# Low Density Low Complexity Airspace

## A Scoping Study

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## Executive Summary


### Background and method

This scoping study examined future options for safe and cost effective ATM and airspace solutions in Low Density, Low Complexity Areas.

The term "Low Density, Low Complexity" was defined as airspace or airports with relatively few commercial IFR movements. An example environment was specified for the purposes of this study, encompassing the North-West of Scotland, Northern Ireland (excluding Belfast), and the Republic of Ireland (excluding Dublin).

Whilst maintenance of the status quo may be preferred by some stakeholders, the LDLCA environment will be forced to evolve to meet regulatory and policy constraints whilst remaining cost-effective and economically viable. The study therefore assessed possible roadmaps including combinations of operational and technical changes which could support maintaining appropriate services whilst meeting stakeholder performance expectations.

Stakeholder consultations, workshops and previous literature were used to identify and validate feasible operational and technical options for the airspace and airports. These were then gathered into possible scenarios to enable dependencies and trade-offs to be highlighted. The performance impact of various scenarios was assessed, including using a bespoke cost model.

### What are the drivers and constraints in LDLCA?

The example LDLCA region is not homogenous, but there are broad performance expectations in LDLCA which differ from high density environments such as the London or Dublin TMAs. Performance drivers were identified through stakeholder workshops and bilateral consultations.

- Safety performance remains a priority. However, sufficient data is not currently available for uncontrolled airspace to provide evidence for the currently achieved level of safety performance, and thus support for the status quo or justification for any changes. For example, airprox data may not be reported by all users of Class G airspace, meaning a dataset of airproxes for the LDLCA region is biased to those who regularly report. The upcoming Class G safety risk study run by the UK CAA may identify more detailed steps to assessing risk in this environment. Clear arguments and evidence should be available prior to any change being made in uncontrolled airspace to create additional safety layers, and be focused upon the safety risk and exact location identified for the risk.

- Cost-effectiveness is a key driver, and must include consideration of capital expenditure, operational expenditure and the cost of transition. Any change or combination of changes will need to show that they are the most cost-effective option for the region, even if the impact on individual stakeholders will vary. The slim margins mean that the capacity for change is limited in certain stakeholders, arguing for well-planned single-step upgrades where possible.

- Enabling airspace users to carry out their intended operation remains important for the LDLCA region. The commercial "lifeline" services are a particular focus, but this driver equally applies to the military and non-commercial flights. Increasing resilience, i.e. reducing cancellations or diversions, is therefore required but at a cost-effective price. The objective can also be met through increasing or maintaining access to controlled airspace, but there are associated threats to access of LDLCA from expanding volumes of controlled airspace. The possible roadmaps seek to mitigate these through innovative airspace and technical enablers.

- Capacity was a performance driver highlighted by ANSPs and Commercial Air Transport (CAT), referring to whether one or more flights could enter the same airspace or airport at the same time. In low density environments, sector capacity or controller productivity is not a consideration.

As well as stakeholder performance expectations, external policy initiatives may also impact upon the solutions chosen. The UK government policy to release spectrum, specifically the plan to free up aviation frequencies (around 100MHz) in the 2.7 to 3.1 GHz range by 2020-21, will impact preferred solutions for non-cooperative surveillance in the UK. Whilst the most obvious impact is a change in Primary Surveillance Radars in the targeted band, the economic benefits arising from spectrum release may lead to a greater willingness to commit public funding to ensuring the safe transition. No funds are currently committed or planned.

The incentivisation of renewable energy, specifically wind power, also drives change in the LDLCA region. Wind farms impact the airspace as they create interference for Primary Surveillance Radars, and in certain cases present new obstacles for military low flying. However, they have clear driving policies behind their deployment, with the Scottish Government targeting 100% of its power supply from renewable energy sources by 2020, and the Irish government aiming at 20% total power from wind energy by 2020. From the data available, it appears as though the wind farm companies will be strongly incentivised to have UK onshore wind farms approved before 2017, at which point the benefits from their business case may reduce by 25% due to a reduction in the duration of subsidised payments for the electricity supplied. This will impact the timelines for the application of operational or technical mitigations, discussed further in the section on non-cooperative surveillance below.

Finally, a series of regulatory constraints were identified, including the Standardised European Rules of the Air (SERA), the proposed Performance Based Navigation Implementing Rule and the Harmonised Transition Altitude decision. Each of these may have a material impact on the types of services and timeline for changes in the LDLCA regions. The timing of future EASA rulemaking opinions may delay specific decisions in the environment – for example, the planned Implementing Rule for Remote Towers may delay procurement of solutions until after publication.

In light of these drivers and constraints, the study highlighted a number of feasible operational and technical changes and timelines to enable safe and cost-effective solutions in LDLCA.

<u>Feasible operational solutions and recommendations</u>

In general, LDLCA will benefit from a move towards enhanced traffic awareness between stakeholders, using this to mitigate potential mid-air collision risk around aerodromes and in the Class G en-route environment.

The study recognised the varying application of policies on controlled airspace in the UK and Ireland. Irish airspace exclusively uses Class C and Class G classifications at present, and surrounds all airports receiving CAT with Class C airspace. This policy has achieved a large measure of agreement among Irish stakeholders. The harmonisation and simplification of the airspace classification structure ensures consistency, removes confusion and produces commonality of classification throughout Ireland. Guidance material is published to assist those who wish to become involved in developing an Airspace Change Proposal.

The UK uses a more granular risk-based approach, taking account of the interests of all airspace stakeholders, and applies a mix of controlled airspace, mandatory zones and uncontrolled airspace for airports with CAT. Most CTR/CTAs are Class D in the UK. Each decision depends upon many factors impacting upon perceived risk, including but not limited to traffic density, airspace complexity, surrounding environment and airborne equipage. It was recognised in the study that this adds complexity to the understanding of the environment by airspace users compared to the Irish situation.

The use of electronic conspicuity is the prime driver for this benefit, and is being studied in-depth by the UK CAA Electronic Conspicuity Working Group but applies equally to the Irish environment. Electronic conspicuity has been proposed for introduction over the last 8-10 years, partially as a recommendation arising from investigations into two mid-air collisions in the UK by the AAIB. Improving stakeholder ability to be conspicuous, either via a radio, a transponder or an ADS-B OUT transceiver, was considered beneficial only if a market for the technical enabler is available for all users. Voluntary uptake of new technology (e.g. ADS-B OUT) was preferred by airspace users such as General Aviation, with mandatory zones (for transponders or ADS-B) used in specific areas to ensure awareness and provide effective risk mitigation. This awareness could be ground-based via an ATC or ATSOCAS service, or airborne via a cockpit traffic display or collision avoidance function (ACAS).

Improvements could potentially be made to access by reducing Class C/D airspace volumes. The use of mandatory zones with Class E airspace around reduced Class C/D airspace could give access benefits whilst ensuring that the controller has an appropriate awareness of proximate traffic and control over IFR traffic at all times

Non-cooperative surveillance will continue to be required by the UK MoD and by civil aerodromes based on a local safety assessment. The study recognised that protection of controlled airspace from infringing traffic may be achieved via means other than non-cooperative surveillance. A limited mandatory zone may give a level of risk-based protection judged appropriate, for example requiring radio and surveillance-based carriage.

The need for the UK civil aerodromes to protect their ability to provide ATSOCAS[1] up to 60NM out from the aerodrome requires regulatory guidance. This needs to consider the hazards that non-cooperative surveillance provides mitigation against, coupled with how, working with cooperative surveillance, a layered approach can be delivered which meets safety and operational requirements. The Lower Airspace Radar Service (LARS) provision may move to increased sharing between civil and military facilities, funded via existing means. This would incentivise airports and military facilities to maintain the ability to use non-cooperative surveillance for ATSOCAS, and therefore must also be taken into account in any regulatory guidance.

The default application of controlled airspace in Ireland carries an economic impact from the provision an Air Traffic Control service. This service may be required for a single CAT movement per day or even zero CAT movements if the airport is aiming to attract CAT traffic in the future. Even if the service is applied for a few operating hours per day, the cost of maintaining ATCOs and technical systems is a major burden for the aerodrome operators. A recommendation is therefore to investigate the means to ensure equivalent risk outcomes through alternatives to full ATC services (Tower and Approach) provided on-site at individual airports with CAT in Ireland.

These may include: Remote Towers providing equivalent services from a centralised location, a reduction in service level to Flight Information Services with safety assessment evidence that no impact on risk exists, and potentially a remote surveillance-based approach service in a surveillance mandatory zone leading to a GNSS approach. Other longer term mitigations might include airborne surveillance, including electronic conspicuity for ACAS equipped operators.

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[1] Air Traffic Services Outside Controlled Air Space

Feasible technical solutions and recommendations

*Communications*

For communications, VHF voice will remain the primary enabler in LDLCA. Data-link implementation must be application driven rather than technology driven, and at present most ATM applications under development target the high density environments and are focused on controller productivity. The use of 3G/4G/5G may open up new opportunities if non-safety critical applications are promoted, for example the provision of tactical in-flight weather updates (e.g. icing conditions) and the sharing of updated flight trajectory data on IFR flights.

*Navigation*

VOR rationalisation presents a short-term issue for the UK. The recommendation is to replace the VOR-enabled functions by RNAV-based functions, used both for IFR routes and for traffic separation or deconfliction. However, the airspace users must be capable of flying these solutions with appropriately certified and approved equipment, and the cost of implementing them must be appropriate for the service provider. If this is seen to not be the case for certain airports, a short-term mitigation could be the application of geographic or vertical separations. Adopting this approach may be a retrograde step, in terms of service delivery, for an ANSP but it may have value as an interim solution or where traffic levels are low enough that the impact is limited.

In the longer-term, it is assumed that airborne equipage and certification in the UK and Ireland is appropriate for the use of RNAV1 solutions, and that these provide the backbone of navigation routes in LDLCA. RNP1 may become the standard from the European PBN Implementing Rule, but is unlikely to be required for low density environments (for capacity reasons) and would impose unnecessary cost on the airframes. However, airspace users who regularly enter higher density environments (e.g. Dublin, Belfast, Edinburgh and Glasgow) are likely to require RNP1 functionality before 2020, which should be taken into account in today's investment decisions. It is important that the regulators consider providing regulatory guidance at the earliest opportunity on the likely roadmap for PBN implementation in the UK and Ireland, as this impacts airspace user investment decisions. The need to upgrade twice in the space of 4-5 years must be avoided.

We recommend that a coherent local and regional strategy is applied to RNAV and APV implementation. APV functionality imposes additional requirements, particularly for dual pilot cockpits, and should be an airspace user decision taking account of resilience and safety benefits.

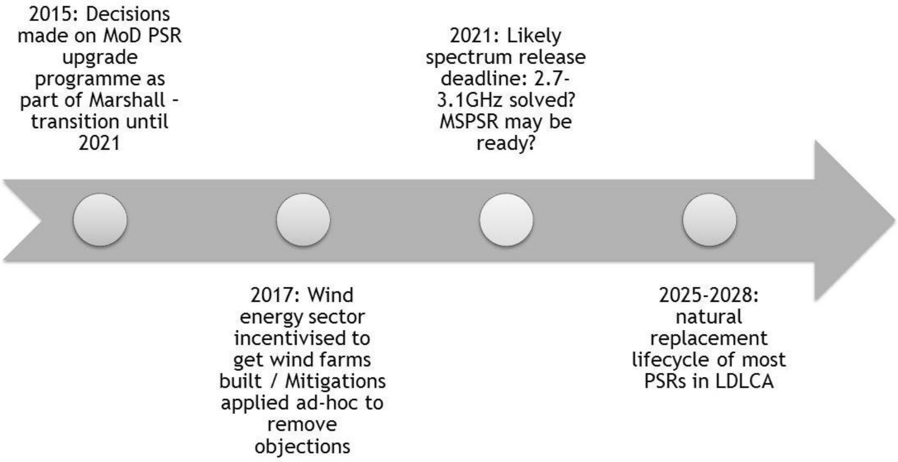
RNAV routes may require a redundant navigation means, probably DME/DME. Whilst on-board inertial systems will provide mitigation for safety-based events (failures), the resilience of the route is compromised by reliance on GPS. In Scotland, this is particularly the case due to the prevalence of military exercises jamming GPS in the region. Galileo is not assumed to be a feasible solution until at least 2023. The low level coverage of the DME/DME or VOR/DME network becomes critical, particularly as many of the routes are below FL195 and not under the license requirements of the en-route ANSP who owns the navaids. The on-going consultations and impact assessments carried out by NERL should take this into account.

*Surveillance*

Non-cooperative surveillance will continue to be required for aerodrome CTR/CTAs and some Class G flight information services. The specific coverage area may change dependent on the evolving requirements for ATSOCAS. The use of distributed surveillance systems such as Multi-Static Primary Surveillance could enable a highly tailored solution, enabling a more precise assessment of wind farm deployment against aviation operational requirements

Without the drivers from wind farm mitigations and spectrum release, many existing civil PSRs in LDLCA would be replaced between 2020 and 2027 dependent on the business case of the alternative solution. The MoD PSRs are expected to be replaced before 2021 as part of Project Marshall's transition period, in order to meet the contractual performance requirements. The IAA PSRs will be replaced at the end of their design life.

However, the wind farm mitigations (and associated government policy driver) and the spectrum release programme could change these considerations. The figure below emphasises the disjointed timeline for non-cooperative surveillance changes.




For certain locations in LDLCA, radar may be the only option as distributed surveillance may not be possible in the open sea.

The UK CAA is working on a Surveillance Strategy to bring together these elements for the UK. The LDLCA regional issues are analogous to the problems faced nationwide, and therefore LDLCA stakeholders should engage with this strategic initiative.

Stakeholders are recommended in the short term to assess which assumptions can be moved in time to align the changes more appropriately, thus avoiding unsynchronised multiple procurements. For example, the business case for wind energy depends on subsidies. These may be able to be moved to apply to a longer timeline (e.g. up to 2022), to ensure enough time to remove wind farm planning objections due to non-cooperative surveillance by using solutions compatible with spectrum release.

The evolution of ground-based cooperative surveillance is less complex than non-cooperative surveillance due to the absence of spectrum release and wind farm mitigation issues. The key drivers are therefore the design lifetime, and potential business case for replacement of MSSRs by cheaper technical enablers. The study concluded that it was likely that the future LDLCA cooperative surveillance environment could be a mix of radar and a solution comprising ADS-B with a Wide Area Multilateration integrity check. ADS-B is currently in a transition period, whilst trust in the new system builds, and therefore the timelines for this solution to be the main cooperative surveillance source may be after 2020, dependent upon regulatory policy. This fits with the design life of the SSRs in the LDLCA region. Ireland is assessing a nationwide deployment of ADS-B, which this study recommends to build confidence in the system and obtain early benefits from situational awareness (electronic conspicuity).

In the future, it is expected that airborne surveillance will play a larger role in assuring safety in the LDLCA region, this being one of the main applications of electronic conspicuity. The absence of a low cost system market has precluded any meaningful technology take-up, along with the debate about the true level of risk of mid-air collisions in Class G airspace. The potential benefits of ADS-B IN/OUT, compared with those found with transponder-only equipage, mean that the business case per aircraft could be more positive assuming a cheap technical solution can be found. The FAA (RTCA) LPSE[2], NATS LPAT[3] and other specifications give encouragement that the market will move forwards on this issue in the next few years, with appropriately certified low cost solutions.

The notion of a Surveillance Mandatory Zone has also been introduced in this report, entailing the fitment of ADS-B OUT or a transponder for access to the zone. This allows those GA (and military) aircraft who wish to equip with an ADS-B transceiver to benefit from access. It is not likely to be appropriate until widespread equipage of ADS-B OUT is seen in LDLCA, estimated after 2020. Nevertheless, to give clear guidance on the issue and encourage equipage, the CAA policy on mandatory zones could consider this for inclusion as a future option.

*Other enablers*

The application of Remote Towers and centralised approach centres is nearing maturity, and in Europe the first units will be operational in 2014 (LFV in Q1, Avinor in Q4). Airservices Australia is also beginning a four month trial of Remote Towers at Alice Springs in October 2013, and the FAA is deploying functionality in Colorado. Both FIS and ATC services can be provided by a Remote Tower unit.

Experience and evidence will be gained from the LFV, Avinor, FAA and Airservices installations, and the cost-benefit and safety cases better appreciated. It is fully expected that the principles of transparent charging will lead to pressure to reduce TWR/FIS costs, and that Remote Towers will give a positive business case, even in the case of island-island communications being necessary.

Early engagement with stakeholders and the CAA is recommended to understand the drivers in more detail, and in particular to identify any integration required with other developments (e.g. licensing, SERA etc).

This study concluded that the application of Remote Towers could be a cost-effective, safe and appropriate solution for the UK and Irish LDLCA regions in the next 5 years, and consideration towards progressing this option further could be made by the Regulator.

A way forward

In summary, the vision for the LDLCA airspace aims to address the challenges from external constraints in a positive and coherent manner, noting that unnecessary services and requirements are not desired in the region. The vision includes RNAV-1 route structures, continued non-cooperative surveillance, a more focused risk-based approach to service provision, and the use of new mitigation layers such as airborne surveillance and enhanced information to provide a safer environment for all users.

The vision will be achieved through a clear strategy laid out for the region at a FAB level, recognising the variance between the UK and Ireland. The strategy should include a stepped

[2] Low Power Surveillance Equipment, comprising specs for a basic transponder with options for ADS-B OUT or ADS-B IN fitment

[3] Low Power ADS-B Transceiver, comprising ADS-B IN and OUT, using either aural awareness or graphical displays

deployment approach to dealing with the constraints highlighted in this report, allowing all stakeholders to plan accordingly. Where uncertainties exist, specific actions should be put in place to provide evidence of preferred options. Particular examples where further evidence is required include the non-cooperative surveillance deployment issues, the use of Remote Towers, and the application and effectiveness of mandatory zones for risk mitigation.

This report is provided to the LDLCA Scoping Study's funding partners, and is recommended to be made publicly available.

It is further recommended that the UK CAA SARG and IAA SRD undertake a programme of work, informed by the Scoping Study, to produce a strategy for low density, low complexity airspace types within the UK Ireland FAB, potentially as part of the Future Airspace Strategy.

This strategic approach could include an LDLCA consultative group, overseeing the production of a UK-Ireland FAS LDLCA strategy including industry consultation. Any plan should be complementary to the UK Spectrum Release Programme's published milestones.

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# 1 Introduction

## 1.1 General

The Future Airspace Strategy (FAS) of the UK and Ireland aims to identify the steps to achieving a vision of “safe, efficient airspace in 2030 that has the capacity to meet reasonable demand, balances the needs of all users and mitigates the impact of aviation on the environment” [1].

To date, much of the work to deliver the FAS has focused on areas of medium and high traffic density airspace in both TMAs and ENR areas. It is necessary to consider how FAS objectives and the wider aviation policies of the UK and Ireland translate into low traffic density and low complexity airspace. An example of such airspace is found in the north and west of Scotland, the west of Northern Ireland and the south and west of the Republic of Ireland. Locally, other parts of the UK and Ireland can be also considered low density and low complexity. The low density, low complexity area, or LDLCA, is a vital part of the overall ATM network in the context of the UK/Ireland Functional Airspace Block (FAB).

This scoping study undertaken by Helios, the UK-based aviation consultancy, aims to help in identifying the options to meet the objectives of the FAS in the low density airspace. The study is overseen by the UK CAA, together with a Project Board with funding partners and key stakeholders[4].

## 1.2 Objectives placed upon the airspace

The vision of the FAS can be translated into a series of key objectives for UK and Irish airspace:

- Safety: enhancements in the safety level achieved in the airspace, through reduction of risk across all operations, should be identified;
- Capacity: the airports and airspace should have the capacity to meet reasonable demand, whilst balancing the needs of all users;
- Environment: mitigate the effect of aviation on the environment, in part achieved by optimising the efficiency of flight operations.

For each of these objectives, assessment for LDLCA must be made in light of the cost pressures placed upon all organisations in the aviation value chain, identifying cost effective ways to meet user needs.

Several secondary aims can also be identified for the airspace:

- Address external developments arising from policy and regulatory requirements that mean that the ‘status quo’ is no longer an option: VOR and NDB rationalisation, the UK spectrum release programme, the impact of wind farms, potential removal of Class F airspace, increased competition with rail and road transport, etc;
- Make the best use of the benefits that new technologies can bring, in particular in terms of safety and cost savings, taking account particularly of the

[4] Project Board members include UK CAA DAP, IAA ANS and SRD, UK Department for Transport, Scottish Transport, Highlands and Islands Airports, UK Spectrum Release Programme, Renewable UK, UK MoD, NATS, and a GA representative.

navigation and surveillance strategies and techniques arising from the SES ATM Research (SESAR) programme; and

- Maintain the connectivity and interoperability with higher density airspace as it develops in terms of operational concept and technical enablers.

The current study looks at the available options and assesses their impact, from today until 2030.

## 1.3 Scope and approach of the study

The purpose of the study is not to develop future strategy and policy, but is to assist and inform stakeholders when making their decisions on future implementations.

The study uses the airspace in the north and west of Scotland, Northern Ireland (excluding Belfast) and the Republic of Ireland (excluding Dublin) as a representative low density, low complexity environment – recognising that the term 'LDLCA' refers to airspace use and not to fixed and clearly defined geographical boundaries. The en-route service above FL 195 is outside the scope of this study.

To ensure a coherent and traceable means of dealing with the various issues in LDLCA, the study is applying a top-down performance-based approach. This is fully consistent with the strategies developed within the FAS, the Single European Sky, and more recently the conclusions of ICAO ANC/12. A benefit of using this approach is to show clear justification for decisions made. If a particular procedure or technology does not show performance-based benefits, but is being kept for "status-quo" reasons, this can be made explicit and alternative approaches investigated.

LDLCA differs from high and medium density airspace areas in the relative priority, and even in the meaning, of Key Performance Areas (KPAs). Safety will remain the top priority, independent of the airspace. Cost-efficiency and capacity are also important in LDLCA, but their context and targets are different. Furthermore, KPAs such as access and equity become very relevant in LDLCA.

The approach is therefore to:

- identify constraints, expectations and assumptions;
- develop a range of feasible scenarios based on the inputs;
- assess each scenario against performance criteria, focusing on a cost model; and
- identify trade-offs and dependencies.

## 1.4 Document structure

The document follows the methodology shown above:

- Section 2 identifies the key characteristics of the current situation in the north and west of Scotland, Northern Ireland (excluding Belfast) and the Republic of Ireland (excluding Dublin) – i.e. the LDLCA 'reference environment' used in this study.
- Section 3 then gives an overview of stakeholder expectations and constraints that were gathered to provide context to the future solutions and their assessment.

- Section 4 provides an overview of solution scenarios to be assessed. These possible solutions are based on the current situation and stakeholder requirements as set out in previous sections.
- Section 5 presents the assessment criteria that will be used to evaluate the scenarios and to gain an understanding of the impact of different decisions.
- Section 6 shows the cost model, its assumptions and estimated costs, and the main outputs in terms of total Net Present Value per scenario.
- Section 7 gives a balanced view of the performance impact for the key performance areas per scenario.
- Section 8 contains the conclusions of the scoping study. It does not make recommendations on a preferred approach, but highlights dependencies, trade-offs and areas of future work.

Annexes A and B contain the acronyms and references lists.

Annex C contains some detailed data on the current situation.

Annex D shows the airspace classification properties.

Annex E shows relevant UK and Ireland Functional Airspace Block initiatives.

Annex F describes the stakeholder expectations obtained through the consultation process and workshops.

Annex G outlines the assessment of dependencies between variables.

Annex H shows the regulatory impacts expected on the LDLCA environment.

Annex I contains a note on the safety data available in LDLCA.

Annex J contains the stakeholder by stakeholder outputs of the cost model.

# 2 Characterising a reference environment for LDLCA

## 2.1 General

To facilitate this study, the geographical scope has been set as the north-west of Scotland, Northern Ireland (except Belfast) and the Republic of Ireland excluding Dublin. This scope is presented on the map in Figure 1 as the area inside the black outline – stressing again that this is solely a reference environment for this scoping study referring to the general airspace usage properties. The upper limit of the airspace considered is FL 195. The scope also excludes any Danger, Prohibited or Restricted Areas.

It is recognised that a variety of operations and airspace is prevalent within this geographical scope, some of which is not typically described as "low density". There is some airspace where full air traffic separation services are provided within controlled airspace, on account of the traffic situation in order to ensure the safety of air traffic. Equally, there are large parts of Class G airspace where very few aircraft operate.

Overall, the LDLCA scope can be characterised by the operation of a few commercial air transport movements per hour. There may be a number of flights in the airspace operating under Visual Flight Rules (VFR), most prevalently General Aviation, Aerial Work and the Military. VFR flights, or smaller airfields from which they operate, usually do not act as a driver on the provision of ATS or underlying ground infrastructure. Nevertheless, they do have requirements on the airspace, primarily from a safety and on-going usage perspective, which are captured and taken into account within this study.

In practice, the boundaries of low density areas are not as strictly defined as a line on a map, particularly when considering airspace, Air Traffic Services, and supporting infrastructure on the basis of customer need. Furthermore, the outlined area will have links to airspace and airports outside the area which need to be considered from a perspective of connectivity and interoperability, i.e. operations in low and high density airspace should not place unduly different requirements on aircraft and pilot.

Finally, as already mentioned, even within the higher density areas in the south of the UK and the east of Ireland there are airports and parts of the airspace that do not follow the general concept of high density commercial jet operations. For those areas, some of the findings of this study could still be relevant.

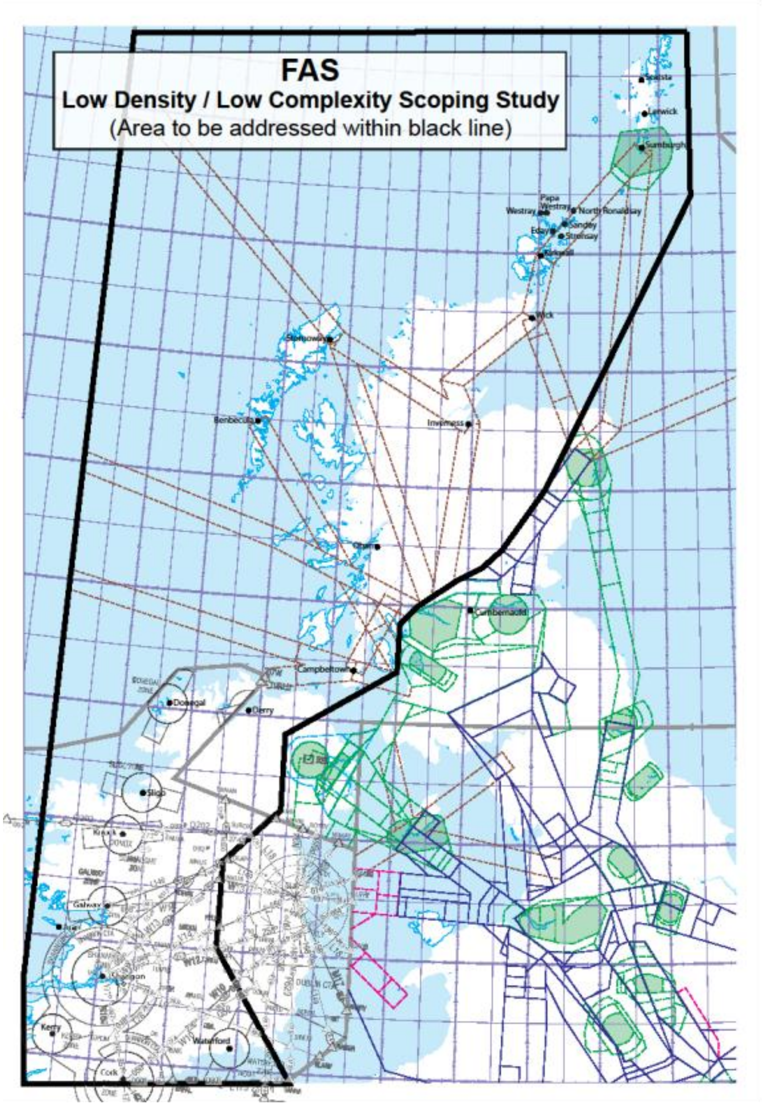



**Figure 1: Geographical scope of the study**

## 2.2 Airports and airfields

There are a significant number of licensed aerodromes in the LDLCA area, which accommodate a wide range of activities. These include both civilian and military aerodromes, some with a high volume of movements.

For the areas outside controlled airspace, there are also a number of unlicensed aerodromes with reasonably unregulated operations – farm strips, fields etc. In general, these aerodromes do not require any specific infrastructure or airspace, and are therefore not considered in detail in this study. However, the operations from these aerodromes, and the airspace that their users fly in, must be considered as they have a bearing on the interoperability and safety of the airspace. This includes microlight activity, gliding and potentially unmanned operations in the future.

Specifically, the publically licensed aerodromes included in the defined scope of this study are:

- In the UK:

    - HIAL owned and operated airports: Barra, Benbecula, Campbeltown, Inverness, Islay, Kirkwall, Stornoway, Sumburgh, Tiree and Wick
    - Other Orkney Islands airports: Stronsay, Eday, North Ronaldsay, Westray, Papa Westray and Sanday
    - Other Shetland Islands airports: Scatsta and Tingwall
    - Other Argyll and Bute airports: Oban, Coll, Colonsay and Glenforsa
    - Eglington / City of Derry
- In Ireland:
    - Cork
    - Donegal
    - Galway
    - Kerry
    - Ireland West (Knock)
    - Shannon
    - Sligo
    - Waterford
    - Connemara
    - Aran Islands airports: Inishmore, Inishmaan, Inisheer

Beyond these airports, there are a wide range of smaller ordinary licensed (i.e. private) and unlicensed airfields in both the UK and Irish geographical area considered. These airfields primarily accommodate general aviation activities such as microlights, gliders, hang gliders, paragliders, parachuting and balloons.

Due to their nature, it is difficult to create a comprehensive overview of all relevant fields and the density of traffic using them. To illustrate the scope of the airfield situation, and in particular to highlight the large number of existing airfields in the area, a list of airfields is included in Annex C. The airfields included in the list generally have some facilities available to support aviation (aircraft parking, fuel). Beyond these airfields, there is a wider range of farm strips etc that can accommodate GA activities.

