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Shaping the future of drones in UK cities

July 2018



**INDUSTRIAL
STRATEGY**

UK Research
and Innovation





This is a short summary of the findings of the Flying High project.
Read the full report online at flyinghighchallenge.org

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Foreword



Tris Dyson

We have a golden opportunity to shape the future of drones in the UK.

There is a moment in time where a new technology is in its infancy, where the opportunity exists to influence how it evolves and shapes our lives. A moment when we can choose for it to be largely beneficial and driven by the needs of those it will affect.

This is also a moment where a country can position itself to take the lead in its development and therefore in the economic benefits.

For drones that moment in time is now.

There are competing views of the future of drones in the UK. Utopian visions of smart cities, congestion solved, services streamlined. Dystopian visions

of surveillance, nuisance and noise. And for many, not much vision at all: an uncertain future, seldom thought of in any depth.

The Flying High project intends to help influence this future. The first step has been to better understand what drones' place in our skies might be, to find out what challenges lie in store, to assess the benefits to cities and the people who live in them, and to start a much-needed conversation to build a shared view of this future.

What should come next is a plan that takes the vision of cities, public services and citizens and frames them as challenges to be actively solved.

This is the future of drones in the UK

We can take control of the future and make drones work for the people

We have explored the current state and future ambitions for drones in urban environments in the UK from contrasting and complementary perspectives: technology, but also the policy, economic and societal impact. This is what we have found.

Drones bring benefits to UK cities: they are worth promoting

Our work on the place-based aspects of drones has been driven through our engagement with cities, and in particular informed by the five cities (London, Bradford, Preston, West Midlands, Southampton) with which we partnered. We find a considerable appetite for the use of drones in these

cities, with a particular focus on the perceived benefits of drone use in public services. We have delved into five of these uses in greater depth. We found significant variation between cities on their vision for drones, as well as the extent to which they have given serious considerations to drones.

Public confidence is key

The conversation has barely started on what drones should and should not do. Thanks to Flying High, cities are starting to think about this, but so far the general public has played very

little role. There is support for the use of drones for public benefit such as for the emergency services. In the first instance, the focus on drone development should be on these use cases.

There are technical and regulatory challenges to scale

We examined the wide array of tasks to which drones can be put. In partnership with the five Flying High cities, we selected five socially beneficial use cases in order to explore their technical, social and economic aspects. These are: medical delivery within London, medical delivery across the Solent, traffic incident response in the West Midlands, fire response in Bradford and construction and urban regeneration in Preston.

In complex environments, flight beyond the operator's visual line of sight, autonomy and precision flight are key, as is the development of an unmanned traffic management (UTM) system to safely manage airspace. In isolation these are close to being solved - but making these work at large scale in a complex urban environment is not.

While there is demand for all of the use cases we investigated, the economics of the different use cases vary: some bring clear cost savings; others bring broader social benefits. Some

would be economically feasible even at small scale while others only bring substantial benefits when operating at scale.

Alongside technological development, regulation needs to evolve to allow these use cases to operate. And infrastructure like communications networks and UTM systems will need to be built.

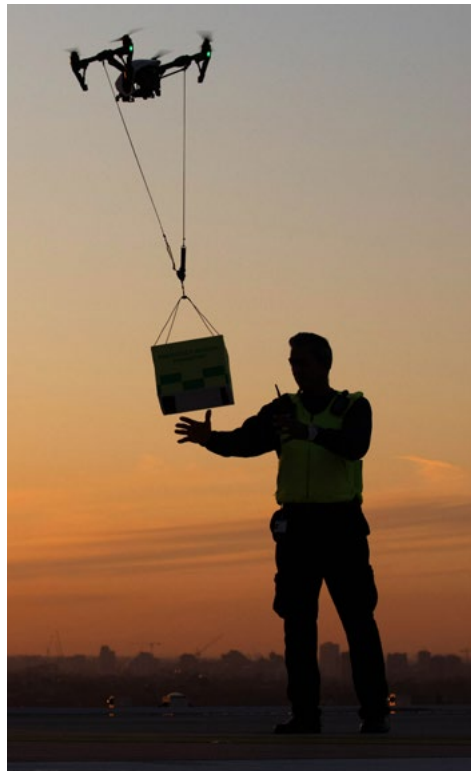


Photo: David Parry, PA Wire

A vision for the future

There is growing alignment between the key stakeholders - government, industry, regulators - on what the future of drones should look like in the UK. There is considerable evidence that the economic opportunity for the UK is substantial. But this is still a work in progress. Prior to the

Flying High project beginning, there was surprisingly little coordination between key players, and cities were largely absent from the discussion.

We need to keep up the momentum - and we urgently need to bring the public into discussions about the future of drones.

Get this right, and the UK stands to benefit

Through our industry mapping, engagement with national stakeholders and our work with the five Flying High cities, we have seen clear evidence that drones are an opportunity for

the UK. Hundreds of companies already operate in the sector and can benefit from new business. UK universities have research strengths in the area. There is public support for many (though not all) use cases. Public authorities can save money or provide new and better services thanks to drones.

We have also seen a threat: UK policy responses to drones are behind those of leading countries. The US, EU and Singapore in particular have taken bigger steps towards reforming regulations, creating testbeds and supporting businesses with innovative ideas.



Photo: John Mills, UCLan

So what needs to happen?

The key recommendation of this report is to organise major challenge prizes related to the five use cases that we have investigated. This process would drive innovation in the key technical barriers to drone development, while forming the core of a continued programme of public and political engagement. Brought together, this can unlock the opportunity for the UK.

