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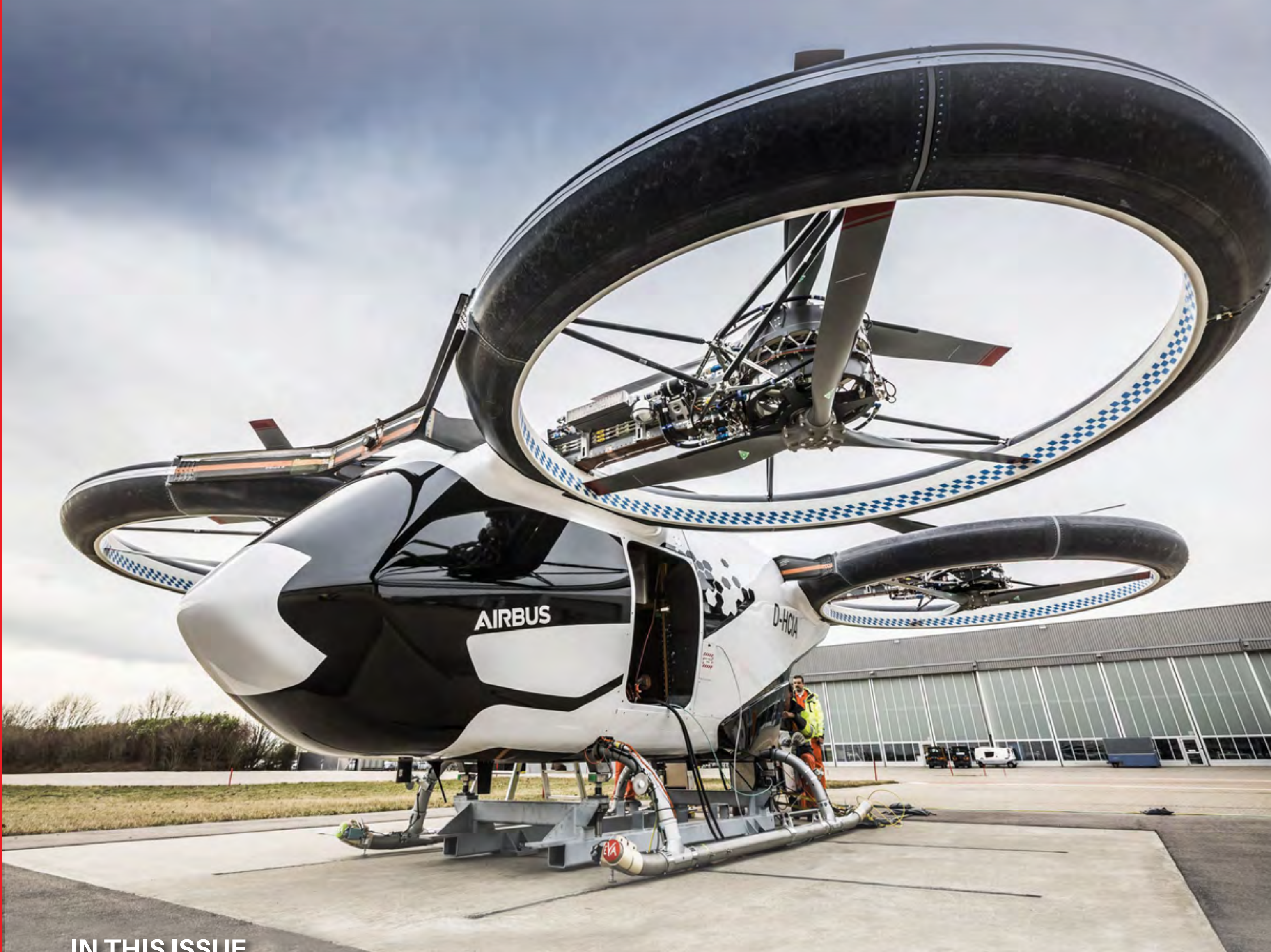