Operations at these airfields are considered in this scoping study, since they are important in understanding the full impact of any changes to the ATM system or airspace. The study is reliant on expert opinion to ascertain performance and cost impact; the lack of reliable data on movements and activity around the unlicensed airfields means that detailed statistics cannot be used.


**Figure 2: Public licensed airports in the LDLCA region**

## 2.3 Airspace users

Almost all categories of airspace users operate in the low density low complexity area defined in the preceding section. Whilst Commercial Air Transport has the most impact on the airspace structure and classification (due to the need to acceptably protect the fare-paying passenger), each of the users have a valid right of access to the airspace on an on-going basis. This influences the scenarios developed within this scoping study, since a balance must be struck between the needs of the Commercial Air Transport, the military, and the wider General Aviation community.

Commercial Air Transport in LDLCA often has the function of providing essential links to and from remote areas and islands. For some of the islands, air transport is and will continue to be the only feasible rapid connection to major population centres with e.g. hospitals. This is known as a “lifeline service”. For remote areas, competition from rail and road is growing in some cases. Some of the operations receive support from local, regional or national authorities, either through declaring the route a Public Service Obligation (PSO) with associated funding, or through direct subsidies for ticket prices, in particular for residents of the remote areas.

The challenging conditions in and around some of the aerodromes, in terms of weather, terrain and facilities, can put forward very specific requirements for the aircraft that operate on these routes.

Generally, the aircraft operated by commercial operators in LDLCA are small turboprop aircraft, ranging from the Britten-Norman Islander (around 10 passengers) up to the ATR-72 (around 70 passengers). In some specific cases

(Inverness, Derry, Cork, Kerry, Knock), medium sized jets are active, such as Boeing B737 and Airbus A320. These jets also operate at Shannon, and additionally some larger aircraft such as B757 and A330 fly from Shannon to the US. Some business aviation aircraft also operate in the region, from medium-long haul business jets to small turboprops.

A specific sub-category of CAT in LDLCA is helicopter traffic, especially traffic to and from offshore oil rigs. Main helicopter operating bases are relatively flexible and can change from time to time, depending on both operational requirements and most economically advantageous ‘home base’ location. More drastic changes to helicopter bases and flight patterns could occur if oil exploration moves to different areas around the UK and Ireland. For example, HIAL are experiencing a significant increase in helicopter traffic serving the West of Shetland basin and all indications are that this traffic is likely to increase over the next few years in line with the significant investment in offshore drilling and production. This additional helicopter traffic is also resulting in increased fixed wing movements (both charter and scheduled) from Aberdeen to Shetland.

The military is an active airspace user in LDLCA. For the UK, the main base in the area is RAF Lossiemouth, and there are several ranges and low flying areas nearby. Recently, Typhoons have started operating from RAF Lossiemouth in addition to the existing Tornadoes. The military uses a ‘train as you fight’ concept, and aims to share the airspace with other traffic as much as possible, rather than block specific areas of airspace.

Beyond the fixed RAF base with its local fleet, the military also uses LDLCA for several exercises every year, specifically Joint Warrior and the qualified weapons instructor course. This puts a higher pressure on the use of the airspace, and specifically for Joint Warrior it brings in aircraft and pilots from different countries who may not be familiar with the area and its characteristics.

In Ireland, the Irish Air Corps operate mainly in and around the Dublin area and the training area to the South-West of Dublin. However, the military are active across Ireland and must be able to operate without restriction in the future environment.

General Aviation shows a wide range of activities in LDLCA, operating a diverse set of aircraft types with varying levels of equipage. Powered fixed-wing flying occurs throughout the region, with touring taking place in Ireland and the west of Scotland, and a large training school in Dundee. Operations in the area also include limited GA rotorcraft, and many gliders and microlights.

In specific cases, residents in remote areas and in particular on the Scottish islands also have access to their own aircraft for reasons of mobility. Outside controlled airspace, certain aircraft and rotorcraft can operate from any piece of land deemed suitable; this is particularly seen with microlights and ultralights in the UK and Ireland.

Other specific airspace users in the LDLCA area are the Coast Guard, SAR and air ambulance services. Remotely Piloted Air Systems (RPAS) are not currently operated widely in the area, or only under very specific conditions, but they may become important users going forward. At present, this study assumes that the RPAS will be required to be fully transparent in terms of operations in the area. In other words, they will need to act exactly as piloted aircraft. Whilst there is a possibility they could be introduced in controlled airspace under IFR in the medium term (e.g. 2020-2025), their integration into Class G airspace appears to be further off, with the success (and evidence) of the sense-and-avoid system a key enabler under development.

As important as the types of operators is the exact construct of the fleet, including equipage and performance.

*Example 1:* One type of helicopter with extended range may enable a certain airfield to be used as a base for flight operations to the oil and gas fields; if this is replaced in future years with a reduced range helicopter, a different airfield may become busier and more complex in terms of operations, with the resultant implication for airspace and enabling CNS.

*Example 2:* Fleet evolution is a critical factor for the potential equipage of the operators in the LDLCA. The presence of small regional aircraft in the airspace is necessary from an operational and economic viability perspective, but brings a fragmented equipage profile for CNS. The cost of retrofitting many of the smaller aircraft is prohibitive for many operators; thus the fleet evolution becomes the driving factor for the ability of the aircraft to take advantage of the latest CNS/ATM evolutions, either through new leasing arrangements or forward fit equipment on aircraft purchases. In some cases, additional requirements are levied on dual pilot operations over single pilot ops, for example the presence of a hot back-up capability.

The current situation for the main airports in LDLCA is described in Table 2 and below. With regards to CAT at UK and Irish airports in LDLCA, the scheduled carriers most frequently operating in this area include Loganair, Aer Arann, FlyBe, easyJet and Ryanair.

For the UK, movement data is gathered centrally by the CAA. For Ireland, data is not gathered centrally, and different sources have been used. In some cases, Irish airports consider traffic data confidential. Where possible, estimates have been included based on publicly available data.

| Airport | Total movements (2011) | CAT (%) | Main CAT operators | Main CAT aircraft types |
|---|---|---|---|---|
| Barra | 1258 | 95% | Loganair | Twin Otter |
| Benbecula | 4366 | 90% | Loganair | Saab340 |
| Campbeltown | 1993 | 55% | Loganair | Twin Otter |
| Eglinton / Derry | 8464 | 50% | Ryanair | B737 |
| Inverness | 30755 | 50% | Loganair, FlyBe, easyJet | A319, E175, DHC-8, Saab340 |
| Islay | 3003 | 65% | Loganair | Saab340 |
| Kirkwall | 14131 | 90% | Loganair | Saab340, Islander |
| Scatsta | 14475 | 90% | Eastern | Jetstream 41 |
| Stornoway | 11255 | 80% | Eastern, Loganair | Jetstream 41, Saab340, Dornier 328 |
| Sumburgh | 12228 | 75% | Loganair | Saab340 |
| Tiree | 1111 | 90% | Loganair | Saab340, Twin Otter |
| Wick | 4734 | 50% | Loganair, Eastern | Saab340, Jetstream 41 |

**Table 1: UK airport movement overview for LDLCA[5]**

[5] UK ATM and CAT proportion taken from CAA data for 2011; main operators and aircraft types taken from Flightglobal.com, for April 2013.

| Airport | Total movements | Main CAT operators | Main CAT aircraft types | Comments |
|---|---|---|---|---|
| Connemara | 5800 | Aer Arann | Islander | Movement figure only covers flights to Aran Islands, as estimated from Aer Arann Islands timetable |
| Cork | 48061 (46% CAT) | Aer Arann, Aer Lingus, Jet2, Ryanair, WizzAir | A320, B737, ATR72 | 2011 traffic figures provided by IAA |
| Donegal | 2857 (78% CAT) | Loganair | Saab340 | 2011 traffic figures provided by the airport |
| Galway | 12233 (31% CAT) | *None currently in 2012* | | 2011 traffic figures provided by the airport |
| Inishmore, Inishmaan, Inisheer | 5800 | Aer Arann | Islander | See Connemara |
| Knock | 8808 (70% CAT) | Aer Arann, Aer Lingus, FlyBe, Ryanair, Lufthansa | A319, A320, B737, DHC-8 | 2011 traffic figures provided by the airport |
| Kerry | 3700 | Aer Arann, Ryanair | B737, ATR42 | Movement figure is an estimate based on Kerry Airport schedule and only covers scheduled commercial flights |
| Shannon | 27828 (69% CAT) | Aer Arann, Aer Lingus, BA, Ryanair, UA | A320, B737, B757, ATR72, A330 | 2011 traffic figures provided by IAA |
| Sligo | | *None currently in 2012* | | |
| Waterford | 750 | FlyBe | DHC-8 | Movement figure is an estimate based on Waterford Airport schedule and only covers scheduled commercial flights |

**Table 2: Irish airport movement overview for LDLCA[6]**

## 2.4 Airspace

Airspace is allocated depending on the need to actively control access to airspace and the nature of the activity that takes place within it.

The application of a particular airspace classification to a particular volume of airspace will usually depend upon the number of air traffic movements within it, the

[6] Note: 2011 traffic figures allowed a like-for-like comparison, as some 2012 figures were not available at the time of this study.

complexity of IFR operations within it and also upon the safety hazards posed to public transport flights operating under IFR (source: CAA website).

There is a clear difference in approach to airspace classification in the UK and Ireland; the main characteristics of each approach are discussed below.

### 2.4.1 UK (Scotland and Northern Ireland)

The bulk of airspace in the Scottish and Northern Irish areas of interest is class G airspace. Class G is uncontrolled airspace, where IFR and VFR flights are permitted and receive flight information service if available and requested, as described above. For Commercial Air Transport, it is the least preferred airspace category to fly in, due to the unknown traffic environment and lack of a separation service. Nevertheless, in certain instances, and subject to a risk assessment by the flight operations function, CAT does transit Class G airspace in a limited manner.

Apart from Class G, the airspace in the north of Scotland is currently characterised by the presence of Class F containing Advisory Routes (ADRs). All participating IFR flights receive an air traffic deconfliction service, in addition to the rules and provisions available in Class G. Class F airspace will be removed in the UK by November 2014, in line with the application of the Standardised European Rules of the Air (SERA).

Annex D summarises the characteristics of Class F and G airspace.

The only exceptions from a UK perspective to the application of Classes F and G in the geographical scope of LDLCA used for this study are:

- use of Class D for the Sumburgh CTR/CTA.
- use of Class C for the section of the Eglington CTA within Irish airspace. Within UK airspace, no CTR/CTA is defined and all airspace is Class G.

*It is noted that Inverness is also currently preparing an Airspace Change Proposal to apply a proportional CTR/CTA.*

Figure 3 illustrates the different classifications of airspace in the LDLCA scope. During consultations, stakeholders noted that the prevalence of Class G airspace in this area might be a simplistic assumption. The different types of traffic and the level of activity render the airspace non-homogenous, but instead potentially complicated from a localised perspective.


**Figure 3: Airspace classes in North Scotland and Northern Ireland**

### 2.4.2 Republic of Ireland

In Ireland, airspace classification follows a simplified structure, being either Class C or G. Again, Annex D lists the rules applied within these classifications.

All airports with an air traffic service and within the scope of this study have a Class C CTR up to 5,000 ft. For Cork and Shannon, the CTR has a 15NM radius; for Donegal, Galway, Knock, Kerry, Sligo and Waterford the CTR has a 10NM radius. For the latter six airports, airspace classification changes to Class G outside operational hours.

For Donegal, Knock, Galway, Kerry, Sligo and Waterford: when the CTRs are published as active, additional associated controlled airspace (i.e. stubs along the approach and departure paths) is also activated as Class C. Outside hours of published operation of the airports, this airspace reverts to Class G. As a general rule, in Irish airspace all CAT is kept within Class C and does not fly into Class G. Occasionally, exceptions occur due to pilot requests for continuous descents or direct routings.

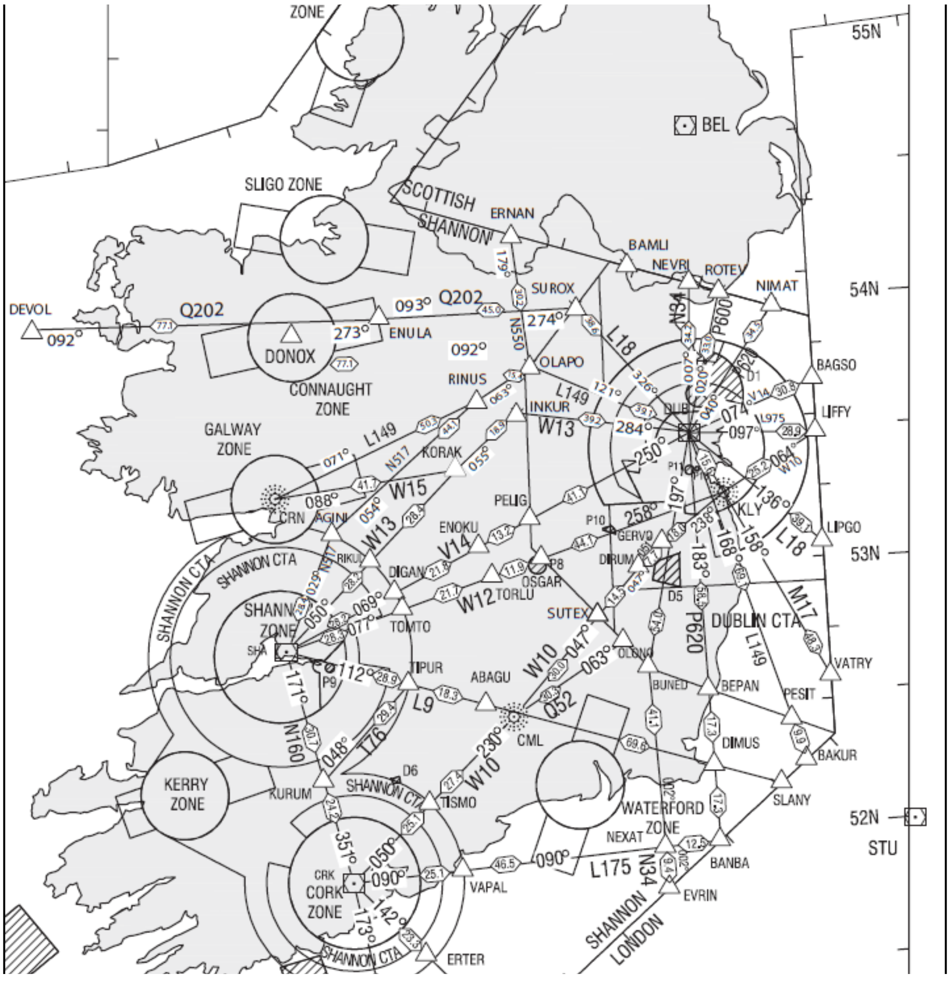



**Figure 4: Airspace for the Republic of Ireland**

## 2.5 Air Traffic Services

### 2.5.1 UK (Scotland and Northern Ireland)

Any Air Traffic Services (ATS) must be provided by a certified Air Navigation Service Provider (ANSP), designated to provide air navigation services in line with the EU's common requirements Implementing Rule [2].

Outside of the en-route license conditions (assigned to NATS En Route Ltd, NERL), ATS in the UK is provided to users on the decision of the operator of an aerodrome or facility (e.g. military range) based on safety, efficiency and financial factors. Note that once an aerodrome or surrounding airspace operational complexity increases over a certain limit, the regulatory authority (CAA) may require a control service to be provided to ensure acceptable safety levels.

The following is an overview of services on and around the relevant airports:

- Approach services are currently provided at Inverness and Sumburgh. Sumburgh APP/APS is provided from Aberdeen under contract with NATS Services Ltd (NSL).
- TWR and APP services are provided at Inverness and Derry during opening hours.
- TWR and APP services are provided for limited time periods at Kirkwall, Stornoway, Sumburgh, Wick and Benbecula. Outside the specified hours, a Flight Information Service is provided.
- A Flight Information Service only is provided at Barra, Campbeltown, Islay and Tiree.

The en-route service above FL195 is outside the scope of this study.

As noted above, Advisory Routes (ADR) currently exist in the LDLCA area, where participating aircraft are provided with a procedural deconfliction service with Class F airspace assigned. The Class F airspace (and underlying routes) is subject to an on-going CAA consultation, with the publically stated intention by the CAA to reclassify the airspace by November 2014 as Class E, with a Transponder Mandatory Zone (TMZ) ensuring it is a “known” traffic environment.

In addition to the civil airspace infrastructure, there are also a number of military areas in the north and west of Scotland, both over land and offshore. The main area of activity is the Highlands Restricted Area, comprising low-flying activity down to 100ft AGL, and the area immediately around RAF Lossiemouth. Several weapons ranges are covered by restricted airspace, including Cape Wrath and Tain.

ATS in Class G follows the guidelines laid down within CAP774 Flight Information Services (FIS), which in the UK includes the concept of ATSOCAS (Air Traffic Services Outside of Controlled Air Space) [3]. Four levels of FIS are defined:

- A basic service – an ATS provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights. This may include weather information, changes of serviceability of facilities, conditions at aerodromes, general airspace activity information, and any other information likely to affect safety. The avoidance of other traffic is solely the pilot's responsibility;

- A traffic service – a surveillance based ATS, where in addition to the provisions of a basic service, the controller provides specific surveillance-derived traffic information to assist the pilot in avoiding other traffic. Controllers may provide headings and/or levels for the purposes of positioning and/or sequencing; however, the controller is not required to achieve deconfliction minima, and the avoidance of other traffic is ultimately the pilot's responsibility;

- A deconfliction service – a surveillance based ATS where, in addition to the provisions of a basic service, the controller provides specific surveillance-derived traffic information and issues headings and/or levels aimed at achieving planned deconfliction minima, or for positioning and/or sequencing. However, the avoidance of other traffic is ultimately the pilot's responsibility;

- A procedural service – an ATS where, in addition to the provisions of a basic service, the controller provides restrictions, instructions, and approach clearances, which if complied with, shall achieve deconfliction minima against other aircraft participating in the procedural service. Neither traffic information nor deconfliction advice can be passed with respect to unknown traffic. A procedural service does not require information derived from an ATS surveillance system. Therefore, due to the ability for autonomous flight in Class G airspace, pilots in receipt of a procedural service should be aware of the high likelihood of encountering conflicting traffic without warnings being provided by ATC.

Both civil and military air traffic control units provide the ATSOCAS, with the majority in Scotland provided through Scottish ATCC (ScATCC), staffed by both military and civilian controllers.

FISOs can only provide a basic service. Controllers at approved ATC units that do not have surveillance equipment available will routinely apply a procedural service to aircraft carrying out IFR holding, approach and/or departure procedures.

### 2.5.2 Republic of Ireland

In Ireland, the IAA provides the en-route and terminal services, with aerodrome services being provided by specified aerodrome ANSPs.

At three aerodromes, the provider of terminal and aerodromes services is the IAA (Cork, Shannon and Dublin – the latter outside the scope of this study). Both Cork and Shannon are operational 24/7.

Six aerodromes in the LDLCA scope operate their own ANSP providing (procedural) approach and aerodrome control (Donegal, Kerry, Knock, Galway, Sligo, and Waterford).

The provision of a control service is predicated on legislation (Statutory Instrument S.I. 856 of 2004) requiring an air traffic control service to be provided if an active radio-navigation approach aid is installed and during the hours it is published as available for use [8] – this would assumedly also apply to GNSS-based approaches.

## 2.6 CNS Infrastructure

Any CNS infrastructure in the LDLCA should be in place to support the services and operations under consideration for that airspace. Whilst there may be the opportunity to take benefit from infrastructure in place for other purposes (e.g. military, or en-route civil services), it must be confirmed that the enablers will be available on an on-going basis.

CNS covers the airports and the surrounding en-route area. With much of the en-route airspace below FL195 in the area being Class G, there is limited need for surveillance, communications or navigational infrastructure.

### 2.6.1 Communications

Communications in LDLCA are currently supported by an infrastructure of traditional VHF ground stations. These provide coverage for the en-route area, and cover much of the LDLCA region below FL195. However, line-of-sight will limit coverage at low altitudes.

On the airborne side, since the majority of the relevant UK airspace is uncontrolled Class G with some Class F routes, there is no requirement for aircraft to be equipped with a radio. The only exception in UK LDLCA airspace is the Class D Sumburgh CTR. In Ireland, airspace around the airports and above FL75 is Class C, with associated requirements for carriage of radios.

In terms of the ground infrastructure, the impact of interference by wind farms needs to be taken into account. This problem is more commonly recognised for surveillance (as will be discussed later), but interference with voice communications is perceived to be an issue and is being investigated further. While there are no known solutions to this problem, in relative terms (compared to surveillance equipment) it is easier to move a VHF ground station as a last resort.

### 2.6.2 Navigation

The ground-based navigation infrastructure in LDLCA is primarily based on and around the airports. Although much of the infrastructure was originally installed to support en-route operations, navaids are also used by the airports to define approach procedures.

Use of GNSS as a primary means of navigation is still limited in LDLCA, largely due to aircraft equipage and availability of procedures – recognising that the two are closely linked. Nevertheless, the existing policies and circular [7,9], and planned regulatory material in the PBN-IR [4], are likely to encourage uptake in the short-medium term.

Some early UK implementation of GNSS-based approaches has taken place, primarily under the EC-funded ACCEPTA programme. Early implementation in the reference LDLCA environment is planned at Benbecula, Barra and Campbeltown, with further procedures due to be implemented at Stornoway, Tiree, Islay, Kirkwall, Inverness, Sumburgh, and Wick. In Ireland there are plans to implement LNAV and LNAV/VNAV GNSS approaches at Dublin airport and at a number of the regional airports. There are also plans to avail of GSA support and implement an EGNOS based LPV approach at Dublin airport. Ireland also has RNAV SIDs & STARs published for Dublin, Cork & Shannon airports.

Current navigational aids in UK airports are shown in Table 3.

Within the UK, many of the ground-based navaids were originally installed to support en-route traffic and are owned and operated by NERL on this basis. This causes issues when NERL make changes to the infrastructure, as the impact is felt in lower airspace – despite the fact that users in lower airspace do not receive a service from NERL and therefore do not pay towards the investment in and maintenance of the ground-based infrastructure.

This is particularly relevant at the time of writing, as NERL is looking to rationalise the VOR infrastructure for reasons of cost efficiency and spectrum efficiency. For en-route traffic suitable alternatives are available, so there is no operational impact in NERL's area of responsibility. For lower airspace however, these alternatives are not generally available, and in any case not to all airspace users. The VOR rationalisation and Spectrum Release programmes are discussed further in Section 3.2.

| | Navigational infrastructure | | | | |
|---|---|---|---|---|---|
| **Airport** | **NDB** | **DME** | **DME/VOR** | **ILS/LOC** | **ILS/GP** |
| **BARRA** | x | | | | |
| **BENBECULA** | x | x | x | | |
| **CAMPBELTOWN** | x | | x | | |
| **CITY OF DERRY (EGLINTON)** | x | x | | x(2) | x(2) |
| **INVERNESS** | x | x | x | x(2) | x(2) |
| **ISLAY** | x | x | | | |
| **KIRKWALL** | x | x | x | x(2) | x(2) |
| **OBAN** | x | x | | | |
| **SCATSTA** | x | | | | |
| **STORNOWAY** | x | x | x | x(2) | |
| **SUMBURGH** | x | x | x | x(2) | x |
| **TIREE** | | | x | | |
| **WICK** | x | | x | | |

**Table 3: Navigational infrastructure at UK airports**

In Ireland, the airports operate their own local navaids – as well as using the wider IAA infrastructure to define approach procedures. This gives the airports much more control, although of course it means that cost for investment and maintenance also lies with them.

Navigational aids at Irish airports are shown in Table 4.

| | Navigational infrastructure | | | | | |
|---|---|---|---|---|---|---|
| **Airport** | **NDB** | **DME** | **DVOR/DME** | **ILS/DME** | **LOC** | **GP** |
| **CORK** | | | x | x(2) | x(2) | x(2) |
| **DONEGAL** | x | x | | | x | |
| **GALWAY** | x | x | | | x | x |
| **IRELAND WEST / KNOCK** | x(2) | | x | x | x | x |
| **KERRY** | x | x | | | x | x |
| **SHANNON** | x(4) | | x | x(2) | x(2) | x(2) |
| **SLIGO** | x | x | | | | |
| **WATERFORD** | x | x | | | x | x |

**Table 4: Navigational aids at Irish airports**

### 2.6.3 Surveillance

At airport level, the majority of civil airports in LDLCA do not have access to surveillance, primarily due to the cost-benefit of providing a surveillance service and supporting infrastructure when there is a low traffic density.

In the UK, the exceptions are Inverness, which has its own primary and secondary radar, and Sumburgh, which receives approach control from NATS Services Ltd under contract to HIAL (provided from Aberdeen), with the use of primary and secondary surveillance data being part of the contract. The surveillance feed for Sumburgh is provided through existing NATS surveillance equipment.

The Primary Surveillance Radars in the LDLCA region are:

- Three PSRs owned by en-route ANSPs – Cork (IAA), Shannon (IAA) and Allanshill (NERL);
- Two PSRs owned by aerodrome ANSPs – Inverness (HIAL) and Compass Head/Sumburgh (NSL) – the latter is used for services to North Sea helicopters;
- Three MoD PSRs – West Freugh, Lossiemouth and St Kilda. Note that Allanshill is also used by the MoD under the FMARS[7] contract with NERL.

The Secondary Surveillance Radars in the LDLCA region are:

- Six en-route ANSP MSSRs – Stornoway, Tiree, Fitful Head/Sumburgh, Allanshill (all NERL), Cork and Shannon (both IAA);
- One aerodrome ANSP MSSR – Inverness (HIAL);
- Two MoD MSSRs – Kinloss and St Kilda – note that Leuchars is considered to be outside the geographical boundary of the LDLCA region of this scoping study.

[7] Future Military Area Radar Services – a contract between the MoD and NATS to allow the MoD to utilise NERL surveillance infrastructure to provide their own services.

- Fitful Head/Sumburgh and Allanshill are within the FMARS programme.

For the NERL owned radars, they are used for provision of ATC services in the en-route domain, mostly over FL 195. Whilst the services are outside the scope of this study, the radars impact upon the environment and any future solution. A particular issue to consider for primary radar in LDLCA is the presence of wind farms, which affect performance in certain cases. In particular in Scotland, significant wind farm development is taking place, with the active support of Scottish Government. The impact this has on surveillance, and the solutions available to mitigate the impact, will be covered later in this report.[8]

In Ireland, the non-State airports (within LDLCA) do not currently have access to surveillance information. The State-run airports within the LDLCA geographical scope – Cork and Shannon – both have primary and secondary surveillance radar.

In the airspace surrounding the airports, the differences in airspace classification between the UK and Ireland lead to different surveillance coverage requirements. Since most of the airspace on the UK side is uncontrolled Class G, there is no requirement for surveillance coverage. In practice, existing surveillance feeds may be used to support ATSOCAS, either civil or military.

In Ireland, Class C controlled airspace exists down to FL75, with a control service provided from Shannon. Primary and secondary surveillance data is available to support the service. Several of the non-State airports have indicated that in theory they could use Shannon surveillance data for their surrounding airspace (down to an altitude that varies between airports, due to line-of-sight issues with terrain), but there are no contractual and financial arrangements in place for this.

[8] Note that the military Air Defence radars are outside the scope of this study. The use of military surveillance for ATSOCAS or SAR is considered, but only at a high level.

# 3 Stakeholder expectations and constraints

This section contains a summary of the main expectations and constraints guiding the development of the airspace and Air Traffic Services in the low density low complexity areas.

## 3.1 Existing transport policies

### 3.1.1 UK Government

The Department for Transport within the UK Government published a sustainable framework for aviation in the UK in March 2011. This framework led into a draft aviation policy framework, released for consultation in July 2012. Both these documents place a focus on enabling the economic growth of the UK through the contribution of aviation, whilst taking appropriate account of environmental factors.

Most of the policy frameworks do not apply to the LDLCA scope, and are more suited to the South East airport debate. However, a few areas are directly relevant, including:

- Regional airport connectivity. Para 2.21 states “Airports in Northern Ireland, Scotland, Wales and regional airports in England also play a very important role in UK connectivity”; this includes policy-based support for regional airports for connectivity and economic benefit, whilst remaining within EU competition guidelines requiring a free and equitable market;
- The use of Public Service Obligations (PSOs) to ring-fence slots into London’s airports from the regions, whilst conforming to EU law and being in response to economic need; the lack of a Heathrow-Inverness route is specifically mentioned, as are the alternatives from Inverness to Gatwick and Luton;
- The use of Route Development Funds, particularly for smaller airports and regions with low passenger demand; para 2.59 states “The UK has highlighted concerns that the current guidance on start-up aid does not provide sufficient scope to support the establishment of routes from outer regions of the EU, including routes from within Northern Ireland, Scotland and Wales”; the government has stated it will look for more flexibility from the EC in the application of start-up aid where this will not distort competition;
- Maintaining a viable network of General and Business Aviation: the policy framework includes support for smaller local airfields on the basis of the impact on the wider GA network and the local economy should the airfield close; it encourages local airports to continue to provide equitable access to GA, whilst taking into account the needs of all users; and it aims to apply proportionate regulation on the sector;
- The application of the European Environmental Noise Directive (2002/49) requiring all airports with over 50,000 movements per annum (excluding training flights on light aircraft) to produce a Noise Action Plan; whilst this currently does not include any airports within LDLCA, a small growth in traffic may lead to the busier aerodromes in the area being required to complete a plan and mitigate noise actively and transparently;
- The application of noise abatement operational procedures, through application of Noise Preferential Routes and the use of continuous descents and climbs, and higher accuracy routes;

- The issue of noise in rural areas, since aircraft noise in the countryside was claimed to be relatively more annoying than in urban areas, due to lower background noise levels; this includes the CAA's legal duties to have regard to the purpose of National Parks and Areas of Outstanding Natural Beauty when ruling on Airspace Change Proposals;

- Noise from GA and rotorcraft; the framework states "It would not be appropriate for the Government to intervene by exercising powers under section 78 of the Civil Aviation Act 1982 to set noise controls at small aerodromes. Industry has developed codes of practice and the CAA has produced guidance" [10].

#### 3.1.2 Scottish Government

Whilst much of aviation policy is reserved under the UK's Department for Transport, and input to by the Devolved Administrations in Northern Ireland, Scotland and Wales, there are aspects of the strategy and policy which are devolved and specific to Scotland. In particular, the degree of application of subsidies and specific economic arguments for applying them are unique to each region.

