The Future of Battlefield Micro Air Vehicle Systems

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Abstract

The most recent survey of Unmanned Aerial Vehicle (UAV) adoption rates shows that the area of small, man-portable systems (generally defined as Micro Air Vehicles or MAVs of maximum take-off weight between 1-5 kg) has one of the highest growth rates of any of the market sectors. There is a growing realisation by military planners that to win the insurgency wars of the present and future, forward units will have to operate within the close confines of urban conurbations and for prolonged periods of time without support. Real-time information and intelligence on enemy strength, dispositions and tactics is therefore essential for battlefield success.

Keywords: *Battlefield MAVs, Micro UAVs, Small Unmanned Systems.*

Introduction

This paper will focus mainly on the design and selection of small rotary wing UAVs due to their inherent suitability for Military Operations in the Urban Terrain (MOUT). The field of small unmanned aerial systems has grown rapidly during the last decade [1]. Many of the early small UAV systems were based on fixed-winged radio controlled devices taken from the hobby market and souped-up with added features such as GPS and video downlink capability [2]. More recently the move has been towards smaller, lighter, more autonomous systems which have the capability to hover and perch with Vertical Take-Off and Landing (VTOL) as an essential rather than a desirable feature. Several companies and research organisations, such as EMT-Penzberg, Microdrones, AirRobot, Draganfly, Ascending Technologies (AscTec) and Middlesex University have been developing multiple rotary-winged UAVs (more than one rotor) and these are now starting to enter the military and civilian markets with great success.

Figure 1. EMT-Penzberg's Fancopter.

Figure 2. AscTec's Hummingbird.

Figure 3. AirRobot's AR100-B.

Figure 4. Microdrones' md4-200.

Figure 5. AirRobot's AR70 co-axial tri-rotor.

Figure 6. Draganflyer X6 co-axial tri-rotor.

Figure 7. Middlesex University's co-axial tri-rotor.

Figure 8. AscTec's Falcon 8.

The growth of small UAV systems

The growth in UAVs over the last ten years has been impressive, driven in large part by the conflicts in Iraq and Afghanistan and the ongoing 'War on Terror'. According to estimates by Frost and Sullivan, the aggregate military UAV expenditure (2003-2012) for the US and Europe is expected to be £20bn, with the US Department of Defense alone forecasting a FY09 UAS procurement spend of US$2bn [3-4]. Probably the most reliable and up-to-date source of information relating to international UAV usage originates from the Unmanned Vehicle Systems Website and Yearbook which lists UAV activity across the international spectrum [1].

The latest data for 2009-10 lists 1,190 Unmanned Aircraft Systems (UAS) being developed in 51 countries throughout the world. This has increased by 22% in the last year alone. Systems of less than 5 kg MTOW now account for 11% of all systems.

Of the 1,190 systems, 683 (57%) are classed as military, 150 (13%) are civil/commercial and 260 (22%) are dual purpose. Other categories are Developmental and Research. In terms of the 51 UAS producing countries, the US is leading with 386 (32%) systems, followed by Israel 83 (7%), France 77 (6%), UK 65 (5%), Russian Federation 59 (5%), Germany 39 (3%) and Iran (38) (3%).

The most common type of UAV remains the Fixed Wing system (72%), followed by Rotary Wing (17%), Lighter-than-Air (3%), Shrouded Rotary Wing (Ducted Fan) (3%), and then a series of other systems which include motorized parafoils, tilt rotors, flapping wings, etc.

