CENTRE FOR MILITARY STUDIES
UNIVERSITY OF COPENHAGEN

Unmanned and Unarmed

On the Future use of Unmanned Aerial Systems in the Danish Armed Forces

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February 2014

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 how unmanned aerial vehicles could be used by the Danish Armed Forces. Based on an analysis of allied and Danish experiences with unmanned aerial vehicles, this report discusses the defence policy issues at stake when acquiring larger unmanned systems.

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ISBN: 978-87-7393-720-4

Denne rapport er en del af Center for Militære Studiers forskningsbaserede myndighedsbetjening for partierne bag Forsvarsforliget 2013-2017. Formålet med rapporten er at beskrive, hvordan ubemandede fly kan styrke det danske forsvars opgaveløsning. På baggrund af en analyse af allierede og danske erfaringer med ubemandede fly diskuterer rapporten de forsvarspolitiske overvejelser en eventuel anskaffelse af større ubemandede systemer kræver.

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ISBN: 978-87-7393-720-4

Abstract

The increased use of unmanned aerial vehicles (UAVs) in military operations is widely debated in Denmark today. This debate is about the ethical and moral aspects of the use of unmanned systems as well as if and how the Danish Armed Forces could or should use UAVs. This report relates to the second question and discusses the challenges to be considered if such systems are to be integrated into the Danish Armed Forces.

The report sees the explosive growth in the use of unmanned systems among Danish allies as the result of two factors. On the one hand, a number of sophisticated military technologies that support unmanned flight have matured. On the other hand, Western air power has dominated the past 15-20 years of armed conflict and opened the skies for relatively vulnerable unmanned aircraft. Combined, the two factors make UAVs today an integral part of Western military power, and ensure that they will continue to be so.

In the Danish public debate UAVs are often seen either as potential replacements for manned fighter aircraft or criticized for their role as an armed platform in the United States' war on terror. Both underemphasize UAVs main current military function as an intelligence, surveillance, and reconnaissance platform. Precisely in that role, larger unmanned systems could significantly support many of the tasks conducted by the Danish Armed Forces--both nationally and internationally, in Greenland and in Denmark.

Based on Danish and international experiences, the report analyzes the considerations a possible acquisition of large and sophisticated unmanned systems requires. In this relation, an important point is that the report does not recommend whether to invest or not invest in larger UAVs. That is, first, a political decision. Larger unmanned systems are costly, and an acquisition should be seen in relation to the wider Danish defense budget and in relation to the general composition of the Danish Armed Forces. Secondly, it is a complex decision. There are many types and sizes of UAVs, and they can perform a wide variety of tasks. Their capacity furthermore depends largely on the sensor packages they contain, and on the command, control, and communications infrastructure they are embedded in. Thirdly, it is an organizational decision. UAVs are complex systems, with which the Danish military has little experience, and they require a large number of highly specialized personnel to exploit the vast amount of data they can produce. Fourthly, the possibilities for international cooperation in relation to procurement as well as in operations should be an important consideration, both to reduce costs and to draw on the knowledge and experience of partners. Finally, the

considerable capabilities UAVs provide must be seen in relation to a number of limitations. UAVs:

- can not yet replace broadly capable manned systems such as fighter aircraft
- have, by virtue of existing regulations, limited use in civilian airspace
- are vulnerable in disputed airspace
- are expensive and labor-intensive
- are still more unreliable than manned platforms

UAVs are thus characterized by a number of limitations that should be balanced against their benefits. Moreover, technology, price, and regulation are all moving targets. Therefore, the question is not only whether and, if so, what, but also when a decision should be taken. To support the process before, during, and after any decision to acquire larger UAVs for the Danish Armed Forces, the report ends with a number of specific recommendations to reduce risks in that decision making process.

Dansk resumé

Den øgede brug af ubemandede flyvende platforme (UAV'er) i militære operationer er i stigende grad til debat i Danmark. Den debat handler om de etiske og moralske aspekter ved brug af ubemandede systemer, men den handler også om, og i givet fald hvordan, det danske forsvar selv kan og bør anvende UAV'er. Denne rapport forholder sig til det andet aspekt af debatten, og diskuterer fordele og ulemper ved eventuel øget anvendelse af UAV'er i forsvarets opgaveløsning.

Rapporten ser den eksplosive vækst i brugen af ubemandede systemer blandt Danmarks allierede som resultatet af to faktorer. På den ene side er en række sofistikerede militære teknologier, der understøtter ubemandet flyvning modnet. På den anden side har vestlig luftmagt domineret de sidste 15-20 års konflikter og åbnet luftrummet for relativt sårbare ubemandede fly. Tilsammen betyder de to faktorer, at UAV'er i dag er en integreret del af vestlig militær magt, og vil fortsætte med at være det.

I den offentlige danske debat ses UAV'er ofte enten som en mulig erstatning for bemandede kampfly eller kritiseres for deres rolle som væbnet platform i USA's krig mod terror. Begge underkender UAV'ers vigtigste nuværende militære funktion som efterretnings, overvågnings- og rekognosceringsplatform. Netop i den rolle vil større ubemandede systemer væsentligt kunne styrke store dele af det danske forsvars opgaveløsning – nationalt såvel som internationalt, i Grønland såvel som i Danmark.

På baggrund af danske og internationale erfaringer analyserer rapporten derfor de overvejelser en eventuel anskaffelse af større og sofistikerede ubemandede systemer kræver. En vigtig pointe er, at rapporten ikke giver en anbefaling om anskaffelse. Det er, for det første, en politisk beslutning. Større ubemandede systemer er omkostningstunge, og en anskaffelse skal derfor ses i relation til det samlede danske forsvarsbudget og i relation til det samlede danske forsvars indretning. For det andet er det en kompleks beslutning. Der findes mange typer og størrelser af UAV'er, og de kan udføre en lang række forskellige opgaver. Deres kapacitet afhænger endvidere af de sensorpakker, de er udstyret med og den kommando, kontrol- og kommunikationsinfrastruktur de er forankret i. For det tredje er det en organisatorisk beslutning. UAV'er er komplekse systemer, som det danske forsvar har få erfaringer med, og det kræver et stort antal højt specialiseret personale, at udnytte den store mængde data de kan producere. For det fjerde bør mulighederne for internationalt samarbejde i relation til indkøb såvel som drift indgå som en vigtig overvejelse. Både for at reducere

omkostningerne og for at kunne trække på partneres viden og erfaringer. Endelig skal de betydelige kapaciteter UAV'er bidrager med ses i forhold til en række begrænsninger. UAV'er:

- kan endnu ikke erstatte bredt anvendelige bemandede systemer som fx jagerfly
- har, i kraft af eksisterende regulering, begrænset anvendelse civilt luftrum
- er sårbare i omstridt luftrum
- er dyre og mandskabsintensive
- er stadig mere upålidelige end bemandede platforme

UAV'er er dermed kendetegnet ved en række begrænsninger der skal balanceres mod deres fordele. Endvidere er teknologi, pris og regulering under forandring. Derfor er spørgsmålet ikke kun om, og i givet fald om hvad, men også hvornår en beslutning bør tages. For at understøtte processen før, under og efter en eventuel beslutning om at anskaffe større UAV'er til det danske forsvar, fremkommer rapporten med en række konkrete anbefalinger der kan reducere risici i beslutningsprocessen.

Recommendations

Preparing for a Decision

- Stand-up a dedicated UAV-unit in Danish Defence Command—perhaps dovetailing the "Future Fighter Aircraft" team, to consider the role of unmanned systems in Danish airpower.
- Maintain or increase participation (in terms of personnel) in NATO's AGS system as it becomes operational to expand the Danish knowledge base.
- Follow UK and NATO attempts at certifying systems for wider use in civilian airspace to facilitate their peacetime and dual-use roles.
- Actively support efforts by national and international aviation authorities to establish solid regulations for the use of UAVs in civilian airspace.
- Engage potential partners for procurement and/or operations early and informally, but in detail.
- Piggyback to the widest possible extent on experiences and lessons of comparable partners and allies already operating UAVs.
- Considering modularity—more potential configurations—means more kinds of missions. This is currently how the manned *Challenger* system works. But modularity also incurs higher expenses and system risk.
- Continue tests and experiments—both in the Arctic and non-Arctic parts of the Kingdom—and involve potential partners in these to create the basis for discussing future joint requirements.
- Software and sensor-packages are crucial for the capability a system will be able to deliver. These are equally expensive and can account for a substantial part of the price of a system.