The Scottish Government outlines its long-term national transport strategies and objectives, which also include specific objectives and policies for the Highlands and Islands region, in the following documents:

- Scotland's National Transport Strategy
- HITRANS-Regional transport strategy for the Highlands and Islands
- ZetTrans-Shetland Transport Strategy
- HIE-Operating plan 2012-2015

The Scottish Government recognises that the provision of air services in the Highlands and Islands is vital to the social and economic welfare of the area. HIAL airports are supported by subsidies from the Government. "*Deficit grant is paid to the company in respect of the losses incurred in its operation and this allows airport charges for domestic flights to be contained at a level which ensures the continuation of essential air services.*" [5]

Three important policies targeted at air links have supported the Government in achieving its objectives, the Air Discount Scheme, PSO routes and the (now defunct) Route Development Fund. The remainder of this section is paraphrased from the Transport Scotland website.

The Air Discount Scheme (ADS) aims to offer an affordable price for air travel for the residents of remote communities in the Highlands and Islands region. It offers a 40% discount on the applicable air fare for residents of all island groups (excluding Barra and Tiree which are served by PSO services) plus Caithness and Sutherland for air travel to the four key airports of Aberdeen, Edinburgh, Glasgow and Inverness.

A lifeline service (or PSO) is an obligation imposed on a carrier to provide a set level of service on a particular route in order to ensure that the service satisfies fixed standards of continuity, regularity, capacity and pricing. Subsidies are then paid to an air operator, contracted via an open competition. Routes operated in the Highlands and Islands would not be viable without being characterised as PSOs. Main lifeline routes include Glasgow-Tiree, Glasgow-Barra and Glasgow-

Campbeltown. Lifeline services have also been imposed on routes within Shetland, Orkney, Comhairle nan Eilean Siar and Argyll and Bute Council, all of which are subsidised by the local authorities. The PSOs in the Highlands and Islands are also exempt from the EU Emissions Trading Scheme.

With regards to air route development, the Government had established the Route Development Fund (RDF) which significantly influenced airlines' route development decisions, but this programme was halted by European guidelines on competition and State aid in 2007. Prior to RDF, the majority of international traffic to Scotland was routed through hub airports such as Heathrow. The RDF contributed to a dramatic improvement in Scotland's direct international air network by concentrating only on those routes that helped business and in-bound tourism.

### 3.1.3 Irish Government

The Irish Department of Transport, Tourism and Sport is in the process of developing an Integrated Irish Aviation Policy. This is currently pre-draft, with the drafting process aided by the release of an Issues Paper [6]. The high level goal set for aviation is to ensure that it supports Ireland's economic and social goals in a safe, competitive, cost-effective and sustainable manner and to ensure maximum connectivity for Ireland with the rest of the world.

As part of the goal to formulate an integrated policy, the Issues Paper sets out a series of questions to understand stakeholder views. This includes the on-going viability of the regional airports given the growth of road-based connectivity, and the level and structure of State control. The Irish State directly owns three airports (through Dublin Airport Authority for Dublin and Cork, and Shannon Airport Authority for Shannon), and provides grants via the Exchequer to other privately owned regional airports.

It is not the place of this LDLCA scoping study to make presumptions on the future operation of any aerodrome in Ireland. Therefore, an assumption has been made that all existing licensed aerodromes will continue to operate, to attract commercial air transport, and to specialise in various areas as the market dictates. Note that the study does not assume that airspace and ATS will necessarily remain fixed as today.

At present, the State contracts two PSOs between Donegal and Dublin, and Kerry and Dublin. These are contracted until the end of 2014. The cost of maintaining PSOs is considered to be high.

## 3.2 Regulatory factors influencing LDLCA

Government policy or regulatory factors will help shape the future of airspace and ATS in the LDLCA region. Some of the short-term regulatory drivers (e.g. pre-2020) will have a material impact on LDLCA and are included in this study as fixed assumptions. However, in some areas, the regulations cannot be seen as long-term assumptions, since regulatory norms can be challenged for justified performance-based reasons whilst ensuring continued acceptable safety.

Note that the exact timescales are often not fixed, and therefore the exact implementation dates will be a variable in the scenarios being modelled.

Annex H describes the external regulatory and harmonisation drivers from Europe and ICAO. It includes the EASA rulemaking programme (existing and four-year plan) and the ICAO Aviation System Block Upgrades of relevance to LDLCA.

### 3.2.1 Spectrum release programme

The UK Government has embarked on a 10 year programme to release 500MHz of public sector spectrum below 5GHz to the market to encourage and boost the UK economy. This is very similar to the US policy, but has more aggressive timelines and is specifically focused at spectrum below 5GHz which is very attractive for mobile communications. The key users below 5GHz are the MoD and aviation and the Government is specifically engaging those sectors.

Releasing spectrum for alternative use may often be a complex process, with long lead times and can potentially be costly. Some of the issues need to be addressed early on in the process, such as international harmonisation and regulatory constraints, while others need to be managed as part of the preparatory and transition phases. The main issues regarding spectrum release arise because:

- Many bands are subject to international agreements and regulations which may constrain alternative uses and take many years to negotiate and change;
- Bands are often shared by more than one user which requires a coordinated approach to release;
- Changes of use in a band and the introduction of new equipment can require interference issues to be solved; and
- Moving users can entail returning or replacing of equipment with associated costs.

The specific risks for aviation with respect to the UK Future Airspace Strategy [1] are presented in the following table:

| Driver | Event |
|---|---|
| Available spectrum may be insufficiently protected | Interference reduces operational capability or limits spectrum availability |
| Government policy on the commercialisation of spectrum | Aviation prevented from obtaining required spectrum capacity |
| Lack of alignment between ground-based and airborne communications technologies | Two-tier communication system reliant upon new and old technology |
| Pressure on spectrum availability for aviation to support transfer of data between users and ATS | Insufficient spectrum capacity prevents implementation of operational changes |

**Table 5: Spectrum release programme – aviation risks**

The Republic of Ireland does not have a similar spectrum release programme as part of government policy. There are no plans to rationalise navigation or surveillance infrastructure for spectrum efficiency purposes.

### 3.2.2 Navigation aid infrastructure rationalisation

Spectrum release, described above, is one strategy to ensure other users can make adequate use of the spectrum below 5GHz. Showing best-practice efficient use of the spectrum is another method. Efficient use of the spectrum is achieved in the navigation area through rationalisation of the ground-based navigational aids. The rationalisation has other benefits and drivers. It saves on the replacement and on-going maintenance costs of the navaid infrastructure, and allows other aviation uses of the frequencies – particularly in the VHF band.

The “Navigation application & navigation aid infrastructure strategy for the ECAC area up to 2020” published by Eurocontrol in May 2008, addresses the provision of a future navigation infrastructure and promotes the rationalisation of ground-based navigation aids with increasing use of space-based navigation aids. Specifically, it envisages any remaining reliance on non-directional beacons (NDB) for en-route navigation to disappear by 2015. They may still be used in limited places for approach navigation applications (including marker beacons).

Furthermore, from 2010 to 2015, the EUROCONTROL strategy foresaw the dependence on the conventional use of VOR to delineate routes to be such that the VOR infrastructure could be rationalised to the point whereby it would only support a route system predicated on aircraft being approved to a minimum standard of RNAV 5.

In the UK, NERL is required to operate and maintain the UK’s en-route navigation infrastructure under its license conditions. One current important aspect of this en-route infrastructure is that it is also being used to support approach procedures and some limited positioning guidance for GA in Class G; no cost-recovery is applied for these ancillary applications.

To meet the infrastructure element of the ECAC navigation strategy, NERL has devised a plan for the provision of a ground navigation infrastructure in the UK to the year 2020. The basic assumption of this plan is that the use of satellite navigation for all phases of flight will become progressively more dominant until a point is reached beyond 2020 when NDB and VOR will no longer be required and DME/DME fixing and/or on-board inertial reference systems will provide a short-period fallback navigational capability to satellite navigation. This is in line with AIC 023/2012 on the application of PBN in the UK, released by the UK CAA.

With respect to NDBs, NATS (NERL) planned to remove all en-route NDBs within its inventory by the end of 2012. These plans were justified by the CAA removal of the requirement for mandatory carriage of ADF for UK registered aircraft and the mandate for RNAV 5 certified equipment along any ATS route (which can be Class A, C or D). To date, most of the en-route NDBs have been removed, with only seven remaining in the UK AIP as of mid-2013. There are many more NDBs used for aerodromes and heliports.

For the VOR infrastructure, two complications affect rationalisation: i) limited VOR service will be required at least until the date when Galileo is expected to become operational (currently 2023) and ii) existing VOR equipment is on the verge of obsolescence and its continued operation cannot be guaranteed in the long term. Many of the en-route VORs are already past their manufacturer design life guarantees, and based on current trends are likely to become unserviceable in a cost efficient manner by around 2017.

NERL consequently proposed a programme to reduce VOR infrastructure from 46 to 19 beacons over a 4 year period commencing in 2013. The proposed network remaining after rationalisation is presented in the following table, with the highlighted VORs being within or impacting upon the LDLCA region.

| | |
|---|---|
| **Aberdeen (AND)** | Saint Abbs (SAB) |
| **Belfast (BEL)** | Seaford (SFD) |
| Berry Head (BHD) | **Stornoway (STN)** |
| Clacton (CLN) | Strumble (STU) |
| Compton (CPT) | **Sumburgh (SUM)** |
| Honiley (HON) | Talla (TLA) |
| Isle of MAN (IOM) | **Tiree (TIR)** |
| Land's End (LND) | Wallasey (WAL) |
| Ottringham (OTR) | **Wick (WIK)** |
| Pole Hill (POL) | |

**Table 6: Proposed rationalised UK VOR network**

Several VORs in the LDLCA region will therefore be removed permanently, namely Machrihanish (scheduled for 2014), Benbecula and Inverness (both 2016-2017). A possible transition issue also exists in the replacement of VORs, where the VOR will be unavailable for a period of time – nominally 2 months – and services may be impacted.

If the VOR is removed from an aerodrome, the existing conventional routes will need to be replaced with GNSS-based routes, both in en-route and on arrival. RNAV5 is the most likely performance requirement, but in certain cases RNAV1 may be required. Whilst the nominal case for RNAV5 can be met with a GPS kit, the redundant source of navigation may need to be DME/DME, which may not be available on all aircraft. A further problem is that DME/DME coverage is limited at lower altitudes (e.g. under 5000ft) in some parts of the LDLCA region.

Many stakeholders are likely to be affected by the rationalisation, with the challenge being to link the changing need for procedures and routes (due to user demand) with the underlying enablers and airborne equipage. Synchronised timescales is the ultimate aim here, to ensure the most positive cost-benefit case for each of the stakeholders. A particular example is the upgrade of Flight Management Computers to give aircraft the capability to fly RNAV1 and revert to DME/DME. There is also a link to the introduction of APV approach capability on-board – the two issues must be considered together from an airspace user perspective.

In Ireland, the same pressure on spectrum leading to rationalisation is not as prevalent. Ireland (including the Dublin area) has six VORs and fifteen NDBs as of mid-2013, including both State owned and privately owned infrastructure. Whilst the obsolescence of VORs and NDBs will still lead to a certain level of rationalisation, the regulatory pressures introduced in the UK are not replicated. However, Ireland is moving towards PBN with the UK; this is described in the next section below.

### 3.2.3 Performance Based Navigation

The UK CAA and IAA have published a joint policy committing them to the implementation of PBN in UK and Ireland [7]. The policy was developed under the auspices of the UK/Ireland Functional Airspace Block. It states that whilst the individual application of PBN is dependent on the applicant of the airspace change, the choice of specification and uniformity of application across the UK and Irish airspace is a matter for regulatory policy and implementation guidance.

The policy is further reinforced by the planned PBN Implementing Rule (IR) currently being developed by EUROCONTROL as tasked by the European Commission. EUROCONTROL has published a Regulatory Approach Document and held consultations and workshops to refine the approach being taken. The regulation aims to ensure a common capability across ECAC airspace.

The UK/Ireland policy currently recommends the following application of PBN. Where this will be enhanced by the application of the proposed IR, this is clarified below.

- All ATS routes (en-route) should be RNAV 5. This could be enhanced in LDLCA by the draft PBN IR's requirement for RNP 1 below FL195 and in terminal airspace, although this may only be applicable to medium-high density areas, since there would be minimal benefit to its application in LDLCA.
- All existing conventional SIDs and STARs should be phased out on an opportunity basis and replaced with PBN terminal procedures (e.g. RNAV 5 arrivals, RNAV 1, RNP 1 or A-RNP).

There is still discussion on the actual implementation environment for the core PBN options. In LDLCA, the benefits case for very closely spaced parallel routes or for fixed radius turns may be difficult to make, particularly given the costs that may be applied to retrofit a wide variety of aircraft to be able to take advantage of the new procedures. Table 2 in section 2.3 above shows the variety of scheduled regional aircraft flying in the LDLCA region; this is supplemented by fixed wing and rotorcraft from unscheduled flights of General and Business aviation and the military.

Many of the modern avionics are able to cope with increased accuracy required from many PBN applications (RNAV1 and RNP1). This applies to GA IFR fitments, both fixed wing and rotorcraft. The capability to carry out baro-VNAV procedures may be a greater issue for these aircraft, as certified and integrated altimeters are not standard on the GA fleet due to cost considerations. As mentioned in the previous section, the ability to revert to DME/DME based navigation may also be an issue in LDLCA due to DME coverage and fleet equipage.

Some regional aircraft are faced with relatively high cost retrofits to be able to comply with the new standards. This may slow down the equipage rate, with aerodromes and ANSPs needing to provide for mixed equipage over a longer period. State Aircraft may also be non-compliant, as they are not required to be certified at present.

### 3.2.4 Wind farms

The UK Government is committed to reducing greenhouse gas emissions within the UK. This means there is now a shift towards economically viable renewable energy sources rather than carbon fuels. Directive 2009/28/EC of the European Parliament and of the Council set the national overall target for the share of energy from renewable energy by 2020 as 15% for the UK. However, it is UK Government policy that 20% of the UK's electricity supply should come from renewable sources by 2020; the Scottish parliament has adopted a very ambitious 100% by 2020. Wind energy's contribution to meeting these ambitious targets is expected to be significant. The UK FAS recognises the need to enhance the supply of renewable energy in the UK and the importance of on- and off-shore wind turbine farms in this respect.

Similarly, the Irish Government considers the increase in on- and offshore wind energy generation as one of the five broad strategic goals in its strategy for Renewable Energy 2012-2020. Recently, the Irish Minister for Communications, Energy and Natural Resources announced that an increase in wind energy from a historic average of 180MW per year to at least 250MW per year will be pursued[9].

Wind turbine projects are therefore being constructed throughout the UK and Ireland, ranging from single structures to developments encompassing multiple wind turbines, known as wind farms. The physical characteristics of such projects coupled with the size and siting of the developments can result in effects which impact on aviation. These include, but are not limited to: physical obstructions impacting the safeguarding of aviation (e.g. approach paths), the generation of unwanted returns on PSR, adverse effects on the overall performance of CNS equipment (interference) and potentially turbulence.

While it is usually the larger commercial turbines that have the greatest impact on aviation, smaller turbines and the preliminary activities for larger turbines (e.g. the erection of anemometer masts on potential development sites) may also have a negative impact on aviation. It is important to note that the cumulative effect of multiple wind turbine developments is much harder to mitigate compared to a single turbine or a small farm.

The following table provides an overview of the aviation areas affected by wind-turbines:

[9] http://www.dcenr.gov.ie/Press+Releases/2013/Rabbitte+brings+certainty+to+Wind+Energy+planning.htm

| Area | Effect |
|---|---|
| PSR | False radar returns (Clutter) and track seduction<br>Loss of receiver sensitivity<br>Receiver saturation<br>Plot extractor/Filter memory overload<br>Presenting an obstruction (shadow) |
| SSR | False targets caused by SSR signal reflections<br>Presenting an obstruction |
| Navaids/Comms | Affects propagation of radiated signals or reception of signals<br>Degradation of integrity and performance<br>*Note that preliminary work is being undertaken to fully understand the impact on VHF ground stations.* |
| Offshore helicopter operations | Safety of conducting IFR procedures in low visibility conditions<br>Integrity of offshore installation safety cases on the use of helicopters to evacuate installation |
| Turbulence | Particularly affects very light sport aviation and micro-light operations (including gliding, parachuting, hand-gliding, paragliding etc)<br>(Note that the CAA is conducting independent research to fully understand the effects of turbulence caused by wind turbines on aviation. Results are expected in 2014.) |
| En-route and approach obstructions | Impacts on Class G airspace due to potential creation of “choke points”<br>Potential impact on Instrument Flight Procedures, Charting Minimum Safe Altitudes (MSA) and Radar Vectoring Areas<br>Anemometer masts difficult to acquire visually (although rarely above 80m AGL)<br>Hazards to ASU, Air Ambulance operations |
| Military operations | Impacts on sensitive CNS facilities, including Primary Surveillance Radars, Precision Approach Radars, and Air Defence Radars<br>Hazards for operational low flying |

**Table 7: Effects of wind turbine installations on aviation**

The most critical issues are generally considered to be the first and last in the table above. Military Low Flying Areas evidently require an understanding about obstacles and require the ability to train safely.

For PSR interference, there are several methods to mitigate wind farm effects currently in development.

- Most crudely, the return area around the wind farm (generating clutter or track seduction) could be blanked by the PSR surveillance system – evidently, this reduces the service provided to airspace users;
- A second radar could be used, viewing the area of interference from a different angle, which may allow any track seduction or clutter to be filtered out using a

multi-radar tracker; this was looked at in the Central Belt of Scotland as a possible solution;

- The radar could be upgraded to improve its tracking of aircraft and filtering of clutter from wind farms (e.g. NERL Raytheon upgrade programme); alternatively, a new radar could be bought with this functionality in-built, if this becomes available on the market.
- An in-fill solution could be used – a specific radar capable of tracking targets in the middle of the wind farm clutter and interference. It is assumed that the C-speed Lightwave solid-state PSR under trials in Kent would fit into this category. One Lightwave radar is likely to be needed per PSR requiring mitigation. Aveillant is also developing a "holographic radar" with a range of 5-8 NM (i.e. positioned close to the wind farm). One issue with this is that several of these may be required for one PSR if multiple wind farms are approved within line of sight. A new model is being developed with a proposed range of 20-25 NM, which may be more practicable and cost efficient. This model may be able to provide a single mitigation to several stakeholder objections (i.e. several radars). In-fill solutions could also be provided to specific airports by other Primary Surveillance Radars – in the Central Belt example above for multi-radar trackers, feeds are also given to individual airports on a mosaic basis.

The use of a single mitigation for multiple wind-farms or stakeholders is to be encouraged. The Central Belt example (Kincardine) shows how this might be achieved, with a new PSR providing data to NERL (en-route) and NSL airports (approach).

### 3.2.5 Removal of Class F airspace in UK

Within the UK FIRs, Class F is specified for most Advisory Routes (ADRs), allowing a deconfliction service to be provided to flights filing flight plans along the routes, but not guaranteeing separation against all traffic since the area may be outside surveillance cover.

The International Civil Aviation Organisation (ICAO) audit of the UK in February 2009, together with a detailed consideration of the airspace classification requirements of the Standardised European Rules of the Air (SERA) (Regulation (EU) No 923/2012), scheduled for UK implementation by 4 December 2014, were followed by the launch of consultations from the CAA with the aviation community concerning proposals to replace Class F ADRs in the London and Scottish FIRs, where the bulk of those routes lie. The CAA's intention is to replace ADRs with airspace classes best suited to the operational conditions associated with them; this is thought to be Class E, but with the addition of a Transponder Mandatory Zone to ensure a "known" environment for traffic. Some ADRs may be re-classified as Class G where very limited traffic is seen.

In order to allow enough time for airspace users, aircraft operators and air traffic service providers to prepare for the eventual changes, replacement of Class F will be completed no later than AIRAC 12/2014 (13 November 2014). This will ensure compliance with ICAO and SERA requirements, as implementation of the latter has to be completed by 4 December 2014.

Note that within Ireland, there are no plans to change the current requirement of providing Class C wherever a control service is provided, and Class G otherwise.

### 3.2.6 Application of Mandatory Zones

The UK CAA has introduced the concept of Transponder Mandatory Zones (TMZ) and Radio Mandatory Zones (RMZ) to enable the application of risk-based airspace management.

From the CAA TMZ policy [16]: "*A TMZ may be established for overriding safety reasons, where the airspace classification would not ordinarily require aircraft to carry a transponder. Where the case can be made a TMZ may also be established within controlled airspace.*"

From the CAA RMZ policy [17]: "*If it is determined that in order to enhance flight safety, the management of a specific airspace environment would benefit from the sharing of greater operational airspace intelligence, and that this could be achieved without the establishment of a higher classification of airspace, a RMZ may be notified.*"

The mandatory zones may be temporary – for example, during a planned radar outage – or permanent.

A third type of mandatory zone has been proposed for the purposes of this report. This is not CAA or IAA policy, or applied anywhere in the UK or Ireland at present. The Surveillance Mandatory Zone (SMZ) is intended to act in a similar manner to the TMZ (i.e. enabling a fully "known" environment for an area covered by ground surveillance), but allows an appropriate ADS-B transceiver to be used on-board the aircraft in place of a transponder.

The advantage of the SMZ is that the airspace user carrying the ADS-B transceiver may decide to equip with ADS-B IN, allowing the display of traffic information, giving additional benefits to the airspace user compared with the TMZ.

Finally, a combined mandatory zone is theoretically possible, with requirements on both radio and surveillance/transponder equipage. This is tentatively called a Mandatory Conspicuity Zone.

## 3.3 Other programmes and initiatives impacting LDLCA

### 3.3.1 UK MoD project Marshall

In UK the MOD owns, operates and maintains a broad spectrum of equipment to provide Air Traffic Management (ATM) services at its airfields, weapons ranges and exercise areas, both in country and overseas. These encompass surveillance radars, navigation aids, landing aids, communications equipment and other elements that contribute to the overall provision of the ATM capability. Studies in the early 2000s revealed that much of this equipment is approaching obsolescence and that significant capital expenditure will be needed to sustain the capability for the future.

The predecessor of project Marshall, the Joint Military Air Traffic Services (JMATS) project, was initiated in November 2005 to identify and evaluate options for the future delivery of the military Terminal ATM capability. Early discussions with the industry indicated much support for a service based solution and a belief that there were significant opportunities to deliver a more coherent and cost effective solution.

Project Marshall is consequently a public-private partnership programme expected to commence by 2015. The winning contractor will provide support for UK military air traffic services, including communications, surveillance and navigation systems at British bases in the UK, Gibraltar, Cyprus and the Falklands, and on deployed operations. Project Marshall does not include the Air Defence infrastructure.

It is the key ATM programme for the MoD as it will provide the capability to support UK military flying and air deployed operations for the longer term. These air traffic services will provide air traffic control and air traffic management for all of the MoD's aerodromes and air weapon ranges both in the UK and overseas including those used for current operations. It will also ensure that the MoD complies with the legal requirements of managing an ATS and enable safe operation of its aerial platforms. The benefits of the programme are expected to arise from improved efficiencies, scale and innovation and the delivery and management of network based-services, applications, equipment and training in MOD military airfields and for deployed operations.

The MoD uses performance-based requirements to manage the Marshall contract, and the winning supplier will be expected to be able to specify how the performance will be met. It is unlikely that an initial focus will be placed on innovative technologies, since this would introduce undue risk to the bids and subsequent programme. This will therefore impact the timelines under consideration for new military ATS enablers in LDLCA (for example, MSPSR).

The specification for Project Marshall requires the existing Primary radars to be updated, since they do not meet standards for Probability of Detection. Therefore, it is likely there will be an upgrade programme during the transition period (2015-2021) during which the existing Watchman radars are either significantly upgraded or replaced with new PSRs. If appropriate wind farm mitigation techniques are not mature (feasible) in the same timeframe, it is possible that the requirement for the upgraded PSR infrastructure to be wind farm tolerant will be dropped from the initial contract. This is dependent upon a Technology Demonstration report, due in late 2013, which assesses the feasibility of the applicable wind farm mitigation solutions.

### 3.3.2 UK/Ireland FAB

The UK/Ireland FAB was established in July 2008 and at the commencement of RP1[10] will have completed over three full years of operation. The FAB is made up of ANSP, NSA, airline and military participants. The FAB is based on a "design and build" concept and has therefore evolved as customer expectations have become apparent through engagement with airspace users and as the ANSPs and NSAs have identified opportunities for performance and efficiency improvements.

Each year, the IAA and NATS produce a four year plan containing the activities planned for the FAB which are intended to deliver operational, safety and financial benefits to the FAB customers. The plan for 2012-2015 was published in May 2012, and a report on progress was published in June 2013. The FAB plan has 4 main focus areas:

- FAB strategic planning;
- Customer priorities;

[10] Reference Period 1, the first reference period for implementation of Single European Sky performance targets on ANSPs and FABs.

- Implementation of new and follow-through projects;
- Key supporting areas including ANSP/NSA coordination, inter-FAB coordination, commercial framework development and SES activities.

The focus of the FAB initiatives has been on the high density areas. However, several relevant parts of the FAB plan can be identified for the LDLCA region, in particular projects for implementation for the period 2012-2015. These are clarified in Annex E.

## 3.4 Stakeholder expectations

### 3.4.1 Framework for capturing views

As part of the study, Helios consulted many of the key stakeholders in the LDLCA region via face-to-face or phone meetings, or through multiple workshops held in the UK and Ireland.

In parallel, a literature review was conducted of work done to date. This included the Future Airspace Strategy activities, along with the Class G in the 21$^{st}$ Century [19] and GA-specific activities.

To ensure the study used a coherent means of analysing the scenarios, the performance-based approach was used as described in section 1.3. The performance workshops held in London and Dublin at the start of the project therefore also guided the study regarding stakeholder objectives.

These consultations and past reports were used to identify main drivers for the LDLCA airspace and services therein, noting that the purpose of the study is not to develop future strategy and policy, but to inform stakeholders when making their decisions on future implementations.

Figure 5 shows the approach to derive stakeholder expectations for LDLCA. These expectations and the constraints above were then used to scope the scenarios, understanding the possible options and timelines.

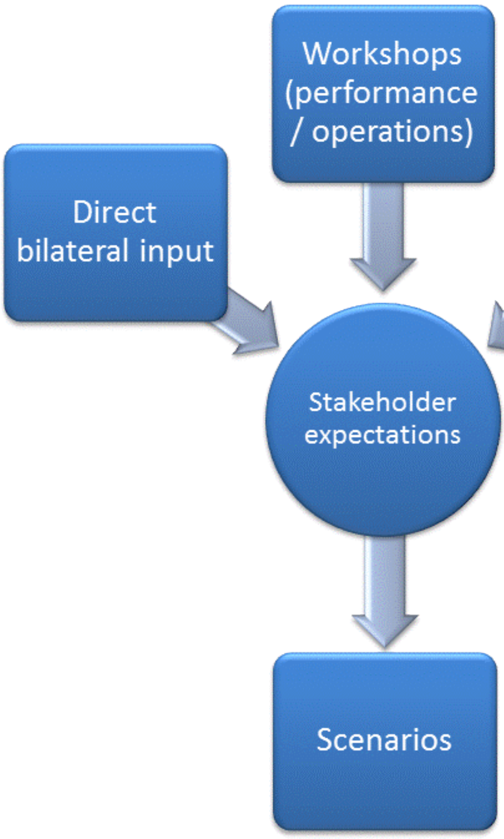



**Figure 5: Identifying stakeholder expectations**

A total of 25 meetings with representatives from 15 different organisations were held as part of the bilateral stakeholder consultation process. Furthermore, the operational workshops were attended by a total of 34 representatives from 23 different organisations. The distribution of participants in the consultations over stakeholder groups is presented in the figures below. Overall, the consultation process has provided many important inputs, and has covered a sufficiently wide range of stakeholders through in depth discussion to provide a solid basis for the development and assessment of future scenarios.

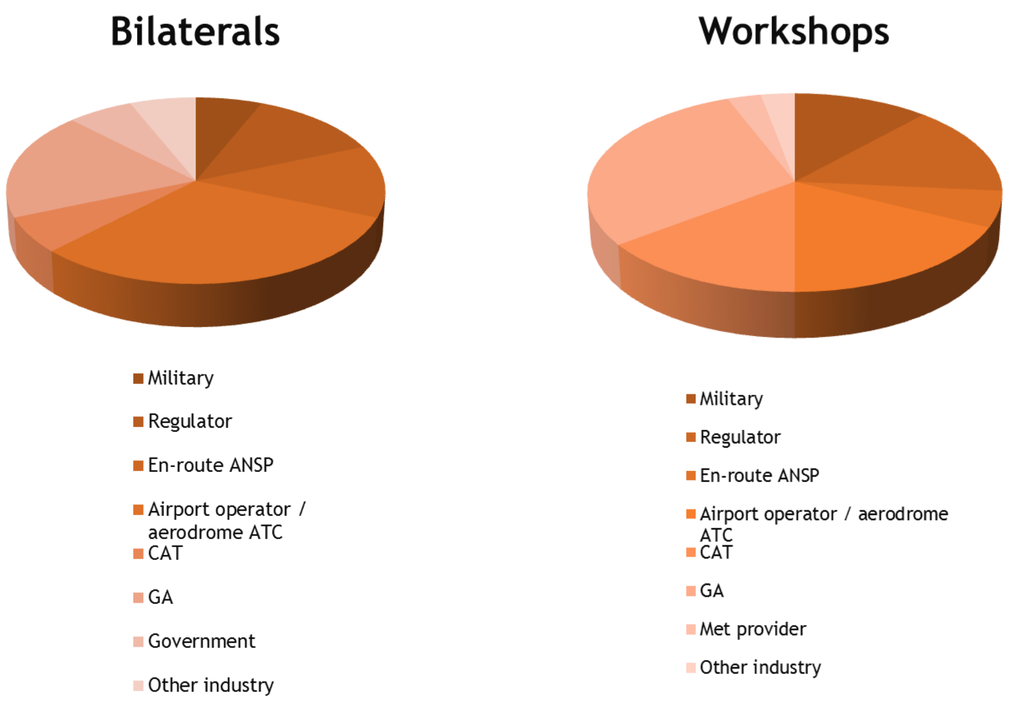



**Figure 6: Stakeholder group participation in consultation processes**

### 3.4.2 Summary of drivers

An overview of expectations by stakeholder group is provided in Annex F. A summary of the main drivers for the future of LDLCA as taken from stakeholder inputs is shown below.