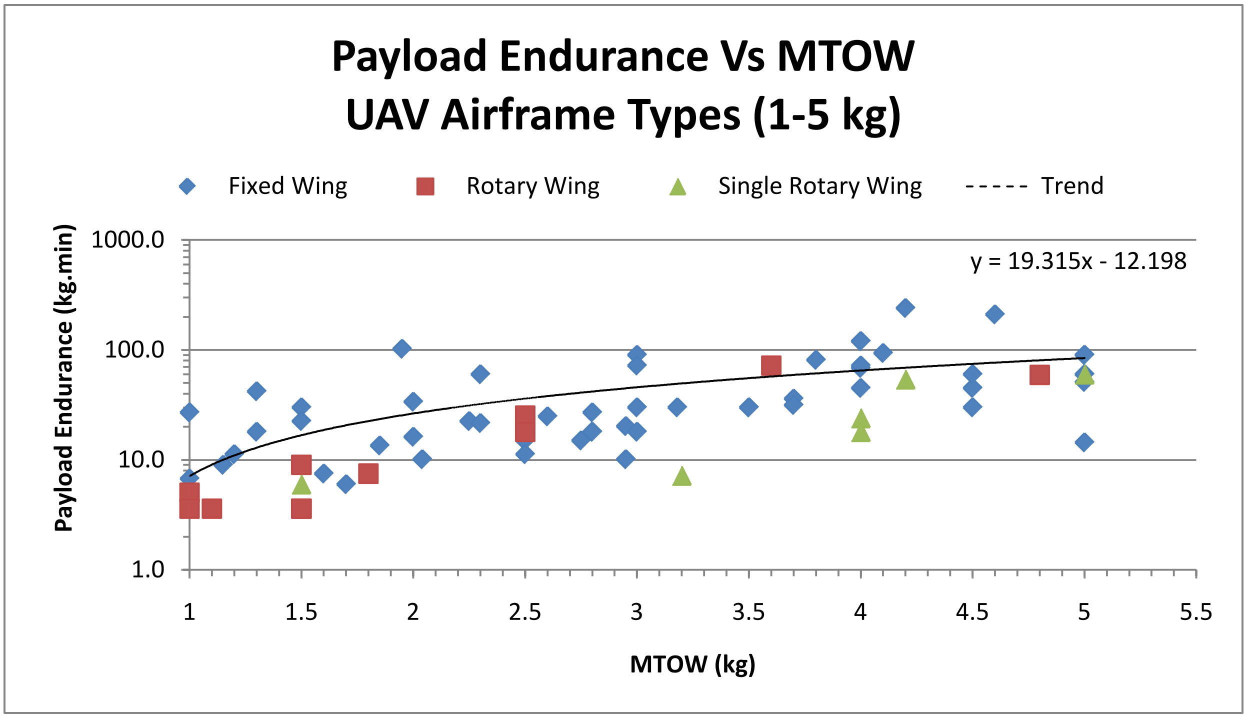

Figure 9. Analysis of small unmanned aircraft systems [1].

Rotary winged UAV successes

Each of the systems presented here (see Figures 1-8) have been successful in their own right. The Fancopter UAV was one of the first Rotary Winged systems to be used by the German Army in 2006; they have since bought another 19 systems in October 2008.

AirRobot originally developed Quadrotors for the German Army, but have recently been developing a Co-Axial Tri-Rotor version. They are also a partner in the µDrones EU consortium.

Microdrones, a developer of quadrotors, are probably the most successful of the small rotary winged UAVs, having sold upwards of 300 md4-200 systems over the last four years. Many of these are being used by the emergency services – police, fire brigade and search & rescue. Microdrone is currently developing a 1.2 kg payload version (md4-1000) to be released in late 2009.

A team from Ascending Technologies in collaboration with colleagues at MIT recently gained first place in the IARC 2009 competition which challenged teams to build autonomous systems to function in unstructured, and GPS denied environments. Their range of innovative designs gives them a distinct advantage over the traditional quadrotor approach.

Draganfly Innovations Inc. has been developing RC aircraft and parts for the past 10 years and have built up an enviable array of expertise and experience in this domain. In August 2008, they released their X6 Co-Axial Tri-Rotor UAV to critical acclaim. In 2009, they released their X4 Quadrotor UAV and in 2010 they plan to release their X8 which will be a Co-Axial Quadrotor UAV.

A team from Middlesex University entered the UK Ministry of Defense (MoD) Grand Challenge Event 2008 with their own design of a Co-Axial Tri-Rotor UAV called HALO® which has a payload capability of between 1-2 kg [5]. This design is protected by Design Registration and is Patent Pending.