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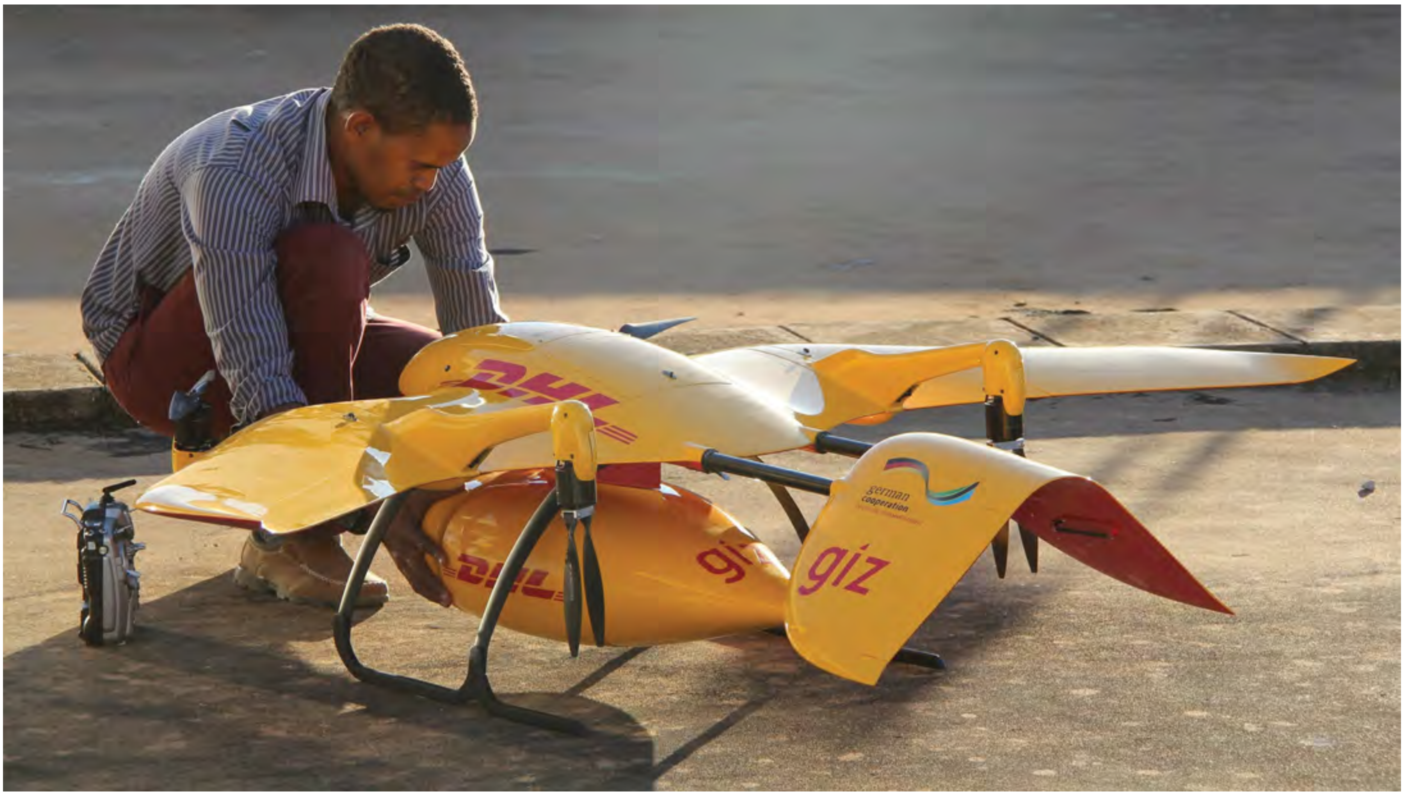
THE ADVENT OF UNMANNED COMMERCE

By Bennie Broughton and Andre P. Meredith



The recent Coronavirus epidemic has, in no uncertain terms, created a new world. From lockdowns to social distancing, the world has had to adapt to the "new normal" towards preservation of life, whilst innovating to ensure that essential services remain operative. In order to survive, many businesses have moved from person-to-person contact to electronic commerce, including online collaboration (video conferencing) and point-to-point delivery.

The aviation sector was undoubtedly also hard-hit by the pandemic, as airlines and charters grounded their fleets, and authorities banned general aviation from operating. During the most stringent lockdown levels, all passenger flights were halted, and along with it, all co-sharing of airborne freight; only dedicated airborne freighters continued to operate to some extent, drastically impacting delivery schedules leading to any activities linked to such services being delayed.