In addition to the challenge prizes, we recommend that regulation be updated to reflect advances in drone technology, particularly around management of urban airspace; and investment in the infrastructure that drones will need if they are ever to operate at large scale.



Photo: Jason Andrews

Mapping the UK drone sector

Strong foundations exist in the UK

Drones are an emerging technology and much of their promise lies in the future. But there is already a significant drone economy in the UK today. Much of the future economic opportunity for the UK will come from these companies and institutions.

Analysis carried out as part of the Flying High project by Nesta, PwC and Glass has identified and mapped over 600 firms that sell drone services or technology and have a presence on the web, as well as mapping all the publicly-funded drone research projects in the UK.

An interactive version of this map can be viewed at flyinghighchallenge.org

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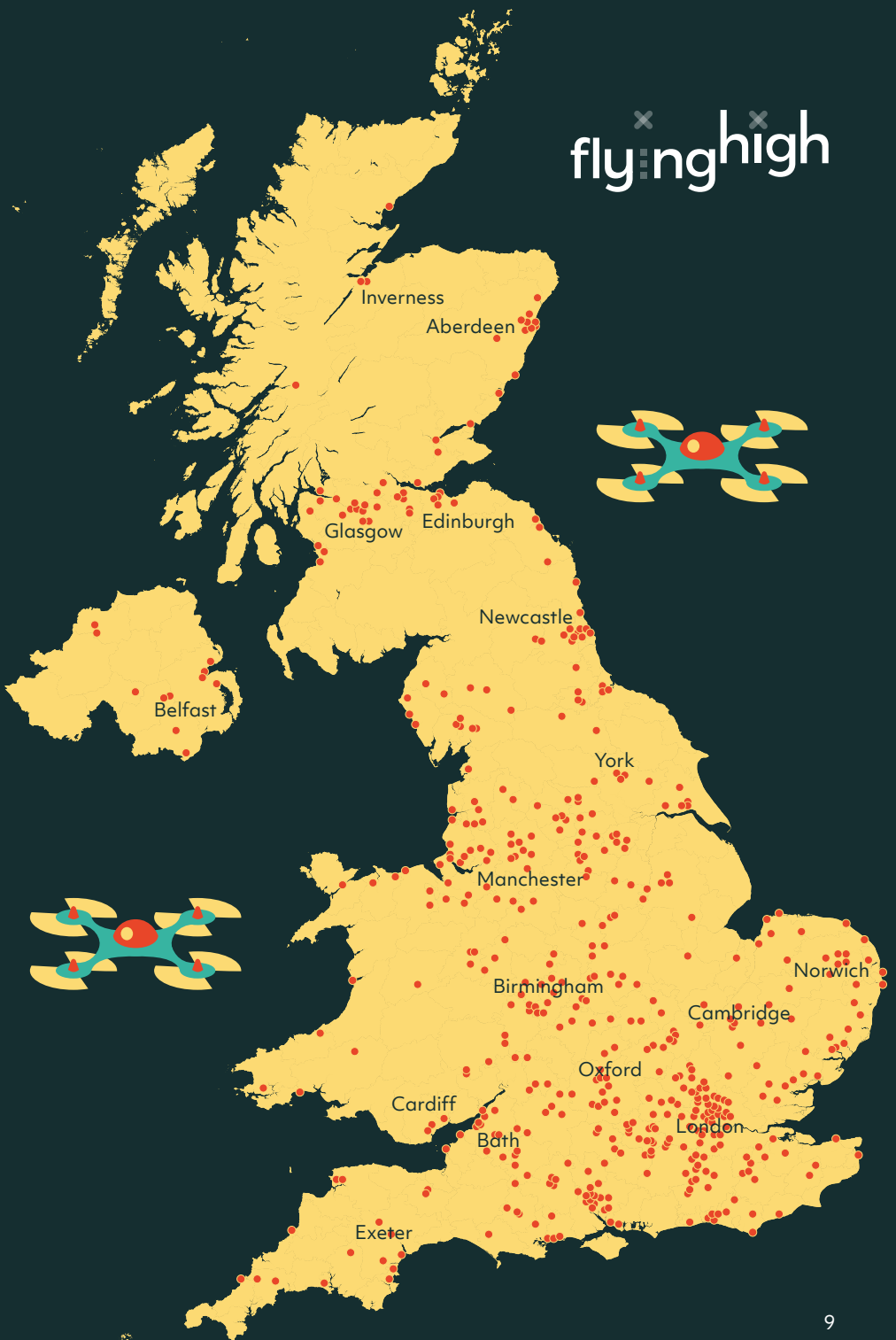


Photo: Jason Andrews



Photo: Jason Andrews

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About the Flying High project

Flying High has brought together cities, public services, industry, citizens and national government to develop drone frameworks for five UK cities. This has included the development of technical and economic use cases.

The programme was structured around several assumptions:

- While drone technology has made significant progress, projects to date have been largely focused on tech push, rather than demand pull; and on individual drones operating in isolation rather than drone systems operating at scale.
- Proving the viability of drones in the UK requires showing that there are useful, economically viable and technically feasible uses for them.
- Technical and economic feasibility are necessary but not sufficient: public acceptance is essential too.
- Key stakeholders such as regulators and business need to be in broad alignment.
- There needs to be a broadly shared vision for how drones will operate: what the rules, regulations and systems will look like in the future.

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To this end, this phase of Flying High featured a number of workstreams:

- **City engagement:** working with five UK cities (Bradford, London, Preston, Southampton, and the West Midlands region) to understand their vision for drones.
- **Technical feasibility:** looking into the technical details of five socially useful use cases identified by the cities (medical delivery, fire services, connectivity across the Solent, traffic incident response, construction and urban regeneration).
- **Economic and social feasibility:** modelling the viability of those five use cases.
- **Key stakeholder engagement:** building alignment between industry and government bodies.
- **Industry and research mapping:** identifying and mapping the UK drone economy.
- **Systems research:** drawing out how drones might operate at scale.
- **Public impact analysis:** assessing what needs to happen next if drone policy is to be successful.



