

Innovation Hub Advanced Air Mobility: Taking a Use Case Approach To Develop Regulation

## Overview

### This document provides an update on the CAA's evolving work to explore Advanced Air Mobility (AAM). It sets out and justifies an approach to regulatory development founded on AAM use cases.

The concept of Advanced Air Mobility is centred around the use of revolutionary new aircraft, but page 2 describes how AAM covers a range of themes from novel propulsion, through to new business models that enable new experiences for consumers.

By virtue of the word 'mobility', it is difficult to fully embrace the concept of AAM without considering its development in partnership with the increasingly integrated transport network, as explored on page 3.

In shifting focus towards an aviation ecosystem that interacts with other transport modes as well as local communities on a more personal level, page 4 explains that we must consider the evolution of roles necessary to deliver it.

Due to its multi-layered nature, page 5 explores how AAM will require significant collaboration between a much broader range of stakeholders to ensure that all aspects of the ecosystem are aligned.

Given the extensive nature of Advanced Air Mobility, we must take an innovative approach to developing regulation. Taking a use case approach, as outlined on page 6, enables us to identify specific regulatory challenges, while not trying to solve the whole of AAM in one go.

On page 7 we take a look at some example AAM use cases. We can start to look at assumptions and common factors across these that offer an insight into what future AAM services may look like.

Regulatory Frameworks for AAM need to be flexible enough to enable future innovation, whilst maintaining or enhancing existing safety levels and mitigation of risks. Page 8 describes our regulatory approach to AAM.

The breadth of impact of AAM results in a wide risk landscape, as detailed on page 9. Using the use case approach allows us to explore risk areas specific to the use case, and in turn building a rich risk landscape for AAM.

In addition to existing aviation parallels, some AAM use cases are likely to also give rise to new ways of exploring safety risks. Page 10 identifies that, in addition to existing aviation parallels, some AAM use cases are likely to also give rise to new ways of exploring safety risks.

Advanced Air Mobility use cases also enable us to explore the broader ecosystem and key non-safety risks, under important areas like consumer issues, which we detail on page 11.

Advanced Air Mobility use cases are unlikely to succeed if they do not account for ever-changing social and political influences. Key risks may stem from society's tolerance of noise or its environmental consciousness, as explained on page 12.



# What is Advanced Air Mobility?

The concept of Advanced Air Mobility is centred around the use of revolutionary new aircraft, but covers a range of themes from novel propulsion, through to new business models that enable new experiences for consumers.

Given the breadth of the topic, multiple definitions and explanations are beginning to be recognised in association with AAM concepts. There may also be differences between the terms used to classify or categorise regulatory distinctions, for example between aircraft types. Terms that the industry may use to communicate their new products and services may also differ for the purposes of communications or marketing.

It is important that terms are harmonised to establish recognised definitions on a global scale. This will help the continued development of use cases and will ensure regulation is clear.

Following our previous publications on 'Future Air Mobility' we have updated our terminology to 'Advanced Air Mobility'. This term has already been adopted by many stakeholders including a significant portion of UK industry and is consistent with the use cases we are exploring. A clear definition of Advanced Air Mobility was coined by NASA, and can be found in the table, alongside other related and increasingly recognisable terms.

### What AAM means to us...



New and novel ways of transporting people, goods and services by air commercially.



Business models and operational solutions that result in new experiences with air-travel and transportation.





Novelty as a result of advanced technologydriven systems.

Term	Definition
Advanced Air Mobility (AAM)	"Air transportation services for people and/or cargo between places [] Local, regional, intraregional, urban – using revolutionary new aircraft." (source: NASA)
Vertical Take-Off & Landing (VTOL)	A VTOL vehicle, or aircraft, can hover, take off and land vertically. This includes traditional rotorcraft, powered lift and other lifting systems such as jet configurations
eVTOL	A major subset of VTOL often used interchangeably – the "e" referring to electric engine used for propulsion, or in part (i.e. 'hybrid')
Urban Air Mobility (UAM)	Air transportation service(s) for people and/or goods ('cargo') in a city or other urban environment(s)
Rural Air Mobility	Air transportation service(s) for people and/or goods ('cargo') in the countryside or other rural environment(s)
Vertiport	Landing and take-off ground or elevated platform developed for VTOL and eVTOL aircraft
Use case	A proposed operation or single set of operations outlining its goals and operating environment . An illustrative example of an AAM concept

# Advanced Air Mobility in an Integrated Transport World

By utilising the term 'mobility', it is clear that the concept of AAM inherently relates to the concept on an increasingly integrated, multimodal transport network.