In Deciding

- Have a clear definition of tasks and consolidated concepts of operations ready.
- Ensure a clear command structure for procuring, certifying, manning, and operating the system.
- Engage other government agencies. UAVs can produce data for many potential users.
- Will Danish UAVs only be a military capability? With expected regulative changes, civilian governmental demand will rise, and with that also the potential for sharing expenses.

- Continue to seek partners and work for synchronicity in when and what to procure, even if it might mean compromising on system requirements or the defence planning process.

In Initial Operations

- Contemplate whether, for an initial start-up period, operations should be conducted from an experienced Allied user's facilities to reduce risk and increase everyday access to knowledge and expertise (as the UK has done).
- Trained personnel, infrastructure, and organization must be in place and be robust at an early stage.

Contents

1. Introduction

The Danish armed forces have operated unmanned aerial vehicles (UAVs) since 1958.[1] It is only recently, however, that they have come to capture the attention, imagination, and fears of Danish policy-makers and the general public. The rapid increase in the use of UAVs is one of the most significant developments in the technology of warfare, providing significant operational advantages for their users. Today, unmanned systems function as an integrated part of all of the branches of the American armed forces and perform a variety of tasks. European militaries have recognized that procuring UAVs may rectify substantial shortfalls in the intelligence, surveillance, and targeting capabilities.[2] Denmark is among these countries.

As Denmark considers acquiring further UAV capabilities, its leaders should bear three things in mind. First, the UAVs in the news today are the result of over 70 years of technological development. The technologies involved have currently matured, but UAVs are still limited in what they can do and are less reliable than mature, manned aircraft. Second, UAVs are not inexpensive. As the U.S. Congressional Budget Office noted, "initial concepts envisioned very low-cost, essentially expendable aircraft. As of 2011, however, whether substantially lower costs will be realized is unclear."[3] Third, UAVs face regulatory hurdles that will hamper their use in peacetime. While they have been used extensively in areas of conflict, contemporary Danish and European airspace regulations severely limit their use in sovereign airspace. Beyond these regulatory issues, this report does not consider the further legal and ethical questions raised by UAV use, which are addressed elsewhere.[4]

Likewise, the United States has developed unmanned combat aerial vehicles (UCAVs) that have been used to fire munitions at targets. This use has been widely reported and debated over the past decade and easily captures the popular imagination when discussing UAVs.[5] To date, however, the primary utility of UAVs for Western nations has been to monitor and provide reconnaissance information to their armed forces. Denmark's UAV use to date has been to provide tactical intelligence to Danish forces. While Denmark might one day consider armed UAV capabilities, they are not considered in this report.

Furthermore, the technological promise of the future often overshadows discussions of the reality of contemporary UAV capabilities. What *could be* and what *is* the case are very different. In the future, UAVs may substitute for the capability now provided to Western armed forces by manned fighter aircraft. As Jens Ringmose cogently argues, however, this

will not be the case for some time.[6] Indeed, such capabilities are barely on the drawing board. Finally, future UAVs may have a substantial degree of pre-programmed autonomy, executing different types of mission adjustments without the benefit of a human being making such decisions. Such developments raise substantial ethical and policy issues that must be debated—although they remain many years away.

Instead, we provide a strategic analysis of the possible uses of the UAVs that are available to the Danish government today and in the near future. To do so, we address the role that airpower has played in how the West uses force abroad. We then discuss UAVs and how their employment has contributed to this Western paradigm for the use of force. Next, we draw four lessons from the American, British, French, NATO, and Danish experiences developing, acquiring, and operating UAVs. These lessons are subsequently applied to the current Danish context. We argue that any decision on the part of the Danish government to acquire UAVs should consider the tasks that UAVs are best-suited to perform, the costs associated with the entire UAV system, and the operational, doctrinal, and other challenges that must be addressed to integrate UAV capabilities into the Danish armed forces. These are not trivial considerations. Larger UAVs are very complex systems with which the Danish armed forces have limited experience, and introducing radically new technology always comes with substantial risks. The Danish armed forces already and routinely use smaller UAVs, and it is only in the potential procurement and use of larger systems that UAVs turn into political defence- and security policy issues. We therefore focus on these systems, concluding the report with a number of recommendations for mitigating these risks should Denmark decide to procure larger unmanned systems, such as *Reapers* or *Global Hawks*.

This report is part of the 2013 contract between the Danish Ministry of Defence and the Centre for Military Studies (CMS), University of Copenhagen. CMS was tasked with preparing a report regarding the future uses of UAVs for the parties to the Danish Defence Agreement. The report therefore follows the quality assurance procedures laid out in the CMS project manual for CMS' research-based services, including external peer review. The results presented in this report are based on desk studies and historical research on UAV development that will be published in 2014 in an additional CMS report. The authors have also participated in a considerable number of seminars and conferences on the use and development of UAVs, and interviews have been conducted with US Air Force personnel, Danish subject matter experts inside and outside of the government, as well as Nordic and NATO stakeholders. The authors want to take this opportunity to express our gratitude to

everyone who has made a formal or informal contribution to the report in providing facts, in discussions, or in commenting on preliminary drafts. Any mistakes or shortcomings are of course solely the responsibility of the authors.

2. The Mystique of Airpower

Western states have for some time taken to intervening in conflicts on the periphery of the Euro-Atlantic region. 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.[7] The 1991 Persian Gulf War signaled the beginning of this era. American strategist and State Department counselor Eliot Cohen argued that "airpower had made the final assault" against the Iraqi military in Kuwait "as effortless as a wartime operation can be."[8] The United States lost 148 personnel in battle, 145 in accidents, and 467 were wounded in action.[9] It lost 37 fixed-wing aircraft and 23 helicopters in combat—none in air-to-air engagements.[10]

This unrivalled accomplishment was made possible by the integration of new technologies that had matured toward the end of the Cold War. It gave the impression that Western airpower possessed a mystical, almost omnipotent, quality. This "revolution in military affairs" consists of the integration of a long-range reconnaissance-precision strike complex into a military force capable of discovering and discriminately destroying targets using military forces located far away.[11] Satellite communications "provided unparalleled support to military commanders for intelligence gathering, map-making, communication, navigation, meteorology and missile-launch detection."[12] Global Positioning System (GPS) technology enabled military forces to locate themselves and enemy forces with unprecedented precision. Computers allowed this vast array of information to be processed and used to schedule the movement of forces during operations, allowing the centralized orchestration of an air campaign and rapid accumulation of synchronized and synergistic effects on the ground.[13] These developments enabled different means of placing munitions on target with far greater accuracy than ever before—whether delivered by cruise missiles or air-dropped, precision-guided munitions (PGMs)—with a devastating effect on Iraqi forces and facilities.

The 1990s and early 2000s saw this airpower revolution enable decisive intervention in thorny conflicts, including Bosnia, Kosovo, and Afghanistan.[14] 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.[15] In Afghanistan, airpower combined with Special Operations Forces, CIA operatives, and the Northern Alliance toppled the Taliban regime in less than 2 months.[16] Airpower had apparently reached its so-often dreamed of 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 imaginations of policy-makers and the public alike for reasons that reflect the mystique of airpower. Apparently, they allow warfare to be conducted with increased precision and without risk to friendly personnel. Indeed, we have witnessed the rapid global proliferation of UAVs. "Since 2005, the number of countries that acquired an unmanned aerial vehicle (UAV) system nearly doubled from about 40 to more than 75."[17] It seems as though every state, and even non-state actors,[18] are acquiring UAVs. But what are they?

Simply put, an "Unmanned Aerial Vehicle" is an aircraft without a pilot inside. The U.S. Department of Defence 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.[19]

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 used most commonly in connection with these systems are *UAVs* and *drones*. When referring to the entire UAV system, including the ground control and communications systems, the term Unmanned Aerial System (UAS) is sometimes used. UAVs are *not* ballistic or semi-ballistic missiles, cruise missiles, or artillery projectiles, all of which are designed to not be retrieved.[20] For the sake of convenience, we use the term UAV throughout this report to cover both systems and individual vehicles.