These events may cause the industry to question the future of co-shared freight deliveries and other manned freight services, which is now paving the way for unmanned commercial airborne cargo services. Although the pandemic has had its fair share of negative effects, it may have created new awareness of the importance of dedicated airborne, terrestrial and maritime cargo services. Such services could prove invaluable, even long after the pandemic is over and forgotten, and may spearhead new technologies to enable sustained cargo deliveries to remote, rugged, unreachable or dangerous regions.

WHERE ARE WE HEADED

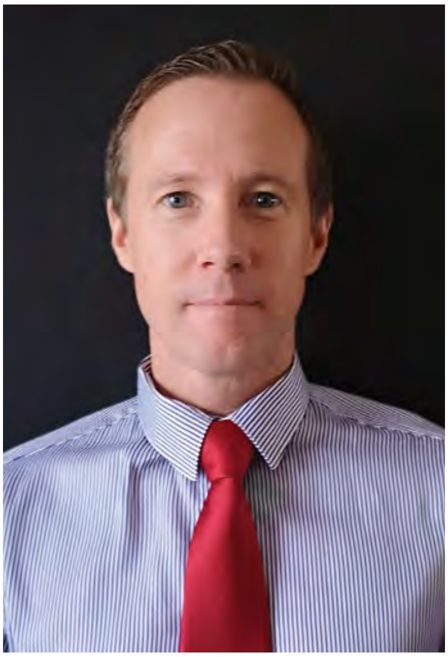
Due to the incredible pace at which unmanned aircraft and their associated technologies are progressing, one can easily imagine a not-too-distant future where unmanned aviation makes up a large proportion, potentially even the majority, of the aviation industry. The impact to date is already apparent: aerial surveys that previously were conducted with expensive-to-operate manned helicopters or fixed-wing aircraft are more-and-more being performed using commercial drones. Precision agriculture, where crops are sprayed using large multirotor drones, are becoming more prevalent. In some countries, drones are now used to regularly transport medical supplies and samples between hubs and isolated areas. Delivery of food, medicines and post are slowly migrating from isolated, once-off experiments to regular, sustainable commercial operations.

However, in contrast to the military domain, most commercial drone operations today are only initial permutations of steady-state operations, essentially building blocks towards large-scale adoption of unmanned technology. This does not imply that the supporting technologies underscoring such operations are absent. A world where virtually all large cargo aircraft fly around the world without pilots; where every isolated village has a regular unmanned postal delivery service; where outlying regions receive their medicines and groceries via drones; where the precision application of pesticides over large farms is all automated using drones; and where many dangerous air operations, such as aerial firefighting, have gone unmanned thereby removing the risk to aircrews - such operations appear to be well within the realm of possibility – and it does not necessarily require undiscovered technology to achieve, either.

EXAMPLES OF CURRENT DEVELOPMENTS

Although widespread adoption as sketched above is still some way off, a number of projects are currently underway utilising unmanned technologies aimed at revolutionising the aviation world. The following is a small selection of the many illustrative examples:

- **Airbus Autonomous Flight Projects:** When it comes to serious players in the aerospace industry, it doesn't get much bigger or more serious than one of the two principle manufacturers of large passenger aircraft. Airbus is currently conducting a series of autonomous flight projects. Although these are generally aimed at reducing operating costs of airlines and improving flight safety, at this point still retaining crews in the cockpit, their long-term vision towards fully autonomous aircraft is obvious. For example, their Autonomous Taxi, Take-Off & Landing (ATTOL) project, which was launched in 2018, demonstrated a series of fully automatic vision-based take-offs in January 2020 with a modified A350 aircraft. This technology is significant in that it does not utilise any ground aids, but rather on-board image recognition technology, similar to how a human pilot would fly the aircraft in visual flight conditions. That milestone was soon followed in June 2020 by a fully automated taxi and landing, thereby demonstrating, along with existing autopilot systems, the capability to perform an entire flight without pilot intervention. In fact, as stated by the Airbus Chief Technology Officer, Grazia Vittadini, "The biggest difficulty in this was convincing pilots to not do anything and keep their hands off the throttle".
- **Russian Cargo Aircraft Project:** Whereas the Airbus project is aimed at developing new systems, other aircraft developers and research agencies are already looking at the next logical step - developing cargo aircraft that are designed from the onset to have no on-board human crews, and only ground-based support personnel for loading and unloading of cargo. One such example is a research project at Russia's Central Aero- and Hydrodynamic Institute (TsAGI) where they are developing a concept for what has been dubbed the Light High-speed Transport Aircraft. The concept aircraft is envisaged to be fully unmanned with a forward loading hatch where the cockpit would normally be, to facilitate loading and unloading of containerized cargo and pallets. The design performance goals will see the aircraft carrying approximately 6 tons of cargo over