Whilst aviation currently forms a critical component of international and national connectivity, it has until now been somewhat separated by its nature, and has often been considered under its own isolated structures and processes.

This unique status has been helpful in enabling the current aviation sector to develop: bringing with it high standards of safety, harmonised international regulatory approaches, and a global mindset when it comes to aviation operations.

However, as we look more closely at AAM use cases and explore macroeconomic trends like Urbanisation and 'Mobility as a Service' (MaaS), it also feels right to ask whether closer coordination with other transportation methods may be needed.

Whilst Government is largely responsible for overall transport strategy, AAM use cases offer an opportunity to consider the role of aviation as part of the more local mobility proposition within a specific jurisdiction. From a Social Licence (as defined in CAP 1900) perspective this approach is advantageous as it supports a strong focus on what the outcome of a mobility service should be for the consumer and locally affected stakeholders.

The motivation to maximise the benefits of integrated and 'smarter' transport systems, particularly where demand is high due to large populations or expansive urban landscapes, can also provide insightful AAM use cases that can be explored and analysed. This has inspired the creation of global initiatives intended to encourage collaboration.

### World Economic Forum: UAM Cities Initiative

This is a useful example of an initiative that is exploring stakeholder integration.

It aims to encourage cities and other local or community based stakeholders to engage with industry and policy-makers to develop positions and support for Urban Air Mobility use cases that support their needs, as well as their responsibilities to the public.

Its first piece of work was led by the City of Los Angeles. It proposes 'Principles of the Urban Sky' as a first step for local authorities and transportation leaders having a say on the developments in UAM and how they can help to meet public transport needs.

These principles and more information about the work of the WEF initiative can be found at <a href="https://www.weforum.org/reports/principles-of-the-urban-sky">https://www.weforum.org/reports/principles-of-the-urban-sky</a>



In shifting focus towards an aviation ecosystem that interacts with other transport modes as well as local communities on a more personal level, we must consider the evolution of roles necessary to deliver it.

Trends under AAM may see a gradual evolution in the roles that currently exist. The outputs of emerging technologies have already given rise to more coordinated activity, for example between energy, technology and transportation policies.

Similarly, the development of remotely piloted aircraft has already driven new thinking on roles and responsibilities – for example introducing distinct roles of the 'remote pilot' and 'drone operator'. New or modified responsibilities have also given rise to questions on how to integrate a greater range of airspace users into the aviation ecosystem.

In terms of regulation, maintaining distinct roles and responsibilities between the regulator and the industry is a key enabler of our performance-based approach: allowing clear oversight and accountabilities to be understood under industry-led safety and security management systems.

As innovators develop their own AAM business models they may consider different roles. These may even evolve throughout the development of their services and operations, as they transition from focussing on design and manufacture towards commercial operation. For example, some AAM organisations are positioning themselves to manage training, operations and maintenance in-house. One example of where conversations on changing roles and responsibilities have been evident is the role of local authorities when it comes to drone use in public parks. These conversations have been important and should continue. However, there is a danger that people look to simply shift responsibility from one party to another; rather than recognising the increased need for enhanced collaboration and to embrace evolving or new responsibilities as well.

The existing aviation sector is made up of a plethora of stakeholders, all playing important and distinct roles. These include:

- Original Equipment Manufacturer (OEM).
- Maintenance organisations.
- Aircraft operators.
- Service operators e.g. airlines.
- Consumers/ passengers.
- State operators (e.g. HEMS<sup>1</sup>, powerline / pipeline operators).
- Drone Operators and remote pilots.
- Flight Crew, including pilots and cabin crew.
- Air Traffic Managers.
- Aerodrome Managers.
- General Aviation community.

As AAM use cases develop, we can consider the impacts of collaboration across public and private sector stakeholders in greater detail; alongside possible effects on skills and training, or on identifying and managing liabilities. Initiatives, such as the UK Government's Future Flight Challenge, and US-based Community Air Mobility Initiative (CAMI) are just two which look to build cooperation efforts on the basis of collaboration.

