 2003, the Marines were the only branch of service using the system.

The Pioneer continued to perform effectively for the Marines during OIF, providing route reconnaissance, RSTA, and BDA intelligence data. Gunnery Sergeant Robert Wilson, an RQ-2 pilot withVMU-1, noted, "The Pioneer is an excellent tool with great potential for changing the way we fight the enemy. We provide a unique overhead view for tactical commanders with imagery intelligence to help them make battlefield decisions and save Marines' lives."[41] As part of the COIN effort, Marines operating in Ar Ramadi and Fallujah relied on the Pioneer as a means to observe insurgents setting up ambush points and moving weapons throughout their area of operations.[42] This allowed the Marines to conduct critical intelligence preparation of the battle space prior to and during their raid, strike and convoy operations in the cities. All in all, the Pioneer flew 388 sorties and more than 1,300 hours supporting various OIF mission requirements.[43]

Finally, it is important to recognize that the Pioneer has supported missions beyond the scope of US military overseas contingency operations. Throughout much of the 90s, the Pioneer also directly supported the US Border Patrol (USBP) through Joint Task Force 6. The Pioneer augmented the USBP by providing a night surveillance capability along southern and northern US borders. Any activity of interest that the Pioneer would pick up during its missions was directly passed to USBP agents for action. The added benefit of having the Pioneer on station influenced USBP decision makers to procure their own RPA (MQ-5 Hunter) system that is still in use today.[44]

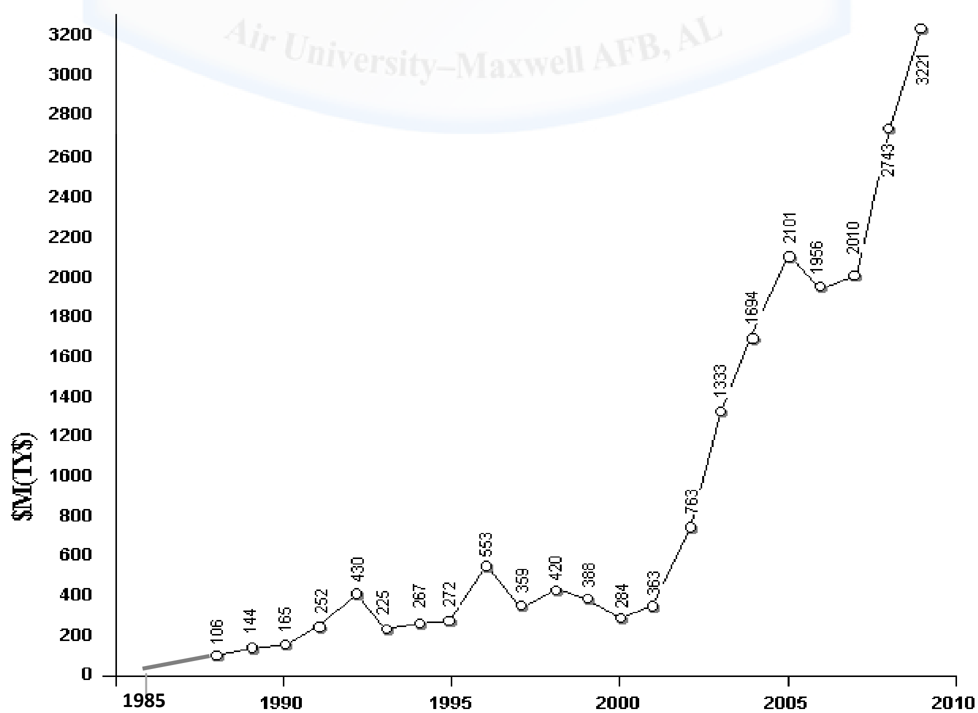
Today, the US Military has essentially retired the RQ-2 Pioneer from operational use. The Navy still maintains their testing program at Patuxnet, but is currently in a transition period awaiting full operational capability of their MQ-8B Firescout unmanned helicopter. While the Army transitioned to the RQ-7 Shadow 200 in 1999 and RQ-5 Hunter circa 2002, and the Marines began operations with the Shadow 200 by May of 2007. Finally, the DoD UAV Training Center at Fort Huachuca also maintains a Pioneer system at this time.[45]

