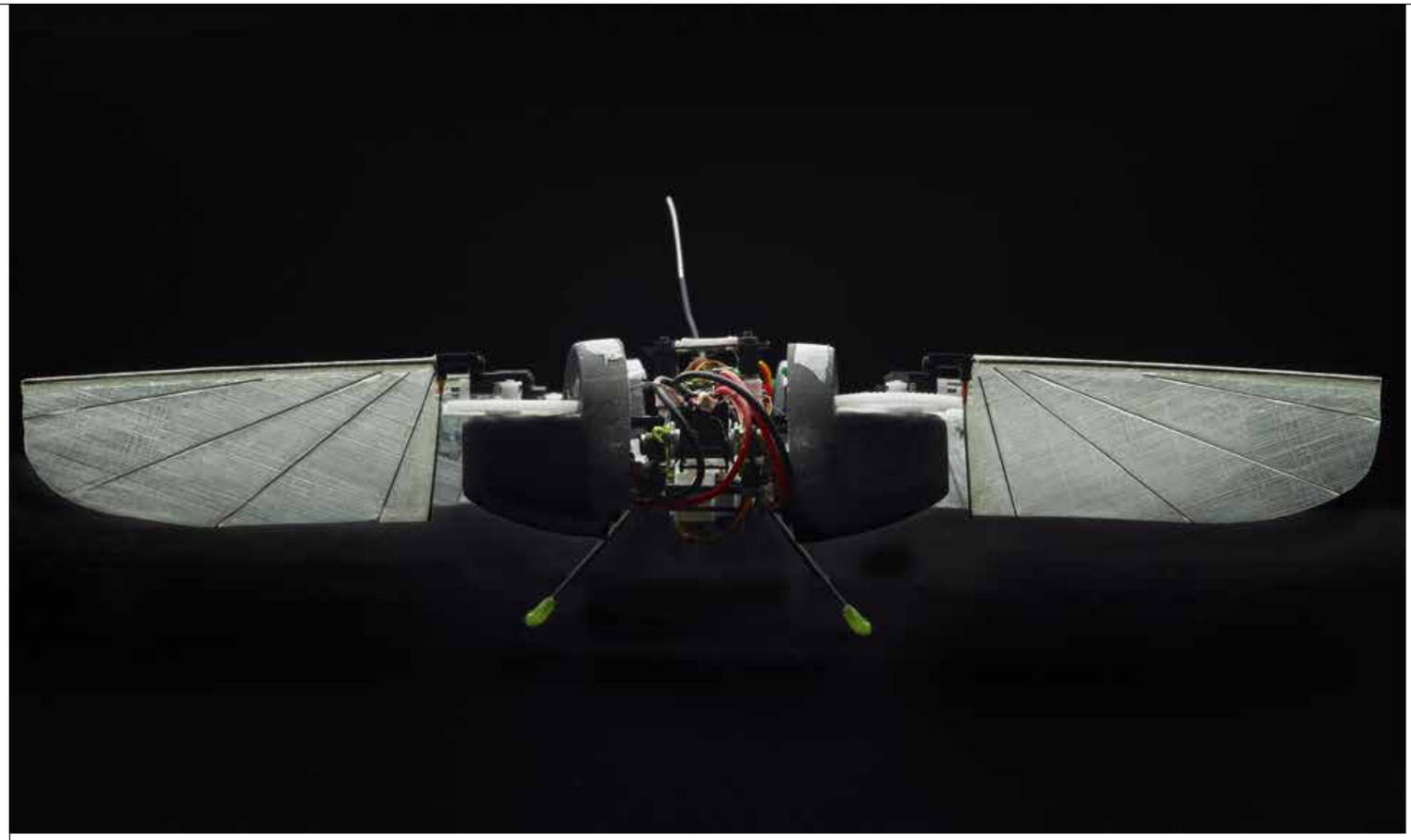

Picture credit: Animal Dynamics

DESIGN FOR LIFE

With a design, inspired by the flying abilities of a dragonfly, the Skeeter is suitable for short-range surveillance missions

Paul Topping *discusses the challenges of designing a system to assure delivery and protect human life in contested logistics environments*

The invasion of Ukraine by Russia has played out far more slowly than the Kremlin had assumed, now looking to become a prolonged conflict which could last for months or years. This has been characterised by the destruction of infrastructure around cities like Severodonetsk or the indiscriminate bombardment with multiple launch rocket systems (MLRS), cruise missiles and cluster munitions in Kharkhiv, Bucha, Irpin, Hostomel and Mariupol.