The Central Intelligence Agency categorizes UAVs in three ways: mini, tactical, and strategic.[21] Mini UAVs fly at low altitudes (0–3,000 meters), can remain aloft for a couple of hours, and operate at close-range to their controller. The American UAV *Raven* falls in this category. Tactical UAVs fly at low-to-medium (3,000–10,000 meters) 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 (10,000 + meters) altitudes, can remain aloft for hours to days, and can operate at a long range from its controller. The U.S. Air Force's *Global Hawk* falls into this category (see Table 1 for a quick overview). As noted, Denmark already operates mini UAVs, including the *Raven* and the *Puma*. The focus of this report is mostly on issues related to larger tactical or strategic UAVs.

Table 1: 3 Types of UAVs[22]

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 

4. UAVs Today: American, British, French, and NATO Experiences[23]

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. Yet a mere 12 years ago, the United States, the first mover in UAV technology, could not operate two of these aircraft simultaneously in a theatre of war against an adversary that lacked air defences.[24] This reflected over five decades of efforts to address the technological and organizational challenges involved. These challenges limited and often redirected the efforts to develop UAVs into an effective military capability.

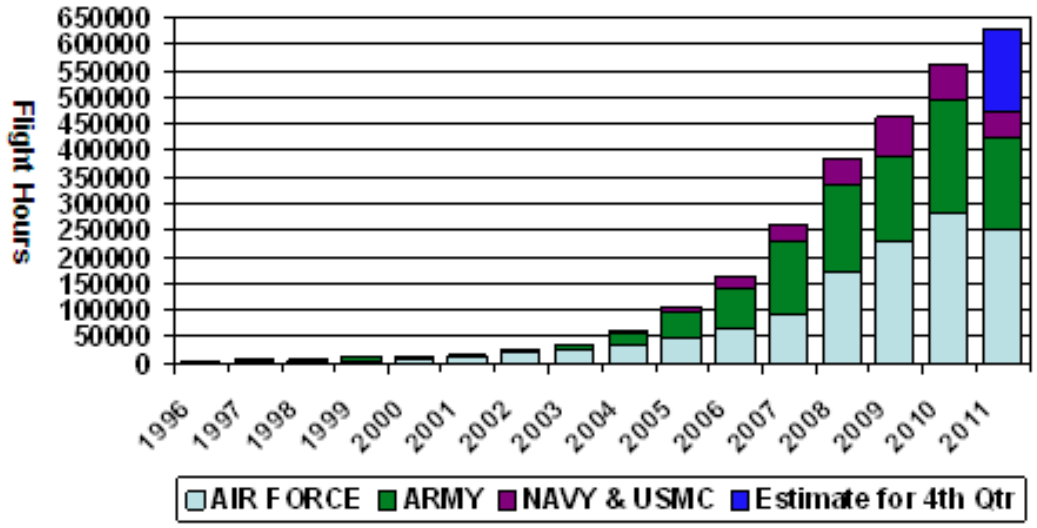
Military capabilities can be seen as the product of technology applied to tactical and operational problems deriving from the threat environment by the organizations responsible for national security. As the threat environment evolves or the focus changes from one aspect to another, these organizations use the technology on hand and that can be developed to address operational and tactical problems. Over time, solutions are often found that accommodate the conceptual orientation of these organizations; solutions that do not fit organizational culture are often ignored.

In the American case, the United States Air Force Strategic Air Command (SAC) and the intelligence agencies pursued three types of systems to accomplish their reconnaissance requirements in the 1950s and 1960s: manned aircraft, such as the U-2 spy plane, UAVs, and satellites. UAVs were unable to compete with manned spy planes and reconnaissance satellites to perform this mission, and the Air Force focused on the former while the intelligence agencies developed and deployed the latter. Modified target drones demonstrated some tactical utility in the Vietnam War, and the U.S. Army, Navy, and Marine Corps maintained some interest. Six UAV test systems were purchased in the 1980s by a Department of Defense agency established specifically to consider options for tactical reconnaissance,[25] and they were put to limited use by the Army and Navy in the Persian Gulf War.[26] Until the late 1990s, however, UAVs failed to meet the tactical and operational challenges posed by the threat environment or the conceptual visions of the military services and therefore languished as interesting engineering projects, not seen as an important military capability with immediate and significant use.

The operations in the Balkans and especially the wars in Afghanistan and Iraq have provided a historically unique concurrence between mission requirements and technological maturity that has enabled significant increases in the use and utility of UAVs. In each theatre, air supremacy was established, allowing slow, low-flying vehicles such as UAVs to perform without encountering 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, much more practical.

Consequently, American (and Allied) UAV inventories have increased significantly. The American UAV inventory increased from 167 in 2002 to 7,500 in 2011—not counting losses over the years.[27] Their use has also increased significantly, as seen in Figure 1: from approximately 25,000 flight hours in 2002 to approximately 625,000 in 2011.[28] This 25-fold increase over a decade reveals the degree to which the American military has adopted UAV capabilities and how tightly UAVs are integrated into the US Armed Forces' concepts of operation.

Figure 1: U.S. Military UAV Flight Hours, 1996–2011[29]



This increase in use has not been without cost. By 2009, for instance, "more than a third of … Predator spy planes … [had] crashed."[30] Accident rates have been high for the entire US 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.[31]

When compared to manned aircraft in the USAF fleet,

> Northrop's *Global Hawk* and General Atomics's *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.[32]

These losses have been expensive but nevertheless 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.[33]

As these systems mature, their mishap rates will likely decline, but it is unlikely they will ever reach the level of comparable manned aircraft.

The United Kingdom has also had experience with developing and deploying UAVs. The British *Phoenix* was used in the Kosovo peacekeeping operation from June–August 1999 and May–October 2000. It flew 270 missions, and 29 UAVs were lost to "hostile action, landing damage and equipment failure."[34] The system was also used in Iraq in 2003–2006. Its performance proved less than stellar: 23 of 89 aircraft were lost in the first year, "all due to technical failures—a ratio of one in six flights undertaken."[35] Although the *Phoenix* had an expected service life of 15 years,[36] it was retired after 8 years[37] at a cost of "approximately £345 million since inception."[38] The inability of the *Phoenix* to operate reliably in Iraq led the British to acquire *Reaper* UAVs from the United States in 2008 under an "urgent operational requirements" act. They also established their UAV operational squadron at Creech Air Force Base in the United States so as to acquire training and experience from the USAF.[39] The British first began operating those aircraft from British soil in April 2013.[40] 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."[41]

The French experience with UAVs also reflects the difficulties of developing the requisite technologies. French industry was unable to meet the needs of the French military, and 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 in 1999 during Operation Allied Force[42] and also in October 2001 as part of the Kosovo peacekeeping operation (KFOR), where it completed more than 25 missions.[43] The *Hunters* were withdrawn from service in 2004.[44] The French subsequently

acquired 30 *Sperwer* and 3 *Harfang*[45] UAVs, deploying them to Afghanistan in 2008 and 2009 after a French unit was ambushed and ten soldiers were killed.[46] The *Sperwers* flew 770 missions, clocked over 2,100 flight hours, and 12 were lost (eight in flight, four in landings) before being withdrawn in 2012.[47] The French *Harfangs* fared better. They flew over 660 missions[48] and recorded 5,000 flight hours[49] before being withdrawn in 2012. The French redeployed two of their *Harfangs* to Mali in 2013.[50] 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)."[51] Essentially, the lack of French military satellites to control their UAVs required them to purchase satellite capacity on the open market, which proved to be more expensive than they anticipated.

Consequently, French Defence Minister Yves Le Drian told French legislators that there was "… 'no alternative' to the [American] *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."[52] Ultimately, the French chose to buy American.

