CENTRE FOR MILITARY STUDIES
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Long Time Coming:

Developing and Integrating UAVs into the American, British, French, and Danish Armed Forces

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Denne rapport er en del af Center for Militære Studiers forskningsbaserede myndighedsbetjening for partierne bag Forsvarsforliget 2013-2017. Formålet med rapporten er at beskrive udviklingen i brugen af ubemandede fly, og hvorledes de repræsenterer de næste skridt i udviklingen indenfor moderne luftmagt. På baggrund af en analyse af erfaringer fra USA, Storbritannien, Frankrig og Danmark, diskuterer rapporten udfordringer og muligheder for disse systemer, og hvilke overvejelser man skal have, når der i fremtiden skal investeres i disse ubemandede systemer.

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This report is a part of Centre for Military Studies' policy research service for the parties to the Defence Agreement 2013-2017. The purpose of this report is to describe the development of the use of unmanned aerial aircraft and how they represent the next step in evolution of modern air-power. Based on an analysis of lessons learned from USA, UK, France, and Denmark, this report discusses challenges and opportunities for these systems, and what considerations one should have when considering future investment in these unmanned systems.

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This report is an analysis based on research methodology. Its conclusions should therefore not be understood as the reflection of the views and opinions of the Danish Government, the Danish Defence or any other authority.

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English Abstract

NATO nations are transforming their military forces to be able to engage in expeditionary warfare effectively. They are incorporating advanced technologies that enable military forces to find and strike targets precisely from great distances at little risk to themselves. The persistence of unmanned aerial vehicles (UAVs) represents the next step in modern airpower's long-range reconnaissance/precision strike complex and has transformed ground operations. They were not demanded until their worth was proven in recent operations—after 60 years of development. The experiences of the United States, United Kingdom, France, and Denmark demonstrate why. UAVs have been difficult to develop, employ, maintain, and integrate into modern militaries and have only recently become effective. Such challenges should temper expectations that they represent an inexpensive alternative to all types of modern aircraft or that their proliferation will have a profound and systematic impact on the nature of warfare.

Dansk resumé

NATOs medlemslande er i gang med at transformere deres militære styrker så de effektivt kan deltage i internationale missioner. De indfører avanceret teknologier der gør det muligt for militære styrker at finde og præcist angribe mål fra stor afstand med lille risiko for dem selv. Ubemandede flys (UAV) udholdenhed repræsenterer det næste skridt i moderne luftmagts langtrækkende rekognoscerings- og præcisionsmidler og har ændret landoperationer. Der var ingen efterspørgsel efter disse UAV før de viste deres værd i nyere tids militære operationer efter 60 års udvikling. Erfaringer fra USA, Storbritannien, Frankrig og Danmark viser dette. UAV'er har været udfordrende at udvikle, indsætte operativt, vedligeholde og integrere i moderne militære styrker og har ikke før for nyligt vist sig som effektive systemer. Disse udfordringer bør dulme forventninger om at UAV er billige alternativer til alle former for moderne fly eller at deres udbredelse vil have grundlæggende og systematisk indflydelse på krigsførelsens udvikling.

Contents

1. Introduction

In 2002, a Hellfire missile launched from an American *Predator* unmanned aerial vehicle (UAV) killed Salim Sinan al-Harethi, a Yemini citizen suspected of involvement in the 2000 attack on the U.S. Navy destroyer USS Cole.[1] This event is usually seen as heralding a decade of military operations made possible by unmanned aerial vehicles (UAVs).

The rapid increase in the use of UAVs is one of the most significant developments in the technology of war, providing operational advantages for their users—not least the United States. Today, unmanned systems function as an integrated part of all branches of the American armed forces. They perform a variety of tasks, making them highly useful assets when the West uses military force. This, at least, was a major lesson drawn by European militaries and ministries of defence following the Libyan air campaign.[2] They identified substantial European shortfalls in the intelligence, surveillance, and targeting capabilities provided by unmanned vehicles.[3] Consequently, efforts to procure or develop unmanned systems are now being taken in NATO as well as in many individual European countries. Indeed, the demand for unmanned systems is increasing—and not just within Europe. The rise of UAVs is a global phenomenon, already increasing the use and utility of airpower.

These developments are relevant to Denmark for three reasons. First, they have stirred political debate amongst the political elite and general public.[4] The political debate in Denmark is characterized by a skeptical stance toward the American use of armed UAVs in Pakistan, as exemplified by critical remarks made by Søren Pind, Venstre's foreign affairs spokesperson, that this practice had left President Obama in a "*moralsk morads*" (moral morass).[5] On the other hand, there is widespread political support for further Danish use of UAVs. At a seminar arranged by the Centre for International Law and Justice and the Centre for Military Studies on 26 September 2013, defense or foreign affairs spokespersons from the Social Democrats, Social Liberals, and Venstre all agreed that the use of unmanned systems, even if armed, should be pursued by the Danish armed forces.

Second, this consensus reflects the reality that the Danish armed forces have relied upon UAVs to facilitate their military operations. As then-Minister of Defence Nick Hækkerup said explained in Parliament (the *Folketing*) on 11 April 2013, "Drones are a useful and effective tool that is already used by the Danish military for surveillance and information gathering. In Afghanistan, for example, the Danish soldiers for several years have used small, handheld, unarmed drones for surveillance and information gathering."[6] In Libya, UAVs played a pivotal role in providing the data necessary for both maintaining command and control over Allied air operations as well as provided detailed real-time targeting information necessary for fighter aircraft to find and hit their targets.[7] And off the Horn of Africa, UAVs have helped patrol the waters in search of pirates.[8]

Third, the Danish armed forces are poised to increase their reliance upon these systems. Then-Minister of Defence Nick Hækkerup also stated in his Parliamentary address that "I can well imagine that the armed forces in the coming years will increase the number and use of drones, for example, for monitoring in the Arctic or otherwise in support of the armed forces' general capabilities. Surveillance drones could also be used in support of civil authorities, for example, for search operations, major accidents, disasters, and the like. News from drones can help minimize civilian casualties and to take care of our own soldiers."[9] This was reflected in the December 2013 Defence Agreement that authorized the testing of capabilities to monitor the Arctic, "including the use of unmanned aerial vehicles (UAVs)."[10] We provide an analysis of the considerations that should guide the Danish decision to invest in UAVs in a separate report.[11]

This report provides an informed basis for these deliberations by placing them within a broader strategic context. First, we show how airpower has come to play such a significant role in how the West contemplates and executes the use of force and how the use of unmanned systems gradually, and then in a revolutionary manner, has contributed to this Western paradigm. We then discuss what a UAV is and tell the surprisingly lengthy story of its development into the systems common today. This is largely an American story, and it provides context for the subsequent analysis of the British, French, and Danish approaches to and uses of UAVs. Through the analysis of the experiences of three different types of states—a first-mover superpower, two second-mover great powers, and a third-mover small power—we draw a series of general lessons that should temper the enthusiasm and trepidation characterizing the debate on the decisions to acquire and use unmanned aerial vehicles being undertaken today and in the near future.

2. The Mystique of Airpower

Many developments within the Danish political system have allowed its leaders and society "to view the use of force as a legitimate and useful tool of statecraft."[12] But a primary enabler has been the development of military technology that increases the efficiency and effectiveness of military force while reducing risks to friendly personnel and non-combatants.[13] American strategist and State Department counselor Eliot Cohen made this argument in the aftermath of the 1991 Persian Gulf War. Airpower proved extremely effective against the fourth largest military force in the world.[14] American airpower destroyed Iraqi air defences within hours, establishing air superiority over the entire country while only losing a few aircraft.[15] This enabled the severe degradation of Iraqi command and control, immobilizing the Iraqi military and destroying over a quarter of Iraqi armored forces in Kuwait prior to the launching of a ground offensive.[16] "Airpower had made the final assault as effortless as a wartime operation can be," argued Cohen.[17] During the war, the United States experienced 148 battle deaths and 145 non-battle deaths, and 467 personnel were wounded in action.[18] It lost 37 fixed-wing aircraft and 23 helicopters in combat—none in air-to-air engagements.[19]

This unrivalled accomplishment was enabled by the integration of new technologies that had matured towards the end of the Cold War. This "revolution in military affairs" consists of the integration of a long-range reconnaissance-precision strike complex into a military force that allows targets to be discriminately discovered and destroyed by military forces located far away.[20] Satellite communications "provided unparalleled support to military commanders for intelligence gathering, map-making, communication, navigation, meteorology and missile-launch detection."[21] Global Positioning System (GPS) technology enabled military forces to locate themselves and enemy forces with unprecedented precision. Computers allowed a vast array of information to be processed and used to schedule the force movements during operations, allowing the centralized orchestration of the air campaign and the rapid accumulation of synchronized and synergistic effects on the ground.[22] These developments enabled different means of placing munitions on target with unprecedented accuracy—whether delivered by cruise missiles or air-dropped precision guided munitions (PGMs)—with devastating effect on the Iraqi forces and facilities.