In line with the performance-based approach to this study, the drivers are first presented in terms of performance expectations. As a second step, drivers are presented in terms of operational, technical and commercial/financial elements – these elements will lead to the variables that form the basis of the scenarios for the future situation.

The drivers reflect diverse stakeholder inputs which mean that they can contain contradictions, and do not represent strict requirements that every future scenario (as defined in the next section) must meet.

| | Stakeholder expectations |
|---|---|
| **Safety** | Safety remains the top priority for stakeholders.<br>At least a tolerable level of safety should be maintained, and the safety level should be improved if appropriate:<br>▪ Around aerodromes – through cost-effective measures<br>▪ From a user perspective (both CAT and GA) – based on where aircraft actually fly and on clear arguments (i.e not simply for the sake of improvement alone)<br>Whether a "Big Sky" approach (i.e. mitigation against collision simply through a combination of the size of the airspace and the free movement of air traffic within this airspace) is sufficient for en-route Class G airspace is still an open question.<br>Aviation risk arising from wind farms needs to be managed – also planning for the potential future growth of wind farms. |
| **Cost efficiency** | ATC services should be provided in a cost efficient manner taking account of the thin margins in the region. This applies at both aerodrome and en-route level.<br>Cost efficient solutions for users must be available if equipage is mandated.<br>CNS infrastructure needs to be available at the appropriate level, i.e. to support safe operations without unnecessary additional costs. |
| **Resilience** | Commercial operations in the region need to be resilient:<br>▪ This is important to aerodromes, commercial and business aviation, and government (e.g. medical flights)<br>▪ Resilience needs to take into account circumstances at and around aerodromes (weather, terrain)<br>Resilience is a business decision. The need for resilience must also consider the availability of contingency. |
| **Capacity** | Capacity is a concern even in LDLCA; bunching of flights can occur during procedural control – for both commercial and general aviation.<br>In LDLCA, 'capacity' can refer to airspace and aerodrome capacity. |
| **Access** | Maintaining a high level of access to airspace is particularly important to the GA community.<br>Military want to have freedom to operate in all areas, all weather conditions – but they recognise the need for "performance-based" airspace.<br>Making the airspace available is only one side of the issue – communicating to relevant users that the airspace is available is equally important.<br>Regulators understand the concerns, and will strive to help address them. |
| **Other** | There are some flight efficiency concerns, related to the ability to fly optimum descents and direct routings, and to ensuring new procedures do not add length to route. |

## Operational drivers

For users, the LDLCA environment should enable all airspace user types to operate based on their main requirements:

- for commercial air transport this means efficient operations through e.g. flying preferred trajectories and continuous descents and ensuring safety of passengers;
- for GA this means freedom to operate when and where they want;
- for military this also means access to relevant airspace, with specific requirements for low flying and 'train as you fight'.

Evidently, restrictions arising from reclassification of airspace, or implementation of new mandatory zones, will either limit access or lead to a requirement for expensive equipment. The importance of maintaining tolerable levels of safety whilst ensuring optimum access will remain key for all stakeholders.

Clear links should be made between the services and the constraints introduced into the airspace and the detailed (exact) traffic requirements. Furthermore, service provision and CNS infrastructure should be considered as separate issues, and assessed for their own benefits. For example, several options exist to address rationalisation of the navaid infrastructure, and each may change the service provision level as well as entailing new procedures or infrastructure.

Other points to note on service provision are:

- APV+FISO could be a cost efficient option for very low density airports
- Provision of the LARS service may change in the future, as well as the acceptance of deconfliction services in Class G (ATSOCAS) due to the need for harmonisation with SERA principles

Specific other drivers include:

- The need to better coordinate military exercises
- The need to understand and consider transition aspects

## Technical drivers

For users, equipage is a significant issue:

- For commercial fleets (particularly regional), capabilities vary. Investment plans in response to regulation must be cost-effective given the fleet lifetimes and leasing strategies.
- For GA, appropriate technical solutions must be available on the market prior to introduction of new technical concepts in the airspace; solutions should be modular and COTS. Lower certification level (or uncertified) solutions should be available, where shown to be acceptably safe, possibly when referring to non-safety critical applications.

Service providers need the ability to implement the best, most cost-efficient solution going forward when the lifetime of current equipment runs out (navigation, surveillance); this depends on:

- maturity of new concepts
- whether disadvantages of new concepts for some stakeholders can be mitigated

System updates, whether direct replacements or changes to new technology, require a feasible timeline. Cost of transition must be taken into account.

Surveillance system needs to be layered, and less spectrum-demanding – one size may not fit all. Non-cooperative surveillance, if decided upon, may need to be argued on a case by case basis.

Wind farm mitigation is a priority; various mitigation options (filters; in-fill; new technology) are considered, and should be applied to all potential primary surveillance means. Technical solutions should be introduced as part of any new procurements to mitigate impact. MSPSR with co-located WAM benefits both wind farm development and spectrum release.

The future military context – but not the technology – is defined through the requirements, performance levels and coverage volumes of Project Marshall. CNS needs to support changes to location of bases / assets, and to types of training / testing.

| Commercial / financial drivers |
|---|
| For users, on-going control of costs is very important:<br>▪ Commercial traffic operates at thin/nil margins in the region. They want a positive NPV for any investment, and need ATS to be cost effective (particularly if it is linked to a regulatory/legislative requirement). New technologies may need to be forward fitted (or new lease) rather than retrofitted.<br>▪ For GA, all aspects need consideration: purchase, installation, and training. An acceptable solution for GA transceiver equipage must be found. Most GA feels it does not need ATS; it exists for the benefit of the commercial users, and GA feels they should pay for it ("beneficiary pays").<br>Aerodromes aim to increase user numbers, attracting commercial routes where possible. In terms of service provision:<br>▪ The level of service must balance safety of paying passengers and cost of provision<br>▪ Centralised services must balance cost efficiency and need for competition<br>Regulatory burden must be proportionate; regulation must be appropriate for regional airports.<br><br>The en-route ANSP expects the users to pay for the service received / infrastructure used ("user pays").<br><br>Innovative funding solutions should be considered:<br>▪ Subsidies (similar to ACCEPTA) to address evolution of system<br>▪ Incentivisation to enable timely transition to new surveillance technology<br>▪ Centralised decision making / funding – e.g. if benefit of spectrum release is greater than cost of surveillance transition. No specific funding has currently been identified.<br>Aviation may be required to contribute to introduction of wind farm mitigations, once mature - wind farms may no longer be considered as a "special case" for mitigation measures.<br><br>At the early stages of Project Marshall, suppliers may not be willing to increase risk through innovation due to the competitive nature of the procurement. In time, contract changes could be used to introduce new concepts to the technology mix. |

# 4 Scenarios and dependencies

## 4.1 Structure of a scenario

This scoping study uses a scenario approach to "test" options for the future of the low density, low complexity airspace.

Scenarios are feasible evolutions of the LDLCA environment, comprising a set of key variables (changes to the airspace, service and infrastructure) and the dependencies between them.

Creating and reviewing scenarios allows all stakeholders to understand the range of options which exist for a low density, low complexity airspace region. It also assists in achieving an appropriate balance between considering the multitude of options available, and conducting a performance assessment at the required depth to give useful and justifiable results.

The scenarios are **not** intended to show a single favoured option for progression; this is not a regulatory impact assessment. Instead, they allow the assessment to highlight trade-offs and explore sensitivities (what-if questions).

Five scenarios were created, covering the main areas of uncertainty and options with the highest impact. Each scenario represents a possible evolution for an LDLCA region over the coming 15 years.

- Scenario 1: Do the minimum necessary
- Scenario 2: Cost minimisation
- Scenario 3: Safety enhanced
- Scenario 4: Modernisation with limited synchronisation
- Scenario 5: Co-ordinated funding

The remainder of this section shows the assumptions and constraints agreed by stakeholders, shows what has been moved out-of-scope and why, and describes the key variables and dependencies in turn. Finally, each scenario is presented as a possible roadmap.

It is recognised that the scenarios are not exhaustive. They were chosen to give a range of options for the development of the airspace, including more radical options to identify the envelope of feasibility for certain changes. The prioritisation of issues given by the stakeholders in the region also helped in focusing the changes to be assessed. The choice of scenarios was then validated by the stakeholders.

Details of the potential variables in airspace, services and infrastructure in the region are contained in section 4.3 below.

## 4.2 Assumptions and out-of-scope elements

Before going into the detailed description and the assessment of the scenarios, a number of assumptions need to be addressed, as well as some elements which are considered out-of-scope for the current study.

Whereas the scenarios focus on high uncertainty, high impact issues, assumptions are those elements of the future environment that we are confident will happen, i.e. they are low uncertainty. However, it is worth noting that there can still be areas of uncertainty attached to assumptions, e.g. a specific change that will definitely happen, but it is not yet clear when it will happen.

The main assumptions for the current study are divided into assumptions on external influences, and assumptions on operational, technical and institutional elements:

| Assumption | Justification |
|---|---|
| **External influences** | |
| The UK Spectrum Release Programme will go ahead (2.7-3.1 GHz band) – but timescales could alter | UK spectrum release is driven by a wider government initiative that is being moved forward, with large potential benefits to the UK Treasury; aeronautical spectrum is an important focus area for the programme. |
| VOR and NDB rationalisation programme will go ahead – timescales are not concrete, neither are exact next steps | Through a combination of pressure towards cost efficiency, frequency reduction, end of lifetime for some current equipment, and reduced requirement for ground based navaids to support en-route operations (due to PBN), NATS (with the support of the CAA) has begun a rationalisation programme. |
| Political wind energy targets will maintain current timescales | Targets are politically driven (through national and European levels), and we are currently not aware of any indication that they may change. |
| **Operational, technical and institutional elements** | |
| Tolerable levels of safety will be maintained | Safety is a top priority in aviation, and maintaining at least a tolerable level of safety is therefore a core assumption of any study looking into the future. |
| Airports will continue to operate in their current location | Changes to the number or location of aerodromes in the LDLCA region are considered to be out of scope (see below). Therefore the study assumes that all current airports will continue to operate – although type and level of traffic may vary. |
| ATSOCAS will continue in the UK | ATSOCAS provides an important layer of safety in the UK outside controlled airspace, and for safety purposes we assume that this layer will remain in place, although details of the service provided may change. |
| Changes to Irish legislation (S.I 856 of 2004) and resultant policy will only be considered where an equivalent level of safety can be assured | Safety is a top priority, and safety levels should at least be maintained. This applies equally to the impact of changes to legislation. |
| UK Class F airspace removed (the current recommendation is to become Class E+TMZ) | A programme to remove Class F airspace is underway, and there are no indications to suggest that Class F will be maintained following the conclusion of the programme. |
| UK MOD Project Marshall will be implemented and will evolve over time in line with performance requirements | Project Marshall is moving ahead, and there are no indications to suggest that it will not continue. As the project's requirements are defined in terms of performance, coverage, etc, it can reasonably be assumed that the supporting technology used could evolve over time. |
| Current issues with TMZs will continue to lead to large numbers of exemptions or restrictions until equipage becomes more common | There are no obvious alternatives to either exemptions or restrictions given the purpose of a TMZ, until widespread equipage is achieved thus addressing the current issues. |
| Current SES Implementing Rule timetables will be broadly respected | Although SES timetables have not always been fully respected in the past, there is no solid basis for assuming any other timeline for future developments than existing timetables. |
| Lifeline services will continue to be promoted, potentially via subsidies. | The political and social importance of access for remote communities means assistance will continue to be given to encourage operators and ensure a viable route exists. |

**Table 8: Overview of assumptions**

Out-of-scope elements for this study are those elements that could potentially have an impact on future operations in LDLCA, but that depend on external decisions that are not considered here, in most cases because they have to be taken at the political level rather than the operational, technical or institutional level.

| Out-of-scope elements | Justification |
|---|---|
| The result of the vote on Scottish independence | It is currently impossible to predict what the outcome of the vote might be, or indeed what the impact of a vote in favour of independence would be. |
| Any changes to the number or location of aerodromes in the LDLCA region considered | There are no solid reasons to assume the number or location of aerodromes will change. Furthermore, political decisions may require and support aerodromes to continue operations even if there are no strong operational or financial arguments. |
| Individual decisions by aerodromes on service levels are outside the scope of this study | Whereas the impact of changing service levels will be considered generically, the study will not aim to address the specifics of individual airports in the area; this should be performed through an individual evaluation and decision and not through an overall scoping study. |
| The evolution of PSO routes – only the current state considered | Similar to the previous point, PSO routes are strongly linked to political decisions, and any changes can therefore not be considered from solely an operational or financial perspective. |
| Any elements of non-equivalence in the introduction of RPAS | Conditions for introduction of RPAS in non-segregated airspace are still being discussed, with regulators focussing on full equivalence. Any changes to this approach are impossible to predict within the context of this scoping study. |

**Table 9: Overview of out-of-scope elements**

In addition to the elements listed above, it is important to note that within this study no detailed traffic forecasting for the area will be done. Scenarios will assume general low growth. One particular element of traffic development that will be considered is the potential for growth in the oil/gas industry in a new location leading to increased traffic and need for new ATS (this argues for a degree of flexibility in infrastructure).

## 4.3 Variables

### 4.3.1 Methodology

During the timescale being assessed within this study (2013 – 2030), there are a wide range of potential changes which could occur in LDLCA regions. These changes were identified through three main sources:

- Literature reviews of on-going developments and past studies;
- Stakeholder consultations;
- Expert judgement on the feasibility of changes.

Two main questions were applied to the potential changes to allow a categorisation and down-selection.

- Is this change both high impact and high uncertainty?
- Is this change feasible in the timescales for an LDLCA region?

The first question allows a focus on the areas of most importance for the region. If a change is low uncertainty (i.e. it is likely to happen or not happen), it becomes an assumption and is treated in a similar manner for each scenario (see section 4.2 for assumptions and elements out-of-scope). If a change is judged to have low impact, it is of less importance to understand its interactions, dependencies and outcomes. The figure below illustrates this approach, which is common to scenario development.

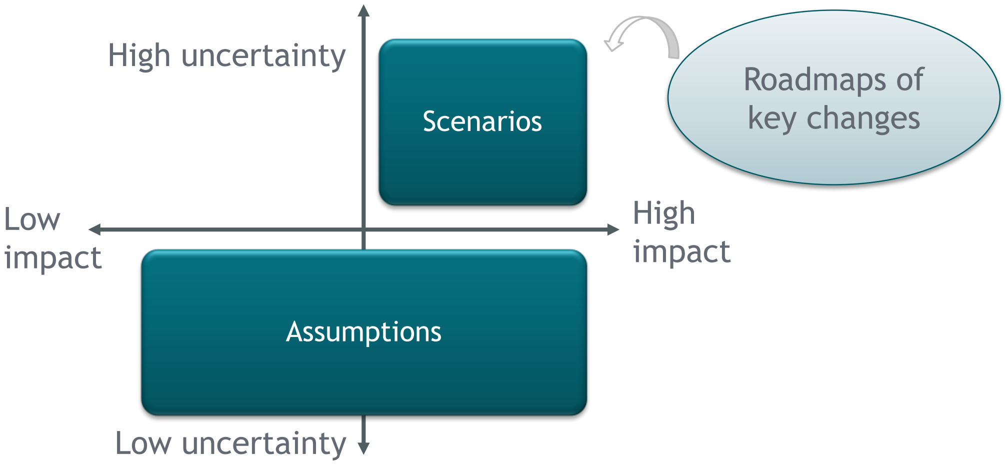



**Figure 7: Categorising variables**

The second question asks whether a particular innovation may be available on the market before 2030, and if so, whether the change is implementable (feasible) in the LDLCA regions.

The following sections show the outcome of the assessment across each of the main areas under consideration: airports (service), airspace, communications, navigation, surveillance, and other impacting variables.

### 4.3.2 Airports (services)

#### 4.3.2.1 Out of scope

NIL

#### 4.3.2.2 Assumptions (low uncertainty)

NIL

#### 4.3.2.3 Variables to be considered in the study

Within the UK, the ability of an aerodrome operator to decide upon the level of service required for its operations is enshrined within CAP670 [13] and the Air Navigation Order [14]. In Ireland, it is governed by S.I. 856/2004 [8], which requires an air traffic control service to be provided during hours of operational use of '*any active holding aid, let-down aid or approach aid by radio communication or signals or by radar*', with Class C airspace also provided.

The decision to use Flight Information Services or a Control Service at an aerodrome is dependent on the traffic density and complexity of operations, as it pertains to hazards to operations at that aerodrome. When traffic levels or complexity decreases, and subject to an appropriate hazard assessment, the operator has the ability to move from an ATC service to FIS. Other mitigations may be put in place at the juncture to ensure tolerable levels of safety are maintained. Therefore, **CAT using FIS at an aerodrome** is considered to be a variable to be modelled for the LDLCA region, in particular for Ireland.

It is recognised that in Ireland, this variable would require a change in legislation and potentially a re-analysis of the hazard assessment which led to the legislation [8] and subsequent policy. This may not be appropriate, since the airspace and control classification in Ireland is "clean" and well-understood. However, it also imposes costs on the service providers which may be difficult to justify when traffic levels decrease.

Another set of potential changes with the potential to improve the cost situation are those dealing with centralised service provision, either for the Approach service or for the Tower service (or both). **Centralised Approach services** involve the setting up of a regional approach centre, able to provide services to a set of aerodromes with feeds from localised surveillance infrastructure if appropriate. The main benefit appears to be in controller availability, rostering and recruitment.

**Remote TWR or FIS** entails the provision of a Tower (ADV or ADI) or Flight Information Service from a location away from the aerodrome, nominally co-located with other ATCOs providing similar services remotely. Both services rely on a highly reliable data stream being sent from the aerodrome to the remote centre. The service includes some form of visual data, normally replicating the view from a visual control tower, including the capability to Pan/Tilt/Zoom as if using binoculars. It could also include data from other sensors, for example motion detection cameras for the runway and manoeuvring area and infrared sensors. The data stream is highly compressed, but still entails an on-going cost to the service provider.

In many cases, the benefits from the centralised approach and remote TWR/FIS services are only realised when the two concepts are implemented in tandem. This is because one ATCO tends to hold ratings for APP/APS and ADV/ADI, and will provide both the TWR and Approach service at low density aerodromes. Therefore, to move this single controller and obtain the Human Resource benefits, both services would need to be provided remotely.

It should be noted that the main cost savings are: for controllers through better pooling arrangements and management of rostering, and on the control tower infrastructure at each local aerodrome. Balancing this is the cost of the Remote TWR/APP system, the transition cost (moving ATCOs etc) and the communications cost for the high bandwidth (e.g. 100MB/s), high reliability communications infrastructure needed on a daily basis.

The changes to human resource management may be particularly beneficial in remote regions reflected by LDLCA. Controllers can be based at a centralised location, and with greater flexibility of rostering. Trials are on-going to look at one controller providing a service to multiple aerodromes (SESAR WP 6.9.3), which would further improve the rostering and resource requirement. However, there are still concerns about the concept of one controller overseeing multiple aerodromes in tandem, primarily in situational awareness and safety. The initial deployments will use 1:1 arrangements.

There are options available for either procuring the remote TWR system directly from the manufacturer (e.g. Saab Sensis), or utilising a service-based approach and transferring controllers over to a service provider. It is not clear yet the advantages or disadvantages of the different approaches due to the immaturity of the market.

Currently, LFV is aiming to move to operational deployment of the Remote Tower concept by Q2/2014, with Avinor following soon after in Q4/2014. The FAA is currently conducting trials in the US (Colorado), and Airservices Australia in Alice Springs. This activity should lead to evidence of the concept's usability, safety and reliability.

### 4.3.3 Airspace

#### 4.3.3.1 Out of scope

NIL

#### 4.3.3.2 Assumptions (low uncertainty)

NIL

#### 4.3.3.3 Variables to be considered in the study

There is considerable debate about the best means of balancing the stakeholder needs in airspace design over the coming years. A risk-based approach will be utilised, the exact outcome of which will probably vary between the UK and Ireland.

One option to be modelled is the possibility of varying the **level of protection around aerodromes**, using combinations of Controlled Airspace (Class C, D or E), Radio Mandatory Zones, and/or Transponder Mandatory Zones / Surveillance Mandatory Zones. Surveillance Mandatory Zones (SMZ) entail the use of either Mode S transponders or 1090ES ADS-B transceivers on-board the aircraft (see 3.2.6). The mandatory zone could be both radio and surveillance (known informally as a "mandatory conspicuity zone").

The options to be used will depend upon the potential effectiveness of the mandatory zones, which itself depends upon take-up of the required technical solutions. In theory, reducing the size of Controlled Airspace may assist users with issues accessing CAS (e.g. gliders), since there is no chance they will be asked to wait or route around. The provision of a mandatory zone will also act as a "buffer zone" to the CAS, ensuring adequate protection for CAT approaching / departing from the aerodrome.

There are various ways of designing this "buffer zone", achieving an appropriate balance of risk control and access suitable for the local environment.

- The Class C or D airspace could remain the same volume, and be enclosed by a surrounding mandatory zone. *This is modelled in scenario 3: Safety enhanced.*
- Portions of the Class C or D airspace could be replaced by a mandatory zone, possibly incorporating Class E airspace. *This is modelled in scenario 2: Cost minimisation.*
- The edges of the Class C or D airspace could be replaced by a mandatory zone straddling the boundary of current controlled airspace (e.g. 3 NM inside, 3 NM outside), with a choice to make between Class E or Class G airspace. *This is modelled in scenario 4: Modernisation with limited synchronisation and scenario 5: Coordinated funding.*

These options are shown in Figure 8 below.

It is recognised that other detailed options could exist for localised environments. However, one of the biggest barriers to this approach, in spite of the benefits it may bring to access and possibly safety, is the complexity that may result. The airspace design must be understandable to all pilots and controllers.

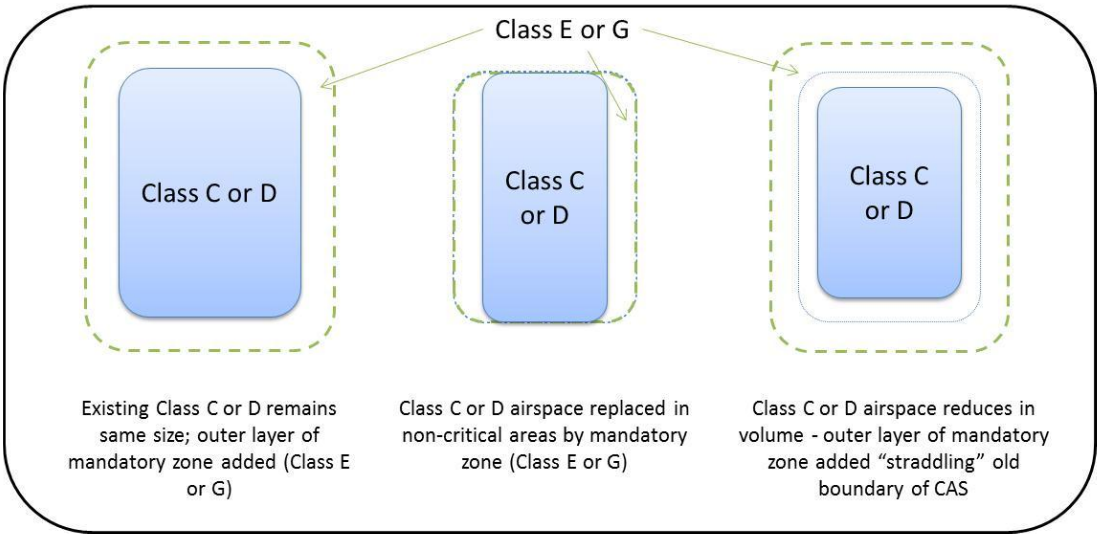



**Figure 8: Options for use of mandatory zones around Class C or D airspace**

### 4.3.4 Communications

#### 4.3.4.1 Out of scope

**Air-Ground Datalink – VDL Mode 2 or ACARS**. This was assessed to be out of scope for the LDLCA regions, as the CAT users do not believe sufficient benefits exist with the existing or proposed applications, including ADS-C-EPP (Extended Projected Profile) which is required for Trajectory Negotiation. The specific deployment of ADS-C-EPP services is still being debated, but is likely to focus on the core areas of high density traffic in Europe (e.g. city pairs). The capacity and throughput issues solved by the use of Controlled Times of Arrival (CTA) and ultimately trajectory negotiation are not likely to be replicated in LDLCA regions. Also, the current and medium-term CAT aircraft fleet in LDLCA regions generally will not be equipped with VDL2 or ACARS, particularly amongst the regional aircraft.

For the advanced datalink applications currently under standardisation (EUROCAE WG-78) and considered in EASA's rulemaking programme [20], it is unlikely that any will be beneficial in the LDLCA environment. D-TAXI is a transmission of taxi routing guidance in text or graphical format, unlikely to be required in the simple aerodrome layouts in LDLCA. Datalink weather information (D-ATIS) is a luxury given controller availability, whilst controller clearances via datalink are unnecessary given VHF channel availability.

**Aeronautical Mobile Satellite Services (AMSS)** – both current and next generation. The AMSS infrastructure has been available for aviation communications use for a number of years, under the ICAO FANS (Future Air Navigation System) concept. Both Iridium and Inmarsat systems are used extensively by Business Aviation and CAT, but have limitations on the length of message, quality of service and cost. The traditional limits on capacity and message delay are being mitigated by the next generation of AMSS aviation communications; Inmarsat Swift BroadBand is entering its trial stage with pioneer airlines, and Iridium NEXT is expected to be available by 2017. There are also plans in the European Space Agency for a possible unique aviation (ATM) communications satellite system, known as Iris.

The issue with AMSS in the LDLCA region is the lack of cost-beneficial applications, in common with Air-Ground datalink above. Whilst the next generation of systems allow for cockpit and cabin communications to be provided via a common infrastructure, thus creating cost-efficiencies, the scope and scale of usage in LDLCA regions is not likely to be high and it is not thought to be a driver for change.

#### 4.3.4.2 Assumptions (low uncertainty)

**8.33 kHz channel-spacing radio** was assessed to be low uncertainty and low impact in the LDLCA environment. Many of the benefits of 8.33 kHz channel spacing apply to the high density environment, where better frequency allocation and channel usage may lead to controller productivity and ultimately capacity gains. Nevertheless, the existing requirements will stay in place, and almost all radios on the market will be compliant with 8.33kHz in the future. Note that an issue exists at present with the certification of 8.33kHz handheld radios, namely that no solution currently exists which has been certified for operational use in the UK and Irish airspace; this may prevent certain aircraft from entering a Radio Mandatory Zone or Controlled Airspace.

#### 4.3.4.3 Variables to be considered in the study

Innovative Air-Ground datalinks for light business aircraft and General Aviation were considered as possible in this study. Trials have been underway in Europe in the use of 3G/4G (and in the future 5G). It is considered feasible to around 10,000 ft AGL, and may also be used whilst the aircraft is on the surface for pre-flight planning. A key issue for the LDLCA regions is the current availability of 3G and 4G; aviation would not be able to dictate the availability, and so the applications would only be available where coverage is seen to be cost-beneficial for the telecoms providers.

It is recognised that the use of 3G/4G/5G would mean a non-protected band is being used for aviation. Within the timeframes of this study, it is expected therefore that only non-safety critical data would be able to be passed via 3G/4G/5G. This seems feasible since, even today, some in-flight re-planning can be done via 3G in GA aircraft using a service provider to negotiate with the Network Manager. In time, elements of the 5G band may become national critical infrastructure. If this happens, legislative and regulatory protection would be applied, and they could be considered for use in safety critical applications.

Examples of current systems utilising 3G/4G include MovingTerrain’s Flight planning device, which allows IFR flight planning and approval via the Network Manager whilst in-flight.

This variable is captured as **Enhanced AIM** (Aeronautical Information Management) within the scoping study. It includes the following potential applications:

- The provision of updated arrival or departure information for IFR CAT (e.g. to GA aircraft under VFR) to assist in conflict avoidance – this application allows the VFR aircraft to manage its own separation by remaining clear of the arrival path of the IFR CAT. For example, a GA pilot could log on to receive all IFR arrival and departure times (updated in real time) for a particular aerodrome; they might then choose to remain clear of the ATZ until the IFR traffic passed. This may be particularly beneficial where unscheduled IFR traffic arrives at a small airport; e.g. Business Aviation jet traffic.
- The provision of MET information to assist in situational awareness – this application could be carried out by text or graphical means. Existing applications have been used for several years in the USA, and have shown the benefits to GA. For the LDLCA region in this scoping study, inclement weather can be a factor in flight safety, and the cost-effective provision of information may assist the GA pilot in managing the situation in-flight.

### 4.3.5 Navigation

#### 4.3.5.1 Out of scope

**GBAS Landing Systems (GLS)** are in development and early deployment at several high density airports. GBAS stands for Ground Based Augmentation System, and allows a single augmentation system deployed locally at an aerodrome to support multiple approaches to that aerodrome (in lieu of ILS). In ICAO and the FAA (including Boeing), the systems are known as GPS Landing Systems. GLS will be used for Precision Approaches (Cat II and Cat III), and is currently undergoing validation as part of the SESAR programme. Limited operational deployments are available with GLS Cat I. It is not thought that there is a significant cost-benefit case for airports with low traffic density; the SESAR Reference Operating Environments (project C.2) do not generally include GLS in the expected equipage for the low density aerodrome scenarios. This is partly due to the cost of the GBAS ground station, but also due to the need to fit the aircraft fleet to take advantage of the new technology.

One benefit of GLS is the ability to utilise a single ground station for all (final) approach types at an aerodrome for all runway ends. This includes curved approaches, offset thresholds, and varying glide path angles. The independence between the local siting of the ground station and the runway (i.e. the ground station can be almost anywhere on the aerodrome with line-of-sight visibility to the approaches) means that certain safeguarding requirements may be relaxed. Also, multi-path interference, seen with the Instrument Landing System, is mitigated for the GLS.

However, for the diverse CAT fleet in the LDLCA region, it is unlikely that these benefits will offset the initial outlay in an acceptable timeframe. Many regional aircraft manufacturers do not yet offer GBAS capability at all. For these reasons, GLS was considered to be out of scope for this study.