What do cities want from drones?

Drones can carry out useful tasks in cities. They can serve as eyes in the sky to look at things and report back to people on the ground, telling us quickly if a bridge is crumbling, a fire is spreading or a person needs help. They can supplement our transport systems by moving things around or getting someone somewhere quickly. Drones can also be robots on wings, performing tasks like repairing that crumbling bridge or putting out that fire.

Our work with cities in the UK to evaluate these opportunities comes at the intersection of several major urban trends. First, in the UK and in other places, cities are taking on more leadership and responsibility than ever since the rise of the nation state. Second, cities have access to an array of technologies that help them make smarter decisions and serve the public more efficiently.

But cities are pragmatic. Every day, they are faced with making choices about how to spend (limited) money, how to best serve citizens' needs and how to solve mundane but important problems while making plans for the future.

Flying High reflects these trends. Cities are excited about the possibilities that drones can bring. But cities are wary of tech-led buzz that can gloss over concerns of privacy, safety and nuisance. Cities want to seize the opportunity behind drones but do it in a way that responds to what their citizens demand.



Photo: John Mills, UCLan



London

London is a rapidly growing city with the UK's most complex airspace, offering an opportunity to define appropriate urban drone use, enhance public services and improve the lives of Londoners.

As a leader in innovation, if London can appropriately shape the use of its airspace and deployment of drones within it, it could offer tangible benefits to the city and its residents and in turn influence urban drone use all over the world. Any future drone activity in London should be focused on high-need uses and societal benefit, prioritising applications that use the unique capabilities of drones, benefit Londoners and support broader London policy and objectives.

Above all else, drones should support London's emergency and essential services, and seek to enhance quality of life, limit environmental impact, ensure safety and support good growth. Decisions on London's airspace should be shaped by Londoners, in concert with national stakeholders. A principle-led, adaptive approach should be taken to policy, recognising that decisions made today could define London's airspace for generations.



The West Midlands

The West Midlands region is eager to drive regional connectivity and economic growth by integrating drone technology into the transport innovation landscape.

A pioneer in the launch of the metro mayor concept and move towards devolution of power from Westminster, the West Midlands seeks to develop local leadership to shape the future of urban drone operations. Smart mobility is the glue behind its transport strategy, and drones offer an opportunity to create opportunities for enterprise and add value to the region's

mobility offerings. Enabling the wider adoption of drones for infrastructure and development support, freight and logistics operations and blue light services sync with the region's needs, but implementation should meet the region's guidance for innovative transport technologies and locals' best interests.



Preston

Preston aspires to embrace the technological opportunities presented by the emerging drone economy to create and retain wealth locally.

Preston prides itself on its community wealth-building approach to enable economic inclusion and growth. The city is eager to use this model to guide the usage of drones, focusing on opportunities to aid in the

regeneration and improvement of the city and its services while growing local businesses and skills. But decisions around future drone use need to be shaped by public input and complement the city's unique character.



Bradford

Bradford has pressing needs which drones can help fulfill but their use must focus on improving public services and creating social benefit.

Innovation and skills are a key part of Bradford's vision for its future and drone technology can contribute to and leverage Bradford's wider local landscape of digital innovation to improve city management, job creation and upskilling. As drone technology enables services such as emergency response, public safety, asset inspection

and city planning to become more automated, cost-efficient and safer, Bradford can reap the benefits of better service delivery at lower cost. However, deployment of drone technology in the city should be inclusive across the community, preserve civil liberties and individual privacy, and be open and transparent.



