UK Civil Aviation Authority

Innovation Hub

Using Drones to Carry Dangerous Goods using Crash Protected Containers

BEIS RPF2 Project Outcomes

Department for Business, Energy & Industrial Strategy

Vehicle Certification Agency

UK Research and Innovation

Introduction and Purpose

The Civil Aviation Authority (CAA) successfully applied to the BEIS Regulators' Pioneer Fund (RPF) in 2021. Two projects were selected from the CAA, one of which was to establish a test regime for crash protected containers to enable drones to carry dangerous goods.

The purpose of this report is to describe the context, outcomes, approach, and next steps of the RPF project.

Contents

The Context

The use of drones[1] to provide public and private services is trending upwards and is expected to continue to increase in volume and frequency into the future.

It is no longer only the remit of science fiction, and we can expect drones to play some part of everyone's daily lives within 10 years either directly or indirectly. The Civil Aviation Authority plays a critical role in this new ecosystem as the aviation safety regulator. It is the CAA's responsibility to make sure that drones are built and flown safely by setting rules and minimum performance requirements for the aircraft, their remote pilots, and supporting equipment or services. In this way, the CAA and the industry need to work closely together in this space of novel technology to make sure that aviation regulation enables innovation to flourish in line with our core principles (safety, security and consumer protection).

In early 2020 we all experienced the impacts that the COVID-19 pandemic had on our lives. On 26th March the country was in its first nationwide lockdown requiring us to "stay home, protect the NHS, save lives"[2]. Within days, the CAA was in discussions with innovative drone companies who had identified a potential to reconnect remote communities across the UK with critical health services. One example was on the Isle of Mull in Scotland where we saw the first trial of a drone delivering personal protected equipment (PPE) from the mainland[3] in May 2020.

Carrying dangerous goods by drone

Well before the COVID-19 pandemic public engagement surveys were asking the fundamental question regarding which drone use cases the public would accept: "blood or burritos"? The results tend to suggest that the public would likely accept drones supporting the emergency services and healthcare before they would accept those which were operating purely for commercial gain. However, items such as patient specimens (blood, tissue samples, or organs) known to be infected with micro-organisms that affect the life of humans or animals, certain medicines, and some vaccines, are considered to be "dangerous goods". This includes completed COVID-19 test samples and COVID-19 vaccines. In 2021, the CAA's Innovation Hub started to research the extent of the market demand for carrying dangerous goods by drones and came across many compelling use cases: for example, NHS Grampian are responsible for the distribution of high-value chemotherapy drugs for the east-coast Scottish mainland and some islands. Being able to transport these life-saving drugs within minutes instead of hours would ensure that the short-life drugs are still viable when they reach their destination.

The carriage of dangerous goods by air must be approved by the CAA due to the additional safety risk that it poses. It was only a matter of time before drone operators, the NHS, and local communities would be knocking on the CAA's door for approval to carry dangerous goods by drone on a routine basis.

Previous work in the CAA

The CAA Innovation Hub commenced a programme of work in January 2021 to identify the specific challenges experienced by the CAA and industry from the transport of dangerous goods by drone. One such challenge was how to prevent the leakage of potentially harmful substances from a drone's cargo hold if the drone were to crash. New drone regulations, which came into effect at the start of 2021, included a reference to a "crash protected container" as one possible way to mitigate this risk, but without specifying any performance criteria or standards. Given the novelty of these regulations, there was also no international work ongoing to define the technical specifications for these specialised containers. There was therefore a need to explore exactly what the CAA would accept as being a safe crash protected container.

[1] Formally, the CAA uses the term Remotely Piloted Aircraft System, or RPAS.
[2] Timeline of UK government coronavirus lockdowns and restrictions, Institute for Government.
[3] Drone to deliver masks to Isle of Mull hospital, BBC News, 26 May 2020.

CAA's RPF Proposal

The CAA's proposal for the RPF was to establish a test and approval regime for crash protected containers.

To achieve this, we would need to work with our partners at the Vehicle Certification Agency (VCA) Dangerous Goods Office[4], who are global experts in dangerous goods packaging, testing, and inspection. By providing the industry with this test and approval regime, this provides another possible mitigation to the safety risks, and is therefore expected to make these types of operations accessible to more operators and end users across the UK.