#### 4.3.5.2 Assumptions (low uncertainty)

The **rationalisation programme for VORs and NDBs** was considered to be low uncertainty; i.e. it is currently underway, and will proceed in removing NDBs and rationalising the VOR infrastructure as far as possible. It is noted that in Ireland, this rationalisation is not extensive, and will entail the removal of NDBs on a rolling basis, and possibly removal of VORs if and when alternatives become acceptable to all users. In the UK, NERL owns many of the VORs, and have an existing three phase plan to replace or remove them. The three phases correspond to the perceived difficulty and impact of individual VORs.

The timelines for the removal of infrastructure are not fully fixed; consultations and legacy procedures may mean that the dates for removal or replacement change. This is captured below in the variables for this study.

#### 4.3.5.3 Variables to be considered in the study

As per above, the timing of the assumptions on VOR and NDB rationalisation is considered to be a variable in this study, dependent on acceptable alternative solutions being available.

Linked to this, the exact **next steps in VOR rationalisation** are also considered to be a variable. For certain VORs, the only procedure which uses them is in the en-route environment, and this can be managed by existing RNAV procedures. For others, particularly those located near an airport, there may be instrument flight procedures which utilise the VOR, or it may be used for procedural separation, even if the entity providing the approach service is not the owner of the VOR.

Where this is the case, three broad options are available to the aerodrome ANSP:

- Replace the VOR with another one, owned by the airport, and maintain existing procedures. This would remove the benefit from VOR rationalisation (in terms of frequency usage) and is not the preferred option going forwards, but would simplify operational transition issues.
- Maintain procedural separations via other means. Each method of procedural separation has a potential associated delta from the most direct approach routing; the necessity to provide safe separations may lead to cost-efficiency penalties for IFR airspace users. Geographical or vertical separations may be used, where aircraft can report e.g. north or south of the aerodrome, such that the ATCO can ensure safe separations are maintained. More efficient procedures can be employed using standardised conventional or RNAV routings, for example laterally separated as per ICAO Circular 324. One issue with the use of RNAV Instrument Flight Procedures is that ICAO Annex 11 requires that these are inside controlled airspace, whereas some today would fall in Class G assuming a direct replacement.
- The highest level of separation assurance could be given by the application of a surveillance infrastructure, giving a surveillance (radar) control service. This surveillance infrastructure would be governed by CAP670 [13], but may not be limited to radar surveillance. It may also be worth challenging the need for non-cooperative surveillance, if the surveillance infrastructure is intended to be used as a direct replacement for VOR-based procedural separation in Class G.

Each of the options will be modelled in different scenarios, allowing the impacts and trade-offs to be assessed.

Performance Based Navigation (PBN) provides two other variables to be modelled in this scoping study. Firstly, the on-going **implementation of APV approaches** will continue, but with various potential timescales for full up-take. The ICAO Assembly Resolution 37-11 specified that all instrument runway ends should be equipped with an APV approach by 2016. No target was applied to non-instrument runway ends, as the ability to design APV approaches to non-instrument runway ends remains an open question, in particular which mitigations will be applied to ensure tolerable risk levels are maintained. The UK CAA is currently drafting guidance on the matter, which is likely to call for a higher decision height when APVs are installed to current non-instrument runways. HIAL are already engaged in the implementation of APV approaches, with three aerodromes included in the first phase. At present, APV approaches are only thought to be applicable to Cat I precision approaches (as per EU OPS [18]); work is progressing in the FAA to understand whether a lower decision height could in time be feasible.

The second area of PBN is the **application of PBN Instrument Flight Procedures**. These are likely to be RNAV-based in the first instance, due to LDLCA fleet equipage and the operational need – i.e. RNP-based procedures are not likely to be necessary in the LDLCA region. As mentioned above, the use of PBN IFPs (namely, SIDS and STARS) in uncontrolled airspace will need to be assessed, as it is not currently ICAO compliant.

Limited RNAV IFPs may need to be designed to airports where the VOR has been removed, since IFR flights will require routes and guidance to the airport. This poses a challenge in terms of the redundant solution in case of GNSS outage, for example due to solar interference, or deliberate jamming by military activity during exercises in the LDLCA region. With VORs being removed, the conventional navaids remaining are likely to be DMEs (Distance Measuring Equipment). With two DMEs coverage required to fly RNAV, there may be issues ensuring appropriate coverage down to the altitude required to begin the APV approach. From initial DME/DME coverage modelling carried out within the European context (i.e. Eurocontrol navigation groups, SESAR), it appears as though DMEs may need to be moved or supplemented to ensure coverage without gaps down to 5500ft. Either option entails a cost – it is not clear where this cost should be borne, given the routes tend to be under FL195 (and thus not part of the NERL license).

The capability of the aircraft in the region, including operational approvals, remains a challenge to the introduction of APV approaches and RNAV Instrument Flight Procedures. For APV approaches, EASA AMC 20-28 [19] sets out the means of compliance for various categories of aircraft and operator. Of particular interest is the requirement for hot standby capability for APV approaches for dual crew aircraft, potentially requiring dual coupled FMS. For single pilot aircraft, a reduced functionality back-up capability is sufficient. The Universal Avionics UNS-1Lw flight management computer appears to be becoming standard on many small regional carriers wishing to carry out APV approaches in Europe. For smaller aircraft with single crew, Garmin's GTN series of navigation computers is the latest option, made easier by EASA's decision to release an Approved Model List (AML) such that certification by type is done for a range of aircraft in one pass, thus reducing cost. The primary functionality can be enabled by a forward field-of-view Multi-Function Display (e.g. Garmin GTN 750), with back-up provided via a smaller box.

### 4.3.6 Surveillance

#### 4.3.6.1 Out of scope

**Space-based ADS-B**: this emerging technology was discussed with several stakeholders, including informal discussions with Aireon, the company promoting this service. It relies upon ADS-B receiver payloads being carried on Low Earth Orbit (LEO) satellites, able to pick up ADS-B signals and relay them to the ground. The initial solution is being developed and promoted by Aireon, an Iridium subsidiary, with the payloads launched on Iridium NEXT satellites and available from 2017.

There were two main issues foreseen with the use of space-based ADS-B in LDLCA regions under Flight Level 195 (i.e. within the scope of this study). One is a perception that there would not be positive cost-benefit in such a low-density environment, but this reason does not automatically preclude it from being examined within this study. The more fundamental disadvantage is that space-based ADS-B requires a top antenna on-board the aircraft, something which is standard on Commercial Air Transport, but reasonably rare in many GA aircraft. This situation is unlikely to change in the medium-term.

Thus, for space-based ADS-B, the benefits are limited to CAT in controlled airspace, something which for LDLCA regions is fairly rare. For high-level airways or oceanic regions, the technology will provide a 99.9% traffic picture. For LDLCA regions (below FL195), the figure is likely to be somewhere closer to 20%, and for that reason, it was considered to be not worth investigating any further as a feasible solution for LDLCA regions. This was validated by the stakeholders.

#### 4.3.6.2 Assumptions (low uncertainty)

NIL

#### 4.3.6.3 Variables to be considered in the study

**The need for non-cooperative surveillance**: UK CAP670 [13] describes two forms of surveillance-based ATS: a radar control service inside controlled airspace, and a deconfliction or traffic service outside controlled airspace (part of ATSOCAS).

SUR01-9 states "*Primary Surveillance Radar (PSR) is normally the minimum level of equipment necessary to provide Radar Control, Traffic Service or Deconfliction Service. SSR or other surveillance technologies may, to varying extent, be required to supplement PSR in order to safely accommodate increases in traffic complexity or density*."

SUR01-11 states "*Non-co-operative surveillance systems shall not be permanently withdrawn from service unless all ATSUs using the system can demonstrate that the traffic demand and complexity can be safely handled using procedural control or remaining surveillance systems*."

CAP670 goes on to state that for low traffic density and/or complexity areas, non-cooperative surveillance is optional. However, it is required if the hazard analysis shows that it is probable for non-transponder equipped aircraft (whether identified or not) to present a hazard to operations due to the uncertainty of their positions, which cannot be mitigated by other measures. This statement presents a subjective condition which could be achieved through different measures. *Note: it is possible that no other solution may be found. However, this scoping study does not dismiss the possibility out-of-hand.* Other measures could include limited controlled airspace and/or a Radio and Surveillance Mandatory Zone. The probability and causes of hazards to operation (in practice, airproxes) would need to be assessed to fully understand the applicability of alternative solutions. This applies to both aerodromes and uncontrolled airspace where deconfliction or traffic services are currently applied.

The MoD have stated (see stakeholder expectations in Annex F) that the ATSOCAS provided using non-cooperative surveillance will remain for their operations. For civil aerodromes using surveillance, provision of ATSOCAS beyond the CTR/CTA is valuable for airspace infringement protection. Nevertheless, out to 60NM, it is more difficult to justify the need for ATSOCAS in Class G airspace, since it is not clear why that portion of Class G is any riskier than other parts. An influence on this may be the provision of Lower Airspace

Radar Services (LARS), which may move in the future to be contracted to civil operators as well as military service units.

The benefit in offering alternatives for meeting tolerable risk levels other than utilising non-cooperative surveillance is the ability to enable wind farm targets and spectrum release. There is also a cost implication.

**Introduction of Multi-Static Primary Surveillance Radar (MSPSR) systems**: for the last eight to ten years, MSPSR systems have been investigated in Europe as a possible alternative means to carry out civil non-cooperative surveillance. The MSPSR principle has been available for defence use for longer. The concept works through a distributed set of transmitters sending out RF transmissions which are reflected off an aircraft's skin and received by one or more receiver ground stations using non-rotating antennas. MSPSR systems may use transmitters of opportunity like radio and television broadcast stations, mobile telephone base stations (preferred to keep the system passive) or dedicated transmitters specially deployed to avoid relying on third party illuminators [15].

The system is likely to be most cost-beneficial to deploy in shorter range volumes (e.g. TMA, or an ATZ and surrounding airspace), due to the complexity and preference on cost grounds for using third party signals. A specific modulated signal may be required to maximise the probability of detection through accurate processing. This would remove the reliance on third party signals, and lead to a direct relationship between service volume and number of active transmitters. Whilst systems in development utilise a mixture of FM signals, DAB, DVB-T and mobile phone bands, the need for spectrum protection may lead to a preference for digital TV bands, since these constitute critical national infrastructure and are protected from undue interference as a result.

In common with Wide Area Multilateration (the equivalent secondary surveillance technique), MSPSR offers better low level coverage and reduced capital costs. However, the distributed network may lead to increased land rental costs and high communications costs to transmit the received signals to the central processing unit.

As yet, there is no proof of applicability within civil ATC. Nevertheless, there are defence systems available with intentions to move into the civil market, and CAP670 [13] recognises this with the addition of a section allowing the use of MSPSR in UK civil ATC surveillance (Annex B to SUR12). This is conditional on a pre-operational trial to show equivalent performance in the service volume to Primary Surveillance Radar. There is a Technology Strategy Board part-funded study active in the UK at present, run by Thales UK, NATS and Roke Manor Research. The R&D system being trialled operates in the digital TV band.

The systems currently available or in development include [15]:

- Lockheed Martin – Silent Sentry (FM signals);
- Thales – HA-100 (FM signals);
- Thales – NECTAR (DAB, DVB-T);
- Cassidian (EADS) – PARADE (FM, DAB, DVB-T);
- Fraunhofer FHR – several mobile experimental MSPSRs;
- ERA – PCL Demonstrator (FM signals);
- Roke Manor (Chemring) / BAe Systems – CELLDAR (mobile phone signals).

The **timing of the assumption on wind farm targets (and associated mitigations)** is another variable to be considered, dependent again on the non-cooperative surveillance evolution. Different areas of LDLCA will have different prioritisation of the wind energy targets; for example, Scottish Government has aggressive targets for energy generation via wind farms which suggest it will strive to remove objections to developments where possible.

The Renewables industry, and particularly onshore wind farms, are faced with two key drivers for the business case. One is the continued use of Renewable Obligation Certificates, which ensure a subsidy is paid for every mW of energy produced via renewable sources by legislating a flat-rate fee with the current value applicable until 2017. A new mechanism will be defined following 2017. The second is the duration of these subsidies, which traditionally have been for 20 years following build, but recently in the draft Energy Bill before UK Parliament, have been proposed to be reduced to 15 years (a 25% reduction) for any wind farm built after 2017. The knock-on impact of this potential measure would be for any wind farm developers to be incentivised to remove objections to developments before 2017[11], to ensure the most positive Net Present Value (NPV) possible.

Across the UK and Ireland, there is limited evidence that some planning objections raised by aviation providers on the basis of radar interference are being overridden. Therefore, the timing of the assumption is important from a point of view of the balance of interests in the next five years or so, and any political drivers. The timing is also important with respect to alignment of non-cooperative changes. If wind farm incentives are strongest up to 2017, whilst spectrum release programme impacting PSRs is targeting 2020 onwards, there may end up being two solutions applied in the non-cooperative domain, to the detriment of the overall business case. Therefore, the **timing of the assumption on the spectrum release** between 2.7 – 2.9 GHz for civil and 2.9 – 3.1 GHz for military is also important.

Spectrum release will depend upon alternative solutions being available, noting that the provision of non-cooperative surveillance for ATSOCAS and some services in the CTR/CTA will not change in the near future. The alternative solutions currently being looked at include [21]:

- Re-allocate frequency by re-tuning radars – potentially costly with no benefits to aviation;
- Deploy new radars (on new frequencies) – dependent upon the lifetime of existing radars, otherwise a very costly solution; for LDLCA, the expectation is that replacement would occur between 2025 and 2027, which is not in line with spectrum release target dates of 2020.
- Deploy new technology (MSPSR) operating on a different frequency and method – see MSPSR option discussion above;
- Some mix of the above.

For cooperative (secondary) surveillance, a series of variables can also be identified. Firstly, the development of performance-based surveillance means that providers are no longer reliant on a single technical solution; i.e. Secondary

[11] i.e. the wind farms should be generating by 2017, with mitigations in place.

Surveillance Radars. Alternatives exist, and are allowed under CAP670, which may also meet the performance requirements for secondary surveillance. The two most common alternative solutions are Wide Area Multilateration (WAM) and Automatic Dependent Surveillance – Broadcast (ADS-B).

Wide Area Multilateration comprises a distributed network of receiver stations (similarly to MSPSR) which receive 1090MHz signals from the aircraft and process the Time Difference of Arrival (TDOA) to plot the exact position of the aircraft. The system can be actively interrogating the aircraft or can rely on signals of opportunity, created by other interrogations (e.g. other SSRs in the vicinity), ADS-B extended squitters or ACAS squitters. The aircraft requires a transponder.

ADS-B uses airborne-derived position, and broadcasts this for reception by anyone within range and line-of-sight. The aircraft requires an ADS-B transmitter, which may be integrated with the transponder, and a means of deriving position information (e.g. GNSS).

ADS-B and WAM can be used together to validate the position report of the other. The variable is whether, and in what timescales, **secondary surveillance deployment (ADS-B/WAM vs Mode S SSR)** might evolve in the LDLCA region.

One issue with the application of WAM in the LDLCA region is that it tends to rely on GNSS based timing to enable the TDOA synchronisation. If GNSS is jammed or suffers interference, a redundant timing solution must be available at potentially additional cost. Another factor in the region is that WAM's distributed sensors may not work on islands or in coastal locations (unless some sea-borne structures are available). Finally, the cost of on-going communications from the distributed sensors may be relatively high given the bandwidth and reliability requirements. Nevertheless, it is expected that the maintenance/spares costs would be significantly reduced compared with MSSRs due to the application of a static (non-rotating) system.

WAM system capital expenditure is generally less than a corresponding SSR, although it depends on the level of redundancy required in the system. For a terminal area system (60sqm coverage), a radar might cost £4M whilst a WAM system may cost £2.5 – 3M.

The WAM system market is dominated by 5 large developers: ERA, Saab Sensis, Indra, Thales and Comsoft. It is currently operational in the UK; for example it was most recently deployed in Newcastle airport's TMA.

ADS-B is also a prime enabler for **electronic conspicuity**. This refers to the ability of the aircraft to be "seen" electronically. For limited applications, a transponder may be sufficient for electronic conspicuity, but it generally refers to both ground and airborne surveillance, and therefore requires a means of transmitting position (rather than deriving it on the ground). There are four levels of applications using electronic conspicuity:

- Ground-based surveillance for ATS;
- Ground-based surveillance for FIS (deconfliction or traffic service, including for airspace infringement protection);
- Airborne surveillance – the ability to be "seen" by other GA (and Military?) traffic;
- Airborne surveillance – the ability to be "seen" by Commercial Air Transport carrying ACAS.

Each one of these may carry different requirements on the technology enabling electronic conspicuity. For example, if CAT are able to "see" the GA aircraft, the integrity of the position may need to be higher to prevent false ACAS TAs and RAs. If it is solely for ground-based surveillance for FIS, a simple integrity check on the ground (similar to a light WAM system) may ensure the data does not contain undetected errors leading to hazards to operation.

Electronic conspicuity has long been a topic for discussion in the UK and Europe more widely – two accident reports from the AAIB in 2005 and 2008 highlighted the need for electronic conspicuity on gliders and light aircraft to mitigate risk in Class G operations. The barrier to date has been the presence of a robust market of low cost, low power, low weight, interoperable and certified equipment. This is beginning to change, with standards nearing completion in RTCA for a Low Power Surveillance Equipment (LPSE), with corresponding technical standards order from the FAA (draft TSO-1199). The system can be built as a basic low power transponder, a transponder with ADS-B OUT, or with ADS-B IN also. In the UK, NATS is also attempting to develop a Low Power ADS-B Transceiver, which would require minimum certification. The cost of boxes complying with these requirements is yet to be determined, but the aim is to have ADS-B IN/OUT transceiver functionality for under £1500 (installed).

The final two applications of electronic conspicuity are taken forwards into a separate variable: the **use of air-air surveillance in mitigating risk**. This refers specifically to the ability of airborne surveillance (ADS-B IN, including a traffic display) to be used by GA, military and CAT to mitigate risks, primarily in uncontrolled airspace. This may include the operation of scheduled and unscheduled CAT into Class G airspace and aerodromes. Dependent on the uptake of electronic conspicuity, which itself depends upon the low cost market solutions, it may be appropriate to apply Surveillance Mandatory Zones (SMZ) in and around airfields where CAT may be operating.

Future steps of air-to-air surveillance may include the ability to use Traffic Situational Awareness with Alerts (TSAA), a standardised application being developed primarily through RTCA by the FAA and industry, allowing traffic alerts to be displayed or aurally indicated to the (GA) pilot using the ADS-B traffic information. This will assist in the effectiveness of the variable.

ADS-B, as a technical enabler for a safety-critical system, is currently in the midst of a transitional phase. Trust in the system is not 100%, due to known issues with installations and the properties of a single source GPS solution. The possibility of undetected errors in the position reported remains an issue. It is expected that some of these issues will be solved in the years to come, with the introduction of basic error detection internally to ADS-B OUT transceivers, and the introduction of dual GNSS solutions (i.e. Galileo).

As this happens, ADS-B is more likely to be trusted as a cooperative form of surveillance, possibly even sole means or backed-up by an integrity check mechanism (e.g. reduced form of WAM). This could lead to more SMZs with low cost ground surveillance including simple conflict probes providing effective mitigation against airproxes.

#### 4.3.7 Other impacting variables

##### 4.3.7.1 Out of scope

NIL

#### 4.3.7.2 Assumptions (low uncertainty)

NIL

#### 4.3.7.3 Variables to be considered in the study

The possible future **availability of central funding**, either through joint ventures or through public-backed investment or grants, will influence the evolution of the LDLCA environment. Business cases may be more easily made at central or regional level than in individual conditions; examples of this include the possibility of a nationwide surveillance infrastructure with data sharing, or the set-up of a regional centre for APP and TWR. Another key funding idea is the possibility of building a business case around the benefits achievable from spectrum release and wind farm planning permissions, and using central funds to offset some of the costs borne by aviation to enable these goals.

No specific public funding initiative has yet been identified or reserved.

### 4.3.8 Stakeholder prioritisation

A subjective assessment was carried out of the stakeholder priorities of which variable should be modelled. Stakeholders were asked to name their top priorities (a maximum of five) for assessment in this scoping study.

The results were then normalised across stakeholder groups, since there were not equal numbers of representatives present at the workshops.

The outcomes were plotted for the UK and Ireland situations, and represent a broad and subjective view of stakeholder interest in certain variables. Figure 9 below shows the collated poll.

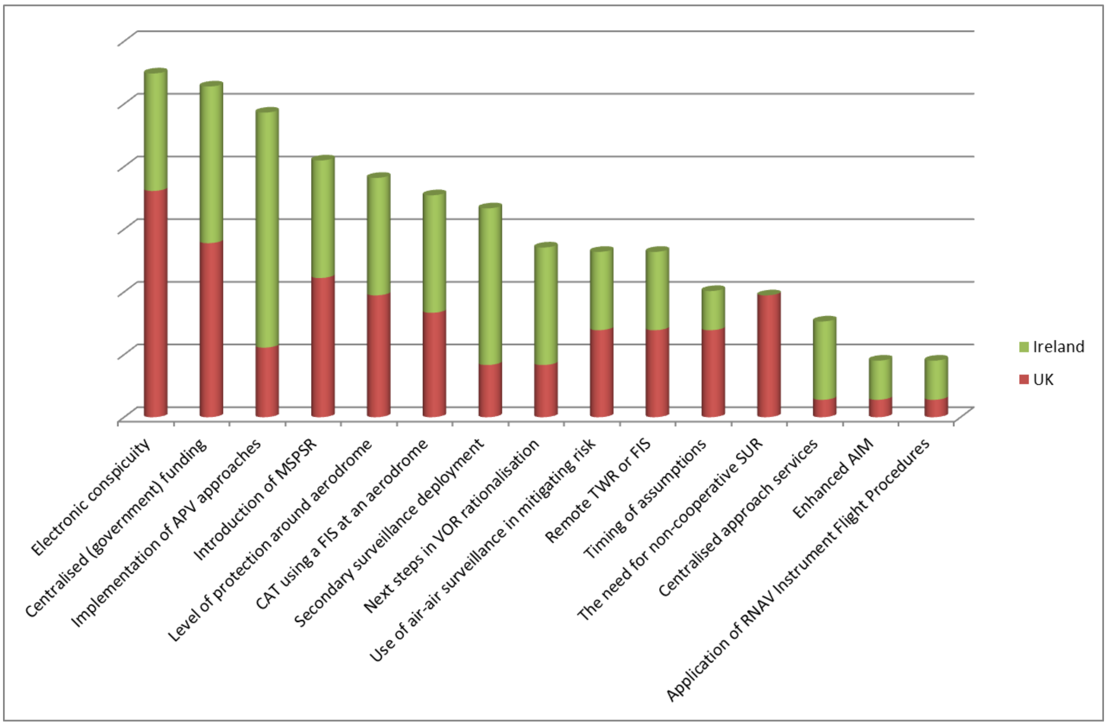



**Figure 9: Stakeholder priorities**

The table below outlines the resultant 15 variables, prioritised in terms of interest by the stakeholders (with 1 being the highest priority). All the variables will be modelled in scenarios.

| Priority | Variable | Description |
|---|---|---|
| **1** | Electronic conspicuity | Ability of the aircraft to be "seen" by ATC or other aircraft through the use of ADS-B |
| **2** | Centralised (government) funding | Future use of organised funding (via public and private means) to create a business case across multiple stakeholders |
| **3** | Implementation of APV approaches | Roll-out of APV approaches as standard at licensed aerodromes in the LDLCA region, including to non-instrument runway ends |
| **4** | Introduction of MSPSR | Deployment (coordinated/regional or local) of Multi Static Primary Surveillance Radar systems |
| **5** | Level of protection around aerodrome | The use of risk-based airspace design to create an appropriate balance of controlled airspace, RMZ, TMZ and/or SMZ to manage risk and allow accessibility to all users |
| **6** | CAT using a FIS at an aerodrome | Appropriate techniques to ensure tolerable safety when using FIS at an aerodrome with CAT |
| **7** | Secondary surveillance deployment | The deployment, coordinated/regional or otherwise, of ADS-B/WAM or Mode S SSR |
| **8** | Next steps in VOR rationalisation | Modelling the potential next steps following VOR rationalisation, including replacing VORs (under new ownership), retaining procedural separation with different enablers (e.g. geographical, RNAV-based etc), or SUR-based separation |
| **9** | Use of air-air surveillance in mitigating risk | Application of ADS-B IN to receive traffic information on surrounding aircraft, and use it as a layer in achieving tolerable safety levels |
| **10** | Remote TWR or FIS | Set up of a centralised centre for the provision of TWR and/or FIS remotely from the individual aerodromes |
| **11** | Timing of assumptions | The varied timing of the assumptions on spectrum release, VOR rationalisation, and wind farm targets/mitigations |
| **12** | The need for non-cooperative SUR | Understanding whether, for those areas where CAP670 sets out non-cooperative surveillance as optional, tolerable risk levels can be achieved via other means (e.g. electronic conspicuity + SMZ) |
| **13** | Centralised approach services | The provision of APP services for a number of aerodromes from a single centralised location |
| **14** | Enhanced AIM | The use of datalink (e.g. 4G/5G) to provide enhanced information to the cockpit, including weather and updated trajectory information of IFR flights (via SWIM?) |
| **15** | Application of RNAV Instrument Flight Procedures | Application of new arrival and departure routes (note: overlaps with one of the possible next steps in VOR rationalisation). Possible link to APV approaches |

**Table 10: Stakeholder prioritised list of variables**

## 4.4 Dependencies

Each of the variables could be assessed independently, but this does not highlight the reality of the inter-relationships and dependencies. These dependencies are valuable in clarifying the possible constraints or knock-on impacts from individual decisions, thus focusing the scope of possible roadmaps.

The operational stakeholder workshops were used to collect information on the dependencies pre- and post-implementation of individual variables. Detailed outcomes are contained in Annex G.

The information was used to assist in understanding potential groupings of changes within a scenario. In particular, two critical decision-making "chains" were identified for developments in the LDLCA region.

The first chain relates to the future surveillance strategy. This chain revolves around four main questions:

- Will non-cooperative surveillance be required in the future LDLCA environment, either locally (around aerodromes) or regionally (for ATSOCAS)?
- Will cooperative surveillance be required in the future LDLCA environment, either locally around aerodromes, or regionally for electronic conspicuity for ground or airborne applications?
- Will the cooperative surveillance require a local mandate (e.g. TMZ or SMZ) to ensure full airborne equipage?
- Which technology will be used to meet the surveillance need, both non-cooperative (primary) and cooperative (secondary)?

There are a series of related questions dealing with ownership, funding, timescales, and equipage availability (both ground and air).

These questions give rise to the following (simplified) decision chain.

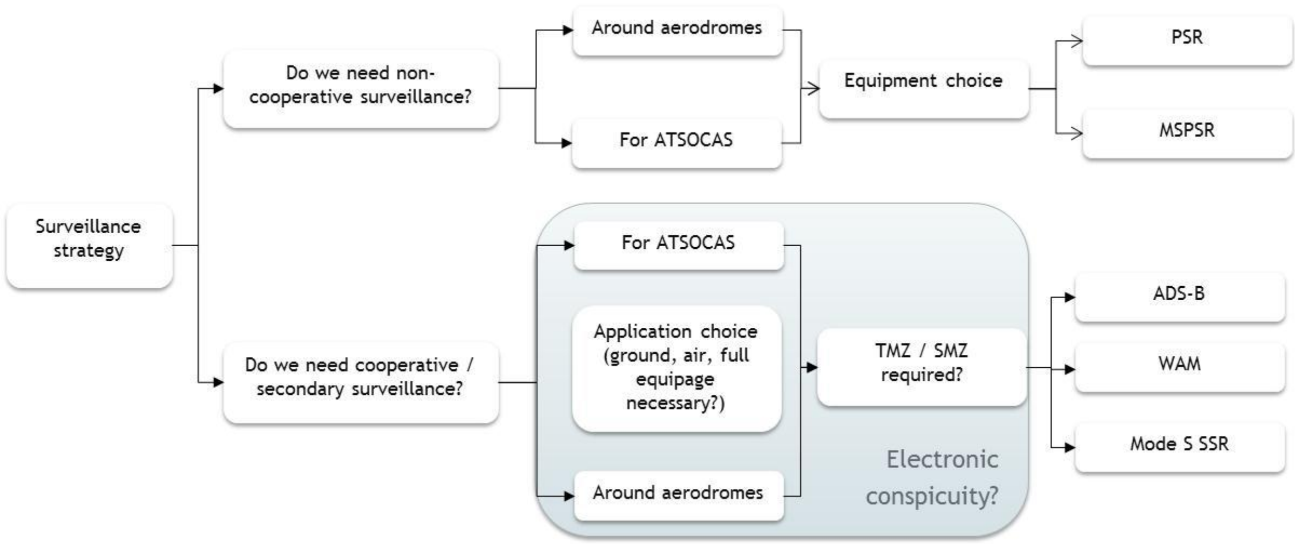



**Figure 10: Surveillance strategy options and dependencies**

The decision whether non-cooperative and/or cooperative surveillance are needed in LDLCA will depend upon which services are provided, and an assessment of the hazards borne by operations according to varying levels of traffic picture being presented to the controller or pilot. This can apply inside controlled airspace (around aerodromes) or for ATSOCAS.

The second dependency chain is the response to navaid rationalisation. Where airports are dependent on ground-based navaids, particularly VORs, for definition of approach procedures, alternatives need to be put in place if the navaids are removed as part of rationalisation programmes.

In this case, four options are available, and choices again depend on various issues and in turn influence other developments.