With this change in pace, comes a change in tactics towards a modern form of siege warfare in this instance, one that is fought over a vast landscape (over twice the size of the United Kingdom), with Russian forces hoping to wear down the will and ability to fight of Ukrainian soldiers and civilians. Though even this has proved a challenge: the siege of the Azovstal iron and steel works in Mariupol is just one example of the will of Ukrainian fighters to fight until the very end; surrender is simply not an option.

As we watch the crisis unfold and this new pattern of engagement play out, the famous words of Robert Hilliard Barrow that: "amateurs talk strategy; professionals talk logistics" has never been more relevant. In siege warfare, the ability to fight is limited by food, water, fuel, ammunition and medical supplies. The same supplies that Russian forces aim to cut off. It is therefore paramount to ensure that these supplies can be quickly and consistently delivered to front line troops and civilians, but traditional routes of resupply cannot be relied upon.

Fleets of trains, trucks and heavy lift helicopters (such as Chinooks) are either impossible or too risky to use, as they can quickly turn into moving targets creating a risk to human life. Their supporting infrastructures can be easily halted or destroyed. This has led many to suggest that a modern war needs modern supply routes.

When fought over vast landscapes these challenges can become compounded. With no traditional front line, small groups of agile soldiers and cost effective nimble systems are proving extremely effective against large expensive mechanised weapons, which used to be highly sought after.

A new era of warfare calls for new technologies to win. One such technology that is playing an increasingly integral part in international conflicts is Uncrewed Aircraft Systems (UASs), commonly known as drones. They can be used to spot enemy positions, perform aerial drops of key supplies in cut off locations and coordinate troops on the ground. Ukraine is today appealing for money to buy 200 military reconnaissance drones for these very reasons.

To guarantee success and protect human life during siege warfare, any suitable UAS or autonomous heavy lift drone must meet five essential criteria: payload versus range, infrastructure independence, ruggedness, cost and integration.

Payload versus range: A short-range UAS simply is not suitable for supply deliveries in a near-peer conflict. The long-range munitions being employed by Russia often have a range of around 200km, meaning that large targets like logistics bases must stay outside of this range. In this instance, a UAS being used to deliver supplies must be able to travel this 200km on a return journey (ie, have a 400km range), while carrying a large payload (eg, the minimum for squad resupply is around 135kg).

Infrastructure independence: Infrastructure has already been a regular target during Russia's invasion of Ukraine. A reliance on infrastructure by any UAS will limit its utility by restricting the locations from which it can be operated. Fixed-wing vehicles often suffer less than rotary wing systems in the payload-range trade off, but fixed-wing vehicles are also far more reliant on infrastructure. Where a rotary wing vehicle might be able to take-off from anywhere, a fixed-wing vehicle often needs a runway or at least a large, clear stretch of flat ground. Flexibility is key in a conflict where conditions change rapidly and where so little can be relied upon.

Ruggedness: An infrastructure-independent vehicle also needs to be rugged enough to tolerate the bumps and scrapes which that entails. Spares and repairs are unlikely to materialise in situations where even basic supplies are hard to come by. Moreover, a vehicle operating in an armed conflict is going to come under fire. If a rotary wing drone will fall out of the sky if a single blade is shattered by a bullet, and a fixed-wing system can no longer be controlled if a wing is punctured by a projectile, the chances of them reaching their destination with a critical payload is low. Deliveries by UAS need to be assured if they are going to play a role in supporting Ukraine, and UAS need to show extreme ruggedness to do that.

Cost: If a vehicle that costs tens or hundreds of thousands can be taken down with just a few cheap bullets, it is easy to decide whether to engage. If a vehicle can withstand the cheap methods of neutralisation, however, and needs a more expensive piece of ordnance to destroy the decision becomes more complex. Expensive and fragile UASs will cost less to destroy than their value; the cost/benefit ratio makes the choice easy. Cheaper and rugged UAS, however put the adversary in a lose-lose situation: they will cost far more to destroy than their value, but the UAS will complete its mission unless it is shot down. The operator always wins, and the adversary always loses.

HEAVY LIFT HELICOPTERS ARE AN EASY TARGET AND CAN QUICKLY TURN INTO MOVING TARGETS

Integration: "Until someone starts thinking about the E2E logistics problem rather than just the 'sexy' vehicle, it's not going to work" says Roger West, Logistics and Support Director at DE&S. The behind-the-scenes work which goes on to ensure that the right supplies are delivered to the right place using the right equipment is an essential but often forgotten effort by industry. A system might do everything it needs to do, but if it cannot be plugged into the tried and tested systems used by defence to provide assured logistics services, it simply cannot be used. If it can be integrated, it can be deployed seamlessly but precious few systems are. This is partly because of industry concerns around IP and partly because governments are understandably cautious about publicly releasing this software architecture. This situation needs to change though: "We need that [common interface] architecture to allow for industry applications to interface with our own systems. I think this specially about the interface to the vehicle systems."