The 1990s saw this airpower revolution enable decisive intervention in thorny conflicts, including those in Bosnia, Kosovo, and Afghanistan.[23] Two weeks of airstrikes against 56 military targets near Sarajevo were sufficient to shift the balance of power on the ground and convince Yugoslav President Slobodan Milosevic to bring his Bosnian Serb allies to a settlement at Dayton. In Kosovo, 78 days of aerial bombardment coerced Milosevic to cede control over highly valued and symbolic, sovereign territory. Only two Allied aircraft were lost and no friendly fatalities occurred.[24] In Afghanistan, airpower combined with Special Operations Forces, CIA operatives, and the Northern Alliance toppled the Taliban regime within 2 months.[25] Airpower had apparently reached its potential of allowing low-cost interventions into difficult and tragic situations. It did so because the technology, infrastructure, organization, and doctrine had matured to provide the ability to find and precisely strike specific targets in a timely manner from great distances and without risk to friendly personnel. UAVs represent the latest expression of this capability.

3. UAVs: All that & more!

UAVs have recently captured the imagination of policy makers and the public alike for reasons that reflect the mystique of airpower. Apparently, they allow warfare to be conducted without risk to friendly personnel. Indeed, there has been a rapid proliferation of UAVs in the interstate system. According to the U.S. General Accountability Office, "since 2005, the number of countries that acquired an unmanned aerial vehicle (UAV) system nearly doubled from about 40 to more than 75."[26] It seems that every state, and even non-state actors,[27] are acquiring UAVs. But what are they?

Simply put, an "unmanned aerial vehicle" is an aircraft without a pilot sitting inside of it. The U.S. Department of Defense defines it as "a powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vertical lift, can fly itself (autonomously) or be remotely piloted, can be expendable or recoverable at the end of the flight, and can carry a lethal or nonlethal payload."[28] They have been referred to by many names over the years: drones, flying robots, pilotless aircraft, RPVs (remotely piloted vehicles), and RPAs (remotely piloted aircraft). The terms mostly used in conjunction with these systems are *UAVs* and *drones*. When talking about the entire UAV system, including the ground control system and link systems, the term is Unmanned Aerial System (UAS). Conversely, ballistic and semi-ballistic missiles, cruise missiles, and artillery projectiles do not qualify as UAVs.[29]

The Central Intelligence Agency categorizes UAVs in three ways: mini, tactical, and strategic.[30] Mini-UAVs fly at low altitudes, can remain aloft for less than one hour, and operate at close-range to their controller. The American *Raven* UAV that Denmark used in Afghanistan falls in this category. Tactical UAVs fly at low-to-medium altitudes, can remain aloft for several hours, and are limited to a range that remains within the line-of-sight of the controller—approximately 300 km or less on land. The U.S. Army's *Shadow* UAV falls into this category. Strategic UAVs fly at medium-to-high altitudes, can remain aloft for hours to days, and can operate thousands of kilometers from their controllers. The USAF's *Global Hawk* falls into this category (see Table 1 for a quick overview).

Table 1: 3 Types of UAVs[31]

Category	Mini	Tactical	Strategic
Altitude	Low	Low to medium	Medium to high
Endurance	Short (about an hour)	Medium (up to several hours)	Long (ranges from hours to days)
Range	Close-range	Limited to line-of-sight (approximately 300 kilometers or less) (about 186 miles)	Long range
Example	Raven 	Shadow 	Global Hawk 

UAVs have several apparent advantages over manned aircraft. These include performing missions where the risk to aircrews is deemed unacceptably high. Missions such as suppressing enemy air defences require that pilots seek out enemy capabilities specifically designed to kill them, for instance. UAVs have been used for such missions in Vietnam, Bosnia, Kosovo, and Iraq.[32] As retired USAF Colonel and current Senior Advisor to the Under Secretary of Defense for Policy Thomas Ehrhard explains, “drones showed infinite courage in their role as protectors of US military pilots.”[33] Aircrews could also be placed in jeopardy in reconnaissance missions over unfriendly countries. American U-2 pilot Francis Gary Powers was shot down and captured by the Soviet Union in 1960, sparking a diplomatic crisis and placing sensitive technology in Soviet hands.[34] When an American UAV crashed in Iran in December 2011, the incident was notable only because the model was one that had heretofore not been publicly revealed.[35]

Removing aircrews from the aircraft can also enable missions precluded by human endurance. The USAF “estimates a limit of about 12 hours for the pilot of a single-seat aircraft” and 40 hours for an aircraft with multiple crew members.[36] Without these constraints, missions characterized by “persistence” are enabled.

Removing flight crew could also enable capabilities precluded by human frailty. Extreme maneuverability resulting in high g-forces is an oft-cited example as a potential advantage of UAVs.[37] It must be noted, however, that such technical capabilities require computing and communications technology beyond that in existence today.

Finally, removing the flight crew also allows aircraft designers to remove systems needed to support a pilot, such as oxygen systems, climate control, and safety systems like an ejector seat. This *could* reduce the cost of these systems, and many believed that removing man from the cockpit *would* reduce the cost of these systems.

But this has not yet been the case. As the U.S. Congressional Budget Office notes, “initial concepts envisioned very low-cost, essentially expendable aircraft. As of 2011, however, whether substantially lower costs will be realized is unclear.”[38] This is because removing man from the machine also increases the cost of other systems that enable remote control or automation, such as communications and ground control systems. The limitations of these systems have resulted in much higher accident rates than for manned aircraft and longer maintenance times. “UAV[s] proved to be more vulnerable than manned aircraft to bad weather, enemy air defences, and mechanical and communications failures. By 1997, the peacetime attrition rate for the [American] Pioneer UAV was 17 times higher than that for manned aircraft. By early 2002, 23 of 65 Predators built, or over a third, had crashed.”[39] It has also required additional systems for launching and recovering the aircraft. The British *Phoenix* UAV used in Kosovo and Iraq, for instance, required five vehicles to transport, launch, control, and recover it after it landed via parachute.[40] Because of such additional requirements, British UAVs had a greater manpower-to-aircraft ratio than fighter jets.[41]

As this suggests, technical advantages and costs play major roles in the development and use of military capabilities. But there are greater considerations. Military capabilities can be seen as the product of technology applied to tactical and operational problems deriving from the threat environment by the organizations responsible for national security. As the threat environment evolves or the focus changes from one aspect to another, these organizations use the technology on hand and that which can be developed to address operational and tactical problems. Over time, solutions are often found that accommodate the conceptual orientation of these organizations—and solutions that do not are often ignored.[42] Intervention by external authorities may overcome the resistance of organizations whose culture or theory of victory retards the adoption of new capabilities or approaches that are believed to be better.[43] The development of UAVs and their integration into the military forces of the United States, United Kingdom, France, and Denmark over the past 60 years reflect variations on such a narrative.

3.1: The American UAV Experience

From the perspective of 2013, it may easily be forgiven if it seems as though UAV technology has been ever-present and ever-effective in the American response to global terrorism. Many of the technologies associated with them are almost as old as manned flight itself,[44] but it must be recognized that they consist of sophisticated technologies and only recently have matured into a usable military capability. Indeed, only 12 years ago, the first mover in UAV technology could not operate two of these aircraft simultaneously in a theater of war against an adversary lacking air defences. Three days into the American intervention in Afghanistan, President George W. Bush and American senior leaders discussed the use of UAVs there. "Why can't we fly more than one Predator at a time?" asked the President. "We're going to try to get two simultaneously," said CIA Director George Tenet. "We ought to have 50 of these things," replied Bush.[45] Such limitations on UAV capability existed despite over five decades of efforts to address technological and organizational challenges that limited and often redirected efforts to develop UAVs into an effective military capability.