<sup>1</sup> HEMS – Helicopter Emergency Medical Services

# The Importance of Collaboration

### Due to its multi-layered nature, AAM will require significant collaboration between a much broader range of stakeholders to ensure that all aspects of the ecosystem are aligned.

Different areas can be identified under a specific use case – one way of doing this is shown here. The examples of roles and responsibilities under different areas, draw out only some of the many linkages and interactions that are necessary between disparate stakeholders in relation to the development, approval, operation and maintenance of such services and operations.



Below are some examples to demonstrate the complex nature of AAM use cases and so emphasising the need for close, coordinated collaboration.

#### Individual aircraft operation / management

- Private ownership and management
- Hired flight crew and other staff carry out the operations
- The CAA issues operational approvals and safety oversight of operations
- The CAA issues safety certification of the aircraft
- The CAA issues licences to pilots and crew, and approve their training

#### Airspace Management, Integration & Modernisation

- With the Department for Transport, the CAA help decision-making for airspace modernisation
- The CAA will make determinations on the overall impact of changes to maintain oversight of efficient use of all UK airspace
- NATS and other Air Navigation Service Providers manage UK airspace and help airspace users to operate within it safely
- Private management of the specific operations and route

#### Ground/ Take-off and Landing Infrastructure

- Private ownership and management (e.g. vertiport operator)
- Hired flight crew and other staff carry out the operations
- Local or other planning authority will issue building or land use permissions
- Additional permissions for example environmental requirements will be issued by the requisite authority. The CAA may issue certification to establish specific operational use (e.g. 'certified' landing and take-off platforms)

Given the extensive nature of Advanced Air Mobility, we must take an innovative approach to developing regulation. Taking a use case approach enables us to identify specific regulatory challenges, while not trying to solve the whole of AAM in one go.

By considering AAM use cases as opposed to focusing on each component, system or technology, we are able to analyse the various advanced air mobility concepts against the existing regulatory frameworks. Through this holistic lens we can identify opportunities for integration with existing airspace users and begin to really understand the regulatory gaps that may arise.

Given the unique nature of each AAM concept, we expect some use cases to overcome practical and regulatory challenges more readily than others. And while there may be some common trends – for example many existing AAM vehicle concepts have a capacity of around 5 seats – we recognise that these will evolve alongside technological and other types of advancement.

Our ability to explore aviation challenges that exist outside of AAM may also be enhanced by comparing and applying multiple AAM use cases. For example, how new and existing aviation services can be safely integrated to make efficient use of available airspace and provide equity for all users.

### Taking a Use Case Approach

The aim of the 'use case' regulatory approach is not to enable all proposals unquestioningly, but to allow AAM concepts to be fully explored so that safe proposals can be developed iteratively in partnership with the Regulator.



## Examples of Advanced Air Mobility Use Cases

Commercial Air Transport (CAT) service for passengers – scheduled urban or rural route, with pilot on board. Zero Emission Commercial Air Transport (CAT) service for passengers – scheduled route, with pilot on board. Remotely-piloted commercial on-demand passenger or cargo service in a rural or urban area.

Personal or private flights with pilot on-board for non-commercial (or 'General Aviation') use.

Example: a company uses VTOL aircraft to run a scheduled commercial flight from A-B. Example: a company uses a conventional aircraft fitted with a zero emission engine to run a scheduled commercial flight from A-B. Example: an unmanned aircraft systems (UAS) service is set up to deliver parcels to a specific location or customer. The drone is controlled by someone in a flight control centre. Example: an individual buys an eVTOL aircraft as a means of personal transport.

Here we take a look at some example AAM use cases. We can start to look at assumptions and common factors across these that offer an insight into what future AAM services may look like.

- Use cases cover a large variety of environments and types of operation including rural, urban, regional, interregional or even cross-border.
- Aviation law recognises further environment variations that affect airspace use and air transportation. For example, the Single European Rules of the Air (SERA) consider different congested areas and these rules need to be understood by pilots, air traffic controllers, flight information service officers, aerodrome operators and anyone else involved in the operation of aircraft. We would expect AAM use cases to consider this context under decisions on how the operation is planned and conducted.