Photo: Jason Andrews

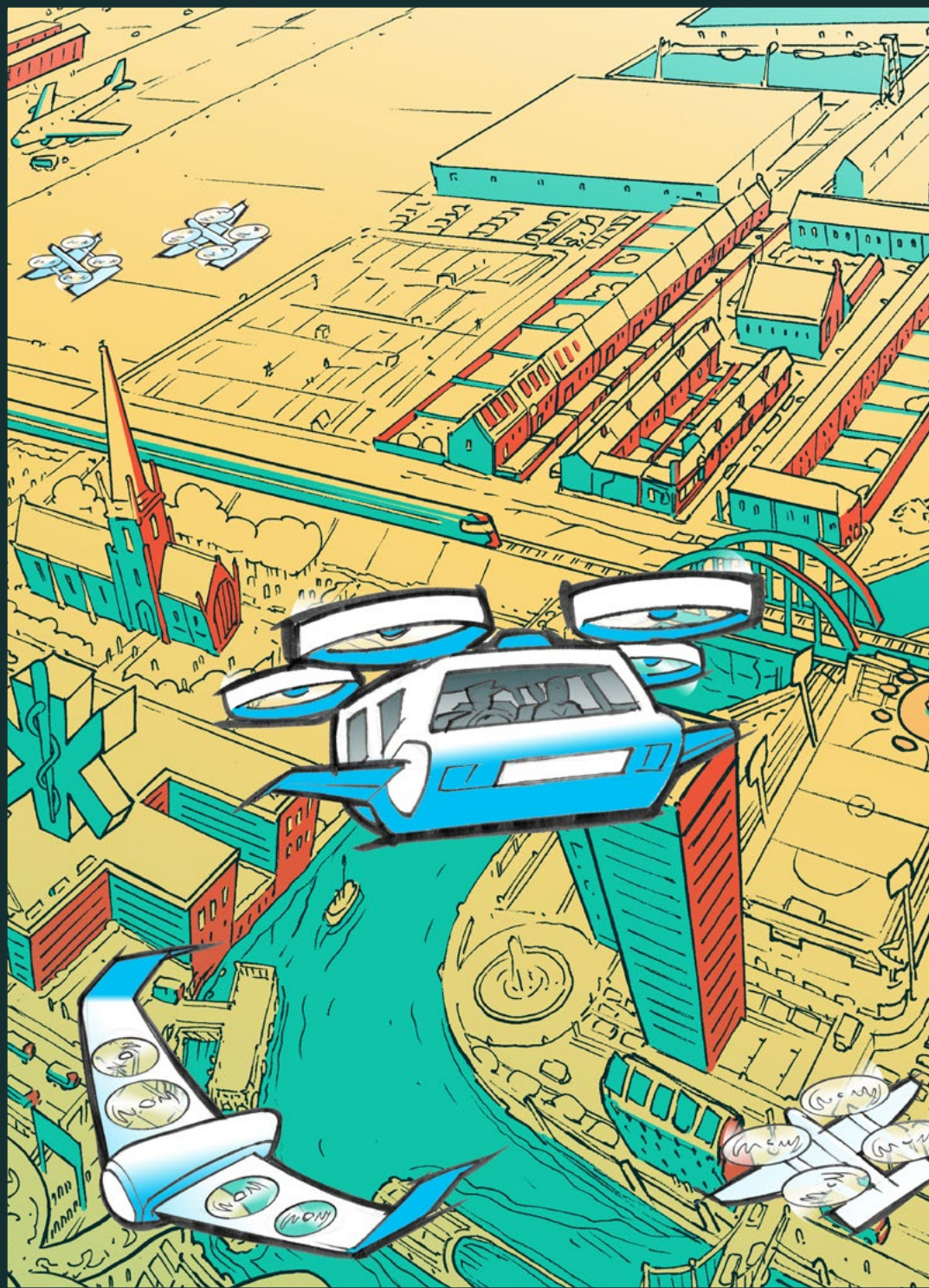


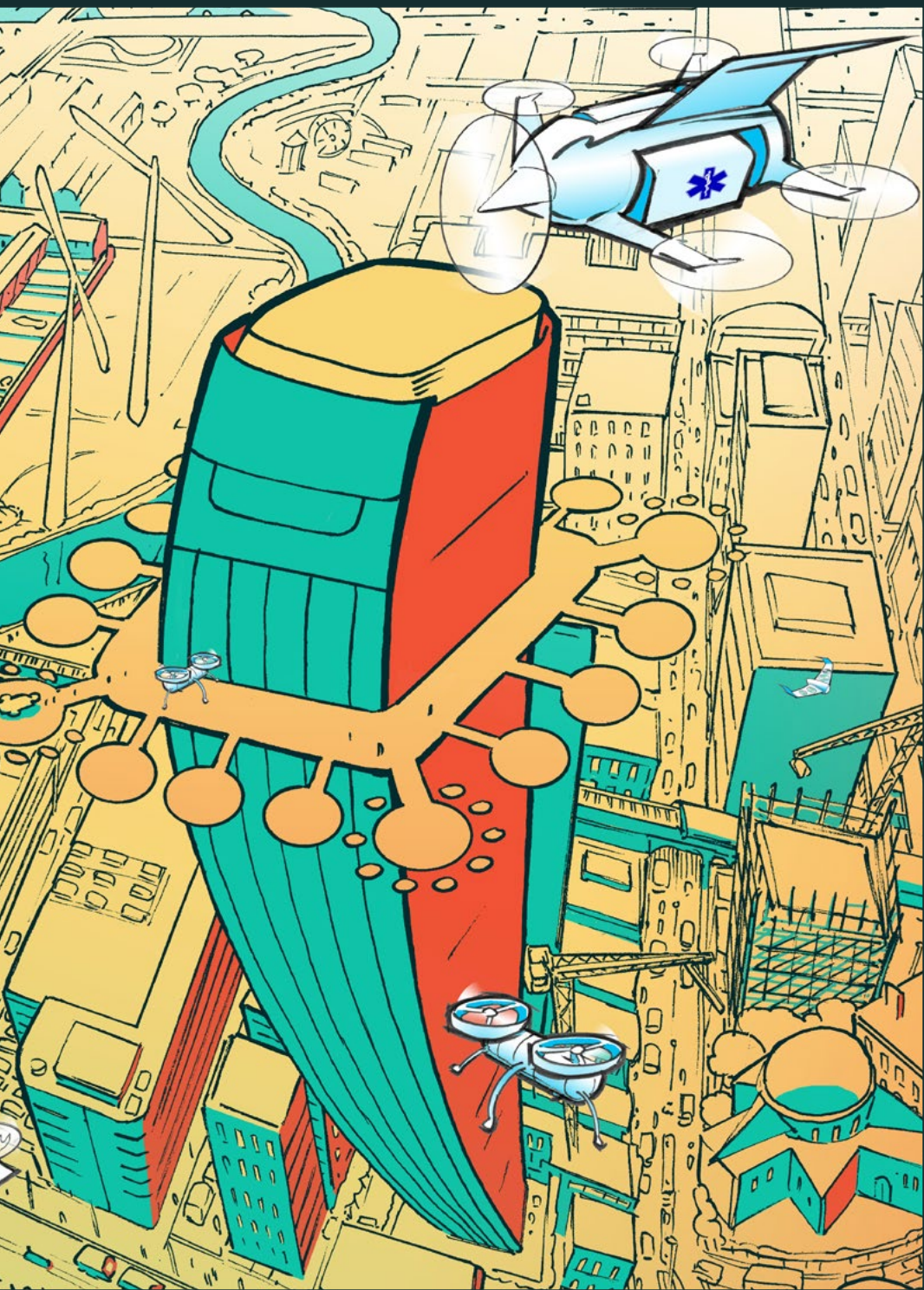
Southampton

Southampton aims to position itself as a hub for the UK drone industry.