During the Cold War, the United States faced a superpower adversary whose political leadership that routinely used secrecy and deception in its statecraft, led a closed society in which information did not flow freely, and possessed vast expanses of territory on which to develop military capabilities feared by the West.[46] Western policy makers required information on the Soviet Union's facilities and military capabilities, and aerial reconnaissance was one means pursued to acquire this information. As most of these targets were composed of buildings, factories, military bases, airfields, and other permanent structures, only episodic over-flight reconnaissance was necessary. In the 1950s and 1960s, the USAF Strategic Air Command (SAC) and the intelligence agencies pursued three types of systems to accomplish this mission: manned aircraft such as the U-2 spy plane, UAVs, and satellites.

All three systems needed to be able to fly long distances, take pictures and gather other sorts of data, not be shot down, and return that information to American officials. The most traditional platform—a manned aircraft—was the first to carry out this type of mission. It required technology to fly long distances at high altitudes to avoid air defence systems, such as surface-to-air missiles, and to do so quickly so as to complete the mission in a space of time that could be endured by its human pilot. The first U-2 flew over Soviet territory on 4 July 1956.[47] Next came satellites. The Soviet satellite *Sputnik* was launched on 4 October 1957 and the first American photo reconnaissance satellite was successfully placed in orbit in

August 1960.[48] It had to overcome the technical problems of being placed into orbit and transmitting information back to earth. Orbital altitude protected satellites from air defences and its information could be retrieved from canisters of film dropped to Earth from orbit. Unlike a spy plane, however, satellites could not change their flight path and were therefore limited to gathering images over static areas. And once their film ran out, they ceased to be useful for photographic reconnaissance. With these limitations, attention was given to UAVs. UAVs required all of the characteristics of manned aircraft, except speed, although speed would increase survivability. They also required a means of being controlled either through automation or remote control. Automated flight paths were difficult to program—unlike orbital mechanics, atmospheric conditions had to be compensated for—and secure means of remote control were not possible over the vast distances behind the Iron Curtain. Because these technological hurdles were so high—not even entirely overcome in the *Apollo* moon program—no UAV for strategic reconnaissance was ever developed or deployed during the Cold War. UAVs were simply unable to compete with manned spy planes and reconnaissance satellites to perform this mission.

UAVs fared better in two tactical mission areas, however: operational intelligence and the suppression of enemy air defences (SEAD). During the Second World War, the U.S. Army Air Forces developed and acquired 14,891 radio-controlled aircraft to use as training targets.[49] During the 1960s, the USAF and National Reconnaissance Office developed the *Lightning Bug* based on that experience. It was a jet-powered aircraft that was launched from under the wing of a DC-130 *Hercules* transport aircraft, flew a pre-programmed pattern, and returned to a designated recovery point by deploying a parachute and being caught in mid-air by a helicopter.[50] The launch-and-recovery system proved rather expensive and required a benign-threat environment. The *Lightning Bug* could travel 1,300 miles and fly as low as 300 feet to take high-resolution photographs. Although useful, its pre-programmed navigation system was prone to errors, hitting fewer than 50 per cent of its target sites on average, and the delays in film processing yielded little usable intelligence to commanders.[51]

In the last year of American involvement in Vietnam, the *Lightning Bug* was upgraded to use "long-range-aid-to-navigation (LORAN) technology that drastically improved reconnaissance effectiveness" as well as "a real-time data link" that permitted using a "television camera in the nose to enhance navigation accuracy."[52] Although the communications link could be easily jammed, 1972 was the beginning of remote-controlled UAVs being used in combat conditions. With these technological improvements, pictures taken by the *Lightning* Bug were clear enough to assess bomb damage and were used by the Chairman of the Joint Chiefs of Staff in Congressional testimony in 1973, the first public acknowledgement of UAV use in Vietnam.[53] Overall, *Lightning Bugs* flew 3,435 sorties over Vietnam and China over 11 years and had a higher than expected recovery rate of 75 per cent, which extended their service life to seven missions per aircraft.[54]

The *Lightning Bug* also proved useful in suppressing enemy air defences. North Vietnam shot down its first American fighter-bomber in August 1965. In 1966, a *Lightning Bug* was outfitted with sensors to record data on North Vietnamese surface-to-air missiles (SAMs) and transmit that data just before being destroyed.[55] Later, another *Lightning Bug* was used to assess the ability to spoof North Vietnamese SAMs and was successful, starting a process of using UAVs to continuously update American countermeasures to North Vietnamese air defences.[56] This method was used by Israel in the 1973 Yom Kippur War as well as by the United States in Operation Desert Storm in 1991—albeit with a different UAV model.

UAV operational experience during the Vietnam War allowed the USAF to develop methods for using those capabilities in the field, de-conflicting and coordinating UAV flights with those of other aircraft. As their utility increased, so did demand for UAVs to address the next focus of American security policy: the Soviet threat in central Europe. It was hoped that UAVs could be further developed to suppress the "multifarious complex of interlocking systems that threatened to … 'sweep the skies clean of enemy aircraft coming within their range'."[57] Developments in microprocessors, integrated circuitry, and high-bandwidth, and real-time communications promised to increase UAV capabilities—"heralding the emergence of a major new weapon system type that had the potential to supplant manned combat aviation."[58]

Since UAVs were being used for tactical intelligence and operations, USAF Tactical Air Command (TAC) took over the development of UAVs in 1976—after the National Reconnaissance Office divested itself of UAVs to focus solely on satellites and Strategic Air Command (SAC) focused on manned reconnaissance capabilities.[59] TAC focused on capabilities that would yield operational advantages in the event of a NATO–Warsaw Pact clash in central Europe. It sought to develop UAVs to undertake "high-altitude, stand-off photography and electronic eavesdropping missions on the NATO–Warsaw Pact border" and provide early warning to NATO commanders. Unfortunately, this potential mission ran afoul of European air traffic control regulations, with the German and Belgian authorities adamantly denying permission to high-flying UAVs in civilian airspace.[60] Given this constraint and the technical difficulties associated with strategic UAVs, the development of this capability was abandoned and the mission defaulted to manned aircraft such as the U-2.

The wartime SEAD mission looked more promising—and more congenial to the combat-oriented TAC. Indeed, "the Air Force was enthralled with the idea of an RPV [remotely piloted vehicle] that could strike critical targets early in a conflict, and spent almost $50 million pursuing strike drone technology in the mid-1970s. None of the modification programs [for *Lightning Bug*] proved adequate in addressing the weather, terrain, and extreme combat environment expected in the European theatre."[61] The primary problem was the inability of the UAV to take off and land on a runway. This was beyond the technical abilities of the time, and developing a workable concept of operations for airborne launch and mid-air recovery by a helicopter during a NATO–Warsaw Pact conflict proved unworkable.[62] As Ehrhard concludes, "The technical, 'genetic' limitations of the RPV and the supporting technology never made the transition from Vietnam, where it was a niche capability, to a configuration that allowed them to compete for an integrated role in air combat on the Central Front."[63] UAVs proved unable to contribute meaningfully to the key USAF missions, and the service put development of UAVs on the shelf until the 1990s.

And there they would have stayed if civilian defence reformers from outside of the USAF had not restarted UAV development. They did so under a joint agency that was given budgetary authority outside of that of the armed services, the Defense Airborne Reconnaissance Office (DARO). This allowed the development of UAVs without the institutionally-oriented mission parameters imposed by the USAF. Furthermore, technology had advanced significantly. "Satellite-based GPS offered a break-through cure for the persistent problem of location accuracy by providing an off-board, omnipresent, highly accurate location signal…. Computing power and miniaturization improved by leaps and bounds, allowing UAVs to carry more capable payloads with more jam-resistant, higher bandwidth data links."[64] The increased availability and use of PGMs that were also enabled by GPS technology increased the need for extensive tactical reconnaissance that could be supplied by lightweight aircraft, such as UAVs. Finally, the threat environment shifted from the impossible conditions of the European Central Front to more congenial environs, such as Iraq during Operation Desert Storm[65] and the former Yugoslavia[66]—conflicts that called for the mystique of airpower.