NATO also opted to "buy American" for its Allied Ground Surveillance (AGS) system. Since 1992, planning has been undertaken in NATO to procure a commonly funded ISR system focused on ground surveillance. A group of 13 (14 now that Denmark has re-entered the project) Allies has since then been developing a joint NATO asset for ground surveillance. As with other unmanned systems, the AGS system picked up momentum in the mid-2000s, and a memorandum of understanding was signed in 2009.[53] The participating countries agreed to develop a HALE (High-Altitude, Long-Endurance) system based on five US *Global Hawks*. Seen as an increasingly critical capability shortfall in NATO, the need for increased capabilities was underlined in NATO's new Strategic Concept, signed at the Lisbon Summit in 2010[54] and operationally made clear by the Libya conflict in 2011. Consequently, at the Chicago Summit (where Denmark re-entered the project), NATO decided that the €2.2 billion system would be collectively operated by NATO, commanded by SACEUR, and operated from a central facility with around 600 military personnel at Sigonella Air Base in Sicily.

The system, due to be operational in 2017, will provide NATO with a strategic ISR capability, in principle at the disposal of all Allies. Challenges remain in ensuring individual Allied capacity for processing and managing the data produced by the system as well as the manning and training of the personnel required to operate a new system, with which few Allied military forces have any experience.[55] Another question is if and when the capability—or its data—will be made available for individual NATO members in need of data, either when conducting non-NATO military operations or in relation to other events or contingencies (e.g. mega-events like the Olympics in London, a terrorist incident, or a large-scale natural disaster).[56]

Additionally, the viability of the AGS system has been questioned in relation to the German decision to end its *Euro Hawk* program.[57] One of the many issues for the Germans—which also haunts the UK *Watchkeeper* system—was getting the system certified to European civilian airspace standards. As this proved to be impossible, the whole system was cancelled—even after investing around €800,000,000. Similarly, the utility of the AGS system risked being radically reduced if unable to operate in peacetime European airspace.[58]

5. Denmark

Denmark has had aerial drones in its inventory since 1958,[59] although they were not particularly high-tech, only used as targets for artillery and missile training. Denmark today has a target drone system—the *Banshee*—that has been in service since 1988.[60] 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, however, Danish political leaders increasingly came to view the use of military force as a more normal and legitimate aspect of foreign policy. Indeed, Danish foreign policy can now be characterized as "military activism," albeit in contexts where larger powers define the situations in which force can be used and how it should be used.[61] During the last decade, wherever Denmark has contributed units of soldiers to ground operations, fighter or transport aircrafts to air operations, or a command and support ship to maritime operations, UAVs have played an increasingly important role. In Afghanistan, they provided the information necessary to conduct operations against the Taliban. In Libya, they provided 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 over Allied

air operations.[62] And off of the Horn of Africa, UAVs have helped patrol the waters in search of pirates.[63]

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.[64] The first UAV Denmark acquired to assist in military operations was the *Tårnfalken*. This system was an adapted version of the French *Sperwer* system. It was purchased because Danish armed forces leaders realized the value of tactical UAVs in low-intensity conflicts, such as those in the Balkans. It was deemed important by military authorities "to be in on this from the beginning,"[65] showing how the Danish Armed Forces had already realized the future potentials of UAVs in the late 1990s. The *Tårnfalken* was primarily used to perform reconnaissance, secondary targeting for artillery, and battle damage assessment.[66] The Danish Air Force received the French UAVs in 2001[67] and allocated them to the Army for operational use in 2002. The Army received 8 UAVs for operations and 2 UAVs for spare parts. On paper, the *Tårnfalken* appeared to be a capable tactical reconnaissance system that had been used successfully by the French. Possessing a 180 km operation range, it was equipped with electro-optical sensors for daylight operations and a passive infra-red sensor for night operations.[68]

The Danish Army was confident that it had considered how to integrate the *Tårnfalken* into its operational concepts, including its operation and maintenance. The Army had realized that integrating the *Tårnfalken* required organizational adjustments, and a UAV unit was therefore stood-up to operate the system from Varde, Jutland, and organized under the Army Artillery Regiment.[69] The unit was to have 90 Army personnel and reach full operational capability in 2009.[70] When deployed, the intention was to increase the unit to approximately 130 men.[71] Despite high hopes, the *Tårnfalken* never reached full operational capability and the program was terminated in 2005.[72] 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 not completed its own system integration at the time. This led to high failure rates in many parts of the system and a critical lack of spare parts, which the producer could not meet.[73] Both issues increased the risks associated with the system, which were compounded by how the system was integrated and operated. First, the project was organized with unclear lines of communication and responsibility, which made decision-making and oversight complicated.[74] Secondly, 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.[75] There are several reasons for this, one being 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 hiring personnel. Thus, no single command was solely responsible for properly manning the unit.[76] Because of the unreliable system, the aircraft would often be grounded due to technical failures, which disrupted the training and certification of the unit. At other times, the aircraft would be airworthy, but there would be no qualified staff available to operate it—again making it difficult to certify the system for operational use. The lack of skilled personnel and high numbers 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 reach operational status. Together with the financial costs, this led to the ultimate termination of the project.

In analyzing the project, *Rigsrevionen* (The Danish Government Auditors), concluded that the Danish defence forces did not fully appreciate the complexity of operating an advanced UAV system or the resources and personnel required to operate it.[77] When the *Tårnfalken* project was terminated, its remnants were sold to Canada to recoup some of the investment made.[78] Canada was subsequently able to make the system operational and deployed it to Afghanistan with the 11 others that they had previously acquired.[79] Those aircraft flew over 1300 flights, logging 4,270 hours.[80] Still, the Canadian *Sperwer* also encountered reliability problems in the field: six crashed, and the Canadians began considering the acquisition of a follow-on system.[81]

Following the *Tårnfalken* experience, the Danish defence forces bought "about 12" new, hand-launched mini UAV, the *Raven B,* in 2007.[82] 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 military units in Helmand in 2008.[83]

After what the Army describes as 4 years of successful operations,[84] 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 airborne longer (2 hours). Moreover, it has the advantage of being able to use the same ground control stations as the *Raven*, therefore requiring little change other than the purchase of the airframe.[85] The *Puma* is used by several countries in Afghanistan and is a well-proven system.[86] Additionally, the *Raven* has apparently also been used in anti-piracy operations,[87] and the Royal Danish Navy has operated the *Puma* from its flexible support ship *Esbern Snarre* off the Horn of Africa.[88]

Figure 2: The *Raven B*[89]

Figure 3: The *Puma* UAV[90]

6. Take Aways

The Danish experiences with the *Tårnfalken, Raven B,* and *Puma* UAV systems—together with those of the United States, Great Britain, France and NATO's planned AGS system—provide a number of lessons that can be used when considering future Danish investments in UAV systems. These concern the development versus 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 during this period. They did not mature until the late 1990s and, even then, American UAV

systems were limited in their capabilities, could only operate in uncontested environments, and were still far less reliable and more prone to crashing than manned aircraft. Second-mover states, including Great Britain and France, also undertook R&D with respect to developing UAVs, but their efforts until now have proven to be less successful, and they ultimately purchased systems developed especially by the first mover—the United States—and adapted them to their own purposes.

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.[91] This mission set very high requirements for range, payload, and speed—even before the specific intelligence gathering equipment was considered. Other capabilities therefore did the job better. But UAVs became a system of choice when the type of conflict shifted to low intensity, where air superiority could be assured and persistent reconnaissance was necessary to locate and fix small, moving targets, such as small units, single vehicles, or individuals. Over the past decade, rapidly changing operational requirements drove the Americans, British, French, and Danes to procure UAV systems in numbers and at a pace that exceeded their original plans.

Integration into Existing Structures: There is a paradox inasmuch as UAVs are by definition aerial vehicles, and yet the air forces 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.[92] The USAF lost interest in UAV capabilities in the 1970s because other systems performed the service's required missions better.[93] The U.S. Army eventually became the primary beneficiary of UAV technology and thirsted for the tactical situational awareness that medium-altitude persistent systems such as the *Hunter*, *Predator*, and *Reaper* could provide. The British, French, and Danish ground forces also demanded such support from above.