As can be seen from Table 1 overleaf, the majority of Rotary Winged systems originate in Germany where they have a strong technical background, good educational system and an entrepreneurial spirit.

Table 1. Small rotary winged UAV specifications.

Name	Origin	Cost (£)	Mass (kg)	Payload (kg)	Endurance (min)	Rotor Ø (m)	Size: Ø (m) x Height (m)	Wind Load (m/s)	Range (m)	Notes:
EMT-Fancopter	DE	90k	1.5	0.3	25	0.6	0.73 x 0.44	4	1000	
AscTec- Hornet	DE	N/A	0.25	0.05	10	0.152	0.28 x 0.28 x 0.15	5	500	
AscTec-Hummingbird	DE	0.9k	0.56	0.2	12	0.203	0.54 x 0.10	10	500	
AscTec-Pelican	DE	N/A	0.25	0.5	11	0.203	0.50 x 0.5 x 0.2	10	1000	
AscTec-Falcon 8	DE	N/A	1.3	0.5	17	0.203	0.85 x 0.8 x 0.15	10	1000	
AscTec-Falcon 12	DE	N/A	3.4	1.5	20	0.305	1.25 x 1.2 x 0.20	10	1000	
AirRobot-AR100-B	DE	20-30k	1.3	0.2	25	0.37	1.0 x 0.20	8	750	
AirRobot-AR150	DE	N/A	2.5	1.0	25	0.37	1.5 x 0.40	8	1000	Q4 2009
AirRobot-AR70	DE	N/A	1.0	0.2	25	0.37	0.71 x 0.40	8	1000	Q4 2009
Microdrones-md4-200	DE	10-30k	0.9	0.2	30	0.37	0.91 x 0.20	4	500-2000	
Microdrones-md4-1000	DE	N/A	3.6	1.2	60	0.37	1.5 x 0.25	5	500-2000	Q4 2009
Draganflyer-SAVS	CA	1.5k	0.54	0.085	12	0.313	0.76 x 0.15	4	250	
Draganflyer-X4	CA	5-20k	0.68	0.25	20	0.38	0.65 x 0.21	4.5	500	Q4 2009
Draganflyer-X6	CA	10-30k	1.0	0.5	20 WNP	0.4 + 0.38	0.99 x 0.254	8.3	500	
Draganflyer-X8	CA	N/A	1.5	1.0	N/A	0.4 + 0.38	0.65 x 0.254	8.3	500	Q2 2010
Middlesex-HALO	UK	5-20k	3.3	1.5	40	0.254	0.7 x 0.254	10	1600	Q4 2010

Notes: *Endurance figures are quoted at maximum payload.*
(Unless otherwise stated, i.e. WNP = With No Payload)
Maximum Take-Off Weight (MTOW) = Mass + Payload.
Some future product specifications are estimates.
Cost ranges reflect the additional cost of sensor payloads.

Current battlefield UAVs

Since the wars in Afghanistan and Iraq began in 2001 and 2003 respectively, the world has witnessed an increasing number of unmanned aerial vehicles entering the battlefield. To date, these number in the low thousands. The current batch of small man-portable drones almost entirely consists of fixed winged systems such as the Lockheed Martin Desert Hawk III and the AeroVironment Wasp III. However, these are beginning to be supplemented by VTOL UAVs which can hover and stare, such as the Honeywell T-Hawk system, which is just about to enter service with the US and UK armed forces.

Figure 10. AeroVironment's Wasp III.

The T-Hawk system consists of two UAVs together with a Ground Control Station (GCS). In Feb 2009, it was reported that the UK MoD had placed a US$5.7m order to buy six of these systems for use in frontline operations. The US Navy placed an order for 90 systems worth US$65m in Nov 2008.