Although DARO had its problems—in particular, it was resisted by the armed services that resented having their budgetary control over reconnaissance programs taken from them—and it ultimately ran afoul of the Congressional advocates of manned systems that had constituencies in the services, its initiatives produced the *Predator* medium-altitude UAV and the high-altitude *Global Hawk*. "The Predator was the first operational UAV that used … GPS for navigation, thereby eliminating the need for a direct line of sight connection with a ground station."[67] It was used in Bosnia by a "special Army military intelligence battalion composed of aviators" from July–November 1995.[68] During that operation, *Predators* flew 52 missions, two being lost to Serb ground fire and communications failure.[69]

It was at this point that the USAF regained interest in UAVs. The Predator's success in an operational role led the USAF to make "an all-out bid to be the 'lead service' for Predator" and control it "for doctrinal reasons," since the Chief of Staff "bristled at the thought of the Army flying a system with performance even higher than that of Hunter," the Army's low-altitude, tactical UAV that was still in testing and development.[70] It succeeded, with the services agreeing that *Predator* would be a joint asset operated by the Air Force and tasked through the Joint Forces Air Component Commander.[71]

Operation Allied Force saw the use of USAF *Predator* and U.S. Army *Hunter* UAVs to provide reconnaissance. "More than in any previous air operation, UAVs were used … for combat support, most notably for locating mobile SAMS, Serbian troop concentrations, and enemy aircraft parked in the open…. UAVs offered EUCOM air commanders and planners the advantage of close battle space awareness without any accompanying danger of incurring aircrew casualties."[72] Despite the assignment of UAVs to the Joint Forces Air Component Commander, they were not well integrated into the air operation.[73] "At least two Predators crashed in Kosovo."[74]

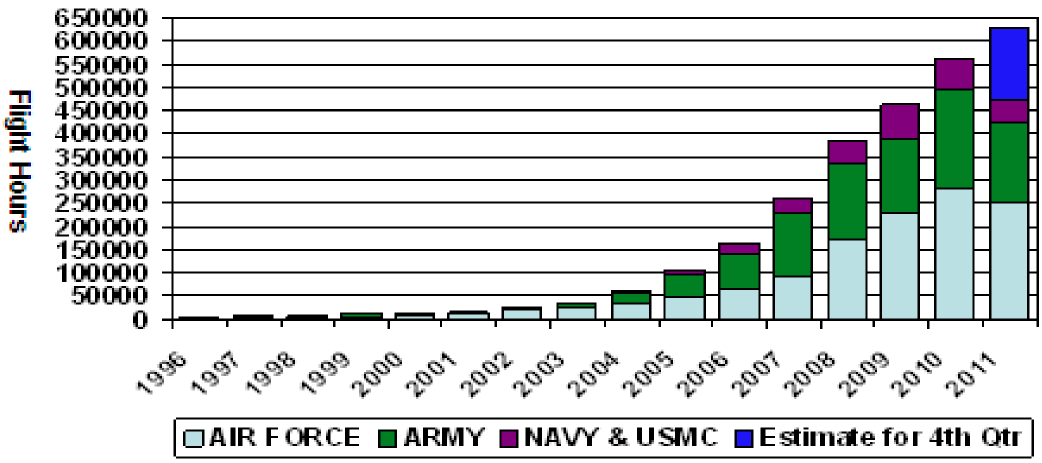
DARO's other success was the *Global Hawk*, a UAV "designed for extremely long transit and loiter times over intercontinental ranges" carrying "a 2,000-pound payload to 65,000 feet at jet speeds in excess of 400 miles per hour."[75] More specifically, the *Global Hawk* "can fly to a target area 5,400 nautical miles away, loiter at 60,000 feet while monitoring an area the size of the state of Illinois for 24 hours, and then return."[76] The *Global Hawk* is essentially an unmanned U-2 or perhaps "the theater commander's around-the-clock, low-hanging (surveillance) satellite,"[77] made possible 50 years after its conception by advances in technology—in particular, an ability to "automatically navigate, 'find the airport and land the plane'."[78] The *Global Hawk* began production in 2002. The USAF possesses 20 and plans to acquire 51 in total.[79]

The wars in Afghanistan and Iraq have provided a historically unique coincidence between mission requirements and technological maturity that have enabled significant increases in the use and utility of UAVs. In each theatre, air supremacy has been established, allowing slow, low-flying vehicles to perform without receiving significant hostile fire. Success in stability and counterinsurgency operations requires a keen ability to discriminate between combatants and non-combatants, a task that the persistence allowed by UAVs permits to be accomplished far more readily than in the past. Finally, the maturity of the technology, especially the far greater availability of military satellite bandwidth, has made instantaneous communication and transmission of dense data streams, such as real-time video, practical.

Yet this coincidence also required strong civilian leadership to overcome the USAF's cultural "preference for embodied platforms that permit warrior-flyers to ride technology into battle."[80] Indeed, during this decade, the USAF preferred to allocate resources to the F-22 Raptor, a fifth-generation air superiority fighter. Secretary of Defense Robert Gates repeatedly urged the service to change its priorities in public speeches and Congressional testimony—to little avail.[81] Eventually, Gates fired the Secretary of the Air Force and the Chief of Staff, ostensibly over another issue, but widely interpreted as for their insufficient dedication to providing UAVs to the joint fights in Iraq and Afghanistan.[82] The result was what Lieutenant General David Deptula, then-USAF Deputy Chief of Staff for ISR, termed an "AF ISR Transformation" that "[r]equires changing the culture regarding ISR."[83]

Consequently, American (and Allied) use of UAVs has increased significantly. The American UAV inventory increased from 167 in 2002 to 7,500 in 2011—not counting losses over the years.[84] Their use has increased significantly, as seen in Figure 1: from approximately 25,000 flight hours in 2002 to approximately 625,000 in 2011.[85] This 25-fold increase over the decade demonstrates the degree to which the American military has adopted UAV capabilities and how well it has integrated them into its concepts of operation.

Figure 1: U.S. Military UAV Flight Hours, 1996–2011[86]



This increase in use has not been without cost. By 2009, "more than a third of … Predator spy planes … [had] crashed."[87] Accident rates have been high for the entire U.S. UAV fleet. "The Air Force in a 15-year period through Sept. 30 [2012] recorded 129 accidents involving its medium- and high-altitude drones: the MQ-1 Predator, MQ-9 Reaper and RQ-4 Global Hawk. The figures include accidents that resulted in at least $500,000 in damage or destroyed aircraft during missions around the globe."[88] When compared to manned aircraft in the USAF fleet, "Northrop's Global Hawk and General Atomics' Predator and Reaper unmanned aerial vehicles have had a combined 9.31 accidents for every 100,000 hours of flying. That's the highest rate of any category of aircraft and more than triple the fleet-wide average of 3.03, according to military data compiled by Bloomberg."[89] These losses have been expensive, but expected and acceptable to the U.S. military. As noted by Gertler of the U.S. Congressional Research Service, these systems "have flown numerous missions while still under development. Predator and Global Hawk, for instance, entered combat well prior to their planned initial operational capability (2005 for Predator, and 2011 for Global Hawk). It may be unfair to compare the mishap rates of developmental UAS with manned aircraft that have completed development and been modernized and refined over decades of use."[90] Mishap rates can decline as these systems mature but will unlikely reach the level of comparable manned aircraft.

In the past, even successful experience within a niche functional area has been insufficient to assure a future role for UAVs in the U.S. military. The technical hurdles that still needed to be overcome to perform more missions in a broad spectrum of contingencies provided ample reason to prefer mature systems, such as manned aircraft and satellites. Most of these have been solved over the past decade, however, and the U.S. military is investing in further UAV development and procurement. In 2012, the Department of Defense requested $3.9 billion, $3.4 billion in 2013,[91] and is projected to request $2.3 billion in 2014.[92] This compares to $667 million in 2001, before the technology was operationally proven.[93]

Still, the United States has been the first mover in UAV development and deployment among NATO nations. As such, its experience can be considered unique and less relevant to other nations whose ambitions and experiences have been more limited. To address these considerations, we discuss the experiences of two great powers, the United Kingdom and France, and a small power, Denmark.