A solution that meets the above requirements does not currently exist. In the Ukrainian conflict, military drones and off-the-shelf drones are being widely deployed, but none have been engineered from first principles. This involves analysing complex challenges down to their fundamental parts and following a scientific framework to find original, worthwhile solutions.

Take the helicopter as an example. Its principal design feature allows it to hover at slow speeds and take off or land without a runway – something that a fixed-wing airplane cannot manage. Helicopters changed the face of aviation and made a wider number of new aerial use cases possible – such as medical transport, military resupply, reconnaissance and search and rescue. But helicopters can very quickly become expensive flying targets for enemy troops – both Russia and Ukraine have already endured heavy helicopter losses, with the Russians believed to have lost more than 170.

Designing a system, like this, from first principals takes time and patience. In the aviation industry, there is a tendency to fall back on old designs that are proven to work safely and effectively, even if they are not fit for purpose. The cost of certification and long testing hours are often deemed too great.

For this reason, in an attempt to navigate this issue and solve logistical challenges on the ground, the classic helicopter design is being diluted into an array of different rotorcraft or hybrid vertical take-off and landing solutions. Complex machines are being repurposed for multiple use cases, smaller Intelligence Surveillance and Reconnaissance platforms are taking on higher payload delivery and drones have not routinely been used to support resupply attempts within Ukraine because solutions on the market do not fit the bill.

IN WARFARE IT IS VITAL THAT SUPPLIES CAN BE QUICKLY DELIVERED TO FRONT LINE TROOPS

At Animal Dynamics we recognise the immediate and ongoing need to design a system that can assure delivery and protect human life in contested logistics environments. This is a problem we have been thinking about deeply, since founding in 2015 and we are dedicated to addressing the immediate need for an UAS engineered from first principals. A robust and reliable system that is not powered by a multi rotor, one that provides heavy lift, extensive range and is able to fold down as small as possible after use.

We have a unique approach to engineering and strongly believe that nature has provided the ultimate rule book on how to move, communicate, and problem solve. It is intrinsically safe, efficient, robust and stealthy. Unlike human nature, it does not over engineer or over complicate. We closely study the clever tricks and subtle techniques that animals use to move, and apply them to our engineering processes. This bio-inspired approach has helped us to design a flapping wing micro drone that takes learnings from the expert flying abilities of a dragon fly and an underwater system inspired by the gliding motion of a manta ray.

We are today focussed on the commercialisation of Stork STM, an autonomous heavy-lift powered parafoil capable of carrying 135kg over 400km. It is the culmination of the bio-inspired learnings made to date, and it directly addresses each of the five criteria needed to qualify for military use. It is scheduled for flight testing, customer demos and trials from Q1 2023.

Our systems have been tested and validated in military theatre. Example clients include: The UK Ministry of Defence, the UK's Defence Science and Technology Laboratory (Dstl), as well as the Defence and Security Accelerator (DASA), and jHub Defence Innovation.

The military has been such a breeding ground for innovation over the years. The microwave, night vision in our cars, duct tape, canned food, the EpiPen and the internet are just some of the many everyday solutions that make our lives better today, that have their technological roots in the military.

We strongly believe that the UAS will be the next big technology to add to this list, with the market expected to reach $54.2 billion by 2027. It provides an effective and affordable solution to global logistical problems and can play a fundamental role in protecting human life. Despite all the technological advances that have been made, humans are still being put in dangerous environments across the globe, which often result in injury or death.

Agricultural aircraft operations have one of the worst accident records in aviation, killing on average more than nine pilots a year over the last five years in the US alone. Humanitarian aid workers suffered over 650 attacks worldwide between 2014 and 2017. Seventy-eight wildland firefighter fatalities caused by activities associated with aviation were identified in the US, from 2000 to 2013.

Conflict, climate issues, forced displacement and acute food insecurities are all combining to create a growing need for new systems that can assure delivery and protect human life in contested logistics environments.

Over the next ten years we can expect to see quantum leaps in understanding around how new technologies (IoT, AI, 5G, big data *etc*.) can unlock autonomy in the air, the infrastructures that will enable them, the regulations that will safeguard us and the drivers that will accelerate adoption and new use cases. We at Animal Dynamics will be at the forefront of this journey, taking humans out of harm's way where there is an immediate need to do so and we welcome you, dear reader, to be a part of our journey ●

Paul Topping is Business Development Director at Animal Dynamics

Fully autonomous, the RayDrive mimics the gliding motion of manta rays to carry out covert surveillance missions

Picture credit: Animal Dynamics