Tethered Drones for Persistent Aerial Surveillance Applications

By: Dr Stephen D Prior, Reader in Unmanned Air Vehicles
University of Southampton

The current generation of free flying Drones, AKA Remotely Piloted Aircraft Systems (RPAS) have two very important drawbacks; the first being an inability to cope with moderate wind speeds (>8 m/s), the second being a lack of endurance, with 20-30 min being typical for most small multi-rotor platforms (<7 kg).

There are also a number of other issues which will also influence Drone (RPAS) use and acceptance amongst the general population, these being Safety, Security and Privacy.

Safety – In the UK, the Civil Aviation Authority (CAA) regulates and issues Permits for Aerial Work (PFAW). Since there is no minimum mass, all classes of Unmanned Aircraft (UA) come under the remit of the CAA. Mass categories are instead used to differentiate between these systems: 0-7 kg, 7-20 kg, 20-150 kg and over 150 kg. Regulation is progressive and can involve pilot licensing, insurance, airworthiness and technical and operating environment complexity. In brief, the Drone operator must not endanger any person or property.

Security – The Air Navigation Order (ANO) (2009) requires operators of Small Unmanned Aircraft (SUA) to operate in a safe manner at all times. One of the key elements is to conduct operations within 500 m horizontally and 400 ft vertically of the pilot in control. These values can be reduced for smaller UA and increased for larger UA. Conditions include a prohibition on flight in controlled airspace or within an aerodrome traffic zone. Most small Drones rely on civilian GPS, which is inaccurate (±2 m), can be jammed, as well as spoofed!

Privacy – In CAA speak there is a distinction between a Small Unmanned Aircraft (SUA) (<20 kg) and a Small Unmanned Surveillance Aircraft (SUSA) – the difference being that the later is 'equipped to undertake any form of surveillance or data acquisition'. This is usually associated with the carrying of a camera or video recording apparatus. However, this does not apply to 'the provision of images or other data solely for the use of controlling or monitoring the aircraft', which is somewhat subjective.

Each CAA PFAW contains the clause that: 'the collection of images of identifiable individuals, even inadvertently, when using surveillance cameras mounted on a small unmanned surveillance aircraft, may be subject to the Data Protection Act. As this act contains requirements concerning the collection, storage and use of such images, SUA operators should ensure that they are complying with any such applicable requirements or exemptions'.

Most users of low cost SUSA do not appreciate that they are potentially breaking the law by recording (HD 1080P) images using their DJI Phantom or Parrot Bebop. The newly announced ability to stream images directly to YouTube further compounds the problem.

The recent House of Lords report on 'Civilian Use of Drones in the EU' highlighted these issues, as well as the enormous benefits that could result from a potential new industry.[1]

Having set out the issues with free flying Drones, we can now focus on alternative solutions to the problem of persistent aerial surveillance applications, as listed here:

Large Event Security/Border Control/Industrial Complex Protection/Disaster Relief.

Port Security/Blue Light Ops/Environmental Sensing/Base Protection/News Agencies.

The ability to be able to conduct urban persistent stare on a target has long been sort after from both military and civilian security organisations. The use of commercial manned aircraft (whether military or civilian, fixed wing or rotary wing) are too expensive and too dangerous to operate within this complex environment.[2] The current options are therefore Helium balloons (aerostats), observation masts, free flying (multi-rotor) drones and helikites. Each solution has its drawbacks in terms of endurance, wind capability, safety, security, privacy, operating height, deployment time, payload and physical size (see Table 1).

A solution to many of these requirements is to use a Tethered Drone System which is connected to a ground control station (GCS) at all times (whether this is static or mobile).

The main benefit of this arrangement is that the Drone is powered from the ground using a generator set or battery pack, thus providing effectively indefinite endurance. The tether also provides a secure communications uplink/downlink.

Further advantages are the extremely fast deployment and redeployment times, the extended wind capability and the fact that the drone cannot escape (flyaway) unless the tether is cut (at which point the small backup battery would supply power to the system for recovery).

Table 1 – Comparison between aerial observation solutions.