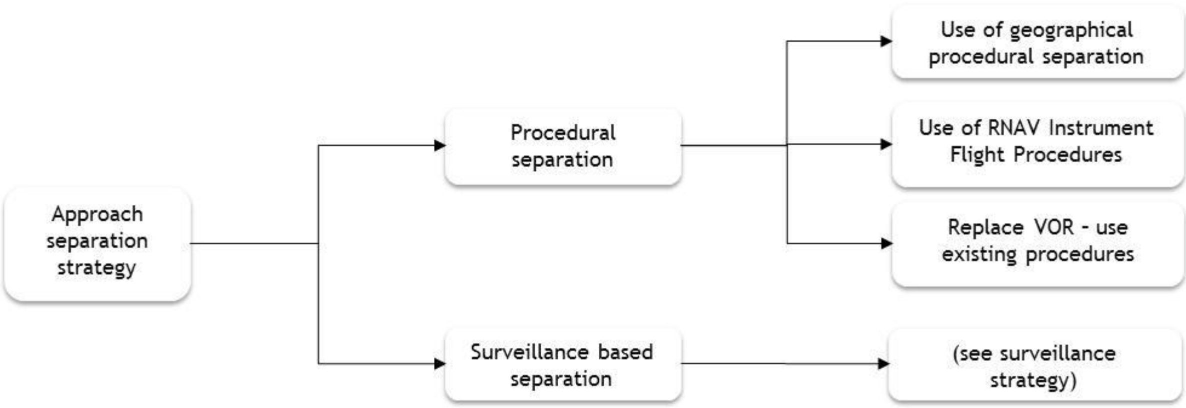



**Figure 11: Approach separation strategy options and dependencies**

Assessing the options and their dependencies in turn:

- There are two over-arching strategies: to maintain procedural separation in some form, or to move to surveillance-based separation in line with CAP670.
- Procedural separation can be provided via three broad means:
  - Use of ground-based infrastructure / replace VOR: This is very much in line with existing procedures; however, ground-based infrastructure is expensive and has a limited life-span. Current infrastructure is often owned by the en-route ANSP, not the aerodrome ANSP, and the en-route ANSPs are generally looking to rationalise the infrastructure. The aerodrome ANSPs have the option to purchase their own navaids, but this is a very costly solution and does not help with VOR rationalisation.
  - Use of RNAV Instrument Flight Procedures: This entails designing and implementing a set of IFP for IFR flights approaching and departing from the airport where the navaid is being removed. It allows for precise routes to be flown, with an expectation of the aircraft's path from leaving CAS down to the Final Approach Fix. ICAO Circular 324 gives guidelines on laterally separating aircraft on arriving and departing routes from an aerodrome. One issue may be the (acceptable) application of IFP in uncontrolled airspace where that currently exists. Another issue may be aircraft equipage to be able to fly the IFP – conventional procedures may also need to be applied.

    - Use of geographical or vertical-based procedural separation: This includes using conventional routes and reporting (e.g. omni-directional departures), using vertically separated levels, or utilising defined geographical areas (e.g. north or south of the airfield). It generally has the highest penalties in terms of flight efficiency, since the airspace is managed coarsely to achieve safe separations. For certain airports, dependent on scheduling of IFR movements, it may be sufficient.

- The second option of adding a surveillance-based service to the airspace would mitigate removal of ground-based navigation infrastructure, but would require significant investment as little or no surveillance infrastructure is currently in place for either Scottish or Irish airports in the LDLCA area. For airports with sufficiently high movements, the associated benefits from surveillance-based services may justify the investment. The surveillance infrastructure would ideally be part of a wider decision (e.g. regional), but this may depend on timescales.

Some of the options will lead to significant training requirements for controllers working in current, navigation infrastructure based, operations.

What makes the dependencies in this area particularly complex is that the timing of issues and optimal solutions becoming available are not consistent. Additionally, different solutions put costs on different stakeholders, which makes the decision making process complicated.

## 4.5 Scenario description

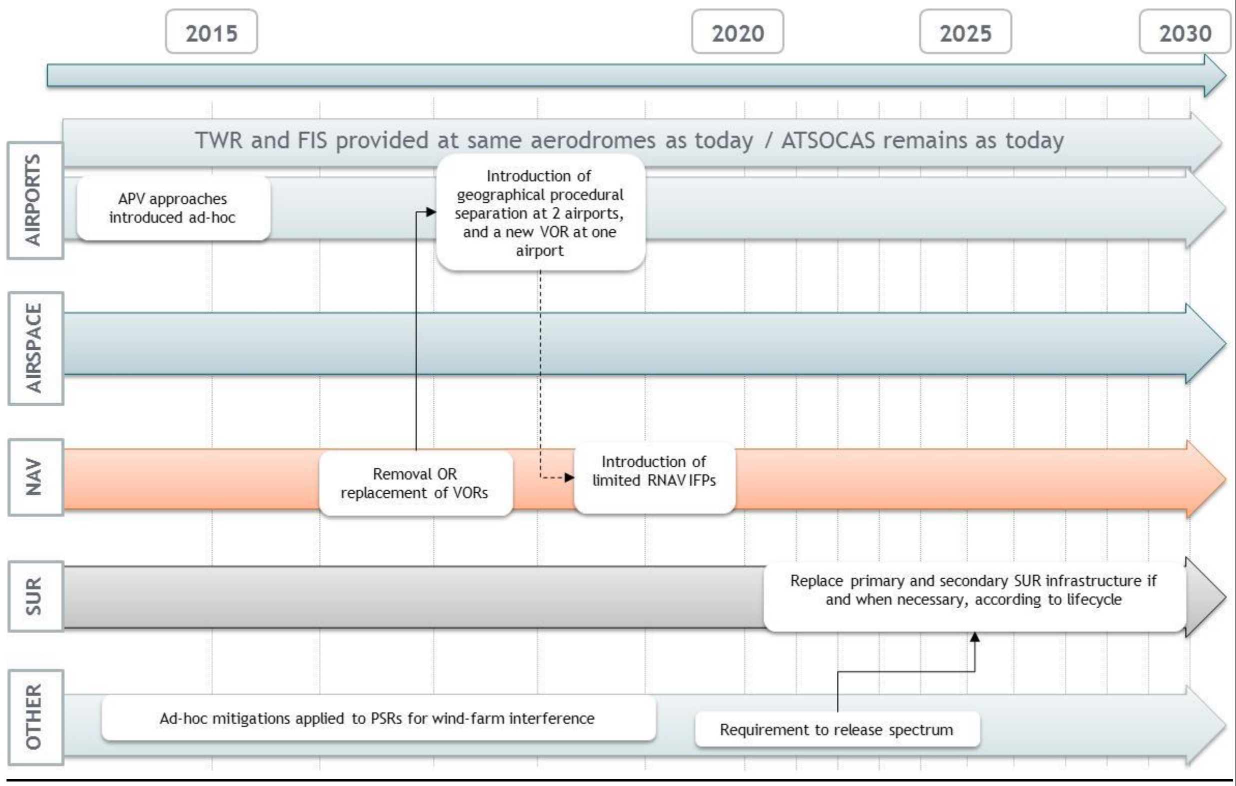
The following sections provide an overview of the scenarios that will be assessed within the scoping study. Each scenario is based around a main decision making principle, and potential future developments are defined around this principle, with particular focus on the main variables and dependencies discussed above. The main variables and dependencies are partly presented as a roadmap from today to 2030, using a timeline that puts a higher level of detail on the period up to 2020.

The purpose of the assessment will not be to identify a preferred scenario, but rather to develop an understanding of the impact of decisions regarding the wide range of issues that affect LDLCA. This approach also allows the definition of scenarios, or elements within scenarios, which are not fully desirable (even if they are realistic), so that their actual impact is better understood.

### 4.5.1 Scenario 1: Do the minimum necessary

**<u>Main principle</u>: Don't change services and infrastructure unless forced**

This scenario will consider the minimum activity required in response to the external factors that mean that the status quo in LDLCA is no longer feasible.




<u>Description of the scenario</u>

*Airports*: Airports maintain current levels of APP/APS and TWR (ADV/ADI) services, provided locally. In the UK, individual airports may decide to provide FIS instead of existing TWR services, but only based on cases / arguments similar to today (e.g. changing density of traffic).

➔ Justification: There is no reason for airports to change service level or method of service provision.

*Airspace*: No further airspace restrictions (classification changes, RMZs, TMZs) are introduced, unless essential to maintaining safety around airports where a reduction in service level is introduced (e.g. move from ATC to FIS). Planned changes to Class F routes are assumed (with some moving to Class C or E+TMZ, and others moving to Class G).

Existing services, including ATSOCAS and LARS in the UK, are kept in place. This may entail a difference with EASA's SERA, since the deconfliction service is not included in SERA at present.

➔ Justification: There is no reason to introduce changes other than those that are common or already planned today.

*Navigation*: Navaid rationalisation continues as per the current NATS programme and associated NATS impact assessments (with a dependency on the replacement planning and the lifetime of the existing infrastructure). Where considered essential by the airport, any removed VOR will be replaced by the airport. This is only realistic for a very limited number of airports, and does not help rationalisation. Only one airport is assumed to take this option. For other airports, a reduction in service level will be introduced, with separation ensured through geographical or vertically based procedural separation. APV approaches are introduced, with limited RNAV routes to ensure IFR access from 2018.

➔ Justification: The aim is to keep changes from today's situation to a minimum, but some cost efficiency issues will need to be considered, and RNAV IFP are necessary to allow IFR access.

*Surveillance*: Primary and secondary surveillance layers are kept in place as long as possible. Technically, the status quo is preferred due perceived difficulty of transition and training. PSRs and MSSRs are replaced by similar systems at end of life. This may delay spectrum release as existing PSRs remain in-band.

➔ Justification: Changes are postponed as long as possible; if changes can no longer be avoided, new technology must provide a service that is proven to be equal to or better than current service.

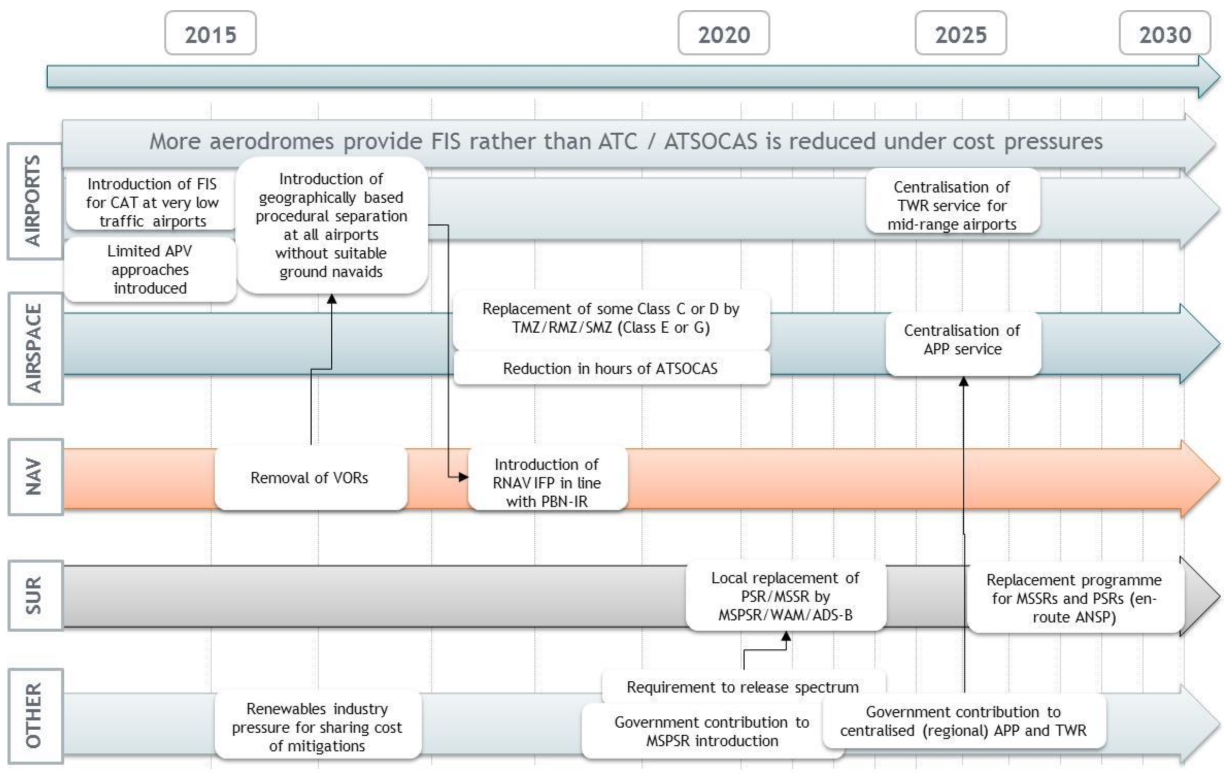
*Other*: Ad-hoc mitigations for wind farm interference are used until 2017 and onwards – these include in-fill (if available), blanking, processing/filter improvements, and third-party technology solutions. They are "ad-hoc" since decisions are taken on a wind-farm by wind-farm basis.

➔ Justification: Aviation does as little as possible towards wind-farm mitigation, but the targets on wind energy force some progress with the wind energy sector paying towards the mitigating enablers.

### 4.5.2 Scenario 2: Cost minimisation

**<u>Main principle</u>: Each stakeholder aims to minimise their costs**

Cost is an important driver for all stakeholders, and this scenario will consider the impact of each stakeholder aiming to minimise their own costs – with limited consideration for the overall cost.




<u>Description of the scenario</u>

*Airports*: Airports aim to move towards cost-effective solutions. Some airports move from ATC services to FIS. Single ATCO operations for APP/APS and TWR (ADV/ADI) at many airports means that centralised APP only becomes cost-effective when also centralising TWR services (i.e. via remote towers) – timelines are therefore delayed due to complexity. Increased use is made of FIS-only operations (possibly centralised).

➔ Justification: Airports can minimise cost of service through either reducing service level, or centralising services and making use of economies of scale and scope.

*Airspace*: It proves difficult to sustain existing ATS. ATSOCAS deconfliction and traffic services are reduced in hours and coverage.

Class C or D airspace around an aerodrome is replaced in limited areas by a mandatory zone (and Class E or G) – this should enable increased access for GA, since no clearance would be necessary to enter the newly created Class E or G. The overall size of the Class C/D and mandatory zone remains the same as before. See Figure 8 second option.

➔ Justification*:* Cost can be reduced through a reduction in service level. Costs minimised for airspace users (particularly GA) by increasing access.

*Navigation*: En-route ANSPs rationalise ground navaid infrastructure at the earliest (safe) opportunity. Aerodromes impacted move to geographical or vertical-based procedural separation with subsidised limited RNAV implementation (in line with PBN-IR timescales est as 2018-2020). Strong opposition from air transport community to mandatory equipage.

➔ Justification: Rationalisation saves cost for the en-route ANSP. For affected aerodrome, only use of geographical/vertical separation and implementation of limited RNAV routes avoids significant investment. This pushes cost onto airspace users in terms of possible reduced service level, and eventually potential cost to comply with RNAV route requirements. The airspace users aim to minimise their costs.

*Surveillance*: Strong opposition from air transport community to mandatory equipage of any air-to-air surveillance functionality – even if modular COTS equipment of limited cost becomes available for GA.

➔ Justification: Airspace users aim to minimise their cost and oppose to forced investment.

*Other*: Government drives spectrum release to realise £2-3bn. Government is willing to support activities to help release the spectrum, if the business case makes sense. This includes supporting the deployment of limited MSPSR using grants.

Renewables industry successfully lobbies to reduce condition on paying for wind farm mitigations – aviation starts to bear the cost with new infrastructure. The scenario assumes that PSR upgrades are still the primary model chosen.

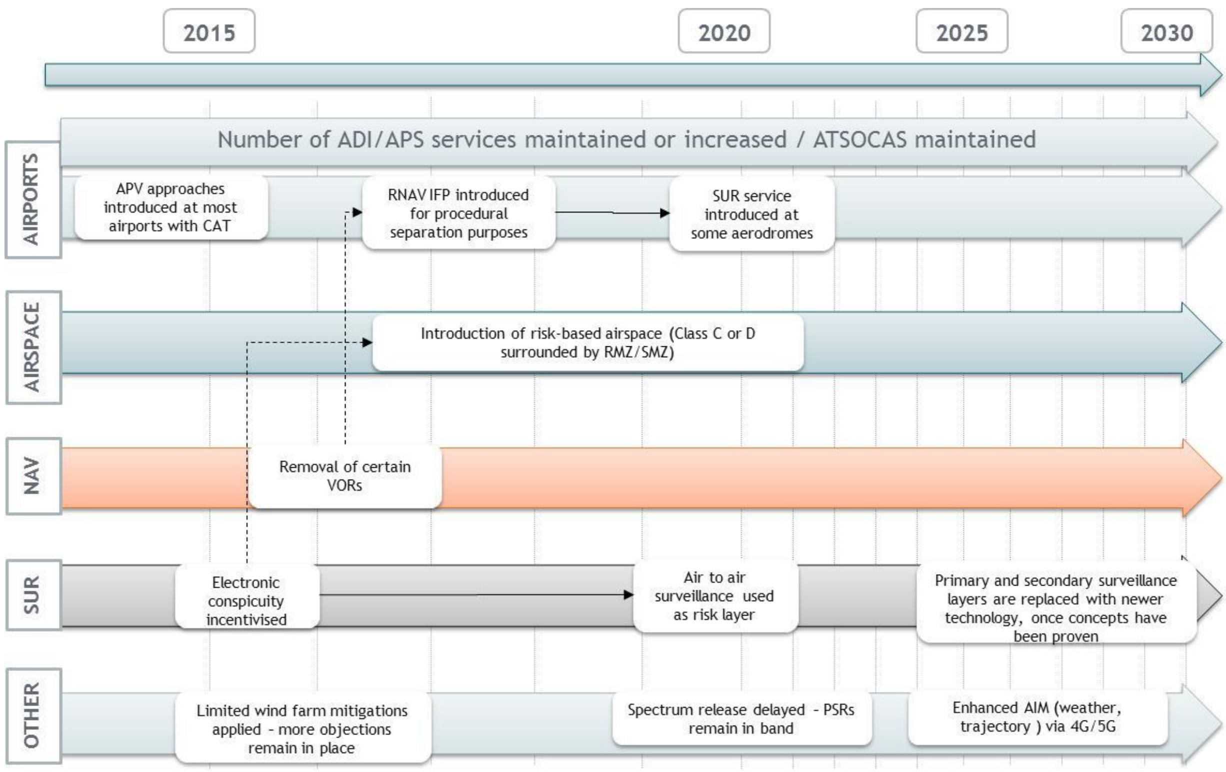
Military continues to operate as today.

➔ Justification: For spectrum release, gains will outweigh costs. The renewables industry aims to reduce its costs on aviation related issues.

### 4.5.3 Scenario 3: Safety enhanced

**<u>Main principle</u>: It is politically unacceptable to maintain current risk levels, for example due to an incident in Class G airspace in the LDLCA region**

Safety enhancements are generally driven by the occurrence of one or more serious incidents. This scenario imagines that an incident involving CAT in Class G has occurred; achieved risk levels are then proactively improved in Class G, and also in the wider low density environment (Class C, D, E), through political pressure.




<u>Description of the scenario</u>

*Airports*: A small increase in the number of surveillance-based services at aerodromes in response to enhanced risk aversion, with more ADI/APS controllers. Resistance to moving to remote TWR, on basis of concerns around safety risk.

➔ Justification: Some aerodrome providers decide to enhance the service to provide an additional safety margin. Others show by historical analysis that acceptable safety is maintained.

*Airspace*: Further airspace restrictions (classification changes, RMZs, TMZs) may be introduced on a case-by-case basis, if safety benefits are identified. Includes introduction of a buffer zone of SMZ/RMZ/TMZ around existing Class C or D airspace – buffer zone may be Class E or G. Negative impact on access, as additional requirement imposed (mandatory zone) and some cannot (or will not) equip.

➔ Justification: Airspace restrictions are a means of enhancing safety and can be applied if and when needed on a safety basis. See Figure 8 – first option – for a schematic.

*Navigation*: Navaid rationalisation is reviewed. 3 VORs removed. Options include RNAV IFP or SUR-based service – RNAV IFP used first (2017) to provide procedural separation, then SUR-based service introduced in line with application of a TMZ/SMZ (2020). APV approaches introduced at most airports with commercial IFR flights (on the basis of safety) – estimated as 16 airports in the LDLCA region.

➔ Justification: With a safety prioritisation, any removal of VORs must have acceptably safe alternatives in place. Additional safety benefits from the use of more accurate navigation route-based separation are desired by stakeholders. APV approaches are judged safer than NPA.

*Surveillance*: Electronic conspicuity is strongly incentivised – no mandate across all aircraft, but individual areas will be subject to SMZ. Primary and secondary surveillance layers are kept in place, but may be updated to latest technology – only once this technology is mature. This may delay spectrum release, due to a risk aversion to new technology. Eventually, as standardisation matures e.g. Traffic Situational Awareness with Alerts, air-to-air surveillance is justified as a reasonable risk layer, particularly inside SMZs.

➔ Justification: Safety levels are supported through ensuring the traffic picture is as complete as possible, especially in critical areas. This is then used on the ground (CAS and ATSOCAS) and in the air.

*Other*: Spectrum release is delayed as safety concerns ensure PSRs remain.

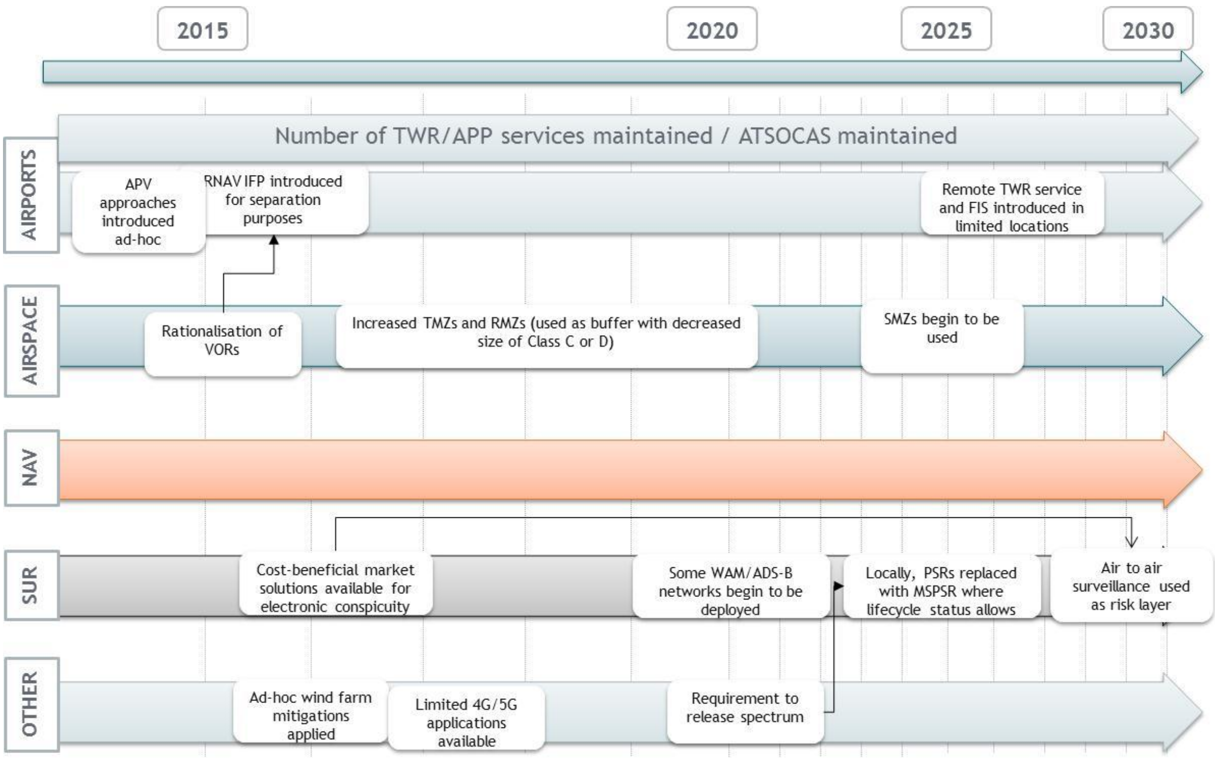
Enhanced AIM is introduced as an aid to situational awareness, including weather applications, and using SWIM applications to give GA a better picture of arriving and departing CAT through the sharing of limited trajectory information of IFR flights.

➔ Justification: Ensuring flight safety is the primary objective.

### 4.5.4 Scenario 4: Modernisation with limited synchronisation

**<u>Main principle</u>: Each problem solved in isolation**

In this scenario, the desire to modernise exists, but each stakeholder or local area defines their own modernisation roadmap, without clear consideration of the overall system, leading to limited levels of synchronisation and fragmented benefits.




<u>Description of the scenario</u>

*Airports*: Remote TWR and FIS introduced in limited areas.

➔ Justification: Airports may introduce cost efficient solutions, if and when available, independent of other developments.

*Airspace*: Some TMZ/RMZ implemented as a buffer around reduced Class C or D volume, giving better access - buffer zone may be Class E or G.

➔ Justification: Risk-based airspace employed (modernisation) – improved access for aircraft appropriately equipped, as no controller clearance required in new “buffer zone” – see the third option in Figure 8 for a schematic.

*Navigation*: Navaid rationalisation and spectrum release go ahead in currently planned timescales. RNAV IFP route network (and associated procedural separation rules) introduced as replacement for VOR-based procedural separation. APV approaches introduced ad-hoc (assume 9 airports between 2015-2017).

➔ Justification: Modernisation calls for benefits gained from RNAV1 route structure and APV approaches.

*Surveillance*: Need for primary and secondary surveillance is maintained.

MSPSR is not sufficiently mature at the time of the spectrum release requirement and wind farm mitigations, leading to piecemeal replacement with PSRs and wind farm mitigations (some as part of Project Marshall). Later, local implementation of MSPSR, dependent on upgrade status of PSRs (i.e. end of lifecycle replacement: 2025 onwards).

With electronic conspicuity becoming available early on through commercial market developments, un-coordinated take-up over 10 years means that air-to-air surveillance becomes appropriate as a risk layer between 2025-2030.

➔ Justification: Various activities with closely linked solutions move forward in an uncoordinated way.

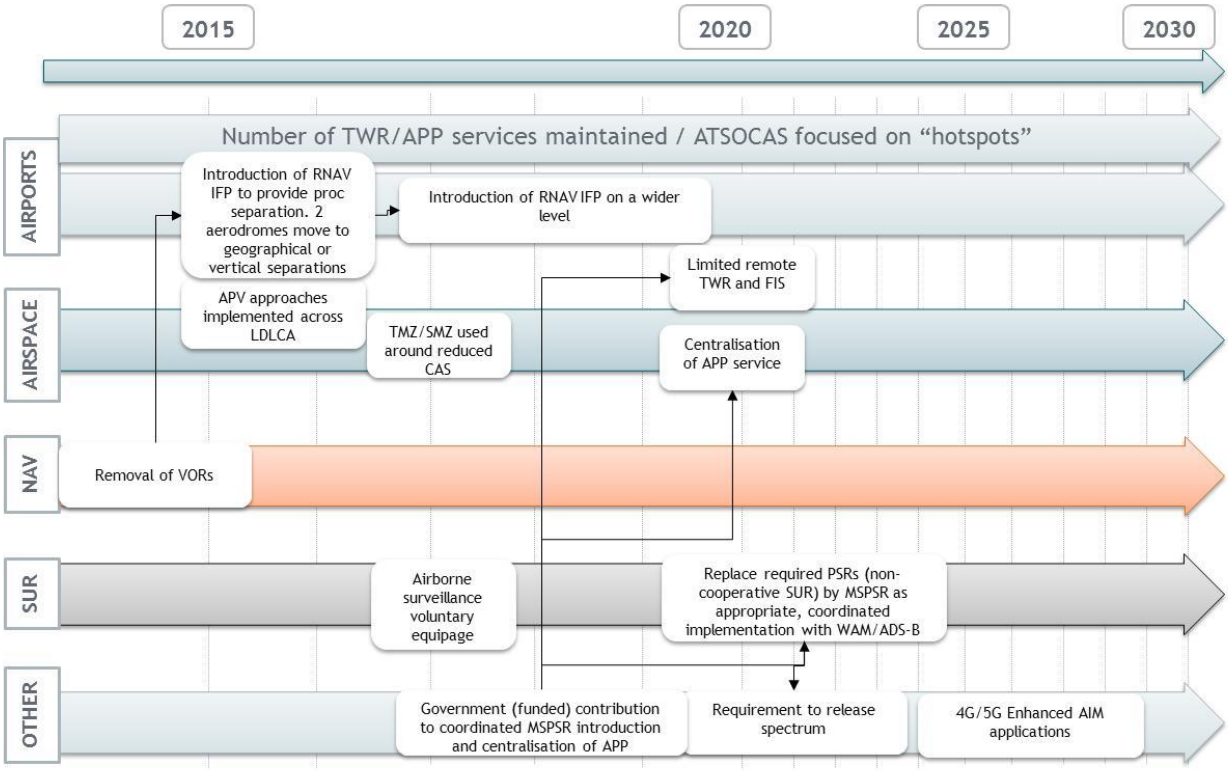
*Other*: Limited 4G/5G applications available from private providers, but not coordinated across stakeholders (e.g. not connected to SWIM).

➔ Justification: Modernisation without planning or coordination gives rise to potentially non-interoperable (but locally beneficial) solutions.

### 4.5.5 Scenario 5: Co-ordinated funding

**Main principle: Problems solved with overall positive NPV and allocation of funds and costs as appropriate**

A common problem of modernisation programmes is that not all stakeholders will benefit, and in particular some stakeholders will face costs without clear benefits. This scenario considers a coordinated approach to funding, where funds can be combined to implement a common solution against a common timeline across stakeholders, whilst potentially mitigating negative business cases for certain stakeholders.




Description of the scenario

*Airports*: Airports look into opportunities to consolidate APP and to implement remote tower operations, and centralised funding can be made available to support the initial investment if a clear business case can be presented.

➔ Justification: Airports recognise the potential benefit of centralised services, but may have a problem overcoming the initial investment.

*Airspace*: SMZs and RMZs used to ensure airspace protection around reduced volume Class C or D airspace (exact solution dependent on local environment) – results in better access – see Figure 8 third solution.

Effective implementation of surveillance infrastructure means airports may offer a surveillance-based ATS. Centralised funding (as above) means that a regional approach centre may be viable, but only if TWRs are also centralised.

➔ Justification: Coordinated surveillance deployment opens up opportunities for airspace re-planning and innovative service provision. Risk-based airspace is used to open up access whilst maintaining or improving safety levels.

*Navigation*: Government, en route ANSPs, regulators, airports and users set out a coordinated navigation evolution plan – including clear funding routes - for navaid rationalisation and use of PBN in

LDLCA:

- Initial move to RNAV IFP based separations where needs exists and aircraft fleet equipage allows, transitioning to RNAV IFP route network and APV approaches in line with PBN-IR.
- Move to SUR-based separation in line with deployment of MSPSR + WAM/ADS-B.
- APV approaches implemented across LDLCA, part-financed with EC/GSA assistance.