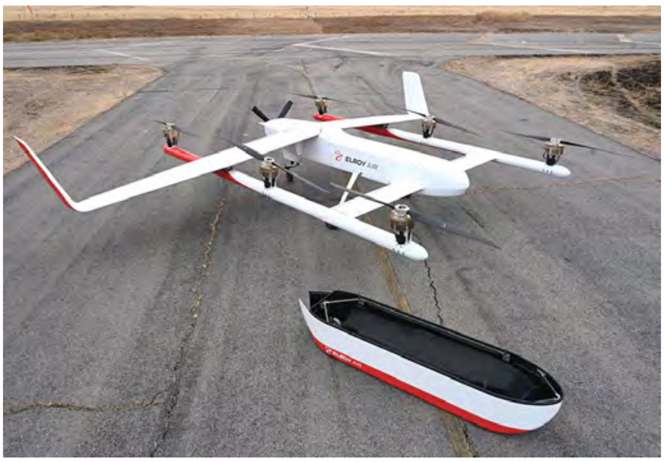


Andre P. Meredith

ranges up to 4000 km and at flight speeds of up to 850 km/h. Take-off and landing would be via conventional runways at existing airports. In other words, this proposed unmanned aircraft is envisaged to share airspace and airport facilities with existing manned aviation, and it is only one example of many similar ongoing projects.
- **Natilus Blended Wing Body Freighter UAV:** There are also many private ventures looking into the potential of unmanned cargo aircraft. For example, Natilus (a California start-up) is in the process of developing a number of UAVs to ship large volumes of air cargo over long distances. Initial plans would utilise smaller prototypes, scaling up to a large Blended Wing Body (BWB) design capable of transporting 120 tons of cargo on trans-Pacific routes. The plan is to have the aircraft operate from maritime ports, where it would be towed out to sea for take-off, then fly below passenger air traffic routes to the destination and land in the sea before being towed to a port for off-loading. A part-scale prototype is currently in development.
- **Zipline:** And on the lower end of the scale, Zipline is a California-based drone delivery company specialising in the development of drones (and provisioning of related services) for the delivery of medical supplies. In contrast to the concepts for future large unmanned cargo aircraft, Zipline is currently fully operational – in at least one country. In May 2019 it was determined that more than 65% of blood deliveries in Rwanda utilised Zipline drones. Similar services are also operating in Ghana, supplying 2500 Healthcare Facilities with medical services. The Federal Aviation Administration (FAA) granted special Part 107 waivers to allow Zipline (in partnership with Novant Health) to deliver medical supplies and PPE to medical facilities in North Carolina during the COVID-19 pandemic.

OBSTACLES

- **Technology:** There are several reasons why we don't see even faster uptake of unmanned aviation services. Some may find it surprising, but the technology itself is actually not a major bottleneck or hurdle in this regard. Military applications of unmanned aircraft have advanced the technology to the point that such operations have become very reliable – almost approaching the reliability of manned operations. Full automation along a pre-programmed flight path, including automatic take-off and landing, has become a standard feature of many new designs. Both large airframes and many of the smaller consumer drones are entirely capable of this level of automation and considerably more, although regulatory requirements mean they must still be monitored by a human when operated in this way. For many years, one of the major technological challenges of operating unmanned aircraft was the so-called sense-and-avoid (S&A) challenge. This is the requirement that a vehicle must be able to detect a potential collision – be it with another aircraft, a static obstacle or terrain – and take appropriate action to avoid the collision. Larger military UAVs operating in controlled airspace benefit from the same aids as manned aircraft, including Air Traffic Control services (relayed to a UAV operator on the ground), TCAS, Transponders, ADS-B, etc, while the "avoidance" actions are usually applied manually by the operator on the ground. For smaller vehicles that operate in uncontrolled airspace, the challenge is, perhaps sur-