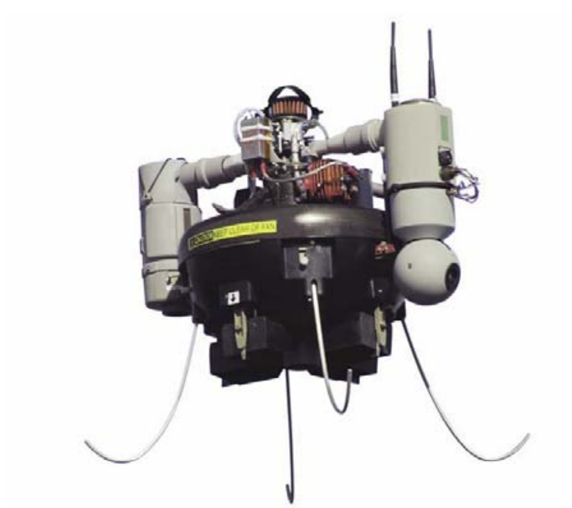

Figure 11. T-Hawk MAV from Honeywell Inc.

The T-Hawk system or RQ-16A to give it its full designation was first flown in January 2005 and originated from within the Defense Advanced Research Projects Agency (DARPA) Organic Air Vehicle program which started in April 2001.

The system consists of a gasoline powered ducted-fan arrangement. With a dry mass of approximately 8 kg it is man portable (just), however, when you include the GCS, the second system and fuel this does burden the individual soldier considerably.

With an endurance of 50 min at sea level and its considerable noise signature, it is not really stealthy. Further problems are its inability to take off in wind gusts of more than 8 m/s, its 10 m horizontal positional accuracy and its 6 m vertical positional accuracy, making it impossible to fly down a narrow street or enter a building.

Due to their high cost, these type of systems will probably only ever be used by Special Forces soldiers. The average soldier, who faces the dangers of IEDs on a daily basis, will therefore remain excluded from the benefits that such systems can give. The goal must be to provide cost effective solutions to the individual soldier in the same way that you would provide them with body armor and bullets.

The future is nano

It is the authors belief that within the short term (5-10 yrs) will see the introduction of VTOL capable multiple rotary wing UAVs (Quadrotors and Tri-Rotors) which will enhance and support the use of larger fixed wing assets in situations where the soldier is operating in congested urban areas.

However, as we look further into the future (10-15 yrs) we will see the introduction of a new breed of Nano Air Vehicle (NAV) probably at the scale of a small bird or even a bee. Leading this research drive is a select group of engineers and scientists at AeroVironment, as well as Harvard University in the US, Prox Dynamics AS in Norway and the muFly group based in Switzerland.

Figure 12. The muFly vision of future NAVs.

The US Government's NAV R&D effort is being driven by DARPA [6] who are funding work at AeroVironment Inc. The Harvard group is being funded via a US$10m National Science Foundation research grant over the next five years [7].

The group at Prox Dynamics AS is a privately owned commercial company and is therefore self-funded. The muFly project is a consortium of six organizations; muFly is a STREP project under the Sixth Framework Programme of the European Commission and is funded by a €2.7m grant (2006-2009).

Conclusion

The defence sector is not known for coming in on time or budget. This inertia has led to many program overruns costing billions of pounds. A recent independent report in the UK found that on average individual projects were running five years behind schedule and £300 million over budget.

When pressed by circumstances beyond their control all governments, including the UK, procure Urgent Operational Requirements (UORs) which are sometimes not thought through and can be very expensive in the long run [8].

Without an influence over where these technological advances are being developed, the purchaser will always be reliant on the supplier for future developments. The UK government via the Ministry of Defence (MoD) should therefore encourage more UK enterprise and technological development via direct support of SMEs, Universities and research organizations with funding which is both easier to obtain and less bureaucratic to manage; allowing for day-to-day necessities as well as blue sky thinking.

The UK MoD's Centre for Defence Enterprise (CDE) was set-up in 2008 to drive this agenda forward; to date it has failed to deliver on the promises it made.

This paper has highlighted several international platforms which have been developed to assist with the difficult technical problem of realizing autonomous unmanned systems.

The technology to provide for situational awareness exists now which can make a real difference in Afghanistan by saving lives, and there is no reason why it should not be procured and deployed with urgency.

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