- Newer and greener types of propulsion form part of the aircraft designs for use cases: proposing environmental benefits in terms of lower emissions, sustainable fuel source development and reductions in noise.
- The majority of use cases are initially scoped around the 'air taxi' size aircraft. Many are considering aircraft with a capacity of up to 5 passengers for local or regional flights, with a smaller number looking at interregional or slightly longer flights with slightly larger aircraft for around 18 passengers.
- Routes under use cases are focussed on short or local journeys. Significant numbers of use cases describe "short hop" or "last mile" transportation models of distances of under 100 miles.
- Many use cases are piloted, although longer-term ambitions include autonomous or Al-driven flight control systems. Many of the aircraft systems do however introduce advanced technology-driven systems, beyond conventional aircraft design.

# A Regulatory Approach to Advanced Air Mobility

Regulatory Frameworks for AAM need to be flexible enough to enable future innovation, whilst maintaining or enhancing existing safety levels and mitigation of risks.

Recognising core principles of aviation regulation, AAM will need to:

- meet the highest levels of safety
- manage aviation security risks effectively
- provide consumers with choice, value for money
- protections and fair treatment when they fly
- effectively manage and reduce environmental impact on communities
- function effectively within shared airspace

Whilst one option is to develop new regulation against these principles, existing regulatory frameworks provide a useful and logical starting point. For this reason, our consideration of recently developed regulation in areas like VTOL (such as the EASA Special Condition for VTOL, published 2019) is a key part of the process for developing national regulation, as well as enabling recognition and validation of non-UK developed aircraft to maintain access to the UK aviation sector.

A scenario-based approach to considering AAM use cases enables us to identify the degree to which existing frameworks can accommodate these operations and where change may be needed or can be driven to bring holistic aviation sector advantages, such as greener transport options.

## Using Use Cases to Expose Regulatory Risks and Opportunities

#### Stage 1 – The Regulatory Gaps

#### What is novel about the use case?

What pathways exist for testing and operation under the current regulations? What does not exist or requires modification in terms of certification paths? How would the use case integrate with existing airspace users?

#### Stage 2 – The Regulatory Risks

What are the risks arising from the regulatory gaps? What mitigations exist, and are they clear and practicable?

#### Stage 3 – The Opportunities for Change

What type of change would enable the regulatory gaps to be closed? Are these changes compatible with the CAA's principles and global aviation standards and recommended practices?

#### Stage 4 – Implementing the Change

What consultation or revision of policy and regulations is needed to implement any necessary changes?

# The Advanced Air Mobility Risk Landscape

The breadth of impact of AAM results in a wide risk landscape. Using the use case approach allows us to explore risk areas specific to the use case, and in turn building a rich risk landscape for AAM.

Identification of risks needs to begin before any regulatory approvals, at the beginning of the design process and throughout its evolution. Understanding the risks pre-empts the physical collection of evidence through testing, but it also enables it to start by identifying potential hazards and mitigations.

One of the challenges for AAM is to be able to draw a comprehensive risk picture when much of the technologies and approaches are untested.

This fact also makes the exploration of risk modelling and early risk management activities even more important for long-term safe development. This means that a more iterative approach and extensive number of scenarios may need to be developed, built upon and reviewed periodically to reflect technological and business use case developments. This agile approach may also need to be applied to risk management assessments for anticipating future AAM regulatory challenges.

Tried and tested risk management methodologies in the aviation sector can play a role alongside newer methods that will develop in future and under AAM use cases, such as through modelling, simulation or machine learning.

The following pages will explore three example risk areas that should be considered for AAM:

- Safety risks
- Consumer risks
- Environmental and Societal risks



#### The CAA risk

matrix used by the UAS Safety Risk Assessment Guidance in CAP 722A.



To meet high safety standards through regulation, risks under AAM operations must be correctly identified and assessed. AAM risk models will need to be assessed based on operators' specific use cases.

The CAA collates and analyses risks based on increasingly advanced and everevolving data assessment processes. This helps to explore future use case risks in aviation, as well as provide guidance to operators to build and enhance their own assessments. This includes for example key risks identified through the well-established 'Significant Seven' which have set a strong baseline for identifying key risks, based on UK fixed wing operations for larger commercial aircraft, oriented towards the current UK operating environment and equipment.

The CAA utilises a number of sources, including the identification of causes of events categorised under international standard descriptions, alongside expert analysis of reporting on incidents and accidents.