Yet air forces and navies have also desired such capabilities—or at least to control their use in the field. Developing doctrine and an organization to develop, acquire, and allocate UAV systems in a manner that serves all three services fairly has provided significant challenges.[94] So, too, has the development of an organization to train personnel, operate UAVs, and develop concepts and doctrine for their use.[95] Housing the "owners" and "operators" of these systems in separate organizations has proven especially problematic—as the Danish

experience with the *Tårnfalken* demonstrated. Finally, the integration of these capabilities with others at a technical level has posed some problems, particularly for those states that have attempted to customize their UAVs for national purposes.

Operational Issues. Finally, UAVs have only recently matured as a military capability—and then only for the first mover, a nation that 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. As noted in the history of UAV use by the United States, Great Britain, France, and Denmark, UAVs are far more prone to accidents, equipment failure, communications glitches, and hostile fire than most manned aircraft—even when controlling for the 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, nor too windy, and where there is no enemy fire attempting to destroy it. It must be accepted that when conditions are not ideal, UAVs will currently be lost at a rate that is disproportionate to that of manned aircraft performing the same sorts of missions.

7. UAVs in the Danish Context

Given the development shown in the previous paragraphs, it is reasonable to expect the use of UAVs to evolve even further in the immediate future. Operational experiences, not least in Afghanistan, have demonstrated the important surveillance and reconnaissance roles played by UAVs in support of ground operations. The utility of unmanned systems is also reflected in the rising number of countries operating UAVs. As noted, the military forces of 76 countries were operating UAVs in 2011.[96] Military forces are not alone with their interest in the use of unmanned systems. Other government agencies—including, but not limited to, police and border controls—see wide potential in the use of UAVs,[97] as do private actors. There are numerous other commercial possibilities as well.[98]

Where does this leave Denmark and the Danish armed forces? Many authorities—civilian and military alike—are interested in what UAVs have to offer, as are commercial firms.[99] The same is true at the political level. Accordingly, at a seminar arranged by the Centre for International Law and Justice and the Centre for Military Studies on September 26, 2013, defence or foreign affairs spokespersons from the Social Democrats, the Social Liberals, and the Liberal Party all agreed that the use of unmanned systems, even potentially armed, should

be pursued by the Danish armed forces. In order to facilitate that pursuit, systematic thinking at the political and strategic levels about how UAVs could be employed and the challenges that must be overcome to use them efficiently is needed. Despite their operational experiences, this is also true for the armed forces.

Below we provide the basis for more systematic debate about the potential use of UAVs by the Danish armed forces. Building on the takeaways from the preceding paragraphs, we outline which deliberations are necessary in order to make the most of the capabilities that UAVs could provide for Danish defence. In other words, we consider the tasks such systems could perform, who is going to use them, how they will be controlled, and how their use could be regulated. To consider these questions, we address missions and tasks, how to reduce acquisition risks by procuring them off-the-shelf in the smartest possible way, how to integrate UAVs into the armed forces, the operational issues inevitably arising with their integration into the existing force structure, their use in civilian airspace, and, finally, how UAVs fit within the context of Alliance politics.

7.1 Mission and Task Definition

First of all, it is important to identify what Denmark and the Danish armed forces want to use UAVs for, and this requires the identification of missions and tasks. Mission requirements, conditioned by the expected threat environment, should be the driving factor for assessing capability requirements. Currently, UAVs mostly provide ISR, which is an essential aspect of contemporary operations in military operations in peacetime and wartime alike.

The core tasks of the Danish armed forces are defined in *"Lov om forsvarets formal."* The Danish armed forces, encompassing the army, air, and naval forces, should be able to i) contribute to conflict prevention, crisis management, and defence of NATO territory ii) detect and defend against violations of Danish sovereignty, and iii) support other government agencies.[100]

The general purposes stated in the law are further codified in the November 2012 Defence Agreement and the resulting annual result-based contract between the Danish Defence Command and the Ministry of Defence. From these documents one can identify three groups of tasks: national operations, international operations, and civilian support operations.[101] For all three, the ISR capacity that UAVs provide in many instances can supplement existing capabilities, replace them, or provide new, enhanced capability. We will consider each group of tasks in turn.

International Operations

For the last 15–20 years, participating in international operations has become an increasingly important aspect of the mission of the Danish armed forces.[102] From the Balkans, over Afghanistan and Iraq, to Libya and Mali, the Danish armed forces have contributed to international military coalitions. UAVs have played an increasingly significant role for important Danish allies in these operations, and thus *inter alia* for the Danish use of military force.

In addition to drawing on the manned and unmanned ISR architecture provided by allies, the Danish Army has been using its own *Raven B* system since 2007 and has recently replaced it with the more capable *Puma* to assist its operations in Helmand, Afghanistan. According to the Danish armed forces, these small tactical UAVs have proven themselves to be a valuable and robust system, and the Army finds them to be a valuable capability.[103] Mini UAVs such as the *Puma* are quickly becoming standard equipment and the Army will want to maintain or further develop such a capability.

When contemplating further investment in UAV capability, one could imagine procuring larger tactical UAVs. These could conduct ground ISR support missions for the Danish Army in a variety of operations, spanning large-scale Allied high-intensity crisis-management operations, peace- and stability operations, as well as providing assistance in smaller special forces operations. In addition to support to other Army units, this capability could function as a Danish contribution to NATO response forces or be deployed as a single asset in support of Allied ground troops—much like the C-130 deployed in support of French troops in Mali. A MALE (Medium-Altitude, Long-Endurance) UAV system such as the *Reaper* or a comparable system could perform these functions.

Another example of the importance of international operations is the efforts of Danish air and naval forces against piracy off the Horn of Africa.[104] For some time, this vast area has been patrolled by Danish naval and air assets—together with a range of allies. In this operation, a UAV capability has been of use. For the Navy, and in addition to existing mini UAVs, a ship-launched, small- to medium-sized tactical UAV, such as the *Scan Eagle*, could be used to supplement ship-based helicopters performing close patrols of the area surrounding the ship. This would create synergy between the helicopter, ship, and the UAV and would enable the ship to identify and check more boats from the sky. Furthermore, a larger medium-sized system, such as the *Reaper* or even a larger HALE UAV, such as the *Triton* (built on the

Global Hawk platform), could replace the primary Danish Air Force ISR platform, the *Challenger*, in its ISR role or be used in conjunction with the *Challenger* to cover a larger area and over a longer period of time—perhaps providing even 24/7 coverage of a given area.

This walk-through shows that for all of the current types of international military operations undertaken by Danish armed forces, the ISR capabilities provided by UAVs are an important asset provided either indigenously or by allies; and that the capability provided by additional UAV systems would present a significant additional operational asset for the Danish armed forces.

Furthermore, and as stated in the 2013–17 Defence Agreement, Danish armed forces should be able to participate in international emergency and disaster management.[105] In such situations, the ISR capabilities of UAVs would represent a valuable asset for the lead civilian national or international emergency management agency. A lack of up to-date information, communication, and situational awareness is often a critical shortfall in the management of large-scale disaster management.[106]

National Operations

In addition to its international tasks, the Danish armed forces conduct a number of national operations.[107] The 2013–2017 Defence Agreement mentions surveillance, the enforcement of Danish sovereignty, and search-and-rescue operations as significant.[108] In addition to these tasks, the Danish military conducts a number of civilian tasks in cooperation with other government agencies.[109]

Significantly, and with increasing importance, these national operations include the Arctic region in the Danish Realm. Whereas the tasks are largely the same, the conditions in the Arctic and non-Arctic regions in the Danish Realm differ radically. The potential requirements for UAVs to be used in Denmark or in the Arctic therefore differ.

The relatively small Danish territory means that sea, air, and land are relatively well-monitored via air and naval presence as well as satellite and radar coverage. In turn, this makes it possible for stand-by naval and air assets to counter potential violations of Danish territory or sovereignty. These functions could be strengthened by introducing a range of UAVs to enhance situational awareness over Danish territory and supplement existing capabilities. Important to bear in mind, however, is that the current unmanned systems

primarily provide ISR. A UAV therefore cannot enforce Danish sovereignty in the same manner as a manned navy or air asset.