Drone technology could play an important part in modern transport systems in Southampton and an even bigger role in growing Southampton's economy, drawing on existing industry strengths and research institutions to train workers, grow new businesses and exercise thought leadership

around integrated smart city approaches, including the development of the UK's first unmanned traffic management system to enable complex drone usage. Yet drone applications need to add value, rather than duplicate services and mitigate any negative impacts to the natural or built environment.





What systems need to be in place?

Urban areas present particular challenges for aviation: the dense and complex environment presents unique problems and risks. With a few exceptions, flying at very low altitude in cities is prohibited, and drone use is not allowed without permission from the Civil Aviation Authority (CAA).

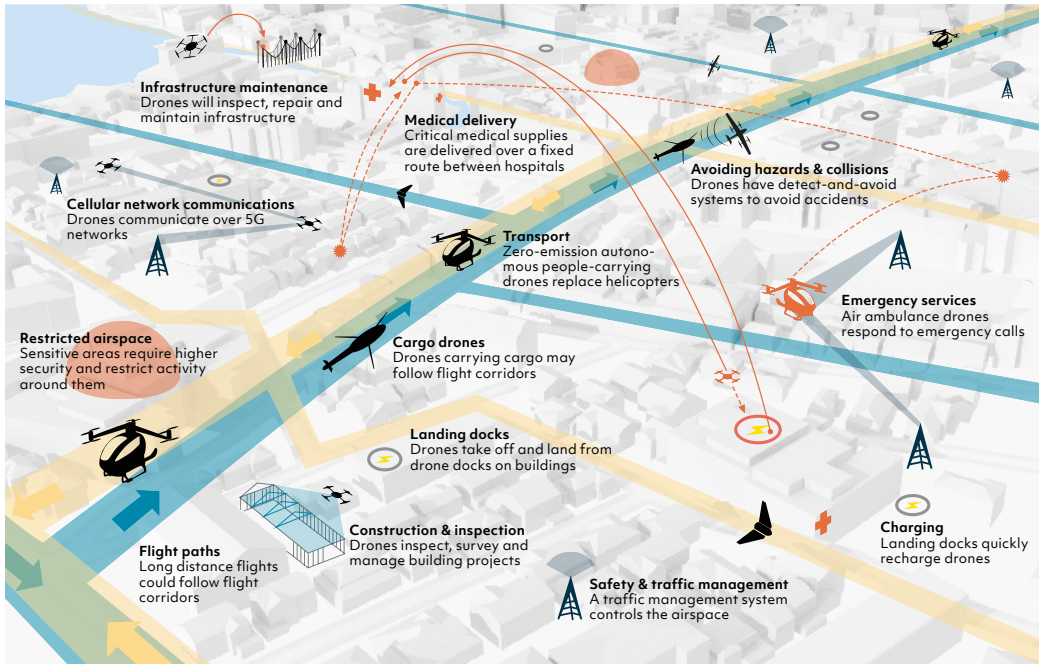
In the future we could see much greater use of this low altitude airspace - but only if systems are put in place to manage the aerial traffic in a way that guarantees safety, security and privacy. It can't just be an extension of today's 'rules of the air' - where safety relies on seeing the aircraft and talking to the pilot.

Drones flying automatically and beyond the visual line of sight of the mission controller need a completely new approach. That means new rules - but also new services to manage traffic, prevent accidents and stop misuse. This will have to take into account drones of different weights, sensors and levels of

autonomy.

A drone traffic management system will include solutions for tracking and identifying drones, automatically granting flight permission, and de-conflicting traffic. A large number of UTM systems are already under development globally. The UTM is likely to be a system of systems, with different services for different types of use case and user. The direction of travel is also to integrate drones into the same airspace as traditional aircraft, which also means drones need a way of interfacing with air traffic control.

Many of the providers are private sector entities, but



oversight of this system will need to be from a government or government-approved body and cities should have a major role.

Large scale low-altitude drone operations could have a significant impact on a city and its residents, so decisions need to be shaped at the local level, with citizens fully involved in the process.

This could result in a new governance framework for aerospace, with cities operating

or procuring UTM services and having a 'skyways' department, much like councils current have a highways department.

And while the overall rules of the urban air will still be set nationally, as technology develops to allow greater use of drones, cities must be involved in decisions around routing or flight paths, the presence of take off and landing and charging infrastructure, designated drone-free zones and operational hours.

Medical delivery in London

A drone delivery network for carrying urgent medical products between NHS facilities, which would routinely carry products such as pathology samples, blood products and equipment over relatively short distances between hospitals in a network.