[4] VCA Dangerous Goods Office

The Outcome and Next Steps

Project Outputs

While the primary focus for the project was to produce the first test procedure for crash protected containers, there were also other outputs achieved:

- **RPAS Crash Protected Containers: Test Procedure, Version 1**
  This document sets out requirements for testing, and criteria for assessment, of the performance of crash protected containers.
- **The Dangerous Goods RPAS Challenge Group**
  This group was established during the project to assist with providing feedback on the test procedure, and to assist the CAA and VCA with understanding the potential market demands for drones carrying dangerous goods.
- **A Market Study on Carriage of Dangerous Goods by Drone**
  With the intelligence gathered through our research and engagement with the DG RPAS Challenge Group, we were able to produce a brief overview of the market requirements for the carriage of dangerous goods by drone. This not only provides an insight for the industry, other regulators, and potential end users, but also enables the CAA to understand the potential roadmap for policy in future.

Outcomes and impacts of the project

The outputs described above reflect the hard work and achievements of everyone involved, but beyond these, the following describes some of the outcomes achieved:

- The RPAS sector has an alternative way to mitigate the additional safety risk associated with carrying dangerous goods, thereby making this type of operation more accessible for end users such as the NHS and those remote and disconnected communities across the UK.
- The industry is more informed on the risks associated with dangerous goods and in carrying them by drone, and therefore is more likely to be able to provide safe and compliant drone services.
- The industry has a formal mechanism to challenge and influence CAA policy on the carriage of dangerous goods by drone, therefore reducing the chance of regulation restricting innovation.
- The CAA has a clearer understanding of the drone dangerous goods market, enabling us to adjust policy and regulatory planning.
- Catalysing the creation of a new market in the UK and internationally for safe and compliant crash protected containers.
- The CAA is in the position to present the first proposal for technical specifications of the crash protected container to international regulatory forums, allowing the UK to be at the forefront of setting new international standards.
- UK businesses have the opportunity to be the vanguard of the international market.

The Outcome and Next Steps

The Next Steps

Following completion of the RPF project at the end of March 2022, we now have the momentum to deliver a series of actions which will further enable the market:

- We will work with industry to deliver the first tests of crash protected containers against the new procedure, hopefully leading to the first approval.
- This will likely lead to the CAA issuing its first approval for an operation that uses an approved crash protected container.
- We will update CAA guidance documents to reflect the outcome of the project and to provide clarity on the approval route for dangerous goods including the use of crash protected containers.
- We will continue to work with the VCA to further develop the test procedure based on market response and feedback to version 1.
- We will take version 1 of the procedure to international regulatory and standards forums as a proposal, potentially leading to international adoption.
- We will continue to work with the Dangerous Goods RPAS Challenge Group to assess the performance of the procedure.

Our Approach

As with any innovation activity, when first drawing up proposal for the Crash Protected Container project there were various gaps and uncertainties in our understanding that meant the approach had to be flexible. The project was therefore staged in 3 phases:

Phase 1: Requirements Development

This first phase brought together the necessary experts from across the CAA and the VCA to agree on the context, assumptions, risks, and methodology for the project. We also brought in experts from the Medical and Healthcare Devices Regulatory Authority (MHRA) who are responsible for defining the end-to-end transport standards for certain medical items. From the CAA we included not just the drones and dangerous goods experts, but also the aviation security team who could clarify any potential security risks.

We ran 2 workshops and several smaller meetings during this phase. The first workshop brought the whole project team up to speed on the expectations for the project, clarified the regulatory background and approach, and agreed the scope and assumptions that would help to maintain control over the project. The second workshop discussed certain areas of contention in detail and sought agreement on specific technical issues.

Our Approach

Some examples of issues that were discussed and agreed include:

- **What types of tests would we expect to be carried out?**

  The VCA identified several possible tests such as drop, compression, puncture, vibration, pressure, submersion, and temperature tests. These were discussed in the context of the assumed use cases, based on market intelligence, which reduced the spectrum of tests down to simply a drop test as this was seen as being most representative of the likely environment. It was also agreed during the first workshop that the scope of the CAA's interests was on the safety of third parties, and so the test procedure would not encompass any conditions relating to the integrity of the contents after a crash (i.e. the dangerous goods inside the container).

- **What is the scope of the regulatory requirements for crash protected containers?**

  It was discussed how there are pre-existing requirements, standards, and guidance for all other aspects of the drone operation. For example, the CAA already has a regulatory framework that determines the requirements for the drone itself, how and where it is flown, how the remote pilot is trained, etc. Additionally, there are already clear standards set by the United Nations (UN) which define how dangerous goods should be packaged ready for transport.

Figure: Describing the scope of assumptions and requirements for the project. Those items highlighted red are covered by pre-existing regulatory requirements or standards.