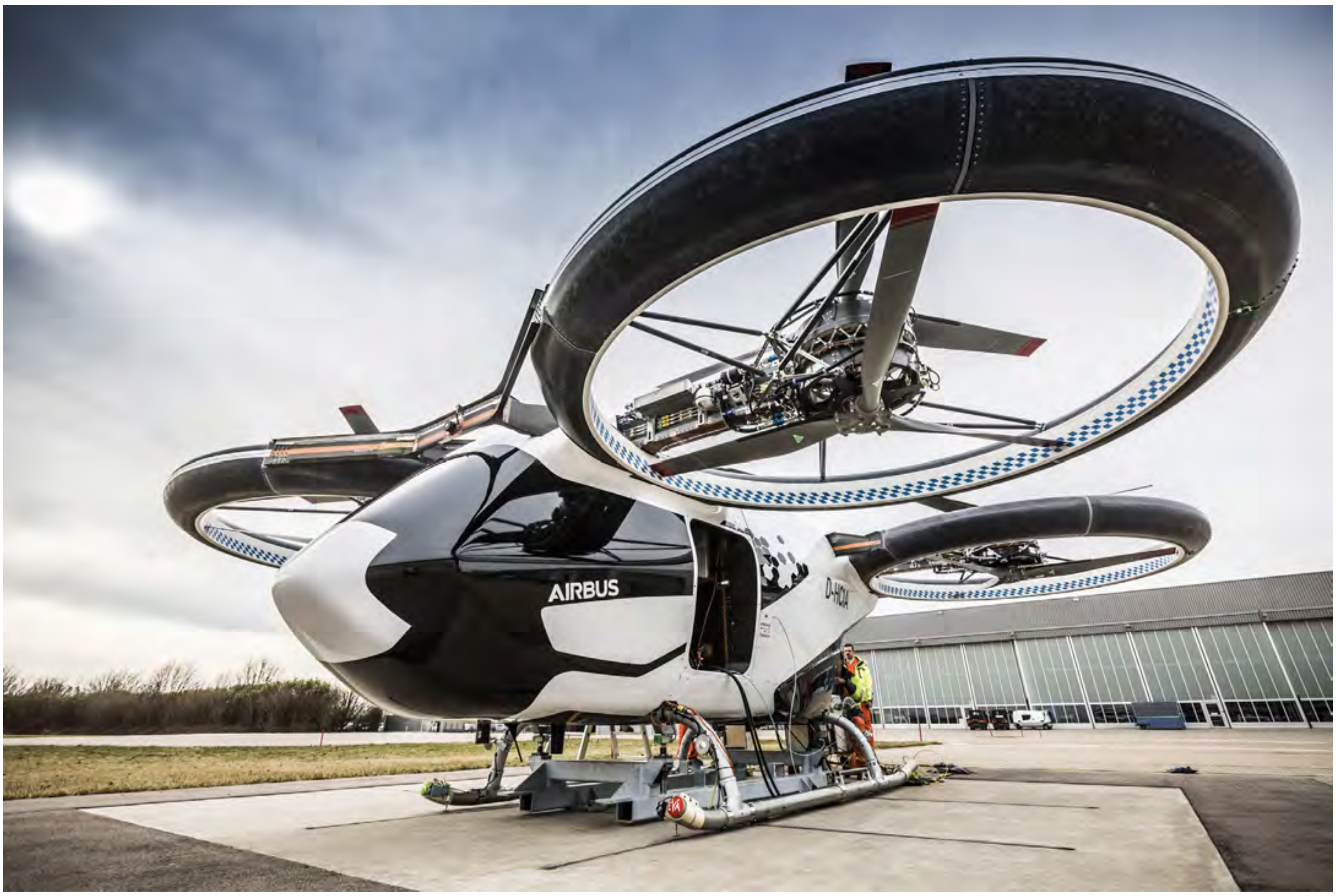
prisingly to some, more complex: The environment is less predictable, and special sensors are required to replace the role of human eyes in the aircraft. In this regard, technology has also been catching up; even many consumer-grade, hobby-level drones are now equipped with a set of sensors that detect obstacles and ensure collisions are avoided. Avoidance is carried out autonomously by the drone, without any pilot intervention required. The capability (and possibly reliability) of these sensors will have to be expanded if the intention is to detect other aircraft when the drone is operated beyond visual line-of-sight, especially within congested airspace.