Another important task for the Danish Navy and Air Force is search and rescue. The increased situational awareness provided by UAVs can be employed to search for ships and/or persons in distress on water and land. As with anti-piracy operations, UAV use in combination with ships and helicopters would increase capacity. The persistence of UAVs would also enable search operations of a longer duration and a wider geographic area. Their presence could help reduce response times and get personnel to the right location faster when coordinated with manned rescue platforms.

Depending on the system and number of platforms, unmanned systems can maintain a continuous, 24/7 operational presence. Combined with their sophisticated surveillance capabilities, this also makes them well suited to support other government agencies with broader responsibilities for public safety, security, and environmental protection. In case of an emergency in Denmark, UAVs could significantly supplement existing monitoring capabilities. Moreover, they can be used to monitor suspected polluters, smugglers, and other forms of unlawful or unwanted activity.

Numerous systems could increase the capability of Danish national operations. In October 2013, for instance, the Italian Air Force deployed its *Reapers* to the Mediterranean to increase its search and rescue capabilities in response to the loss of life of migrants attempting to cross the Mediterranean Sea into Europe.[110] A comparable system would increase Danish capabilities—but so too would a smaller, perhaps ship-launched, tactical system.

In the Arctic territories in the Danish realm, the Danish armed forces face very similar tasks but under very different circumstances. The Danish territory in the Arctic covers vast distances, which are imbued with very little physical infrastructure (civilian or military), very fragile, often not non-existing, communication facilities, and harsh environmental conditions. Therefore, while there is a significant and widely acknowledged current and future demand for increased ISR capabilities in the Arctic,[111] the region presents other and more significant challenges to the employment of unmanned systems than operations in the non-Arctic part of Danish territory.

First, a UAV system to be used in the Arctic would need to be able to overcome the challenges associated with the harsh climate, meaning a system able to cope with high winds

and possessing a well-developed de-icing system. Many smaller systems are slow and built for a temperate climate, making them vulnerable to both wind and temperature. This, secondly, makes it logical to consider a larger MALE or HALE system. One such system is the US *Global Hawk*, which the Canadian Forces have experimented with for Arctic operations.[112] Given its longer range, such a system would also make sense with respect to the vast territory. A larger system, on the other hand, requires substantial physical infrastructure and is expensive to procure and costly to maintain. Thirdly, large long-range UAV systems are over-the-horizon systems, and operating them therefore requires satellite coverage with substantial bandwidth. Establishing such communications architecture, especially for real-time data transmission, requires substantial investments.

Summing up, the Danish armed forces already use mini UAVs and their operations depend on the ISR capabilities provided primarily by Allied UAVs. Further, additional investment in UAV systems would enhance the capabilities of the armed forces to carry out a significant number of the tasks they are assigned—both nationally and internationally. Finally, the ISR capability provided by a UAV system is a general capability and could therefore find use in many of the operations conducted by the Danish armed forces—military as well as in support of civilian authorities.

Any decision to procure such capability needs to be closely balanced against other needs and capabilities. It is therefore ultimately a political decision. Considering past experiences, however, *how* to buy also requires substantial attention.

7.2 Procurement: Off-the-Shelf, But How?

Looking at the historical lessons associated with the development and operational use of unmanned systems, a number of issues come to the fore in relation to how to procure a system.

First, the experiences of the United States, United Kingdom, and France suggest that developing systems capable of reliably conducting military operations is difficult, even if the component technologies are mature and available. The French experience, in particular, is instructive. Ultimately, France chose to purchase and adapt an American system as an "interim solution" until an indigenous European system could be developed and produced. In this they followed the British, as well as the Italians and Germans.[113] On the one hand, this history of how larger European states have come to rely on American (or alternately Israeli) systems indicates that Denmark should pursue, to the largest possible extent, mature and

well-proven systems. According to the Danish Army, this has been an explicit aim in procuring the *Puma* mini UAV.[114] The same aim should apply in the case of a larger, more complex system.

Secondly, and as reinforced by the Danish attempt at operating *Tårnfalken*, UAVs are complicated systems.[115] What is more, the Danish armed forces have very little experience operating larger systems. Both indicate that risk-reduction should play an important role in future procurement. This means, on the one hand, that attention should be given to service and maintenance in the contractual process with the seller. On the other hand, attention should also be given to procure a system that, to the greatest extent possible, already fits requirements so as to minimize the need for national customization to make it operational.

Thirdly, procuring a system operated by Allies should be made a priority in itself. Common and compatible systems enable interoperability, thereby increasing the efficiency of a system, as such. Further, running common systems provides opportunities for shared maintenance and other forms of cooperation. Finally, the joint use of a system introduces Danish operators to a wider community of knowledge, reducing the risks associated with a limited national knowledge base.

Fourthly, as shown above, UAVs could find wide use in many operations conducted by the Danish armed forces. There will be a temptation to procure a multi-function system that can accommodate every mission type and task for all interested agencies. Such systems reduce the ability of the system to perform individual missions efficiently and effectively and generally increase their cost.

7.3 Integration

The different branches of the military will have different requirements; overall, however, ISR is the key word. Each service must consider how to integrate these new systems into their existing structure as well as how "their" system works to enhance overall Danish ISR capability. The services should coordinate, perhaps through a joint anchor point for the use and procurement of UAVs. A key lesson from the previous Danish experience with the *Tårnfalken* suggests that dedicated resources, consolidated responsibility, and oversight for UAVs is necessary for managing the complex process of integrating a new capability in the Danish armed forces.[116]

One option would be to establish a unit in the military that would be responsible across various levels in the military command structure. Such a unit would also serve to establish a group of personnel that understands the issues around UAVs, including procuring, integrating, and operating these systems. Such a unit could be responsible for developing the doctrine necessary to operate these systems in service, joint, and combined operations—i.e., those with coalition partners and Allies. Finally, it could also serve as a reservoir of personnel that deploys with the system when it is allocated to Alliance operations.

7.4 Operational Issues

System Risks

UAVs are complex systems with significant advantages for their users; but they are not infallible. Indeed, they are less reliable than manned aircraft and crash far more often. This has been true for the United States,[117] Great Britain,[118] and France.[119] There are many reasons why UAVs are less reliable and more prone to crashing. First, most UAVs are slow-moving aircraft and therefore vulnerable to many types of air defence measures. They have been downed by ground fire, anti-aircraft artillery, and surface-to-air missiles.[120] They are highly dependent on communications and will react poorly if communications are severed, whether due to equipment failure, weather or geographic conditions, or enemy action. Third, they are not designed to be all-weather aircraft. Slow-moving, they are wind-sensitive aircraft. Their systems have been affected by the severe heat of desert conditions, severe cold, and extremes of high-altitudes. Most are not equipped with de- and anti-icing equipment and heated fuel systems, rendering them unable to operate effectively in Arctic conditions.

By definition, UAVs lack a pilot onboard to control the aircraft. This means that control must be asserted remotely, which is achieved by pre-programming a flight path, as was done on early systems, via continuous communications with the aircraft from a remote location, or some combination of these. Remote control requires line-of-sight communications with the aircraft that can be established directly, or beyond-line-of-sight communications through ground station relays or satellites.

In Denmark, establishing lines of communication with the UAV is not a significant problem, but it will be when operating UAVs in the Arctic. A massive area, line-of-sight is not possible in the Arctic, ground stations would be difficult to build and maintain, and there is little satellite coverage above 85 degrees north. These conditions will make it almost impossible at this time to operate UAVs in the Arctic. Should this be the ambition, solving the

communication issue is imperative. In plain terms, UAVs need satellites. Investing in satellites is therefore necessary for effective UAV use in the Arctic, and this investment in satellites could in itself increase ISR capability.

Costs and Personnel

Should Denmark decide to acquire a MALE system like the *Reaper* or a strategic HALE UAV like the *Global Hawk* to patrol Arctic regions, it is important also to consider the issues of man-power, pricing, logistics, and organization.