Therefore, it was relatively straight forward to establish the project's scope as being limited to the performance of the crash protected container, and to assume that all other related parameters and features of the drone operation would be covered by these existing requirements.

The result of this first phase was a confirmation from the VCA that they had all of the necessary information to commence the development of the procedure.

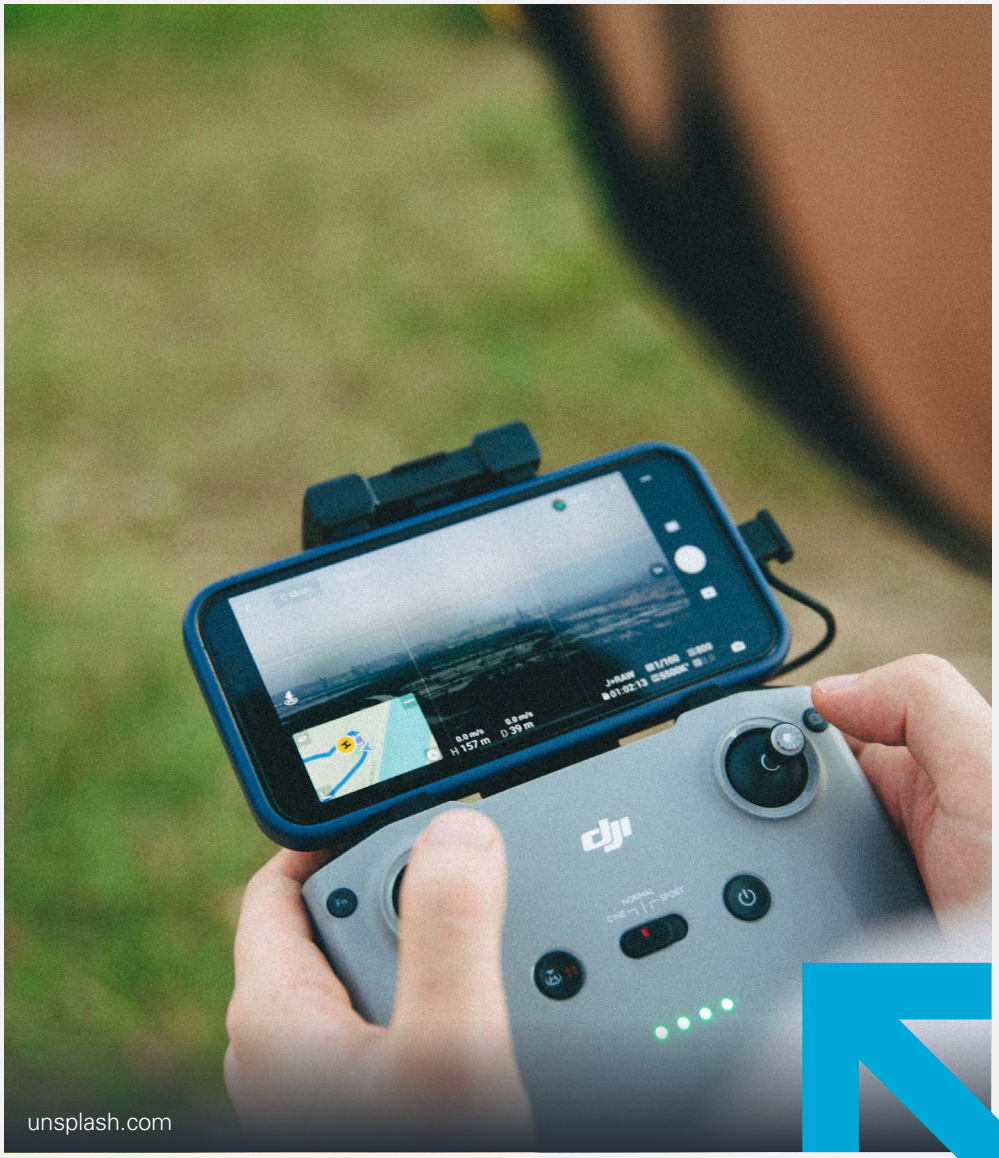
Our Approach

Phase 2: Development of the Procedure

The second phase was led by the VCA and focused on drafting the text of the procedure based on the requirements defined in phase 1. Given their extensive experience in this area, the VCA did not have to start from scratch, but with the drone market being very novel it was soon evident that there was a need to gather intelligence from the industry.