Considering the features and assumptions of the example use case identified on page 8, robust consideration will be given to risk identification and analysis in relation to traditional rotorcraft (helicopters). Whilst the AAM aircraft range is potentially very varied, similarities in terms of take-off weight, operational use in lower levels of airspace and aircraft navigation and control systems may in some cases be comparable with existing helicopter operations. Existing risks identified in this area are therefore likely to be a helpful starting point for exploring specific risks under several AAM use cases.

Taking this example further we can look at causes of helicopter accidents as reported on globally between 2000 and 2017, where the top risk areas fall under:

- System or component failure or malfunction (non-powerplant)
- Loss of Control
- Controlled Flight into Terrain (CFIT)

Further consideration of these risks under AAM use cases will be needed.

More information on these themes is available on the CAA website

- <u>CAP 1864</u>: Onshore Helicopter Review
- <u>CAP 1931</u>: Safety Management Systems for Innovators
- Safety Management Systems information for organisations <u>https://www.caa.co.uk/Safety-initiatives-and-resources/Working-with-industry/Safety-management-systems/Safety-management-systems/</u>
- Mandatory Occurrence Reporting <u>https://www.caa.co.uk/Our-work/Make-a-report-or-</u> <u>complaint/MOR/Occurrence-reporting/</u> and <u>https://www.caa.co.uk/Our-</u> <u>work/Make-a-report-or-complaint/MOR/The-MORs-code/</u>

# Novel Safety Risks

In addition to existing aviation parallels, some AAM use cases are likely to also give rise to new ways of exploring safety risks.

Prominent areas include those where novel technological features meet human factors such as:

- Mixed piloting modes or functions in responses to piloted, remotely piloted or pre-programmed operation of an aircraft;
- Higher levels of automation across a single flight control system; and
- Different types of engagement between the above and external roles, such as air traffic controllers and ground handling operators.

Recognising this is an evolving picture in terms of exploring both existing and future risks, these points represent only the beginnings of a much larger conversation across public and private sector stakeholders on addressing risks.





We can expect to see key AAM use case risks reaffirming wider aviation risk areas, as well as bringing in newer thinking with emphasis on the novel aspects. For example:

- Loss of Control. Irrespective of whether there is a remote pilot or on-board pilot, in-flight hazards may lead to loss of separation from obstacles, terrain and other aircraft.
- Lack or loss of electrical propulsion during operations. Whilst system failure due to powerplant is lower in existing aircraft data, many AAM scenarios include new powerplant technology, for electric or other (e.g. hydrogen): the novel nature of this powerplant technology makes it a key area for exploration.
- Battery failure and malfunction. As a subset of the above, battery failure during operation or malfunction is a potential critical risk.

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# **Consumer** Risks

### Advanced Air Mobility use cases also enable us to explore the broader ecosystem and key non-safety risks, under important areas like consumer issues.

AAM is an important driver for important conversations beyond just the safety risks, not least those related to passenger and other end-user views on new services and operations. Early identification of consumer risks is important for assessing viability and feasibility of the commercial business model. Given the interplay between commercial and consumer needs – i.e. meeting consumer needs through acceptable business means - consumer-focused risks need to be fully explored.

Some of the risks under this area will be linked to regulatory questions based around consumer protections and existing economic legislation and existing regulatory processes. How these and other rules will be applied for commercial AAM however needs to be further explored. Questions include:

- How will service providers and others assure booking-related information, the collection of fees and specific passenger scheme (e.g. ATOL) requirements?
- What and how will airline licensing requirements apply to AAM operators and other stakeholders in relation to new services?
- What role will economics play in managing and regulating AAM services? For example, will there be specific mandates or incentives associated with different types of propulsion?

Under our Future Air Mobility Call for Insight (CAP1922) we began to identify some of the risks relating to the potential consumer impacts of the proposed service or operation.

Existing consumer protection and 'duty of care' requirements are helpful identifiers of such issues. These often emanate from cross-sector regimes or authorities, like the Competition and Markets Authority (CMA). Best practice guidance can also prove a useful basis to identifying these risks, for example, <u>LATA's Passenger Rights Principles</u>.