UAVs may be "unmanned," but they are manpower-intensive systems. For example, manning five *Global Hawk* airframes would require approximately 500 personnel.[121] NATO's organization for operating its AGS-system—also based on the *Global Hawk*—is approximately 600 people. Consequently, and based on a rough calculation, operating three HALE UAV units—the number of air frames Canada deemed necessary to be able to patrol Canadian territory 24/7—would require roughly 280 personnel.[122] While requiring fewer personnel to operate than a *Global Hawk*, a MALE tactical UAV such as the *Reaper* would also be manpower-intensive, especially if it is to provide continuous coverage. Moreover, it is also necessary to consider the operational differences between the two systems. A *Reaper* would need to deploy (including ground-station crew and so forth) to Greenland in order to operate there, leaving it vulnerable to the local weather. A *Global Hawk*, on the other hand, could fly from Denmark (or other locations) and remain above hard weather. Furthermore, it covers substantially more ground, thus providing more coverage per airframe. Additionally, the systems are expensive both in acquisition and operating costs.

Determining the actual costs of such systems is inherently difficult. However, to name a couple of examples, France expects to pay $874,000,000 for 12 *Reaper* UAVs,[123] the Dutch are in the process of acquiring four *Reapers* at a cost of "up to" €250,000,000,[124] and a House of Commons report has referred to the cost of procuring and operating UK UAVs in Afghanistan from 2007 until December 2011 as amounting to £729,000,000.[125] To indicate broadly the costs associated with procuring, operating, and manning current UAV systems, Figure 4 and Table 2 below compare the costs and manning of the *Global Hawk* and *Reaper* UAVs.[126] These figures should be read with caution: they are compiled from a number of sources and function only to provide a rough indication of the price and manpower ranges. Furthermore, Figure 4 breaks down the required manpower in its various functions. Here, it is important to note that approximately one-third of the staff needed is involved with processing

the data produced by the system. These are highly trained personnel, and they must be recruited, educated, and trained before the system can be put to use.

Figure 4: Example of USAF manning size of unmanned systems[127]

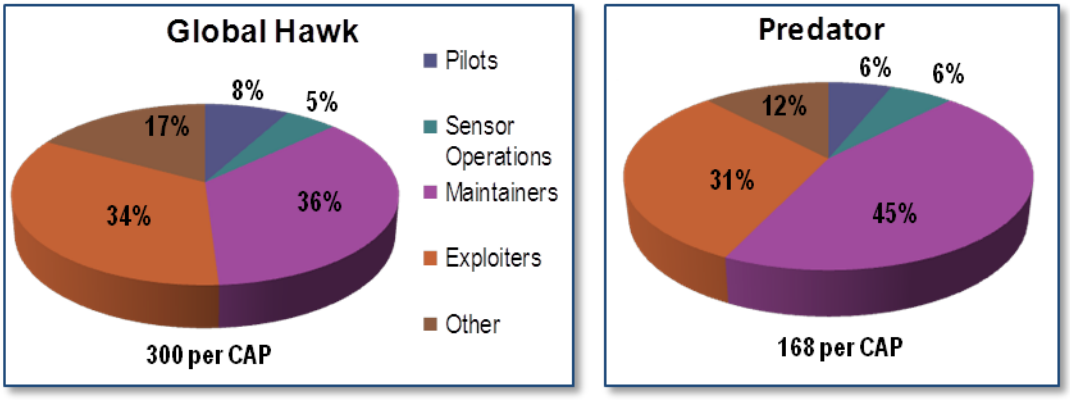


Table 2: Comparative Prices of *Global Hawk* and *Reaper* UAVs

	Global Hawk	*Reaper*
Unit price	$30–50,000,000[128]	$4–5,000,000[129]
Unit price with ground stations	$233,000,000[130]	$60,000,000[131]
Manpower to operate	280 (3 units)	171 (4 units) [132]
Endurance	24–32 hours[133]	27 hours[134]
Examples of types of operations	High-altitude, long-endurance ISR[135]	Medium-altitude, long-endurance intelligence collection in support of strike, coordination, and reconnaissance missions[136]

Significantly, Figure 4 illustrates how it does not require a lot of personnel to *fly and operate* UAVs. It is the *supporting personnel*—and especially those needed for the processing, exploitation, and dissemination of data for intelligence—that increases requirements. Exploitation of the data captured by the UAV is, after all, the primary purpose of acquiring them. Drawing again from the lessons associated with *Tårnfalken*, where the lack of highly

specialized and well-trained personnel was deemed pivotal to the ultimate failure of the system,[137] this underlines the pivotal significance of establishing a well-functioning, well-educated, and robust organization for operating the system.

Regulation[138]

Another issue that needs to be taken into account when contemplating UAV procurement is national and international airspace regulations, developed by the International Civil Aviation Organization (ICAO) and its "Standard and Recommended Practices." These severely limit the usability of unmanned systems. Overall, the challenge for utilizing UAVs is that current airspace regulations have been developed on the basis of manned flight. This has meant the development of strict safety regulations and that "see and avoid" capacity is an essential safety measure regulating the use of airborne platforms—manned or unmanned.

In contrast, the development of military UAVs has not followed general manned safety standards. They are, first, unmanned precisely to perform more risky operations. This is also part of the explanation for the relatively high UAV failure rate: they are not built to the same standards as manned systems. Consequently, their use incurs third-party risks, limiting safe areas of operation. Secondly, providing UAVs with the capability to "see and avoid" comparable to that of a piloted aircraft is technically challenging, and currently limiting the use of existing UAVs and allegedly holding up the deployment of the British *Watchkeeper* UAV.[139]

This seriously reduces the usability of UAVs in peacetime and outside closed military airspace. For instance, airspace regulations mean that operating a ship-based UAV in Danish territorial waters is limited to the immediate vicinity of the ship itself, significantly reducing the effective range of the UAV. Similarly, using a MALE system like the *Reaper* for domestic tasks in Denmark would require closing substantial parts of an already congested civilian Danish airspace and finding ways to mitigate the risks to the third parties associated with accidents due to potential malfunctions. A HALE system like the *Global Hawk* circumvents some of these regulative challenges, as it operates at altitudes above regular civilian air traffic, therefore only requiring enough closed airspace around its base of operations so as to be able to reach its operating altitude. This is the approach pursued by NATO with its AGS system, planned to operate from Sigonella, Sicily. In the Arctic, on the other hand, the regulatory prospects for using UAVs are brighter. Little air traffic combined with a very sparse population and large territory makes it easier to configure the airspace in a

manner that will make UAV operations possible while still complying with civilian safety regulations.

Still, the development of UAVs is also regarded with keen interest from commercial civilian actors, who see a wide range of potential business opportunities. Consequently, national and international authorities are working hard to develop regulations that will allow increased use of UAVs in civilian airspace. In 2011, ICAO published *ICAO Circular 328: Unmanned Aircraft Systems (UAS)*, providing the initial guidelines for the use of UAVs.[140] Furthermore, the EU published a "Roadmap" in 2013 for integrating UAVs in European airspace.[141] According to this ambitious plan, which still requires final approval from the European Commission, the complete integration of UAVs into European airspace is expected in the timeframe of 2023–2028. This goal, however, remains dependent on the development of a wide range of industry standards, pilot training certification systems, and requirements and standards for various types of aircraft. Additionally, the wider civilian use of UAVs raises significant questions regarding both public safety and security as well as the individual's right to privacy. All of these issues need to be addressed at the national and international levels before the significant integration of UAVs in civilian airspace will be possible.

In sum, airspace regulations severely limit the operational usability of UAVs—especially in relation to many of the peacetime tasks conducted by the Danish armed forces—as well as any potential civilian or dual application. These, and their expected developments, need to be taken into consideration along with the other operational challenges facing UAV users.

Interoperability

A final operational consideration to take into account is the interoperability of the system. For instance, if Denmark decides to procure a larger tactical system like the *Reaper*, interoperability should not just be understood in relation to international allies. A UAV is basically a platform capable of producing very large amounts of (real-time) data. Depending on the kind of sensors the aircraft is equipped with, it will be able to produce very different kinds of data.

That means that the system could potentially cater to many different customers. The utility of the system increases with the number of costumers it can service. Interoperability should therefore be understood in relation to civilian authorities, research institutions, branches of the Danish armed forces, and allies.