While the problem of sensing potential collisions is being overcome by better, more widely available low-cost sensors, solutions for automatic avoidance has also progressed significantly. A comparison may naturally be drawn to the work done by the developers of self-driving cars. What is interesting to note is that, while the 3D environment of flight at first appears to be a more challenging one, the reality is that it is more predictable and simpler to control when compared with a typical “urban road” scenario. The biggest challenge facing self-driving cars is in dealing with completely unexpected, random events. For example, a child suddenly appearing from behind a parked car and darting across the road, whilst running after a runaway ball, is an extremely difficult “sense-and-avoid” problem to solve. On the other hand, this type of unexpected event is much less common in open airspaces (even congested ones), and with suitable sensors the available reaction time is usually longer, while the avoidance options are simpler to execute than those available to a car operating in confined spaces. With the advent of more advanced artificial intelligence incorporating neural networks and machine learning, automatic oversight of unmanned aircraft is steadily approaching the level of dependability required for fully automated flight.

There are, however, two much more challenging obstacles to overcome before unmanned aircraft will start to approach the wide range of applications currently seen as science fiction - those being current Legislation and Acceptance by Society.

- **Legislation:** Immediate challenges towards establishment of regular unmanned airborne cargo operations are largely headed by the obligatory regulatory framework governing unmanned flight operations. Most notably, the seamless integration of unmanned and manned aviation within common airspace – especially over built-up areas and within congested airspace – remains a problem worldwide. Major regulatory authorities are working around the clock to address this problem, and a number of potential solutions have been proposed. But authorities remain reluctant to allow regular unmanned flight to take place in controlled and congested airspace, requiring operators to follow often lengthy processes to obtain the necessary authorisation to do this.

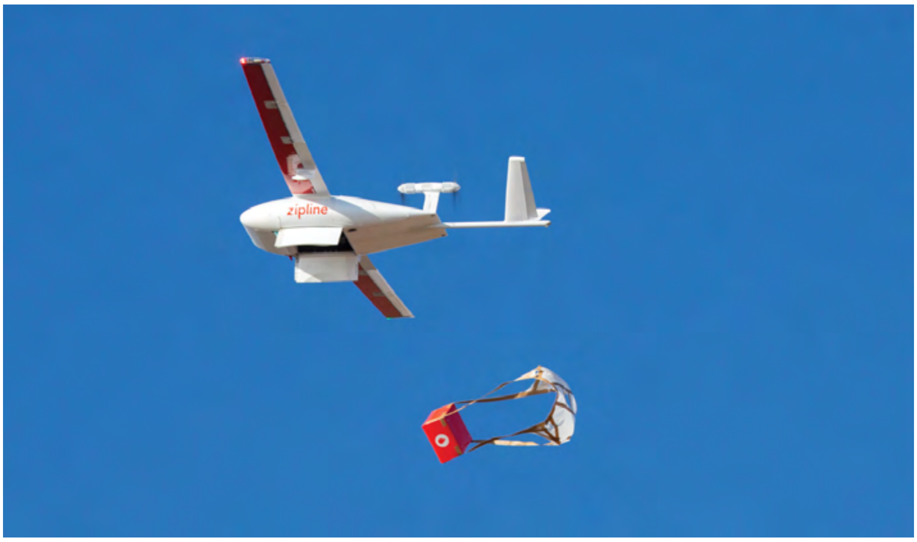
The legal requirements to achieve the aforementioned are primarily governed by national regulatory authorities and the immediate state of their regulations, creating uneven barriers to unmanned operations in view of multi-national programs. For example, countries like Rwanda are already allowing regular long-distance UAV operations (see the Zipline example), while it is impossible to get permission for any type of commercial drone operations in many other countries. In fact, in 2020 there were 27 countries that had either effectively banned drones or made it almost impossible to get permission for private operators and/or commercial companies to obtain permission to operate drones. While some countries took a deliberate decision to ban smaller drones due to, for example, security concerns,



in many others there is simply a complete lack of relevant legislation.