Consideration of passenger journeys under AAM scenarios will require exploration of issues such as:

- Aircraft delayed, diverted or cancelled. Passenger experience is of a high level of interest, with increasing social and political pressure on industry.
- Accessibility for all. Passengers requiring assistance to board and use the service, as well as defining associated terms of carriage and where the service provision begins and ends.
- Liability for operations. Liability is a key area for existing aviation and air service operations. The development of new aircraft and operations has already lead to changes in approaches, through engagement with legal professionals and insurers. As the use cases expand these areas are also likely to give rise to more mature thinking.



Advanced Air Mobility use cases are unlikely to succeed if they do not account for ever-changing social and political influences. Key risks may stem from society's tolerance of noise or its environmental consciousness.

Our Future Air Mobility Call for Insight (CAP 1922) identified some risks in terms of environment and social impacts of the proposed service or operation.

In terms of social impacts, this is a continuation of our exploration of the concept of Social Licence (CAP1900), which highlights the significance of effective engagement and consideration of stakeholder needs when formulating proposals for new aviation services.



The existing standards for management of the environmental impacts of aviation, and current risk models, are a good place to start. Whilst these are subject to change there are strong indications that political and societal concern for environmental impact will only increase this focus.

For example, the UK Airspace Modernisation Strategy (2018) highlights the Government's expectation that "unlocking the benefits of modernisation will make journeys faster and more environmentally friendly". Preferred use cases can therefore reasonably be expected to support reductions in the environmental impact of aviation - whether by reducing noise over populated areas, or by use of aircraft whose propulsion systems use electricity generated under a zero or low emissions process.

Other environmental considerations that are significant to aviation will also be considered under AAM. These include:

- Acceptable noise limits. In terms of legal certification requirements, the nature of many of the AAM aircraft designs are aimed at limiting aircraft noise to below current health and safety limits. However, it will also be important to demonstrate noise levels which are perceived as being at an acceptable level to avoid irritation and adding to overall urban noise.
- Zero emissions flights. While the emissions of the AAM aircraft itself will be of significant importance, there may also be a need to prove the sustainability of the end-to-end process, including for example how the electricity used to charge the aircraft on the ground is generated.
- Visual impacts and maintained distance (including privacy). Society may become more or less accepting of increasingly busier skies, particularly if flights take place at lower altitudes and the frequency of operations is increased. This could lead to the perception of increasing infringements on privacy or increasing risk to third parties.

Thank you to those who responded to the Future Air Mobility Call for Insight (CAP 1922). Alongside this publication, the feedback provided to us will support ongoing work on the development of our thinking on AAM.

This includes important collaboration under the following:

- Through our Regulatory Sandbox we are working with the Eve-led Consortium on a project looking at a specific AAM use case. You can learn more about the project from the Consortium's perspective on their website: <u>https://ukairmobility.com/</u>
- The CAA is one of the key partners of the Future Flight Challenge, managed by UK Research and Innovation (UKRI). You can learn more about this on their website: <u>https://www.ukri.org/our-work/our-mainfunds/industrial-strategy-challenge-fund/future-of-mobility/UKRI</u>

### **Further References**

- IATA Passenger Rights https://www.iata.org/en/youandiata/travelers/passenger-rights/
- CAP1900 Social Licence to Operate: Concept Guide for New Technologies
  www.caa.co.uk/CAP1900
- CAP1930 Testing Novel Technology in UK Airspace www.caa.co.uk/CAP1930

### Tell us what you think

We want to hear your views on this publications and the themes it explores under AAM.

To submit feedback please contact innovation@caa.co.uk

### About the Innovation Hub

We are creating a regulatory environment where innovation in aviation can flourish in line with CAA principles, setting the CAA and the industry on a common journey, by:

- Making it easier for innovators to access CAA expertise & providing a focal point of contact and information;
- Helping innovators maximise regulatory readiness by testing them in safe environments; and
- Accelerating the development of new policies and regulations.



Visit the CAA Innovation Hub for latest updates, guidance and challenges – <u>caa.co.uk/innovation</u>

The Innovation Hub does not provide regulatory approvals or define CAA Policy. Approvals will be assessed independently by our regulatory teams and their decision about whether or not to grant an authorisation or approval will be subject to current regulatory requirements. Whilst the Innovation Hub endeavours to ensure the accuracy of its guidance and materials, the nature of innovation is one of forecasting, continuous development and change and you should seek independent advice on your specific circumstances.