Criteria	Tethered Drone	Free-Flying Drone	Aerostat	Helikite	Observation Mast
Endurance	*****	*	***	****	*****
Wind Capability	****	**	****	*****	*****
Safety	****	**	***	***	*****
Security	*****	*	*****	*****	*****
Privacy	***	*	****	****	**
Height (AGL)	****	**	*****	*****	*
Low cost	***	*****	*	***	**
Quick Deploy	*****	*****	*	**	****
Payload	***	*	*****	*****	*****
Physical Size	****	*****	*	**	***
Overall Score/50	**40**	**25**	**32**	**38**	**37**

Note: 1 star = Worse; 5 stars = Better.

Sky Sapience HoverMast

As can be seen above, each aerial observation solution has advantages and disadvantages. However, we can conclude that based on this analysis, all of the other alternatives are better than a free-flying drone. The tethered drone sits in a niche area, somewhere between the retractable observation mast (<32 m) and the typical aerostat (~300 m+).

One of the major strengths of a tethered drone is its ability to continuously operate in the main vertical area of interest for aerial surveillance, namely 50 to 100 m (150 to 300 ft) AGL, which is in line with UK CAA regulations.[3]

The author is aware of at least ten tethered drone systems worldwide, ranging from the 77 kg SICX-75T gasoline powered, single rotor (2.5 m) helicopter from Atlanta Instrumentation and Measurement LLC, to the 80 g Hexrotor (18 cm) from CyPhy Works.

The SICX-75T Helicopter

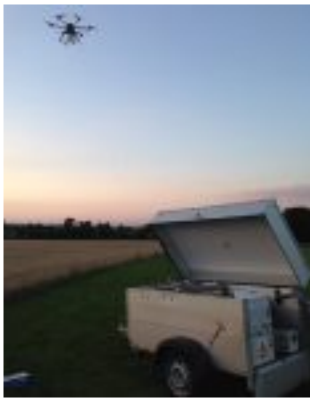
CyPhy Works Hexrotor

In between these extremes are several aerial systems ranging from 1-10 kg from Israel (IAI and Sky Sapience) as well as several more Quadrotors from the US (Hoverfly Technologies, Inc. and Drone Aviation Corp.). In Europe, we have the Rapace system in France (demonstration phase with the French Army) and the Cobra Quadrotor from Ermes Technologies (Eurolink Systems Group) (on trial with the Italian Army).

Tethered systems from around the globe

At the University of Southampton, we are working with our industrial partner Cardinal Security Ltd on a cost effective, sub 7 kg Tethered Drone System, which encompasses all of the above features in a compact, portable and flexible solution.

In developing the next generation tethered small multi-rotor UA capable of persistent surveillance; we hope to be able to convince governmental agencies, like the Civil Aviation Authority, as well as the average citizen, of the benefits, safety and security of such systems, when used appropriately.



AETHER Tethered Drone System

A recent US study has concluded that in the first three years of UA integration more than 70,000 jobs would be created in the United States with an economic impact of more than US$13.6bn. This benefit is projected to grow through 2025, with more than 100,000 jobs created and an economic impact of US$82bn.[4]

References:
1. House of Lords (2015), Civilian Use of Drones in the EU, 7th Report of Session 2014-15, European Union Committee, 5 March, London, The Stationary Office Ltd (HL Paper 122).

2. Mailey, C. (2013) Are UAS More Cost Effective Than Manned Flights? Available from: http://knowledge.auvsi.org/blogs/chris-mailey/2013/10/24/are-uas-more-cost-effective-than-manned-flights

3. CAA (2015) CAP722 Unmanned Aircraft System Operations in UK Airspace – Guidance, 6th Ed, 24 March. Available from: https://www.caa.co.uk/docs/33/CAP%20722%20Sixth%20Edition%20March%202015.pdf

4. AUVSI Economic Report (2013) The Economic Impact of Unmanned Aircraft Systems Integration in the United States, March. Available from: http://www.auvsi.org/econreport

UNIVERSITY OF Southampton

For further information please contact:
Dr Stephen D. Prior
The Faculty of Engineering and the Environment
University of Southampton
Email: s.d.prior@soton.ac.uk
http://blog.soton.ac.uk/robotics/