3.2: The British and UAVs

The United Kingdom has also had experience developing and deploying UAVs, although it has not been as successful as the United States. "The MoD has operated unmanned aerial systems since the 1960s, for example the MQM57 drone system was introduced 1964/5, the *Midge* drone was operated from 1971 to the early 1990s (including use in Op Granby in 1991), and the *Phoenix* tactical UAV system from the late 1990s."[94] These British UAVs were tactical UAVs, with narrow and limited capabilities and many of the same problems encountered by the American systems. They therefore proved ill-suited for solving the tactical and operational challenges facing British forces when they eventually saw combat.

The MQM57 Radio plane *Falconer* was a radio-controlled model plane, originally designed for hobbyists, that was further developed as a target drone for the U.S. Army Air Forces during the Second World War. It was later shared with NATO members in the 1960s.[95] "The MQM-57 was launched from a lightweight stand with the aid of two takeoff rockets. A remote ground operator flew the *Falconer* via radio signals and tracked it by radar. At the end of a mission, the MQM-57 floated to the ground underneath below a parachute deployed from the top of the fuselage."[96] The UK's second UAV system, the Canadair CL-89 *Midge*, was developed by Canada with British sponsorship and purchased by the British, West Germans, France, and Italy.[97] This UAV was launched via rockets from rails mounted on the back of a truck, flew a limited pre-programmed path, and could be recovered after landing via a parachute and airbags. The *Midge* resembled a cruise missile and was deployed with an artillery troop of 72 soldiers.[98] Although the British were involved in more than 30 armed interventions in the postwar period,[99] neither the MQM-57 nor the *Midge* was used until the latter was deployed in Operation Desert Storm, where it "made little contribution to the war."[100]

The British replaced the *Midge* with the *Phoenix* UAV in the mid-1990s and deployed it in the Kosovo peacekeeping operation from June–August 1999 and May–October 2000. It flew 270 missions, 29 being lost to "hostile action, landing damage and equipment failure."[101] The system was also used in Iraq in 2003–06. Its performance proved less than stellar: 23 of 89 were lost in the first year, "all due to technical failures—a ratio of one in six flights undertaken."[102] Although the *Phoenix* had an expected 15-year service life, [103] it served only 8 years before being retired[104] at a cost of "approximately £345 million since inception."[105]

The inability of the *Phoenix* to operate reliably in Iraq led the British to acquire *Reaper* UAVs from the United States in 2008 and establish a UAV operational squadron at Creech Air Force Base in the United States so as to acquire training and experience from the USAF.[106] Although this international arrangement raised concerns in Parliament, "the procurement of a US system has provided substantial advantages to the UK. The MoD has assured us that the UK retains operational sovereignty over its Reaper UAVs—it can maintain, upgrade, and use them independently."[107] After 5 years of gaining invaluable operational experience, the UK began operating those aircraft from British soil in April 2013.[108]

Concurrent with the rapid investment in unmanned systems demanded by ongoing operations in Afghanistan, the UK engaged in a number of projects still in development—both with international partners and as sole contractor. The most mature system is the so-called *Watchkeeper*, a tactical system that builds on the Israeli *Hermes* program and will be operated by the UK Army. The *Watchkeeper* was supposed to be introduced in 2010–11[109] at a cost just below £1 billion, but the project has yet to be delivered for operational service.[110] Apparently, the issue is that the British MoD requires the system and its air-worthiness to be certified to civilian standards. Another project in development in the UK is the *Scavenger* program. The system is designed to provide the UK with a medium-altitude, long-endurance (MALE) capability, combining ISR with land and sea attack capabilities.[111] The program is only now ending its concept phase, and with development costs of around £2,000,000,000,[112] it will first enter service in the next decade.[113] In addition to these two programs aimed at delivering capabilities, the British MoD is funding two technology development demonstration programs, the *Mantis* and *Taranis*. Like concept cars, both systems are not actually planned for production but solely to demonstrate and test technology.[114] However, the *Taranis* is one of the options pursued by the UK as the replacement for its manned

Tornado strike capability, showing that some envision that unmanned systems will eventually compete with manned systems in strike roles.

Britain arguably was caught off-guard and unable to unilaterally adapt to what has turned out to be quite a revolutionary development in UAV use. Consequently, all British UAV systems currently in use are either leased or procured under the "urgent operational requirements" program in order to meet "an immediate operational need rather than any long-term endorsed capability requirement."[115] Indeed, when it comes to the current use of unmanned systems, Afghanistan has functioned as a defining experience for the UK, showing both the immediate battlefield significance of unmanned systems as well as the need for investing in future capabilities. This has led to a veritable explosion of activity since 2006–07, where the British armed forces have seen the introduction of a number of new unmanned systems—all, apart from a naval system, of which are used in Afghanistan—as well as increased emphasis on research and development (R&D).

As of April 2013, the UK had deployed approximately 330 of five types of UAVs in Afghanistan.[116] Four systems operated by the British Army—*T-Hawk, Black Hornet, Desert Hawk*, and *Hermes* 450—account for most of the numbers.[117] They vary from the micro-UAV *Black Hornet* to the relatively large, runway-launched *Hermes* 450. These systems fulfill a number of surveillance and target acquisition tasks supporting British Army operations in Helmand. Additionally, the Royal Air Force operates 10 (initially five) *Reaper* UAVs that primarily provide ISR in theater but can be armed to function in a strike role.[118]

The significance of unmanned systems for British operations in Afghanistan is reflected in the rapid increase in flying hours as well as the number of systems. For example, UK *Reapers* flew 300 hours in 2007, the year that they were introduced, and over 10,000 hours in 2010. The same increase can be seen in the case of the *Hermes*: flight hours increased from 1,500 in 2007 to almost 15,000 hours in 2010.[119] Afghanistan, in other words, demonstrates how the use of unmanned systems has become an integrated and essential part of modern warfare and the extent to which British commanders and soldiers also depend on the capabilities they provide. In addition to the systems used in Afghanistan, the Royal Navy completed a £30,000,000 deal in August 2013 for procuring the tactical ISR *Scan Eagle* system for use on Royal Navy ships. This system was also funded as an urgent operational requirement.[120] The Royal Navy is also investigating whether to complement the fixed-wing *Scan Eagle* system with a rotary wing system.[121]

All of the systems procured under the urgent operational requirements program and currently operated by the UK armed forces are acquired from other nations and are thus largely off-the-shelf products. The *Black Hornet* was produced by Norway, the *Hermes* system by Israel, and the *Scan Eagle* and *Reaper* are American products. According to a House of Commons report, the cost of procuring and operating the UK UAV systems in Afghanistan from 2007 until December 2011 amounts to £729,000,000.[122]

To sum up the UK experience with UAVs—their integration as well as their doctrinal developments—it is fair to say that these systems were of marginal interest and use until driven by operations in Afghanistan. Operational requirements have led to an increase in system types, numbers, and a significant increase in their use. Driven by immediate operational needs, the UK armed forces have a range of tactical systems available, and the *Reaper* system providing a theater-wide medium altitude, long endurance (MALE) capability. According to current plans, the UK will not possess any strategic high altitude, long endurance (HALE) capability before the introduction of the *Scavenger* system. If and when that will happen is difficult to predict, both because of budget pressures and the delays and cost-overruns that are endemic to large developmental defence acquisitions.

However, maintaining focus on the R&D of unmanned systems is arguably about more than merely providing capability to the UK armed forces. No major European combat aircraft production is currently being planned. That incurs substantial risks to the defence industrial base of major European countries, including the UK. Consequently, investing in R&D related to unmanned aerial systems is, for the UK, also a strategy for maintaining the knowledge and industrial base necessary to maintain and develop future airpower—in both Britain and Europe.[123] The development of unmanned systems is therefore also a matter of international cooperation, and the 2010 UK–France defense treaty is, for instance, also about the joint development of UAV systems. The *Scavenger* program, for instance, is often mentioned in relation to increased UK–French defense cooperation,.[124]

3.3: The French and UAVs

Like the British, the French experience with UAVs reflects the difficulties with developing the requisite technologies and the preference of the services to acquire more familiar and mature capabilities that have immediate operational applications. These difficulties and reluctance have made the French experience one of dependence on foreign suppliers for unmanned aerial systems since the 1970s.