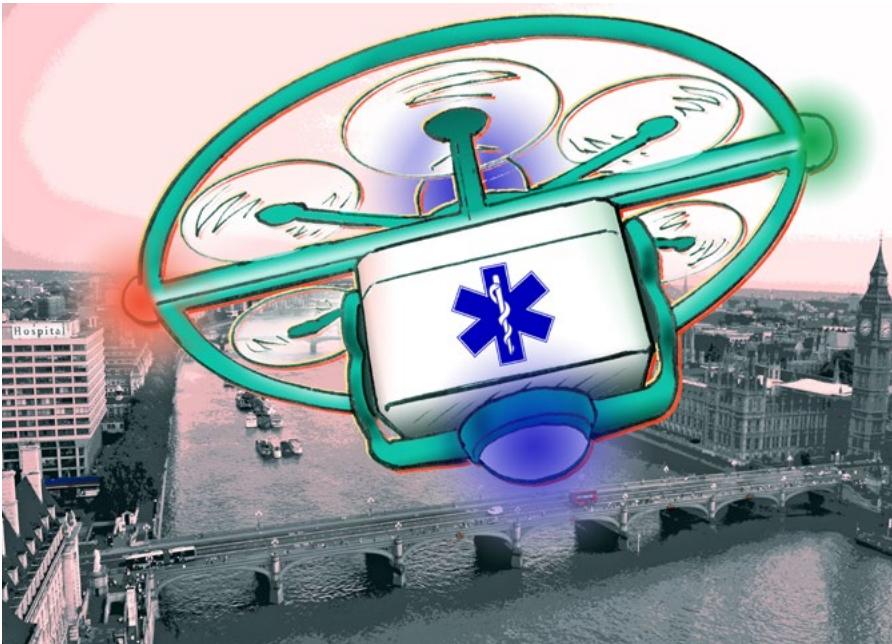


Illustration: ILVA. Background image based on a photo by Tom Arthur, CC BY-SA 2.0

London has 34 hospitals in relatively close proximity. Deliveries between hospitals are

frequent, and in many cases, time sensitive, but traffic and the lack of major roads restricts this.

The key benefits to drone medical deliveries in London would be:

- Saving time by flying over the congested streets.
- Saving money (if the service operates at large scale).
- Making medical logistics more efficient by enabling deliveries which are not currently feasible.
- Providing quicker test results to patients.
- Reducing traffic on London's roads.

In order to better understand the feasibility of this use case, we have focused specifically on one possible connection in this network: the movement of pathology samples for post-kidney transplant monitoring between Guy's and St Thomas' hospitals in South London. This aligns with NHS plans to consolidate pathology testing into networks of multiple hospitals.

There are some technical challenges that need to be solved, owing to the complex environment. Safe operation in a heavily built-up area with complex and restricted airspace would require extensive testing. It would also require more sophisticated communications systems than are presently in place, along with ways of better

managing shared airspace, in particular helicopters which operate along the Thames.

To be feasible, regulations around operation in built-up areas, under heli-routes and over the Thames would need to either be relaxed, or a specific exemption for these operations would need to be granted.

The drone connection between Guy's and St Thomas' should be seen as a pilot or proof of concept. The economic benefits of this use case would only manifest themselves as part of a broader network carrying a wide range of medical deliveries in a broader network of hospitals.

However there are no insurmountable barriers to this use case being feasible.

Traffic incident response in the West Midlands

Responding to traffic incidents in the West Midlands, to support the emergency services.

The key benefits would be:

- Situational awareness for emergency services prior to their arrival and while they are on-site, allowing them to allocate the right resources and respond more effectively.
- Time saving for emergency services in reopening roads, saving money.
- Reduced congestion.

In order to better understand the feasibility of this use case, we have focused specifically on response within a 7-mile radius of Birmingham International Airport, an area which covers several major roads including the M6, M42 and M40, parts of both the Birmingham and Coventry urban areas and rural areas in between. We have modelled a service which would use two fast fixed-wing VTOL drones:

an initial response drone with a high-powered zoom lens to get the quickest possible images of the site; followed by a drone carrying high-resolution video and Lidar.

There are some technical challenges that need to be solved, primarily around safe operation and endurance. The location of Birmingham International Airport is in the

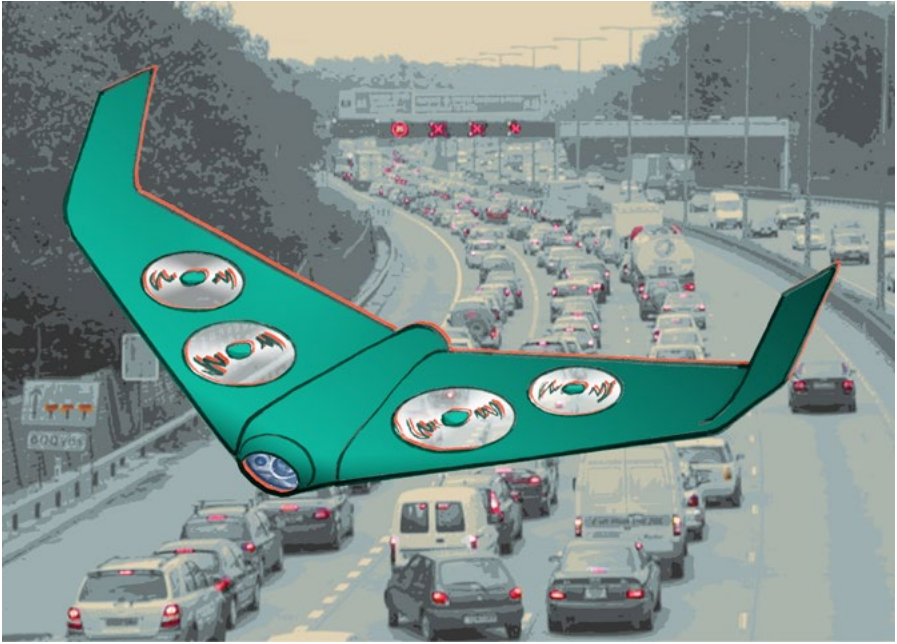


Illustration: ILYA. Background image based on a photo by Ben Gamble, CC BY-SA 2.0

middle of this zone, which also covers built-up areas. The drones would not be restricted to fixed routes, so they would need to be able to operate safely throughout the area, with as few restrictions as possible. This would require sophisticated and reliable communications networks and a sophisticated airspace management system to safely combine drone traffic and its other air users, particularly around the airport. The long duration of incidents would require good endurance.