Shaping a Legacy for Tomorrow

Throughout its storied history, the RQ-2 Pioneer has been criticized as a system that has fallen short in meeting its operational warfighting requirements. Indeed the Pioneer cost the Navy millions of dollars in system upgrades to get it to an initial operations capability. But looking back over the last twenty years at what this RPA has accomplished and delivered to the warfighter, and the influence it has had on next generation systems cannot be denied. From 1986 to 2006, the Pioneer registered over 40,000 flying hours with more than 13,000 of those hours flown in combat.[46] During Desert Storm, Pioneer demonstrated to senior leaders how RPAs could effectively complement other information systems, providing a total battle space view to all commanders, from the tactical battlefield commander to the operational-level decision makers.[47] More importantly, the real reason why the Pioneer's role in Desert Storm was so critical to the future of RPAs was that it changed the opinions and attitudes of military officials about the role of RPAs in future ISR architectures.[48] In other words, the success of the Pioneer during Desert Storm was a pivot point that directly shaped the future role of the RPA in the US military. This notion was further codified in the Defense Department's 2007 UAV Roadmap report which highlighted the Pioneer's combat successes as the reason why there were follow on RPA systems like Predator and Global Hawk.[49]

A look at the RPA annual funding profile from 1985 to 2010 (figure 2) illustrates the significant spike in defense spending that has taken place to facilitate development of these systems over the last 25 years. The Pioneer started this revolution when it came on board in 1986, and validated the need for this ISR capability with its sustained performance throughout the 90s and into the twenty-first century with the support it provided during OIF.

Figure 2. RPA Annual Funding Profile (1985-2010)[50]



The lessons learned during the Pioneers two decades of employment have been equally important to the development of the RPA generation seen today. First, the issue of limited endurance the Pioneer suffered from has been remedied in many of its cousins used today. For example the Hunter RPA can maintain a loiter time of up to 11 hours while the Predator can remain on station 16 to 24 hours depending on its configuration.[51] These enhancements provide the warfighter with extended periods of persistent ISR coverage to meet mission requirements. Second, construction of the newer generation RPAs have improved since the Pioneer and as such are not as vulnerable to the negative effects of weather on system employment. Although wind can still adversely affect launch and recovery of the newer systems, the implementation of de-icing capability has drastically improved the survivability of these aircraft when flying in harsh weather conditions. Third, improvements in technology have drastically improved overall capability and effectiveness of the newer generation RPAs. Systems are now able to fly missions beyond line of sight to the ground control station; they are carrying Synthetic Aperture Radar (SAR) packages making them all-weather capable with regards to ISR collection; and they are now flying with weapons onboard making them armed reconnaissance platforms able to prosecute time sensitive targets if need be. All of these capability upgrades can be directly attributed to the Pioneer and the fact that it opened the eyes of US military leadership and the technological developers to realize the potential of what these RPAs could provide to the warfighter.

Conclusion

The fog of war remains a real phenomenon that commanders must overcome on the twenty-first century battlefield. The RPA revolution has provided an unprecedented means of intelligence gathering and information flow that has effectively minimized the fog of war in combat today. The RQ-2 was truly the pioneer RPA that laid the foundation for the ISR capabilities the US military enjoys today. The Pioneer's successes during operations in Iraq, Somalia, Bosnia, and Kosovo effectively paved the way for the future of US RPA programs and caused a paradigm shift in how the military leadership viewed the potential application of these systems on future battle fields. Through years of employment, the Pioneer has provided a database of knowledge on how future generation systems needed to be designed, and what capabilities they would need to bring to the fight to meet the warfighter requirements of tomorrow. Today, the demands for RPA support on the battlefields of Iraq and Afghanistan are at an all-time high because commanders understand the value of the ISR data that these systems provide. This is a true testament to the Pioneer, and the influence on the RPA revolution it set into motion twenty-five years ago.