During the Cold War, the French focused their efforts on developing UAV technologies. Their first—and only—independent success was the development of the R20 artillery reconnaissance drone, which was adapted from a target drone.[125] This sled-launched, turbo-jet monoplane was radio-controlled and designed to perform reconnaissance missions. It reached operational status in 1972 but proved technically unreliable. As the French Army considered the threat environment that it was to operate in, where "it was necessary to penetrate air defenses to report information on massive troop concentrations and adjust the firing of sub-strategic nuclear weapons," the French opted to consider alternatives, and the R20 was retired in 1976.[126]

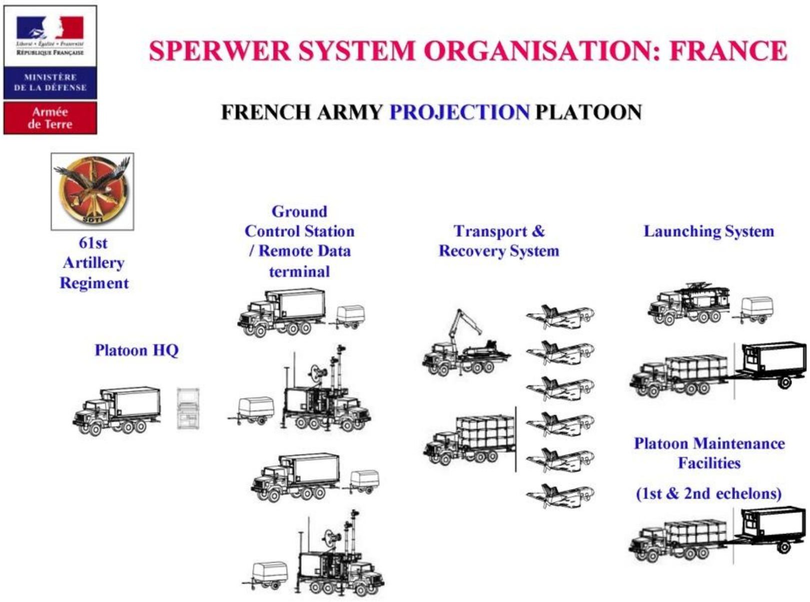
The French then purchased the British-sponsored, Canadian-manufactured Canadair CL-89 *Midge* in 1980. The French first used the *Midge* UAV in Operation Desert Storm after discovering that helicopters were too valuable and vulnerable to hostile fire when used to provide airborne reconnaissance.[127] While many *Midges* were lost to hostile fire and technical malfunctions, the French considered the experience a success.[128] The French then deployed the *Midge* in Bosnia and Herzegovina between 15 February and 20 May 1995, where it conducted "more than thirty flights" despite being vulnerable to enemy ground fire.[129]

The success of the *Midge* in Bosnia encouraged the French to seek an improved UAV capability to serve as part of its reconnaissance-target-strike mission complex. French industry was apparently unable to meet the needs of the French military, so it turned to Israel, who had developed and sold the *Hunter* UAV to the United U.S. Army in 1989. The French successfully adapted the *Hunter* to be integrated with its other systems, and it was deployed to Kosovo during Operation Allied Force.[130] It was also deployed in October 2001, where it completed more than 25 missions.[131] The *Hunter* was also used to provide security for the 2003 G8 summit in Evian and withdrawn from service in 2004.[132]

The French subsequently acquired 30 *Sperwer* and Israeli-made *Harfang* UAVs, deploying them to Afghanistan in 2008 and 2009, respectively. The *Sperwer* is basically the same system the Danish army unsuccessfully attempted to bring into service in 2001—a tactical UAV with a 150 km radius. Thirty *Sperwers* were deployed to Afghanistan in October 2008 to meet an urgent operational requirement for tactical intelligence after a French unit was ambushed and ten soldiers were killed.[133] They flew 770 missions, clocked over 2,100 flight hours, and 12 were lost (eight in flight, four in landings) before being withdrawn in 2012.[134]

The French ordered five more airframes so as to maintain the *Sperwer* capability for other contingencies.[135]

Figure 2: French Army *Sperwer* Platoon Structure



The French also acquired the *Harfang* system, a HALE UAV based on the Israeli *Heron*.[136] Three *Harfangs* were deployed to Afghanistan, with their contingent of 40 personnel.[137] They flew over 660 missions[138] and logged 5,000 flight hours[139] before being withdrawn in 2012. The French redeployed two of their *Harfangs* to Mali.[140] The Harfangs "performed well during Operation Serval…. But the Harfang system was unexpectedly costly to acquire and uses expensive Ka-band commercial satellite links for command, control and communications (C3)."[141]

Consequently, France began considering acquiring American *Predator* or *Reaper* UAVs in 2010.[142] Although the French defence contractor EADS Cassidian proposed "buying four to six more Heron UAVs from Israel and upgrading them for France" in June 2013.

> "French [D]efense [M]inister Yves Le Drian told French legislators that there was 'no alternative' to the Reaper. The U.S. Congress was soon notified of the possible $1.5 billion sale to France of 16 MQ-9 Reaper UAVs and eight mobile ground control stations, Ku-band communications systems, 40 Raytheon MTS-B EO/IR video systems and 40 GA-ASI Lynx SAR/GMTI radars."[143]

Ultimately, the French bought American.

There are lessons to be learned for a second-tier power desiring to acquire UAV capabilities. France would seem well-poised to face the revolutionary increase in the significance and sophistication of unmanned systems over the last decade. From the early 2000s, the French recognized that the revolutionary developments in the use of unmanned systems would require new systems, new investments, and new R&D. This has been the case both in order to maintain and develop French defence industry as well as to find a replacement for the already today outdated *Harfang* system.[144] Ensuring this has been a difficult process for France and successive French politicians (and procurement organizations). Stated in brief, the challenge has been to balance four often-conflicting needs in deciding on a strategy for the use and development of—in particular—armed MALE/HALE unmanned systems.

First, France has required increased capabilities in the short term, as demanded by operations in which a clear ISR shortfall has been identified. Conversely, the technology is developing rapidly, and long-term requirements must be factored into the equation. That trade-off in itself complicates decision-making.

Second, France is gifted with a large aerospace industry, where a number of companies individually or in various consortia ought to possess the capacity to compete for contracts to develop the needed capability. Managing that competition has proven difficult for more than one French government, however, and a range of examples of government-supported development programs exist, where the investment has not been capitalized as a result of shifting government policies and priorities.[145]

Third, there is the issue of international cooperation. European defence cooperation has always been a French priority—both as a matter of principle and in order to ensure the volume necessary for making major defence development investments economically viable. In the field of unmanned systems, France has actively sought European partners. The French had purchased the Canadian–British *Midge* in the 1970s, and French companies modified the Israeli *Hunter* system to meet French requirements in the 1990s. Already in 2006, the French engaged the Germans on a joint system (Spain and Italy were later included, and Turkey also discussed participation). This program—the *Talarion*—slowed to a halt in 2010, however, due to being more expensive and risky than anticipated.[146] Talks with the UK on potential cooperation on the *Watchkeeper* program commenced almost simultaneously. Additionally, 2012 witnessed new talks between France and Germany on a common MALE UAV development program for the 2020–23 period together with an interim solution.[147] These various attempts and initiatives seeking international cooperation are obviously made exceedingly complicated given conflicting operational requirement and the attempt to include the industrial interests of all parties involved. Still, as reflected in the conclusions of the European Council meeting of 19−20 December 2013, the development of unmanned capabilities is prioritized as an area for continued and expanded European cooperation.[148]

Indeed, the fourth issue complicating French endeavors to develop unmanned capacity is precisely that of maintaining an independent defence industry—seen as a core part of French sovereignty. That comes at a substantial cost, however, when off-the-shelf solutions already exist. Indeed, as the French Delegate General for Armaments, Laurent Collet-Billon, explained,