Operating in restricted airspace around the airport and a number of other sensitive sites would require either an exemption from current rules, special permission or a change in regulation.

Our economic analysis suggests that this use case would bring significant benefits, with reductions in traffic disruption being the main contributor: even the small-scale pilot outlined here would bring around £2.4m in social benefit over 12 years.

Construction and regeneration in Preston

Drone services supporting construction work for urban projects in Preston. This would involve routine use of drones prior to and during construction, in order to survey sites and gather real-time information on the progress of works.

The key benefits to drones for construction and urban regeneration in Preston would be:

- Increased efficiency in construction site management.
- Reduced waste.
- Speedier recovery from incidents.
- Reduced risk of injury for workers.
- Better environmental management.

In order to better understand the feasibility of this use case, we have focused specifically on a major forthcoming construction project in Preston that could be a test case for this use of drones. This is the M55 link road project, where a major new road will be built starting in 2019.

We have explored the use of a drone with cameras, thermal imaging and Lidar to support the construction work there. A drone launched from the construction site would fly in a regular pattern over the construction site in order to gather information on important

topics such as the progress of work, location of materials and staff and any safety issues that might be arising.

Of the use cases we have looked into, this is the closest to being realised already: drones are already widely used in building projects. However to be used routinely and as regularly and intensively as we anticipate, the technology needs advances in communications, airspace management and, most of all, autonomous flight - and restricted airspace near the

site would currently be very challenging to operate in.

Our economic analysis concludes that the use of drones in a construction project such as the M55 link road is highly economically beneficial: we project productivity gains of £15.7m over the duration of the project.

Use of drones for this purpose is therefore already feasible, with technological advances enabling wider and more efficient use in future.



Illustration: ILYA.

Supporting the fire and rescue service in Bradford

Emergency response drones for West Yorkshire Fire and Rescue service. Drones would provide high-quality information to support mission planners and controllers to direct resources when the alarm has been raised, arriving on the scene faster than is currently possible and helping staff plan an appropriate response for the seriousness of the incident.

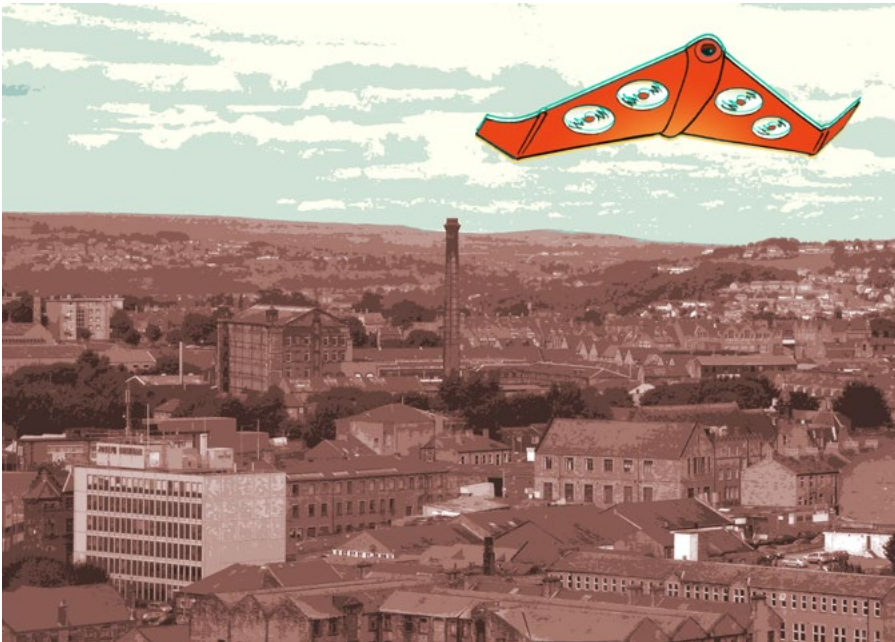


Illustration: ILVA. Background image based on a photo by Tim Green, CC BY-SA 2.0

Drones would provide real-time information to firefighters working at the site of an incident, giving early warning of

structural problems, identifying hotspots or individuals in need of help. They could also help map out high-risk sites.

The key benefits to drones for fire and rescue in Bradford would be:

- Time savings, in particular around avoiding staff time being spent on false alarms.
- Cost savings, by avoiding the need for helicopters and by reducing resources spent unnecessarily on false alarms or small fires.
- Improved safety for firefighters and for members of the public caught up in fires.

In order to better understand the feasibility of this use case, we have focused on how a drone service centred on Bradford Fire Station. As with the West Midlands, we've looked into a two-drone service that gets rapid eyes on the scene, followed by high-resolution imagery.

The technology required for this use case is very similar to our proposed traffic incident response service in the West Midlands, and hence the challenges are similar. Safe operation across a whole city is critical and needs communications and traffic management infrastructure

that is not currently in place; particularly if operating in the half of the city which is within Leeds-Bradford Airport's controlled airspace.

To be feasible, regulations around operation in built-up areas would need to either be relaxed, or a specific exemption for these operations would need to be granted.

Our economic analysis suggests that such a service would be highly feasible: the cost savings it brings about for the fire and rescue service would pay for themselves within four years and deliver a net cost saving thereafter.

Southampton-Isle of Wight medical delivery

Linking Southampton across the Solent to the Isle of Wight using a delivery drone.