G*lossary*

BDA	Battle Damage Assessment
COIN	Counter Insurgency
DoD	Department of Defense
ECM	Electronic Counter-Measures
EO	Electro Optical
EW	Electronic Warfare
FLIR	Forward Looking Infrared
GCS	Ground Control Station
IAI	Israeli Aircraft Industries
IR	Infrared
ISR	Intelligence, Surveillance and Reconnaissance
LGB	Laser Guided Bombs
LPD	Landing Platform Dock
MPCS	Mission Planning and Control System
NRT	Near Real Time
OIF	Operation Iraqi Freedom
RPA	Remotely Piloted Aircraft
SAR	Synthetic Aperture Radar
TCU	Tracking Communications Unit
TTP	Tactics, Techniques and Procedures
UAV	Unmanned Aerial Vehicle
UHF	Ultra-High Frequency
USBP	US Border Patrol
VHF	Very-High Frequency

[1] Clausewitz, *On War*, 101.
[2] DoD, *Quadrennial Defense Review 2010*, 22.
[3] Trefz, "From Persistent ISR to Precision Strikes: The Expanding Role of UAVs," 7.
[4] US Navy Fact File, "RQ-2A Pioneer UAV," http://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=2100&ct=1
[5] Carlson, "Past UAV Program Failures and Implications for Current UAV Programs," 5.
[6] *Ibid.*
[7] *Ibid.*
[8] *Ibid., 6.*
[9] *Jane's Unmanned Aerial Vehicles and Targets*, 77.
[10] US Navy Fact File, "RQ-2A Pioneer UAV," http://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=2100&ct=1
[11] *Ibid.*
[12] Rodriguez, *Testimony before the Subcommittee on Military Research and Development and Military Procurement, Committee on National Security, House of Representatives, Unmanned Aerial Vehicles: DoD's Acquisition Efforts*, 3.
[13] *Jane's Unmanned Aerial Vehicles and Targets*, 77.
[14] *Ibid.*
[15] *Ibid.*
[16] *Jane's Unmanned Aerial Vehicles and Targets*, 78.
[17] *Ibid.*
[18] JP 3-09.3,*Close Air Support*, GL-19.
[19] *Jane's Unmanned Aerial Vehicles and Targets*, 77-78.
[20] *Ibid., 78.*
[21] Carlson, "Past UAV Program Failures and Implications for Current UAV Programs," 7.
[22] *Ibid.*
[23] Fulghum, "Outrider UAV Tackles Army, Navy Requirements," 70.
[24] Krulak, "Riding the Dragon into the 21st Century, Innovation and UAVs in the United Sates Marine Corps," 11.
[25] Rodriguez, *Testimony before the Subcommittee on Military Research and Development and Military Procurement, Committee on National Security, House of Representatives, Unmanned Aerial Vehicles: DoD's Acquisition Efforts*, 12.
[26] *Jane's Unmanned Aerial Vehicles and Targets*, 78-79.
[27] Military Periscope.com, "RQ-2 Pioneer," http://www.militaryperiscope.com/weapons/aircraft/rpv-dron/w0004685.html
[28] *Ibid.*
[29] *Jane's Unmanned Aerial Vehicles and Targets*, 79.
[30] Longino, "Role of UAVs in Future Armed Conflict Scenarios," 9-10.
[31] Jones, "UAVs an Assessment of Historical Operations and Future Possibilities," 19.
[32] *Jane's Unmanned Aerial Vehicles and Targets*, 79.
[33] Singer, *Wired for War*, 56-57.
[34] *Ibid.*, 57.
[35] *Jane's Unmanned Aerial Vehicles and Targets*, 79.
[36] Cheney, *Conduct of the Persian Gulf Conflict, An Interim Report to Congress,* 6-8.
[37] Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, 477.
[38] *Jane's Unmanned Aerial Vehicles and Targets*, 79.
[39] *UAV Roadmap 2007-2032*, 67.
[40] *Jane's Unmanned Aerial Vehicles and Targets*, 79.
[41] Leicht, "VMU-1 Pioneer UAV provides 'Birds Eye' View of Combat Zone," http://www.globalsecurity.org/military/library/news/2004/09/mil-040921-usmc02.htm
[42] *Ibid*

[43] *Jane's Unmanned Aerial Vehicles and Targets*, 79.
[44] *UAV Roadmap 2007-2032*, 37-38.
[45] *Jane's Unmanned Aerial Vehicles and Targets*, 79; *UAV Roadmap 2007-2032,* 71.
[46] *Jane's Unmanned Aerial Vehicles and Targets*, 79
[47] Longino, "Role of UAVs in Future Armed Conflict Scenarios," 9.
[48] Jones, "UAVs an Assessment of Historical Operations and Future Possibilities," 25.
[49] *UAV Roadmap 2007-2032*, 48.
[50] Bone, *UAVs: Background and Issues for Congress*, 11.
[51] *UAV Roadmap 2007-2032,* 65&70.

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