> “the problem with the MALE UAV is simple; the first French proposal is 1.5 billion euros, while U.S. Predator drone would cost around 700 million euros. It seems to me that there is a contradiction for [French] industry [i.e., EADS] to ask the state to help export its equipment and, at the same time, submit a proposal to buy a product that costs 800 million more than rival [foreign products].”[149]

These four conflicting needs have made it difficult for France to formulate the strategic, long-term plans necessary for making and following through on its decisions concerning the development of unmanned capability. A number of research and demonstration projects exist in cooperation with other European states. The UK–France defence agreement of 2012 names a substantial number of unmanned systems for increased cooperation.[150] Still, no new operational capability has materialized as a result of French efforts since 2006. Accordingly, as in the UK case, France decided in the spring of 2013 to purchase a number of American *Reapers*. Two of these were delivered before the end of 2013, as they were urgently needed to support current operations in Mali.[151] At a later stage 10 more will follow, at a price of approximately $874,000,000.[152] This figure does not cover the actual cost for France, as the system requires substantial modification for it to be integrated in the existing French infrastructure.[153]

In sum, France is in a situation comparable to the UK. For a number of reasons, investments in development have been unable to indigenously provide the capabilities required by urgent operational needs. Consequently, the strategy has been to purchase a well-tested U.S. system.

This leaves France with a functioning high-end tactical system, as well as a range of lower-end tactical systems. An indigenous and non-American capability will not be available before the next decade. Still, the development of unmanned systems is recognized as a central element in the 2013 French White Paper: Defence and National Security, and it argues these are fundamental both for the French use of armed force and for providing the knowledge necessary for France to make independent, "sovereign decisions."[154] Therefore, it seems safe to conclude that France will continue to focus on the development of unmanned capabilities—including armed and more stealthy systems—thus ensuring their survival and usability in a future and more contested airspace environment.

Seen together, both the UK and France—together with other larger European countries—face similar challenges regarding UAVs and development and procurement options. On the one hand, immediate operational requirements drive individual countries toward off-the-shelf American or Israeli products—the two leaders in the world market. On the other hand, larger European countries are interested in investing in their own long-term solutions; however, economic pressures are driving them toward common joint development projects. Still as stated by a report by the German Institute for International and Security Affairs (SWP), there is "no consensus amongst the potential users on weaponry, size and design of a future European MALE UAV."[155] This lack of harmonized requirements will continuously inhibit European cooperation, as illustrated especially by the French case.

3.4: The Danes and UAVs

Denmark has had aerial drones in its inventory for almost 55 years—since 1958.[156] It was not the most technologically advanced equipment and only served as targets for artillery and missile training. Today, Denmark has a target drone system—the *Banshee*—in service since 1988.[157] Throughout the Cold War and the 1990s, Danish policy makers avoided using these UAVs for purposes other than being shot down in target practice.

After the Cold War, Danish political leaders across the political spectrum increasingly came to view the use of military force as a more normal and legitimate tool of statecraft. Indeed, Danish foreign policy can now be characterized as military activism, albeit in contexts where larger powers define the situations where force can be used and how it should be used.[158] Wherever Denmark has contributed units of soldiers to ground operations, fighter, or transport aircraft to air operations, or a command and support ship to maritime operations over the last decade, UAVs have therefore played an increasingly important role. In

Afghanistan, they provided the information necessary to conduct operations against the Taliban. In Libya, they provided the detailed, real-time targeting information necessary for Danish aircraft to find and hit their targets as well as the data necessary for maintaining command and control of Allied air operations.[159] And off of the Horn of Africa, UAVs have helped patrol the waters in search of pirates.[160]

Danish military and civilian policy makers have therefore been interested in increasing their understanding of the capabilities of UAVs and invested in these systems in the late 1990s to support Danish forces in the field.[161] The first UAV Denmark acquired to assist in military operations was the *Tårnfalken*, an adapted version of the French *Sperwer* system. It was purchased because leaders in the Danish armed forces realized the value of tactical UAVs in low-intensity conflicts, like those in the Balkans. It was deemed important by military authorities ‘‘to be in on this from the beginning,’’[162] showing how the Danish military had realized the future potential of UAVs in the late 1990s.

The *Tårnfalken* was primarily intended for reconnaissance, targeting for artillery, and battle-damage assessment.[163] The Danish Air Force received the French UAV in 2001[164] and handed it over to the Army for operational use in 2002. The Army received eight UAVs for operations and two for spare parts. On paper, the *Tårnfalken* appeared to be a capable tactical reconnaissance system with a 180 km range of operations. It was equipped with electro-optical sensors for daylight operations and a passive infra-red sensor for night operations.[165]

The Danish Army was confident that they had considered how to integrate the *Tårnfalken* into its operational concepts, including its use and maintenance. The Danish Army had realized that integrating the *Tårnfalken* required organizational adjustments, and a UAV unit was established under the Army Artillery Regiment to operate the system from Varde, Jutland. [166] The unit was to have 90 Army personnel in garrison and approximately 130 men when deployed.[167] It was to reach full operational capability in 2009.[168] Despite high hopes, the *Tårnfalken* never reached full operational capability and the program was terminated in 2005.[169] There are several reasons for this—highly publicized—failure.

First, the system was still at a developmental stage and very few operational experiences existed. The manufacturer, Sagem, had yet to complete its own system integration. This led to high failure rates in many parts of the system and meant a critical need for spare parts that the producer was unable to meet.[170] Both issues increased the risks associated with the system.

These risks were, however, compounded by how the system was integrated and operated. First, responsibility for the system was unclearly divided between Air Materiel Command, Tactical Air Command, and the Army's Operational Command. This made decision-making and oversight complicated.[171] Second, these organizations were geographically separated from one another, complicating communications. Third, it proved very difficult to recruit, train, and maintain a sufficient number of qualified personnel to operate the system. Accordingly, the unit responsible for operating *Tårnfalken* was never fully manned and lacked qualified personnel.[172] There are several reasons for this, one of which is that the Army was responsible for defining the structure and number of positions in the unit, whereas the Air Force was responsible for recruiting and training personnel. Thus, no single command was solely responsible for properly manning the unit.[173] Because the system itself was unreliable, the aircraft would often be grounded due to technical failures. This disrupted the training and certification for the unit. At other times, the aircraft would be airworthy, but then no qualified staff would be available to operate it—again making it difficult to certify the system for operational use. The lack of skilled personnel and high levels of accidents created a vicious circle, multiplying the significance of both problems.

In sum, a very complex and accident-ridden aircraft without sufficient service agreements and reliable spare-parts deliveries, combined with a shortage of qualified staff and a complex project organization with unclear responsibility rendered it difficult to make the *Tårnfalken* operational. Combined with the financial costs, this led to the eventual termination of the project.

In analyzing the project, Danish Government Auditors (*Rigsrevisionen*) concluded that the Danish defence forces did not adequately appreciate the complexity of operating an advanced UAV system or the resources and personnel required to operate it.[174] When the *Tårnfalken* project was terminated, its remnants were sold to Canada to recoup some of the investment made.[175] Canada was subsequently able to make the system operational and deployed it to Afghanistan with the 11 others that they had acquired directly from Sagem.[176] Those aircraft flew 4,270 hours on over 1300 flights.[177] Still, the Canadian *Sperwer* also encountered reliability problems in the field: six crashed and the Canadians began to consider acquiring a follow-on system.[178]

Following the experience with *Tårnfalken*, the Danish defence forces purchased "about 12" new hand-launched mini-UAV, the *Raven B,* in 2007.[179] The *Raven B* was much lighter and smaller than the *Tårnfalken* but equipped with electro-optics that enabled all-day operations—albeit with a shorter range (10 km). The *Raven B* was deployed to Afghanistan to support the Danish Army units in Helmand in 2008.[180] These units own and operate the *Raven B* themselves, thereby simplifying operations and maintenance issues.