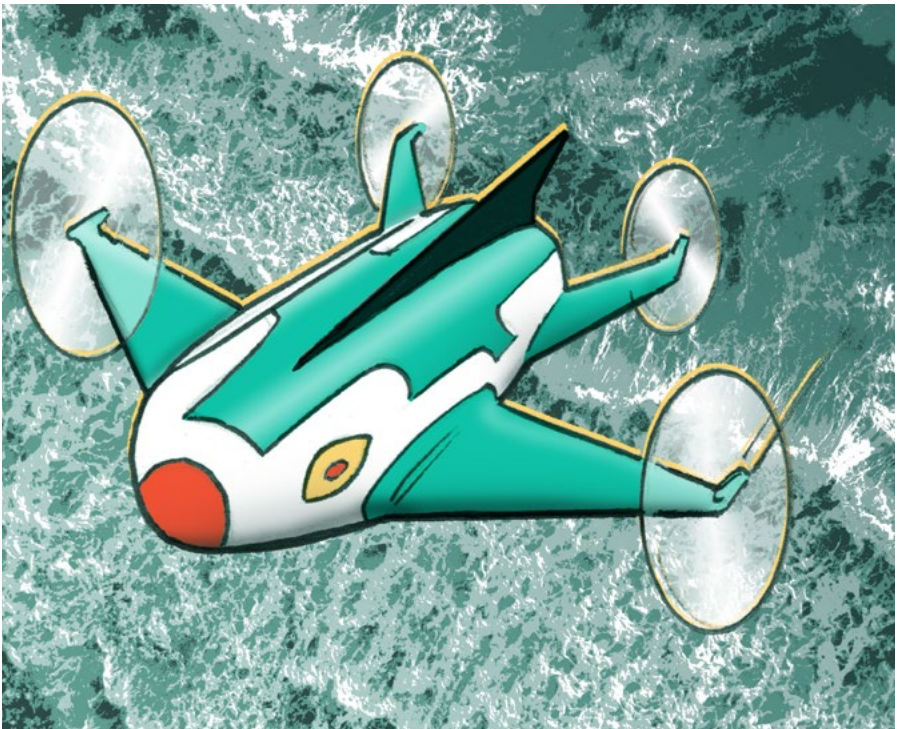


Illustration: ILYA.

The Isle of Wight is the UK's second most populous area (after Northern Ireland) not to have a fixed link to mainland Great Britain. The Solent is a barrier to people and goods, with relatively slow and expensive ferries providing the main connectivity. Similar

drones could also serve other isolated centres of population such as the Scottish islands.

Drones could carry light payloads of up to a few kilos over distances of around 20 miles, with medical deliveries of products being a key benefit.

The key benefits to drones for carrying medical products to the Isle of Wight would be:

- Saving time by avoiding the slow ferry service and roads.
- Saving money.
- Making medical logistics more efficient by enabling deliveries which are not currently feasible.
- Providing medical products and tests to patients more quickly.

In order to better understand the feasibility of this use case, we have focused on carrying blood products from Southampton General Hospital to St Mary's Hospital on the Isle of Wight, as well as Portsmouth and Bournemouth, for ad-hoc short notice deliveries and occasional emergency shipments. A fixed-wing VTOL drone would carry blood in batches of up to 10 units between the two hospitals.

Drones already exist which can carry payloads of this size over comparable distances, but there are challenges around the drone flying beyond the operator's line of sight, and around allocation of airspace in restricted areas such as near Southampton Airport. A system to manage airspace and share it between drones and other air traffic would be required for this to operate safely, as would robust communications infrastructure.

What's next?

Challenge prizes have been used to kick start transatlantic flight, driverless cars and private spacecraft.

The same approach can put the UK ahead on drones, with challenge prizes structured around these five use cases breaking down the

technological barriers ahead and involving the public in making decisions about the future.

Challenge prizes reward the first or best organisation to solve a technical challenge. They:

- **Create better solutions to technical problems.**
Prizes incentivise new thinking and reward the best solutions, wherever they come from, however they work.
- **Bring together innovators and help them thrive.**

Prizes help innovators by providing access to information, ideas, profile-raising opportunities, investment and expertise.

- **Unlock systemic change.**
Prizes raise awareness, inform policy and shape the future of markets and technologies.

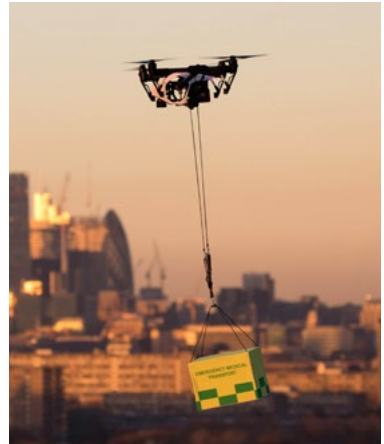


Photo: David Parry, PA Wire



Photo: Jason Andrews

We propose to:

- Work with city-led consortia to run a series of challenge prizes based around these use cases.
- Invite industry to compete in these prizes to develop drone platforms that meet these needs, and solve the key technical and infrastructural challenges that lie in their path.
- Collaborate with regulators to create opportunities to evolve and adapt regulations to enable demonstrations and testing.
- Invite competitors to develop, test and demonstrate their solutions in testbeds: first in virtual environments, then in testing facilities, and finally in real urban environments.
- Use these testbeds both as an opportunity to prove the technology, and in order to meaningfully engage with the public and involve them in decision-making about the future of drones.
- Use the challenge process to complement the building of further alignment between stakeholders and to inform the development of policy in the field.

We think this is the most open and democratic way of moving drone technology forward. Rather than the closed and secretive pushing of technology that can so easily lead to growing

public mistrust, we seek to create opportunities for technologists, business and the public to develop products and services that bring real value to our cities.

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