➔ Justification: Various states lead to costs and needs for different stakeholders; a coordinated approach will help share the burden.

*Surveillance*: Government sets out coordinated strategy for modernisation of surveillance infrastructure, and contributes through centralised funding. A need for non-cooperative SUR is maintained in controlled airspace. Outside CAS, MSPSR is used to cover "hotspots" for enhanced effectiveness of deconfliction / traffic service – with funding to be decided. MSPSR is deployed in conjunction with WAM/ADS-B (co-located).

Funding of wind farms mitigation is shared by renewable energy and air transport sectors. "Stop-gap" solutions are used (and focused on PSRs with long lifecycles remaining) until MSPSR deployment can be used strategically to remove objections long-term.

Voluntary equipage of ADS-B IN (traffic displays) is encouraged at a national level.

➔ Justification: Various states lead to costs and needs for different stakeholders; a coordinated approach will help share the burden. Non-aviation parties (government, renewable energy industry) have an interest in an early resolution.

*Other*: Military will continue to operate as today.

4G/5G applications are enhanced by the release of spectrum leading to incentives to deploy infrastructure nationwide (including LDLCA regions). Enhanced AIM applications are introduced 2025 onwards.

➔ Justification: Coordinated decisions made enable viability of additional (non-safety critical) services via 4G/5G.

### 4.5.6 Surveillance issues

To assist in the clarity of the specific surveillance options contained in the scenarios being modelled, a summary of the impact of each scenario on the cooperative and non-cooperative surveillance services is presented below.

For current non-cooperative surveillance, the following infrastructure is assumed as per section 2.6.3:

- Three PSRs owned by en-route ANSPs (Cork, Shannon, Allanshill), with Allanshill within FMARS;
- Two aerodrome PSRs (Inverness owned by HIAL, Sumburgh/Compass Head owned by NSL), and
- Three MoD PSRs (West Freugh, Lossiemouth, St Kilda).

For current cooperative surveillance:

- Six en-route ANSP MSSRs (Stornoway, Tiree, Fitful Head/Sumburgh, Allanshill, Cork and Shannon) – note that Fitful Head and Allanshill are within FMARS;

- One aerodrome MSSR (Inverness), and
- Two MoD MSSRs (Kinloss, St Kilda).

It is not this study's place to model the differences in consortium approach for the MoD Project Marshall. Therefore, we have taken an assumption that the non-cooperative functionality will need to be upgraded during the transition (2015-2021), and assumed a common cost in the cost model if this is done via PSRs (i.e. either Watchman+ or a new PSR). The costs are counted as capex as MoD will own the assets, even though it will be delivered to the MoD on a service-based price.

| Scenario name | Cooperative scenario modelled | Non-cooperative scenario modelled |
|---|---|---|
| Do the minimum necessary | En-route ANSP MSSRs maintained until 2025-2027 – replacement programme takes place at rate of 2 per year.<br>Aerodrome MSSR maintained until 2026, then replaced by MSSR. Both assume extension of design life by 3-8 yrs.<br>MoD MSSRs replaced by MSSRs in 2025. | 2015-2018 - Ad-hoc wind-farm mitigations applied.<br>Three en-route ANSP owned PSRs replaced in 2025-2027 by new PSRs.<br>Inverness PSR replaced 2026.<br>Three MoD PSRs replaced 2020 (Marshall) – assumed spectrum release and wind-farm mitigation compliant. |
| Cost minimisation | Two en-route ANSP owned MSSRs replaced by WAM/ADS-B in 2022. Four en-route ANSP owned MSSR replaced in 2026-2027 (two per year).<br>Inverness MSSR replaced 2021 by ADS-B/WAM (co-mounted with MSPSR).<br>MoD MSSRs replaced with MSSRs in 2025. | 2015-2018 - Ad-hoc wind-farm mitigations applied, paid for jointly between wind and aviation sectors.<br>Two en-route ANSP owned PSRs replaced by MSPSR in 2022. One en-route ANSP owned PSRs replaced in 2027 by new PSR.<br>Inverness PSR replaced 2021 by local MSPSR.<br>Three MoD PSRs replaced 2020 (Marshall) – assumed spectrum release and wind-farm mitigation compliant. |
| Safety enhanced | En-route ANSP MSSRs maintained until 2025-2027 – replacement programme takes place at rate of 2 per year.<br>Inverness (2026) replaces MSSR with ADS-B/WAM (co-mounted with MSPSR)<br>Two new aerodromes procure MSSR in 2020. Five aerodromes use ADS-B network in 2020.<br>MoD MSSRs replaced by 2 MSSRs in 2025. | 2015-2018 – Limited wind-farm mitigations applied (more objections remain in place)<br>2026 – 2 PSRs replaced by MSPSR in Scotland (regional deployment) due better low level coverage – assumed Allanshill and Inverness.<br>Two new aerodromes procure PSR in 2020.<br>Three PSRs replaced by PSRs in 2028 (two en-route, one aerodrome)<br>Three MoD PSRs replaced 2020 (Marshall) – assumed spectrum release and wind-farm mitigation compliant. |
| Modernisation with limited synchronisation | En-route ANSP MSSRs maintained until 2025-2027 – replacement programme takes place at rate of 2 per year.<br>2028 – Inverness MSSR replaced by WAM/ADS-B<br>2020 – seven aerodromes + en-route ANSP install regional ADS-B network (situational awareness)<br>MoD MSSRs replaced by | 2015-2018 – Wind-farm mitigations applied to PSRs (apart from MoD)<br>2028 – Inverness PSR replaced by MSPSR (local)<br>2025 – two en-route PSRs replaced by MSPSR (one regional solution – e.g. Cork and Shannon)<br>2028 – two PSRs replaced by |

| | | |
|---|---|---|
| | WAM/ADS-B in 2025. | new PSR (Allanshill and Compass Head)<br>Three MoD PSRs replaced 2020 (Marshall) – assumed spectrum release and wind-farm mitigation compliant. |
| Coordinated funding | En-route ANSP MSSRs maintained until 2021. Then replaced by coordinated national programme of ADS-B/WAM (co-mounted with MSPSR).<br>Inverness replaces MSSR with ADS-B/WAM in 2021 (coordinated national programme).<br>No new aerodromes require SUR.<br>MoD MSSRs replaced in 2021 by ADS-B/WAM (coordinated national programme). | 2015-2018 – Limited wind-farm mitigations applied.<br>2021 – Inverness and Compass Head PSRs replaced by MSPSR (coordinated national programme)<br>2021 – three en-route ANSP owned PSRs replaced by MSPSR<br>Three MoD PSRs replaced by MSPSR in 2021 (as part of Marshall, but assuming national co-funding). |

**Table 11: Surveillance changes modelled in scenarios**

# 5 Assessment criteria

This study informs future stakeholder decision making for the LDLCA regions of UK and Ireland. Whilst a critical aspect of this scoping study is the identification of the options contained in section 4.3, the evaluation of the relative performance and financial merits of the options will provide a valuable justification of any future investment and regulatory decisions, or identify work to be carried out prior to these decisions.

A high level view of the main drivers, cost and performance impacts is presented in the following sections. The scope of this study does not allow a detailed business case to be developed for individual stakeholders and changes.

Assessment criteria reflect issues and performance areas identified in stakeholders' requirements, where possible broken down by stakeholder. The criteria break down into two specific groups: firstly, criteria linking back to the most important Key Performance Areas, based on the outputs of the performance workshops held in the initial stages of the scoping study; and secondly, a qualitative assessment of each scenario's success in meeting external (e.g. regulatory) drivers.

In line with the main performance drivers presented in Section 3.4.2, the KPAs considered are:

- Safety: The overall objective is to maintain at least tolerable levels of safety. For the ATM and airspace issues of LDLCA regions, safety levels are largely determined by the probability of Controlled Flight Into Terrain (CFIT) and mid-air collisions or airproxes. The safety level will be a balance between measures to contain the number of CFIT or mid-air collision accidents, and traffic levels, i.e. the measures need to be proportionate to the risk caused by the level of traffic, we should not be aiming to 'improve safety for the sake of improvement alone'.

- Cost efficiency: For this performance area, the objective for each stakeholder will be to keep control over costs. This applies to the initial investment required (capex), the cost of operating a changed environment (opex) and transition issues such as training. On a purely cash-flow basis, specific benefits can also be assessed, for example a reduction in fuel burn or cancellation costs.

- Resilience: Resilience was identified as an important area both commercially and politically. Particularly important for CAT, resilience entails the ability to operate into aerodromes at all times and under all circumstances such as varying weather conditions.

- Access: This is an important performance area for General Aviation and the military. The objective is to continue to allow as many of the users access to as much of the airspace, for as much of the time as possible. This will be achieved through minimising use of airspace structures that limit access, and, where such structures are considered necessary, through ensuring structures are used that still allow access within certain conditions.

- Capacity: The objective is to provide the airspace, airport and controller capacity to enable users to fly without being 'held up' due to a lack of capacity. This will in particular apply to CAT operations into the airports. There is generally increased margin in capacity compared with high density airspace, but specific hotspots still incur delays as the provided capacity is less than the demand.

The core of the assessment in this study is a cost model, identifying the key changes in cash-flow as a result of the ATM or airspace options per scenario and per stakeholder.

This is supported by a qualitative assessment of the other KPAs and the external regulatory drivers. Qualitative indicators are defined for each of the performance areas. These include direct outputs (e.g. reduction of mid-air collisions between CAT and GA, between civil and military, etc) or accepted contributing factors (e.g. reduction of airspace infringements, or reduction of airproxes).

The assessment captures the various groups of changes that the LDLCA environment may go through within a single scenario, e.g. if within a scenario both surveillance and navigation environments change – but not at the same time – then this leads to a series of different states from today to 2030.

Whilst the KPAs bring understanding of the performance impact of each scenario, there are a number of regulatory assumptions against which the scenario is measured. These include:

- Spectrum release:

  Timescales for spectrum release: since the release of spectrum itself has been included as an assumption, i.e. the relevant target spectrum will definitely need to be released, the main variation lies in in the timing of the release and possibly in any phasing of the release.

- Green energy targets:

  Ability to meet green energy target: this is the reverse case of spectrum release: the assumption is that the target and timing will remain in place, meaning that the assessment criterion is whether or not the target can be met.

- Interoperability:

  Interoperability with high density area: although difficult to quantify, interoperability with high density airspace is essential because these are connected areas, not discrete areas. This must therefore be part of the assessment.

  Interoperability with SES and SESAR: similar to the link to high density areas, this will be difficult to quantify, but is considered essential. Since the high density areas can be assumed to be interoperable with SES and SESAR, this issue is very closely linked to the previous one.

The following table summarises the criteria and indicators used.

| Criteria | | Indicators (to be assessed through expert judgement, not evidence) |
|---|---|---|
| **Safety: maintain tolerable levels of safety** | | |
| Reduction of mid-air collisions | | |
| | Reduction of airproxes | Number of airproxes:<br>▪ GA-GA<br>▪ CAT-GA<br>▪ CAT-CAT<br>▪ Civil-military |
| | Reduction of airspace infringements | Number of airspace infringements |
| | Reduction of unintended excursion from controlled airspace | Number of unintended excursion from controlled airspace |
| Reduction of CFIT | | |
| | Reduction of CFIT during approach | Number of APV procedures in place<br>Proportion of arrivals using APV approaches |
| | Change in CFIT due to terrain / obstacles | Number of near-misses with wind-farms? |
| **Resilience** | | |
| Maximising ability to operate to schedule | | |
| | Reduction of cancellation | Number of cancellations due to weather<br>Number of cancellations due to service availability |
| | Reduction of diversions | Number of diversions due to weather<br>Number of diversions due to service availability |
| **Access** | | |
| Maximising access of all users to airspace | | |
| | Maximising available uncontrolled airspace | Extent (number and volume) of restricted areas<br>Proportion of time military areas are available |
| | Maximising access into controlled airspace | Extent (number and volume) of controlled airspace (Class C or D) |
| | | Number of logged issues with entering CAS |
| | Maximising access into restricted areas | Number of rejected requests for entry into restricted airspace |
| **Capacity** | | |
| Minimise delays | | Number of ATM-attributable delays > 5 mins |
| **Cost efficiency** | | |
| Minimising capex | | Overall cost of implementation<br>Cost of implementation by stakeholder group |
| Minimising opex | | Number of staff required to meet service level<br>Maintenance costs |
| Minimising transition cost | | Cost of training |

**Table 12: Criteria used in scenario assessments**

# 6 Cash-flow model

## 6.1 Principles of the model

The cash-flow model uses discrete capital and operational expenditure elements to model to overall financial situation per scenario. The model deliberately does not use balance sheet principles of depreciation of the capital assets, to ensure easy visualisation of the decision points in each scenario.

Discounted[12] and non-discounted costs on a per annum basis are presented in the model.

Each stakeholder grouping is modelled separately within each scenario. Individual stakeholders or aerodromes are not modelled.

In line with the overall study, the model assumes a timeline from 2014 to 2030.

In order to take account of ranges of costs, a simplified set of low, medium and high figures are included for each cost.

[12] Discounted costs take account of the reducing future value of money – i.e. £1 today is worth more than £1 in ten years' time. A discount rate of 8% is used in this model, in line with industry norms.

## 6.2 Model assumptions

| Assumptions |
|---|
| "Whole area" (e.g. 30 ground stations) refers to the example LDLCA region used during the study (i.e. north and west Scotland, west N Ireland, and Republic of Ireland excl Dublin |
| "Regional" (e.g. 15 ground stations) refers to an area covering 4-5 aerodromes, approx 200 sq miles - there may be some overlap in solutions |
| "Localised" (e.g. 5 ground stations) refers to an area covering an aerodrome and surrounding 50 sq miles - the solution may be non-optimised. |
| The figures for the number of ground stations required to cover the areas are an estimate - they will need to be validated by detailed coverage mapping studies |
| Wide Area Multilateration ground stations will always include the ability to receive, process and display ADS-B signals |
| It is assumed that the PSRs applicable to the example LDLCA region are Cork, Shannon, Inverness, Sumburgh (Compass Hd), Allanshill (Aberdeen), and four MoD sites. |
| It is assumed that the Mode S SSRs applicable to the example LDLCA region are Cork, Shannon, Inverness, Allanshill, Stornoway, Tiree, Sumburgh (Fitful Hd) and two MoD sites. |
| All CAT are equipped with a Mode S transponder at the start of the period (2014) |
| A discount rate of 8% is assumed. |
| All prices are in GBP (2014) |
| The cost model solely looks at changes (i.e. deltas in costs) - it does not attempt to present an investment case for any specific change. |
| Military aircraft based in LDLCA are assumed to be State exempt and considered as OAT. No costs are therefore assumed for airborne equipage. |

**Table 13: Cost model – general assumptions**

Specific quantitative assumptions were also used in the model. These are set out below.

| Assumption | Assumed value |
|---|---|
| Number of airports with APP+TWR service in sample LDLCA region - either ADI/APS or ADV/APP | 15 |
| Number of airports with TWR service only in sample LDLCA region - either ADI or ADV | 1 |
| Number of airports with FIS only in sample LDLCA region | 5 |
| Number of CAT aircraft based in the LDLCA region | 50 |
| Number of GA aircraft, including microlights, gliders and all forms requiring radios or transponders | 1000 |
| Number of Military aircraft - transport | 30 |
| Number of military aircraft - non-transport | 50 |
| Number of windfarms affecting PSR | 25 |
| Number of ATCOs (small airport) | 5 |
| Number of ATCOs (medium airport) | 12 |
| Number of FIS (very small airport) | 5 |
| Number of ATCO equivalents (ATSOCAS) | 5 |
| Value of a CAT flight in the LDLCA region (k£) - i.e. delta if flight does not operate | 2.5 |
| Value of a GA flight in the LDLCA region (k£) - i.e. delta if flight does not operate | 0.25 |
| Average number of ATCOs for a three-airport centralised TWR/APP facility (ADI/APS) | 8 |
| Cost of an extra NM flight (CAT) (£) | 10 |
| Cost of an extra NM flight (GA) (£) | 0.5 |

**Table 14: Cost model - specific quantified assumptions**

Note: the value of a CAT flight is based on average net economic benefit per domestic flight in EU-27 being £3500 and includes benefits to passengers. This figure is then re-calculated for small regional aircraft (=£2000), and increased due to social obligations of lifeline services (e.g. ave. 3 medical pax per flight)

## 6.3 Costs used in the model

Rough orders of magnitude (ROM) are used for each major cost item. Where possible, the items are validated with market prices, stakeholder expertise, or credible reference sources. The source is noted in the Excel cost model. All costs are in £000s.

| Cost element | Assumed cost (£k) | | |
|---|---|---|---|
| | High | Medium | Low |
| **Air - Commercial Air Transport (CAT)** | | | |
| PBN (RNAV1 +APV) - single pilot CAT | 80 | 50 | 30 |
| PBN (RNAV1+APV) dual pilot CAT | 220 | 150 | 100 |
| ADS-B-OUT capability | 100 | 70 | 40 |
| ADS-B IN (incl display) | 700 | 400 | 200 |
| **Air - General Aviation (GA)** | | | |
| Mode S transponder (GA) | 5 | 3 | 1 |
| Radio equipage (GA) | 3 | 2 | 0.5 |
| ADS-B OUT capability (GA) | 3 | 1.5 | 0.5 |
| ADS-B IN (incl display) (GA) | 5 | 3 | 1 |
| Enhanced AIM capability (GA) | 2 | 1 | 1 |
| PBN (RNAV1+APV) capability (GA) | 12 | 6 | 4 |
| **Military (MIL)** | | | |
| Single PSR in-fill or filter solution (MIL) | 800 | 300 | 200 |
| **Ground (ANSP + Aerodrome)** | | | |
| New DVOR (incl installation) | 500 | 400 | 300 |
| RNAV IFP design cost - limited routes (1-2) | 40 | 30 | 20 |
| RNAV IFP design cost - use for proc separation (>2) | 80 | 60 | 40 |
| APV approach design cost | 40 | 30 | 20 |
| Cost of Airspace Change or Route | 120 | 60 | 40 |
| Single PSR/SSR co-located | 9000 | 7500 | 5000 |
| Single PSR in-fill or filter solution | 800 | 300 | 200 |
| Single Mode S SSR | 5500 | 4000 | 3000 |
| Single PSR | 7500 | 5500 | 4500 |
| MSPSR whole area (30 g/s) | 15000 | 10000 | 7000 |
| MSPSR regional (15 g/s) | 9000 | 6000 | 4000 |
| MSPSR localised (5 g/s) | 5000 | 3500 | 2500 |
| ADS-B wide area (20 g/s) | 4000 | 3000 | 2000 |
| ADS-B regional (8 g/s) | 2000 | 1200 | 800 |
| ADS-B localised (2 g/s) | 700 | 500 | 300 |
| WAM+ADS-B whole area (30 g/s) | 16000 | 12000 | 9000 |
| WAM+ADS-B regional (15 g/s) | 9000 | 6000 | 4000 |
| WAM+ADS-B localised (5 g/s) | 5000 | 3500 | 2500 |
| Remote tower centre - capex + transition | 4000 | 2500 | 2000 |
| Centralised approach centre - capex + transition | 4000 | 2500 | 2000 |

| | | | |
|---|---|---|---|
| Opex cost of running Remote Tower per annum | 250 | 200 | 150 |
| Introduction of geographical/vertical separation | 20 | 10 | 5 |
| Annual VOR maintenance costs | 30 | 20 | 15 |
| Ongoing cost of running a local tower | 120 | 95 | 75 |
| **Staff costs** | | | |
| TWR/APP controller p.a. | 120 | 80 | 50 |
| FISO p.a. | 45 | 30 | 20 |
| ATSOCAS controller p.a. | 120 | 80 | 50 |

**Table 15: Cost model - detailed costs**

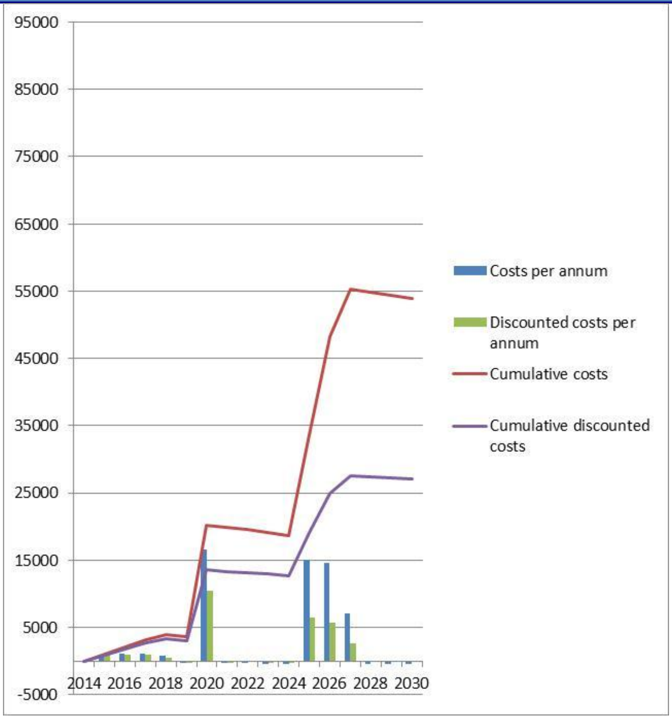
## 6.4 Outputs

The cost model outputs a series of cash-flows (discounted and non-discounted) over the period per scenario and per stakeholder.

The five figures below show the plots of the total cash-flows for the five scenarios. The vertical axis is deliberately fixed (at -£5m to +£95m) to be able to facilitate comparison between scenarios.

Note that the Net Present Value (NPV) for each scenario (2014-2030) is shown by the cumulative discounted cash-flow line on each graph.

**Scenario cash-flow plots**



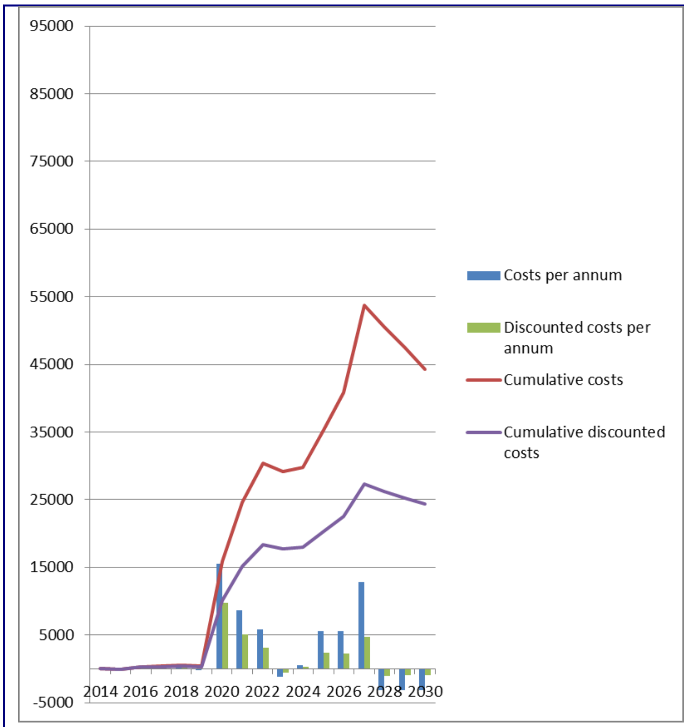

**Notes**

**Scenario 1: Do the minimum necessary**

NPV = £-27.1m

As with all scenarios, overall costs are driven by necessary surveillance upgrades due to performance requirements (MoD) or end of design life (civil).

Very limited new technical or operational enhancements are included to give benefits to users. APV provides most of the benefit seen, but at a reasonably high cost for dual pilot operations for the limited installations assumed under this scenario.

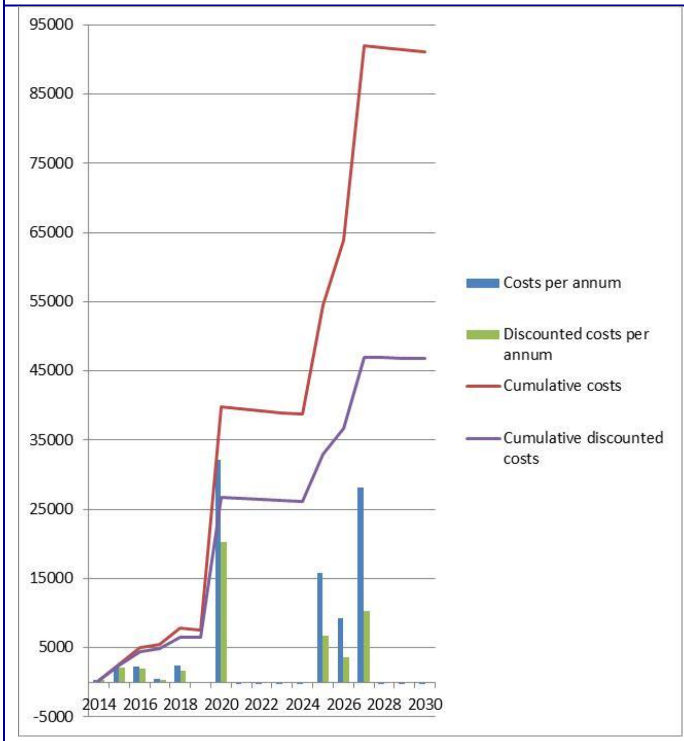



**Scenario 2: Cost minimisation**

NPV = £-24.3m

Whilst exhibiting a lower overall cost than the “do the minimum” scenario above, the necessity of replacing ageing surveillance infrastructure is still the driver.

Some enhancements with a positive business case are included, moving some costs earlier (2021-2022) but ensuring the overall NPV is lower. Acceptance would depend on financing cost and exact discount rate used for the project.




**Scenario 3: Safety enhanced**

NPV = £-46.8m

Safety costs money. The NPV is much higher than the first two scenarios.

In particular, the inclusion of new surveillance-based services (two new co-located PSR/SSRs) leads to significant costs in this scenario. Where the costs fall is a matter for debate; cost recovery from users may not be possible, leading to the government bearing the cost.

Some costs are borne later in the timeframe, due to risk aversion of change. Whilst this provides a small positive uplift to the overall NPV, the risk of ageing infrastructure failing is not monetised.

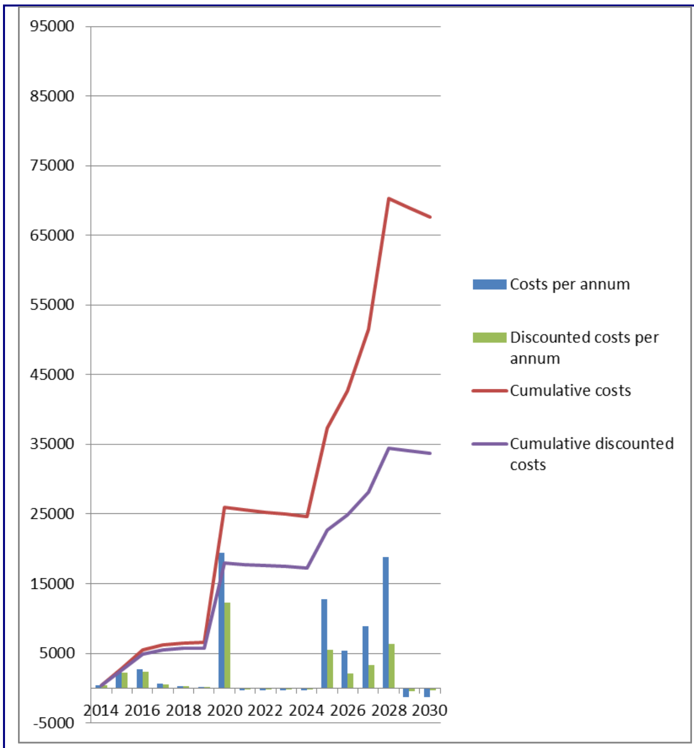
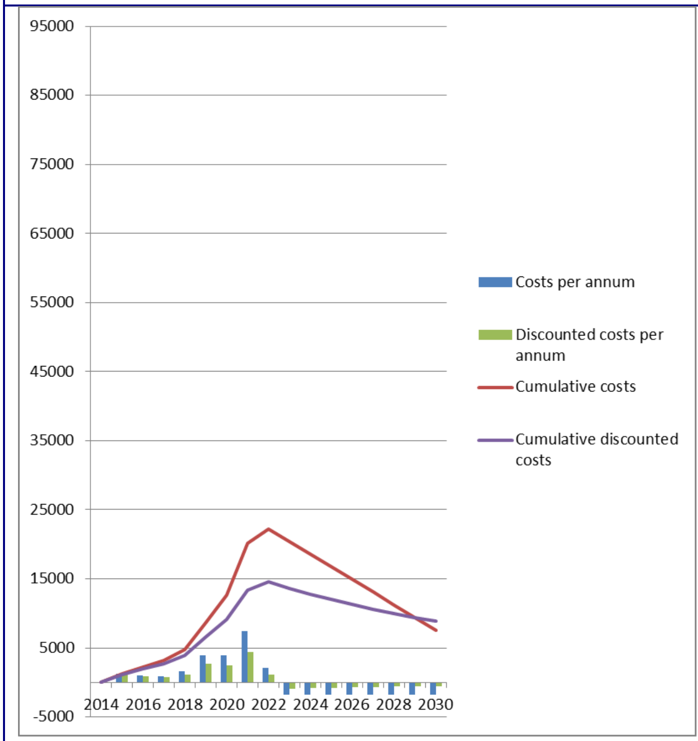
| | |
|---|---|
|  | **Scenario 4: Modernisation with limited synchronisation**<br><br>NPV = £-33.7m<br><br>Costs are applied as individual users modernise, but without the synchronisation (e.g. of airborne and ground equipage), there are few monetised benefits identified.<br><br>The NPV is thus higher than the first two scenarios. Note that if it was considered over a longer timeframe (e.g. until 2040), there may be more similarity as benefits would accrue. |
|  | **Scenario 5: Co-ordinated funding**<br><br>NPV = £-8.9m (*noting that cost to government of grants of 30% of the cost of the new surveillance system is not modelled, but would be fully covered by benefits of spectrum release*)<br><br>The NPV is significantly different here due to the reduced cost to individual users of purchasing a combined surveillance system. It is recognised however that significant political and commercial constraints exist.<br><br>On a purely monetary basis, this scenario shows that coordinated funding of a distributed system is worth investigating.<br><br>The opex cost of distributed surveillance has been considered to be similar to radars. This may not be the case, due to the additional cost of G-G communications with the sensor network. |

**Table 16: Cost model outputs per scenario**

## 6.5 Note on cost sensitivity

The range of costs given above evidently influence the final NPV determination. Whilst there was not scope in this study to conduct a detailed sensitivity analysis, it was worthwhile to examine the major cost driver – that of surveillance infrastructure – and determine whether the conclusions of the study and scenarios would be impacted by adjusting the values used.