After what the Army describes as 4 years of successful operations,[181] the *Raven Bs* have reached the end of their useful service life. The Danish armed forces have therefore replaced the *Raven B*s with another mini-UAV, the *PUMA AE.* The *PUMA* is larger than the *Raven B*, equipped with better sensors, has an increased range (15 km), and can remain air-borne longer (2 hours). Moreover, it has the advantage of being able to use the same ground control stations as the *Raven*, and therefore required little change beyond the purchase of the airframe.[182] The *PUMA* is used by several countries in Afghanistan and is a well-proven system.[183] Additionally, the *Raven* has apparently also been used in anti-piracy operations,[184] and the Royal Danish Navy is currently operating the PUMA from its flexible support ship *Esbern Snarre* off the Horn of Africa.[185]

Figure 3: The Raven B[186]

Figure 4: The PUMA UAV[187]

4. Conclusions

Denmark has oriented its security policy toward being "an impeccable ally" to the United States and providing "the kind of output that NATO [is] calling for: deployable expeditionary forces that [are] sustainable in terms of national logistics and reinforcement and that could be put in harm's way in the combat zones where NATO now need[s] to be engaged."[188] It has joined with the United States, the United Kingdom, and France in transforming its armed forces so that it can effectively play this role.[189]

This transformation has been enabled by the development of technologies that have provided a vast improvement in the ability to find and precisely strike targets from great distances. This "revolution in military affairs" has had its most dramatic expression in airpower. But airpower alone has not been able to achieve the desired political results in many of the interventions undertaken by these Western allies. The stabilization and state-building missions of the past decade have accelerated the integration of ground and air operations.[190] Unmanned aerial vehicles have provided persistent surveillance that has enabled more effective and less hazardous ground operations, including those common in counterinsurgency.[191] The tactical intelligence that these systems provide has been in high demand in these operations, and many NATO countries have therefore invested in either developing them or acquiring them off-the-shelf from others.

The experiences of the United States, United Kingdom, France, and Denmark provide a number of lessons that can be used to consider future investments in UAV systems. These concern development versus acquisition and the adaptation of off-the-shelf systems, the role of mission requirements and the threat environment, integration of UAVs into existing military structures, and operational issues.

Development versus Off-the-Shelf. The United States was the first mover in UAV development. It invested 60 years and untold billions of dollars to develop the technology that would enable manned aircraft to travel intercontinental distances, rockets to put satellites in orbit, systems to enable near-instantaneous intercontinental communications, omnipresent location systems, and the processing of vast amounts of information that could enable high levels of automation in aircraft. Many systems incorporated some of these technologies over this period. They matured in the late 1980s and were married together to enable long-distance precision reconnaissance and strike capabilities. UAVs represent a continuation of this revolution. Second-mover states, such as Great Britain and France, also undertook UAV

R&D, but their efforts were less successful. They have been able to develop mini and tactical systems, but with fewer capabilities than their American counterparts. Thus far, they been most successful achieving an operational capability when they have purchased systems developed by others off-the-shelf and adapted them to their own purposes. Given urgent operational requirements, they have most recently relied upon their relationship with the United States to acquire UAV capabilities off-the-shelf. The Danish experience has been with off-the-shelf UAV systems, which will likely continue to be the case in the foreseeable future.

Mission Requirements and Threat Environment: The tasks that a military platform must accomplish and the conditions under which it must be used significantly impact its development and adoption. The Americans first conceived of UAVs as strategic reconnaissance platforms capable of spying on the Soviet Union. Such a mission set very high requirements for range, payload, and speed—even before considering the specific intelligence gathering equipment. Other capabilities did the job better, however, and the next hot war produced a different threat environment. The high threat environment posed by North Vietnamese air defences pushed the USAF to develop a means of saving pilots while still penetrating enemy air space and striking targets. Despite the increased capability developed for tactical UAVs, such as the *Lightning Bug*, when the next mission set was considered—penetrating Warsaw Pact air defences in central Europe—UAVs were not yet capable enough. But UAVs became the system of choice when dealing with a low-intensity conflict, where air superiority could be assured and persistent reconnaissance was necessary to locate and fix small, moving targets, such as small units or individuals. Over the past decade, operational requirements drove the Americans, British, and French to procure UAV systems in numbers and at a pace that outstripped their original plans. Denmark, on the other hand, has relied upon the capabilities of its allies to supply the products produced by all but the mini-UAVs that assist Danish forces at the company level.[192] Still, Danish requirements to exercise sovereignty over the Arctic have led it to consider substantial investments in tactical and strategic UAVs despite steep defence budget cuts.[193]

Integration into Existing Structures: UAVs are, by definition, aerial vehicles; nonetheless, the air forces of these countries have not been the primary users or beneficiaries of UAV capabilities. In the case of the United States, the intelligence services bore the primary burden for the development of many of the underlying technologies throughout the Cold War. The USAF lost interest in UAV capabilities in the 1970s because other systems better performed the service's required missions. The U.S. Army became the primary beneficiary of UAV technology and thirsted for the tactical situational awareness that medium-altitude persistent systems such as the *Hunter* and *Predator* could provide. British and French ground forces also demanded such support from above, the latter after suffering 10 combat deaths in an ambush in Afghanistan. The RAF control the UK's MALEs in Afghanistan and did so co-located with the USAF so that they could learn how to integrate them into joint expeditionary operations. Danish ground forces in Afghanistan acquired and deployed the *Raven B* mini-UAV themselves, its limited range and uses obviating the need for inter-service cooperation and coordination.

Yet air forces and navies have also desired these capabilities—or at least to control their use in the field. Developing doctrine and an organization to allocate UAV systems, development, and acquisition in a manner that fairly serves all three services has proved challenging. So too has the development of an organization to house and operate UAVs as well as train operators and further develop concepts of operation and expertise.

The Danish experience with the *Tårnfalken* especially shows the difficulties of building a joint unit to operate and maintain these systems. Danish operations with other forces in Afghanistan and Libya have provided some members of its armed forces some experience with UAV operations. But if Denmark is to acquire tactical or strategic UAVs for national use, the British experience working cooperatively with the United States to operate UAVs presents an apprenticeship model that its forces in Helmand have used to good effect.[194] Participation in multinational UAV ventures, such as the NATO Allied Ground Surveillance (AGS) program or together with Nordic partners in the Arctic, might also prove fruitful.

Operational Issues. Finally, UAVs have only recently matured as a military capability—and then only for the first mover, who has spent over six decades working on the problem of integrating various advanced technologies into working systems. Still, they have not been designed with longevity in mind. UAVs are far more prone to accidents, equipment failures, communications glitches, and hostile fire than most manned aircraft—even when controlling for maturity of the platform in its development cycle. Aeronautical engineering can be complicated, and removing the man from the cockpit also removes the ability to instantaneously assess and adjust to environmental conditions and malfunctions. These craft operate best in ideal conditions: fair weather that is neither too hot nor too cold, not too windy, and where there is an absence of enemy fire. Under less-than-ideal conditions, UAVs will be lost at a rate that is disproportionate to that of manned aircraft performing the same sorts of missions.

As unmanned aerial vehicles are procured and developed by friendly states, neutrals, and adversaries, their potential to provide benefits and cause harm must be viewed objectively. UAVs are the next step in modern airpower's long-range reconnaissance-precision strike complex in that they add the potential of persistence to the mix. The aircraft themselves, however, thus far represent a niche capability with inherent limits. They have proven difficult to develop, employ, maintain, and integrate into modern militaries. Only with tremendous effort have they been made into a usable and efficacious military capability. We can expect others attempting to develop and/or acquire UAVs to encounter similar difficulties.

Such difficulties should temper expectations that the proliferation of UAVs will have a profound and systematic impact on the nature of warfare; or even complicate Western military operations to a significant degree. They should also temper the enthusiasm of Allied militaries to invest in the development of such capabilities in the expectation that they offer a less expensive alternative to other types of aircraft, such as fighter jets. To the degree that they perform useful functions and meet the mission requirements formed by the prevailing threat environment in a cost-effective manner, they should be pursued. But they do not offer a magic bullet to any particular military mission set, nor do they obviate the need to invest in a spectrum of air capabilities. The air forces of tomorrow will therefore look substantially like those of today, with unmanned capabilities complementing manned, just as fighters complement bombers, tankers, reconnaissance, electronic warfare, and other types of aircraft.

5. Notes

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