Accordingly, if the system is to be of value to civilian authorities, it must be equipped with sensors that will produce information that they find useful. Environmental authorities, police, police intelligence services, or emergency management authorities will perhaps share data requirements with each other and with the Danish armed forces—or maybe they won't. Furthermore, these civilian authorities need to be in possession of the communication infrastructure necessary to receive, process, and disseminate the data produced by the system.

The same issues pertain to the branches of the Danish armed forces. Operators and end-users will often not be within the same branch, and again depending on the particular system and its sensor package, it will be able to produce a wide variety of data that can be used to support a wide variety of operations, including defence intelligence. The armed forces must therefore consider and put in place the structures necessary for exploiting and disseminating the produced data.

Finally, as is the case with the Danish armed forces in general, the data produced by a Danish UAV and the system itself must be interoperable in order to function as seamlessly as possible in the Alliance context. This is the case if the system is deployed as part of a Danish contribution to an international operation—and especially so if it is supposed to be deployed as a stand-alone Danish contribution.

7.5 Alliance Politics—Procuring with Allies?

Substantial Danish procurement decisions are never just a matter of defence policy and planning. These decisions are always also a matter of alliance policy.[142] Defence investment buys both military capabilities and political goodwill. NATO Secretary General Anders Fogh Rasmussen has repeatedly noted that ISR capabilities are an important NATO shortfall.[143] Accordingly, investing in UAVs makes sense in the Alliance politics context, and the Danish decision at the Chicago Summit to re-engage in NATO's AGS system can be understood in this light. Equally, multinational procurement has for some time been a priority issue for NATO under the heading of "Smart Defence."[144]

However, more than just Alliance goodwill makes it reasonable to consider multinational procurement solutions. First of all, UAVs—especially larger systems—are expensive to acquire, costly to operate, and require a substantial number of highly specialized personnel to be useful. Exploring how to share these costs and risks with partners makes sense.

Further, Denmark shares particular needs with a number of allies. The increased political salience of the Arctic region and the substantial expected increase in regional activity as a consequence of climate change creates an increased demand for ISR capabilities—not just for Denmark. It would therefore make sense to work closely with like-minded Arctic nations such as Canada, Norway, and the United States in contemplating and developing potential new Arctic capabilities. International cooperation need not be centered regionally on the Arctic, however. A substantial number of countries could potentially share a Danish interest in exploring whether and how to pursue new unmanned capabilities together.

How to go about joint procurement and perhaps even operation is a complicated issue. International procurement initiatives are often accused of overpromising and under-delivering—while ultimately experiencing cost overruns and schedule delays. While that is sometimes the case, there are also examples of multinational cooperation providing capabilities that would otherwise not have been within the reach of individual nations or providing significant economies of scale in both procurement and operating costs. The NATO-operated AWACS system and the user cooperation in relation to the F-16 fighter aircraft are two notable positive examples. Central to successful international procurement are synchronization in time (when to buy) and requirements (what to buy). In turn, that requires international dialogue, compromise, and flexibility in the defence planning process of individual countries.[145]

8. Conclusions: Take Aways for a Continued Danish Debate

In conclusion, there are four overall and key takeaways for future strategic and political debate on if—and if so, how—to further integrate unmanned systems into the Danish armed forces. This report has shown that UAVs have matured as a technology, and the experiences of allies and the Danish military strongly indicate that UAVs will play an increasingly pervasive role in the future use of military force. Denmark needs to take due note of this and put itself in a position to make informed choices in this regard.

When deciding to procure the *Tårnfalken* system in the late 1990s, a core argument apparently was that it was "important to be in on this from the beginning."[146] This argument builds on the early recognition and realization of the substantial potential associated with

unmanned systems that has only been validated by recent developments. At the same time, *Tårnfalken* also shows the risks involved in standing up radically new capabilities.

Deciding on acquiring a UAV system therefore remains a major decision. Most systems above mini UAVs are expensive, putting additional pressure on an already strained Danish defence budget. Any decision must therefore be thought through in relation to wider questions regarding the meaning of airpower for the Danish armed forces and the future composition of the Air Force.

Secondly, it is a complex decision. A UAV is not just *a* UAV. While this report has used the most well-known American systems as examples, UAVs come in many shapes and sizes, and a large number of systems exist and they can carry out a significant number of different tasks. The capabilities of a UAV depend, furthermore, to a large extent on the sensor package the system is equipped with and the command, control, and communication infrastructure within which it is embedded. In debating a choice of system, it is therefore necessary to be precise when developing the tasks from which the particular mission requirements for Danish UAVs will then follow.

Thirdly, it is an organizational decision. Deciding to procure a completely new system with which the Danish armed forces have very little experience operating necessitates a significant number of organizational decisions—and organizational investment. Integrating, manning, using, and exploiting the effects provided by such a system in an efficient manner requires solidly anchoring the system in a capable organizational structure.

Fourth, it is perhaps not a decision at all. It is by no means inevitable that Denmark will decide to invest further in unmanned systems—at the present time, or as such. First, Denmark partakes in the NATO AGS system, providing commonly operated Alliance-wide strategic ISR capacity. Second, the experience so far has been that in international operations, larger allies have provided most of the required ISR capability—manned or unmanned. Denmark could decide that this capability is not part of the package that it can or will offer in international operations—neither now nor in the future. And finally, Denmark could continue to pursue manned solutions for national operations.

UAVs come with significant advantages and also with serious drawbacks. Some of these have been mentioned, but to sum up:

- UAVs are not replacements for general purpose manned systems—yet.

- They cannot be used in civilian airspace because of regulatory issues—yet.
- They are highly vulnerable in contested airspace.
- They are expensive and manpower-intensive, and
- They are not as reliable as manned platforms—yet.

Accordingly, UAVs are currently characterized by a number of drawbacks that must be balanced against their benefits. Furthermore, and as indicated in the bullets above, UAV technology, UAV costs, and the regulations for the use of UAVs are all moving targets. Therefore, the question is not just *if*, and *if so, what*, but also *when* to decide on further investments.

Our analysis outlines a substantial number of more general issues to be taken into consideration when contemplating if and how Denmark is to procure and operate unmanned systems. The following concrete recommendations can hopefully inspire and facilitate these complex decisions. The recommendations are split into three phases: (1) when preparing for a decision, (2) when deciding, and (3) if commencing initial operations.

8.1 Recommendations

Preparing for a Decision

- Stand-up a dedicated UAV-unit in Danish Defence Command—perhaps dovetailing the "Future Fighter Aircraft" team, to consider the role of unmanned systems in Danish airpower.
- Maintain or increase participation (in terms of personnel) in NATO's AGS system as it becomes operational to expand the Danish knowledge base.
- Follow UK and NATO attempts at certifying systems for wider use in civilian airspace to facilitate their peacetime and dual-use roles.
- Actively support efforts by national and international aviation authorities to establish solid regulations for the use of UAVs in civilian airspace.
- Engage potential partners for procurement and/or operations early and informally, but in detail.
- Piggyback to the widest possible extent on experiences and lessons of comparable partners and allies already operating UAVs.
- Considering modularity—more potential configurations—means more kinds of missions. This is currently how the manned *Challenger* system works. But modularity also incurs higher expenses and system risk.

- Continue tests and experiments—both in the Arctic and non-Arctic parts of the Kingdom—and involve potential partners in these to create the basis for discussing future joint requirements.
- Software and sensor-packages are crucial for the capability a system will be able to deliver. These are equally expensive and can account for a substantial part of the price of a system.

In Deciding

- Have a clear definition of tasks and consolidated concepts of operations ready.
- Ensure a clear command structure for procuring, certifying, manning, and operating the system.
- Engage other government agencies. UAVs can produce data for many potential users.
- Will Danish UAVs only be a military capability? With expected regulative changes, civilian governmental demand will rise, and with that also the potential for sharing expenses.
- Continue to seek partners and work for synchronicity in when and what to procure, even if it might mean compromising on system requirements or the defence planning process.

In Initial Operations

- Contemplate whether, for an initial start-up period, operations should be conducted from an experienced Allied user's facilities to reduce risk and increase everyday access to knowledge and expertise (as the UK has done).
- Trained personnel, infrastructure, and organization must be in place and be robust at an early stage.

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