It is understandable that aviation regulators may feel uneasy to adopt and support the use of such new, potentially invasive technology. The solution is for the developers and operators to prove that it could be beneficial, safe and effective by establishing confidence in the technology over time. One potential solution to achieve the aforementioned is to initially stick to intercity routes, and remain far from heavily-built-up regions, and also stay clear of major air routes. Deliveries of goods to city outskirts and along predefined air routes (perhaps specifically designated for unmanned flight operations) to test such concepts and help evaluate potential solutions would be far easier to establish. This would also act as a confidence-building exercise, leading to expansion of the operational envelope and exploration of more adventurous options.

- **Acceptance by Society:** The final obstacle that of acceptance by society is a very real barrier that can only be overcome by continuous demonstration of reliability and safety. Each incident involving UAVs, regardless of whether it is the fault of the vehicle, operator or someone else, represents a setback in this regard.



One can expect that certain applications may never (or only very far into the future) reach general acceptance. For example, no matter how safe unmanned aircraft are shown to be, it is unlikely that future passengers will feel safe in an aircraft with no pilot on board.

In other areas, acceptance is already here; as an example, the use of smaller drones for photography, surveys and even last-mile medical deliveries have already gained significant acceptance in many countries.

As the potential for disaster increases, for example operations that may involve heavy unmanned cargo aircraft operating into airports located in or near urban areas, more work will be required to demonstrate consistent safe operation to the point that such operations will be accepted by society at large.

A LIKELY WAY FORWARD

As demonstrated by the small selection of examples highlighted here and the many more reported on in the news on an almost daily basis, the technology of unmanned aviation will forge ahead. We will see more applications of smaller drones used for the delivery of emergency supplies in isolated areas - probably over ever-increasing distances and on a more regular basis - continuing the trend already set in some African countries, such as Rwanda. Due to the legislative challenges, it is likely that these experiments will initially be limited to areas that are isolated enough to minimise the potential risks to people on the ground and other aircraft, or through, for example, establishment of publicised operational corridors for these drones.

Most of the more regular drone delivery services (where implemented) are still occurring over relatively short distances. However, it is likely that much longer distances, such as delivery from the mainland to isolated islands, or between isolated islands, or across large stretches of unpopulated areas such as deserts or arctic regions, could be demonstrated in the very near future. As these smaller demonstrations solve the technological problems around safety, reliability, communications, route planning, obstacle sensing and avoidance, redundancy, automation, onboard decision-making through artificial intelligence, etc., and demonstrate that such drones can be operated at equivalent safety levels to manned aircraft, one can expect an increase in the development and fielding of larger drones carrying heavier payloads over longer distances on a regular basis.

Legislative restrictions should start to decrease as technology matures and related operations are shown to be reliable and repeatable. Initial drone deliveries to remote areas and over unpopulated regions, under strict oversight (operating within experimental drone flight classes), should pave the way for regular delivery flights to equivalent regions. As these regular services become more prevalent and the reliability of the systems are demonstrated on a continual basis, one can expect delivery flights to more densely populated regions, and then finally within busy air routes.

Legislation should be matured alongside these developments and should be simplified to allow unfettered unmanned cargo flight operations within reasonable timeframes, similar to that required for manned aviation. This should include the development of supporting processes and paperwork that enable regular drone delivery services, including task planning and filing of Flight Plans.

CONCLUSION

In conclusion, as the novel utilisations of drones keep on expanding and technology races ahead to satisfy this demand, there is potential for an ever-increasing chasm to grow between legislators and operators. The COVID-19 pandemic has stressed the need for the rapid development and deployment of cargo delivery drones, which will require regulatory support to see this novel use of the technology become a regular, safe option. An incremental confidence-building development and demonstration program will be the safest and most effective means to prove to regulators and the general public that the technology can be trusted and fielded “within the real world”. Not only will this have to be done at a national level, but due to the potential international reach of many future large cargo drones, there will have to be some measure of legislative harmonisation to ensure that such aircraft may operate cross-border and within foreign airspace.

The development of new enabling technologies to make our world a safer, better and more effective place will continue and cargo drones is but one such technological advancement that has emerged from the wake of the COVID-19 pandemic. Long after this debilitating period in our history has been forgotten, cargo drones will still be providing essential services delivering freight, post, medical supplies and other goods to every corner of the globe. This is what we foresee; the technology is already largely in place (or fast on track) to support such an initiative with the firm support from aviation regulators. ✈