In November 2021 we established the Dangerous Goods RPAS Challenge Group, with a first meeting in December. Following detailed feedback from the Challenge Group during 2 formal meetings, together with a series of 1-to-1 interviews with each of its members during early 2022, the VCA were able to dramatically enhance their knowledge and appreciation of the drone market leading to a favourable shift in the approach taken for the procedure. As a result, the procedure evolved during phase 2 to be more encompassing of various aircraft configurations and use cases shown by the market analysis, thereby broadening the applicability of the final test procedure.

Throughout this phase the VCA have been very conscious of keeping the procedure practical and not creating a new challenge for industry. The first draft of the procedure was circulated to the Challenge Group in February 2022, and later updated to version 1 in March following review and feedback.



Our Approach

Phase 3: Integration of the Procedure

The final phase of the project was for the CAA policy experts in our Dangerous Goods and RPAS teams to integrate the new test procedure into existing documentation and processes. This would enable a container approved by the VCA to be recognised by the CAA when considering an application for the overall approval or licence for the drone operation.

By the end of March this work had made excellent progress, and the teams are working hard to establish the appropriate internal processes to enable this integration.

Throughout the project, there has also been a great amount of learning for the CAA regarding the carriage of dangerous goods by drone and the use of crash protected containers which has further enabled this integration. This has also fed into other enabling work outside of this project.

There was originally intended to be a fourth phase to validate the test procedure through real, physical testing. It was identified during phase 2 that this would not be possible to complete within the time available for the project. But through our engagement with the Challenge Group members, we are on track to witness the first tests within months of the project closure.

Reflections on the Project

This project has demonstrated how several public and private organisations can come together at relatively short notice, to coalesce around a common challenge and openly collaborate for the benefit of the wider sector.

Reflecting on the process and performance of the project there are lessons that can be learnt to continuously improve our approach on future initiatives. One example is a positive reflection on the industry stakeholders who accepted our invitation to share their experiences and to engage in the project at quite short notice. In hindsight, we would look to engage these stakeholders earlier as part of the requirements development phase.

Due to the novelty of this subject, we were required to use expert judgement to forecast what could be achieved. For this project we were fortunate enough to have world-leading experts who could steer the project in the right direction from a very early stage.

There were however a variety of unknowns that had to be accounted for:

- We identified many variables and possible scenarios in which the crash protected container could be required. Many of these were based on market research as well as inputs from technology research programmes.
- As a result, it was not clear at the start of the project how this would impact on the complexity of the test procedure. A highly complex procedure would have led to it being costly and most likely would have created a barrier to this evolving sector.
- It was not clear during the requirements development stage whether the capability for testing existed in the way that would be required. Clearly a drop test from a height of 400ft would be a challenge.
- Finally, there was a risk that at the end of the development phase, the CAA policy experts would not accept the test procedure as being robust enough.

As a result, we developed a series of mitigations to try and avoid these pitfalls:

- We had very early engagement with the VCA and MHRA before the project commenced. Furthermore, we had continuous engagement with the VCA throughout the project, and established good communication of insights and intelligence such that the whole project team was up-to-date throughout.
- Establishing the DG RPAS Challenge Group resulted in a substantially greater understanding of the potential challenges and outcomes in applying the procedure and using the containers.
- The VCA demonstrated great flexibility when developing the procedure and were quick to adapt in response to the increasing volume of intelligence and feedback gathered.
- CAA policy experts were embedded into the project team, engaging throughout the project and sharing their views openly with the VCA and Challenge Group.

Conclusion

We are immensely proud to have delivered this project within the 6-month timeframe provided by the RPF. It could not have been achieved without the open and willing engagement and collaboration of so many stakeholders.

We are excited to take this to the next step, to see how the market responds, and to present the proposal to our international regulatory colleagues.

Thanks

Special thanks goes to the following organisations and teams for their support to this project.

- VCA Dangerous Goods Office
- MHRA Innovation Team
- Members of the DG RPAS Challenge Group
- CAA Dangerous Goods Office
- CAA RPAS Sector Team
- CAA RPAS Policy Team
- CAA Aviation Security Team
- CAA Innovation Hub
- BEIS Regulators' Pioneer Fund Team
- UKRI Innovate UK Future Flight Challenge

UK Research and Innovation

This document has been created by the CAA Innovation Hub in association with the Future Flight Challenge from UK Research and Innovation.

This project has been made possible by a grant from the £3.7 million Regulators' Pioneer Fund launched by the Department for Business, Energy and Industrial Strategy (BEIS). The fund enables UK regulators and local authorities to help create a UK regulatory environment that unleashes innovation and makes the UK the best place to start and grow a business.