The table below shows the difference for each scenario outcome if:

- Non-cooperative surveillance in-fill solutions were increased to £800k;
- Primary surveillance radars cost £4.5M, Mode S SSRs cost £3M, and co-located solutions cost £5M.
- MSPSR and ADS-B were adjusted to reflect the High assumed costs put forward in the model (see Table 15).

The table sets out the final Net Present Value using the median cost values and the adjusted ones as above.

| | Median cost values | Adjusted cost values |
|---|---|---|
| Scenario 1: Do the minimum necessary | -£27.1M | -£22.6M |
| Scenario 2: Cost minimisation | -£24.3M | -£25.6M |
| Scenario 3: Safety enhanced | -£46.8M | -£41.8M |
| Scenario 4: Modernisation with limited synchronisation | -£33.7M | -£36.9M |
| Scenario 5: Co-ordinated funding | -£8.9M | -£13.9M |

**Table 17: Cost sensitivity for surveillance**

The main conclusion from this short analysis is that the overall results are consistent, although stakeholder may take slightly different decisions for cost minimisation where the relative costs of surveillance infrastructure changes.

Even without government funding available, scenario 5 – representing coordinated decision making – is still the best NPV outcome for each set of costs.

# 7 Performance view per scenario

Showing a balanced picture of benefits and costs is important in assessing the potential trade-offs to be applied in the LDLCA region.

The cost model showed that a coordinated funded scheme would bring significant NPV benefits by reducing the discounted cash-flow overall. However, there is no indication about potential added risk as a result of moving to distributed surveillance techniques reasonably early in the timeframe, thus avoiding costly radar replacements in 2025-2027. There is also a limited modelling of access and resilience issues.

This section gives a one page view per scenario outlining the main impacts on performance, including cost, and assessing the scenarios ability to meet the external constraints. It follows the criteria given in section 5.

For the cost criteria, the criteria are: relatively high cost (NPV -£30-50m) = red arrow; median cost (NPV -£10-30m) = orange dash; relatively low cost (NPV -£0-10m) = green arrow. NPV is the Net Present Value; i.e. the sum of the discounted costs and benefits over the time-period.

For safety, MAC refers to Mid Air Collision risk, most often measured through airprox reports as well as accidents. Airprox reports are only of limited value in Class G, since no separation minima and minimal deconfliction criteria (under ATSOCAS) apply and thus reporting is not routinely carried out.

## Scenario 1: Do the minimum necessary

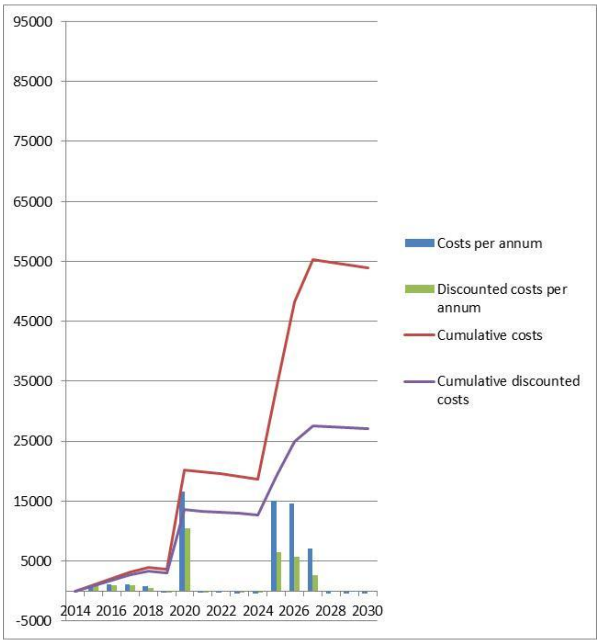
### Safety

Localised decrease in CFIT risk due usage of APV instead of Non-Precision Approaches – assumed to be 2014 onwards, dependent on deployment of APV approaches. The scenario assumes 13 APV approaches are deployed in the LDLCA region by 2020.

No other safety (risk) changes. The replacement of VOR-based procedures with geographical/vertical separation and limited RNAV IFPs is assumed to be tolerably safe.

All changes to infrastructure are assumed to be accompanied by a safety case, approved by the appropriate authority.

### Cost




NPV = £-27.1m

### Access & Resilience

Each APV approach at an aerodrome adds to the resilience of that aerodrome to low cloud base. It is expected that decision heights to instrument runways would be around 200ft, and around 500ft to non-instrument runways. Assumed impact is an extra CAT flight per month per aerodrome.

Some access issues due to implementation of RNAV IFPs rather than VOR conventional routes. RNAV1 is expected, with some aircraft not compliant losing access ability.

### Capacity

Limited decrease in capacity due to application of non-optimum geographical or vertical separation procedures. This is assumed to only impact two aerodromes in this scenario.

### Other factors, including external constraints

Relatively easy to transition – little “forced” equipage

APV targets from ICAO assembly (2016) not met, but PBN-IR target dates are aligned

Key airports align with PBN-IR (limited RNAV1)

Spectrum release target at risk

Ad-hoc solutions to wind farms not desirable to stakeholders (and costly to wind sector), and possibly spectrally inefficient

## Scenario 2: Cost minimisation

### Safety

Tolerable levels of safety are maintained. However, a near-term small decrease in safety margins is expected as more FIS introduced instead of ATC services, and ATSOCAS hours are also reduced.

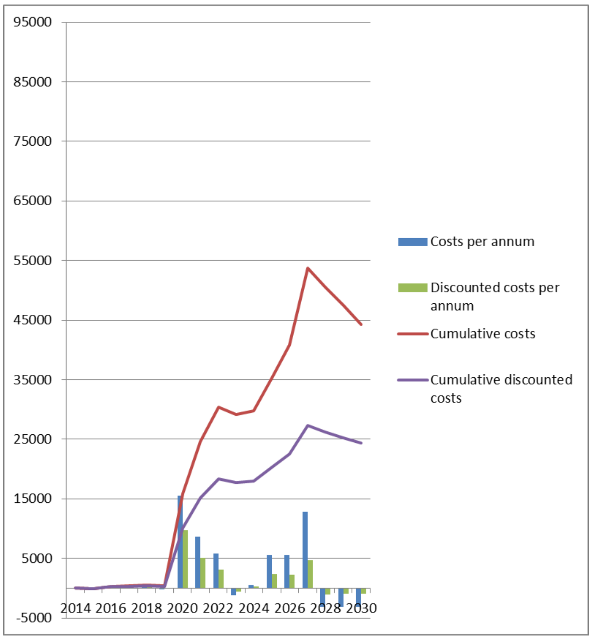
Introduction of limited APV approaches improve safety levels (instead of NPAs). No risk impact expected from intro of RNAV IFP (reduction in risk from systemisation; increase in risk from reliance on GNSS).

Remote Towers are risk neutral (assuming a safety case).

2018 - Possible slight increase in MAC risk from the transfer of small portions of Class C or D airspace to be Class E or G (plus a mandatory zone).

2020 - Reduction in risk due introduction of limited MSPSR and resultant enhanced low level coverage (more conflicts detected).

### Cost




NPV = £-24.3m

### Access & Resilience

Access improved as possibly Class C or D airspace removed or operating hours reduced, with the ATC change to FIS.

Improved access from some Class C/D airspace being adjusted to Class E/G + mandatory zone.

Possible reduction in access from remote TWR/FIS (particularly during transition, with additional mitigations being applied)

### Capacity

Very limited decrease in capacity due to application of non-optimum geographical or vertical separation procedures. This is assumed to only impact two aerodromes in this scenario, and then only until 2020 (PBN-IR).

### Other factors, including external constraints

Concerns over increases in risk from cost-based changes may slow transition timescales

RNAV1 airborne equipage may be a block for certain local airports dependent on fleet

Spectrum release achieved

Wind farm mitigation cost is shared – leads to localised move to MSPSR

Using remote TWR/FIS difficult due ATCO acceptance, but possible by 2025 (following LFV/Avinor evidence, having been operational since 2014)

## Scenario 3: Enhanced safety

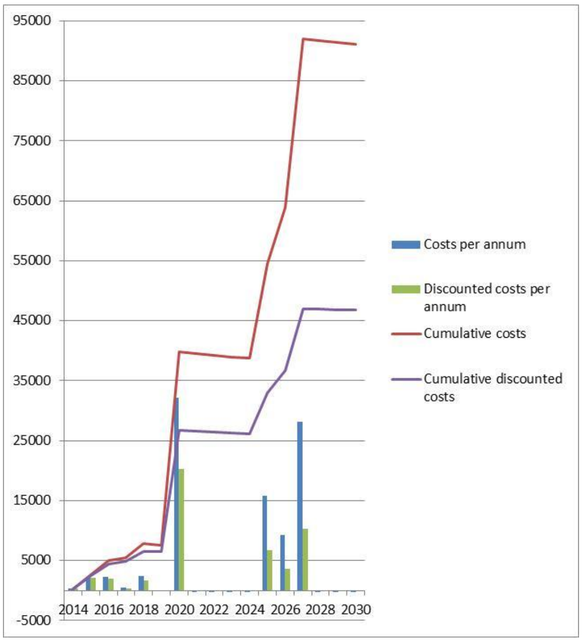
### Safety

Reduced risk through addition of new mitigation (airborne surveillance), cockpit weather and applications of SMZs.

RNAV IFP introduction has no impact on overall risk levels (see scenario 2) – possibly an increased severity of risk attached to loss of GNSS?

Slight decrease in risk due addition of ATC services at aerodromes, and buffer zones of RMZ/TMZ/SMZ introduced around CAS.

### Cost




NPV = £-46.8m

### Access & Resilience

Reduced access through application of RMZ/TMZ/SMZ around existing CAS, blocking those without appropriate equipment.

Improved weather information in cockpit allows better decisions, possibly increasing GA resilience.

### Capacity

Capacity reductions through additional buffers being applied (e.g. in deconfliction or separation provision).

Potential decrease in airspace availability for military training and operations.

### Other factors, including external constraints

Changes are “forced” through politically.

Spectrum release delayed through concerns over transition risk.

Limited wind farms (onshore) approved due to risk concerns.

Compliance with PBN-IR where needed

# Scenario 4: Modernisation with limited synchronisation

## Safety

RNAV IFP introduction has no impact on overall risk levels (see scenario 2)

APV approaches improve safety (w.r.t existing NPAs) through reduction in CFIT risk

No MAC risk impact from introduction of mandatory zone buffer around reduced volume CAS (this is location dependent).

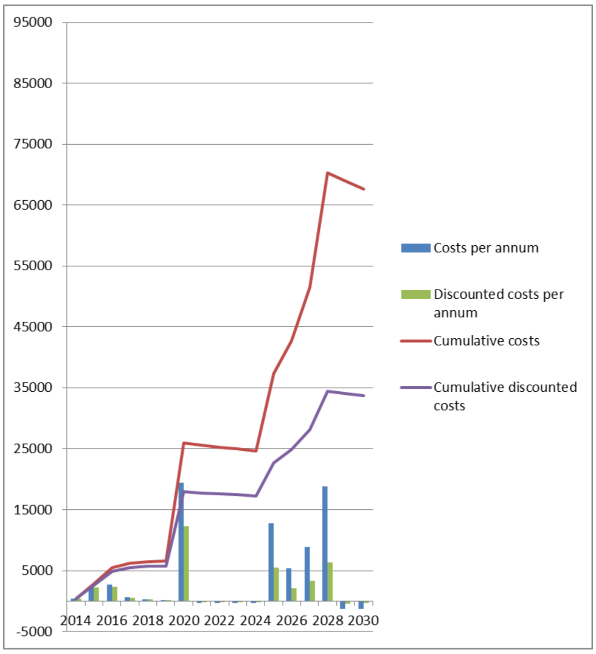
Limited 4G/5G applications bring benefits from sharing of weather information.

2020 – piecemeal move towards distributed surveillance gives small safety benefits as coverage areas focus on hotspots and improved low level coverage exists

2025 – Remote TWR/FIS is risk neutral, assuming appropriate mitigations included

2030 – Airborne surveillance decreases MAC risk.

## Cost




NPV = £-33.7m

## Access & Resilience

Improved access as volume of CAS reduces (with RMZ/TMZ/SMZ buffer added). This would be dependent on appropriate market for equipment to comply with mandatory zone.

RNAV IFP route network used as main procedural separation means on removal of VORs may require RNAV1 equipage, which may lead to access issues (e.g. additional delay) for flights without RNAV1 capability.

Limited remote TWR/FIS may lead to access issues (see scenario 2)

## Capacity

Capacity at aerodromes with RNAV IFP route network introduced should be improved – it is a more granular separation means than VOR-based procedural separation.

Additional buffers may be applied to deconfliction standards and separation minima during the transition to new technology or new operational concepts, leading to slightly reduced capacity.

Remote Towers may also improve capacity, enabling ATC services where otherwise they would not be cost-beneficial.

## Other factors, including external constraints

Decisions taken at a local level – which may be easier to manage and gain agreement

Lack of synchronisation across stakeholder groups leads to lower benefits

New policy needed for “buffers” around reduced CAS – this takes time to implement

Spectrum release has limited benefits in expected timeline (fragmented decision making)

## Scenario 5: Coordinated funding

### Safety

Early voluntary equipage of airborne surveillance adds a mitigation layer and decreases risk

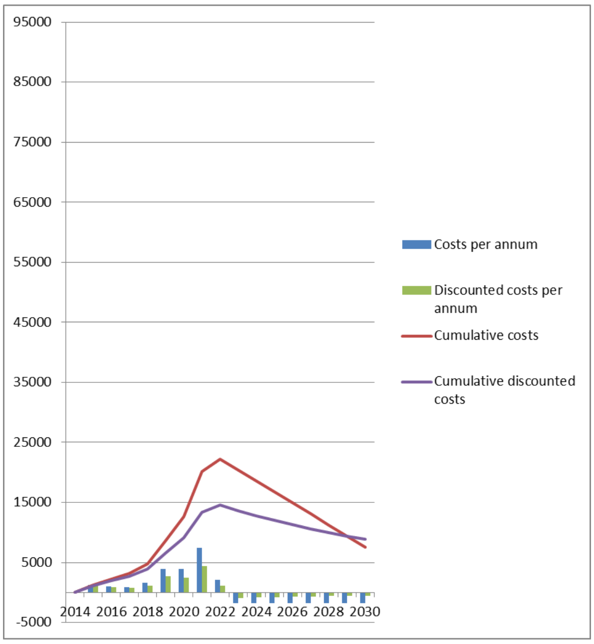
Early MSPSR introduction improves regional coverage and decreases risk

There may be a concern with unknown risks from MSPSR during transition – this may lead to additional buffers (see capacity)

2020 – Remote TWR/FIS is risk neutral, assuming appropriate mitigations included

2025 – use of cockpit AIM for weather and sharing of tactical flight plan data reduces risk, particularly at non-controlled aerodromes.

### Cost




NPV = £-8.9m

### Access & Resilience

Application of RNAV1 may lead to access issues, dependent on equipage levels.

RMZ/TMZ/SMZ buffers with reduced CAS (as per scenario 4) benefits access.

Increasing surveillance-based services theoretically improves access, as ATCOs should be more willing to accept VFR traffic.

Limited remote TWR/FIS may lead to access issues (see scenario 2)

### Capacity

Capacity at aerodromes with RNAV IFP route network introduced should be improved – it is a more granular separation means than VOR-based procedural separation

Additional buffers may be applied to deconfliction standards and separation minima during the transition to new technology or new operational concepts, leading to slightly reduced capacity.

Remote Towers may also improve capacity, enabling ATC services.

### Other factors, including external constraints

Coordinated decisions on MSPSR, RNAV IFP and centralised TWR/APP bring difficulty (but potential strong cost-benefit)

Possible concern with early introduction of technologies without proof from other States

Wind sector assisted by early intro of MSPSR (assuming it removes objections)

Spectrum release goes ahead on-time

Use of 4G/5G encourages innovation for datalink applications

# 8 Conclusions

## 8.1 Overview

This scoping study has examined the range of options for the provision of a safe and cost effective solution in Low Density, Low Complexity Airspace, meeting regulatory constraints and customer needs. An example environment was specified, encompassing the North-West of Scotland, Northern Ireland (excluding Belfast), and the Republic of Ireland (excluding Dublin).

The options were selected by identifying the stakeholder expectations, defining potential operational and technical options, and assessing the potential dependencies and trade-offs for the various options, most obviously through a cost model. At each stage, wide stakeholder engagement was encouraged to validate the feasible ways forward.

The parameters of a safe and cost effective solution change according to customer demand, resultant traffic volume and overall complexity. It was recognised early on in the study that the characterisation of a homogenous body of airspace and airports as “LDLCA” was misleading, failing to make explicit the variety of traffic movements and users within the region chosen. However, in terms of commercial IFR, the airspace and airports in “LDLCA” have relatively few movements throughout.

A question arose whether single solutions are appropriate in this airspace, either operationally or for technical enablers. A reduction in the complexity of airspace designs or technical enablers may bring benefits, most obviously to safety and also possibly to cost efficiency. Safety benefits accrue from a common awareness of the application of rules. Cost efficiency arises from a common solution being applied, potentially leading to common procurement. In the future airspace considered as part of FAS and SESAR, systemisation of airspace and controlling paradigms is considered essential for safe increases in traffic and complexity. Similar arguments could be applied in a lower density environment.

However, there is the strong possibility of over-designed solutions since the tendency can be to design a single solution to fit the most constraining situation. As an example, the blanket application of a single class of airspace and requirement for ATC services may lead to a wide safety margin, but may also inhibit providers from spending money on attracting the traffic they need to survive and potentially lead to a loss-making enterprise.

Any solution should retain the flexibility for decision making, recognising that individual airports will generally wish to maximise their traffic, and remove barriers for commercial operators adding routes (e.g. operating hours, accessibility/resilience).

In the LDLCA environment, the appropriate solution is also not completely driven by safety and cost-effectiveness. Lifeline services to remote airports may not be profitable in their own right, and may be subject to Public Service Obligation funding. Any Air Traffic Service provided may also not follow strict business principles of cost recovery via charges. The political and social benefit of the lifeline service must be taken into account in any assessment, imposing requirements on resilience and access for flights which then dictates the level of ATS and appropriate equipage. Thus, care should be taken in interpreting the findings of this study as a monetised investment case.

## 8.2 What are the drivers and constraints?

Recognising that the environment is not “one-size-fits-all”, there is still value in understanding the generic performance drivers for each stakeholder group within the airspace.

In many cases, stakeholders expressed a desire to maintain the status quo. The LDLCA environment will be forced to evolve to meet regulatory and policy constraints whilst remaining cost-effective and economically viable. However, the principles and reasons behind the desire for a status quo should be taken into account in decision making.

- **Safety** is still a priority in the LDLCA environment, but cannot currently be accurately assessed in uncontrolled airspace due to a lack of sufficient data. Clear arguments and evidence should be available prior to any change being made in uncontrolled airspace, and be focused upon the risk and location identified. Annex I shows the limitations of the existing airprox data, and highlights the need to understand risk in greater detail. The upcoming Class G safety risk study run by the UK CAA may identify more detailed steps in understanding trends and causes in risk in Class G operations, in particularly looking at “leading indicators” – those factors which act as precursors or indicators of changing risk levels. The promotion of voluntary safety improvements which are shown to provide effective mitigation to specific risks is a preferred way forwards. Examples in this scoping study include APV approaches, air-to-air surveillance (electronic conspicuity using ADS-B), and 4G/5G Aeronautical Information applications.
- **Cost-effectiveness** is a key performance driver, and must include consideration of capital expenditure, operational expenditure and cost during changes. It is expected that any change or combination of changes will need to prove that they are the most cost-effective option for the particular objective or performance expectation. With very slim margins, the capacity for change in some stakeholders is also limited, arguing for well-planned single-step upgrades where possible. This is shown in the relatively low cost (Net Present Value) seen in scenario 5: coordinated funding, in comparison to other scenarios. Whilst this is partly due to the modelling of public funding part-assistance, many of the benefits in coordinated decision making are independent of the funding model. Another issue arising from the scenarios was the overriding driver of the cost of PSR/SSR upgrades, and the long associated timeline.
- Enabling airspace users to carry out their intended operation remains important for the LDLCA region. The commercial “lifeline” services are a particular focus, but it also applies to the military and non-commercial flights. Increasing **resilience**, i.e. reducing cancellations or diversions, is therefore required, but at a cost-effective price. The objective can also be enabled through increasing or maintaining **access** to controlled airspace. There are threats to access from expanding volumes of controlled airspace. The future roadmap should seek to mitigate these through innovative airspace and technical enablers.
- In very low density environments, **capacity** is not measured as number of aircraft accepted per hour. Rather, it is a measure of whether zero, one or more flights can enter the same airspace or airport at the same time.

Regulatory constraints were also identified, against which the success of an approach could be measured – see Annex H for the full list. Of most interest to

LDLCA will be the Standardised European Rules of the Air (SERA), the proposed PBN Implementing Rule, the Transition Altitude decision, the surveillance Implementing Rule progression (particularly if it eventually includes aircraft under 5.7 tonnes MTOW), and the Remote Tower operations Implementing Rule. These may delay certain decisions in the environment – for example, a delay in the Remote Tower IR until 2020 may delay procurement of eventual solutions until after that date, such that stakeholders manage the risk of non-compliance.

The study considered important policy initiatives external to the aviation domain. The **Spectrum Release** programme is a specific activity directed by UK Cabinet's Public Expenditure Committee (Asset Sales), with a focus on aviation in the UK CAA aimed at responding to the government's challenge to ensure efficient and best value use of radio spectrum. The near-term aim of freeing up aviation frequencies (around 100MHz) in the 2.7 to 3.1 GHz range will impact preferred solutions for non-cooperative surveillance. Critically, it also brings a massive financial benefit to the argument for change, in the shape of the government proceeds from the spectrum licensing. In an environment with thin margins where business cases can often only be made on the basis of public subsidies, the expected proceeds could be used to partly offset some of the capex and transition costs to aviation stakeholders. This would mitigate risks of delay, although adding a layer of complexity with the number of stakeholders and agreements which would need to be progressed.

The **incentivisation of renewable energy**, particularly wind power, creates a further driver for change in the LDLCA region. This is applicable to Scotland in particular, with targets of 100% renewable energy sources by 2020. Northern Ireland and the Republic of Ireland also have power generation targets from wind energy.

The timelines of subsidies and grants for wind energy supply leads to a constrained horizon for decision making on wind farm deployment due to the positive business case created by the subsidies. From the data available, it appears as though the wind farm companies will be strongly incentivised to have onshore wind farms approved and operational before 2017, at which point the benefits from the business case may reduce by 25% due to a reduction in the duration of subsidised payments for the electricity supplied.

## 8.3 What operational changes might be made?

The consultations and identified user requirements highlighted diametrically opposite but legitimate expectations of the airspace and ATM evolution.

If the stakeholders traditionally disadvantaged by controlled airspace are willing to accept it and pay for it, then a simplified environment of Class C and Class G, as in Ireland, will be appropriate. However, if stakeholders cannot afford to maintain a full ATC service with low traffic volumes, or if some stakeholders would lose access if controlled airspace and mandatory carriage requirements were applied, it is right to examine possible options.

Ensuring the flexibility in service supply may be a requirement in the next ten years for this environment. The ability to move to and from an ATC service dependent on traffic levels is one element of this. An appropriate set of risk mitigations may be required if an aerodrome does move from an ATC service to a Flight Information Service. These could include airborne surveillance (including electronic conspicuity for ACAS equipped operators), and a mandatory zone if appropriate.

Several opportunities have been investigated in this study for evolving solutions which meet the LDLCA performance drivers outlined above. In particular, the study identified the following:

- Improving stakeholder ability to be conspicuous, either via a radio, a transponder or an ADS-B OUT transceiver, dependent upon a market being available. If voluntary uptake looks slow, one option could be to calculate the cost of equipping all users with a low-cost transceiver using public funds, and tie this into the coordinated funding approach espoused in scenario 5 in this study.
- Identifying the appropriate balance between maintaining or improving safety levels by improving conspicuity on the ground or in the air, whilst ensuring improvements in access by reducing Class C/D airspace volumes. The use of mandatory zones with Class E airspace around reduced Class C/D airspace should give access benefits whilst ensuring the controller has appropriate awareness of proximate traffic and control over the IFR traffic at all times.
- Moving from TMZs to an SMZ (Surveillance Mandatory Zone), assuming appropriate ADS-B OUT markets, may give the users a higher benefits case from equipping leading to faster take-up. The move of 1090MHz transponders to include ADS-B OUT is a good step in this direction. It also gives the service provider the opportunity to move away from SSR if desired, since users will be equipped with ADS-B, and WAM could be used as a light integrity check on the ADS-B position.

Early on in the study, the need for non-cooperative surveillance in the LDLCA region was challenged, particularly additional operational requirements outside controlled airspace. From a risk-based perspective, the non-cooperative surveillance of military aircraft is considered a necessary requirement by the MoD. This requirement would encompass the three MoD PSRs in the region, as well as the NERL-owned Allanshill radar under the FMARS programme.

There is also a continuing local requirement for non-cooperative surveillance in CTR/CTAs around aerodromes, based on a local safety assessment. These currently include Cork (IAA), Shannon (IAA), Inverness (HIAL), and the unique case of Compass Head (NSL) serving North Sea helicopter traffic.

The need for these aerodromes to protect their ability to provide ATSOCAS (Flight Information Services in Class G airspace) is a more nuanced discussion. For protection of the controlled airspace from infringing traffic, there may be other ways to achieve the same goals; a limited mandatory zone may give a certain level of risk-based protection judged appropriate. The provision of ATSOCAS away from the immediate CTA/CTR is a useful service, but difficult to justify unless a “hotspot” of risk can be shown to exist. Otherwise, understanding the reasons why a particular portion of uncontrolled airspace is subject to surveillance when other parts are tolerably safe but not covered by any surveillance becomes difficult. This may need to be explained in more detail when considering distributed surveillance in the future, which allows a more specific service volume to be defined (i.e. the ANSP may have to pay to ensure coverage of a wider volume).

In the UK, it is possible that the funded Lower Airspace Radar Services may be further shared between MoD and civilian units, dependent on military base opening hours and surveillance coverage areas[13]. This would strengthen the argument from the ANSPs' perspective for protection of the ATSOCAS capability, since it would include a source of revenue.

## 8.4 Which enabling elements could be a viable option in LDLCA?

### 8.4.1 Communications

It is clear that VHF air-ground communications will be maintained in LDLCA for the foreseeable future. 8.33kHz radios are standard amongst most of the LDLCA fleet – however, handheld solutions have not yet been approved, and are preferred by the lighter end of General Aviation. Making full use of RMZs as part of risk-based airspace would require appropriate solutions to be available to the full range of stakeholders.

Whilst datalink could have a place if cost is driven down, it must be application driven, and at present most applications for ATM appear to target solely high density environments. The use of 3G/4G/5G may open up new opportunities if non-safety critical applications are promoted. The provision of tactical in-flight weather updates (e.g. icing conditions) and the sharing of updated flight trajectory data for IFR flights may be relatively quick wins, enhancing safety in the LDLCA environment.

### 8.4.2 Navigation

VOR rationalisation presents a short term call to action. Very few airports are seriously impacted, with only three in LDLCA planned to have VORs removed.

Of the three, two are ultra-low IFR traffic, and could apply geographical or vertical separations with a simplified RNAV route connecting to the airport. This was considered a retrograde step by the ANSP, and may remove some options for traffic growth in the future. APV approaches could also be implemented, but business cases must be made for the local operators, since the cost of dual FMS capability (hot back-up) may be prohibitive for some given the limited number of flights or approaches flown.

For Inverness, traffic density and airspace complexity is such that more granular procedural separation may need to be applied. The cost of applying a simplified geographical or vertical separation may be too high over a number of years, given potential flight inefficiencies due to additional delays or non-optimum routes. The simplest solution might be to keep the Class G airspace and apply RNAV route based procedural separations by implementing a small network of RNAV1 routes. An alternative would be to move to surveillance-based separations, which would in theory provide the best solution for CAT, but at a potential cost in staffing. Both solutions lead to a desire for an airspace change to safely manage the situation.

In each case, a coherent approach with APV approach implementation is called for. For most airspace users, a single/redundant box will enable both RNAV1 and APV. APV functionality imposes additional requirements, particularly for dual pilot cockpits, and should be an airspace user decision taking account of resilience and safety benefits. Upgrading only once is essential. Therefore, planning whether RNAV1 will be the most stringent PBN requirement in the airspace is critical. This planning will also need to take account of adjoining airspace and the routes flown by the LDLCA fleet – if the aircraft flies to Glasgow or Dublin, for example, they

[13] The LARS review is due to report soon after the conclusion of this LDLCA scoping study.

may be required to equip with RNP1 to meet the higher density TMA requirements.

The proposed PBN Implementing Rule may require aircraft over a certain size to equip with RNP1. The exact timeline and scope of this IR are not yet finalised. However, in order to prevent two upgrades within 2-3 years, clear communication should be given on the detailed UK and Ireland PBN roadmaps (e.g. will the same requirements be levied on LDLCA regions as for high density environments?).

RNAV routes may require a redundant navigation means, probably DME/DME. Whilst on-board inertial systems will provide mitigation for safety-based events (failures), the resilience of the route is compromised by reliance on GPS. In Scotland, this is particularly the case due to the prevalence of military exercises jamming GPS in the region. Galileo is not assumed to be a feasible solution until at least 2023. The low level coverage of the DME/DME or VOR/DME network becomes critical, particularly as many of the routes are below FL195 and not under the license requirements of the en-route ANSP who owns the navaids. The on-going consultations and impact assessments carried out by NERL should take this into account.

### 8.4.3 Surveillance

Non-cooperative surveillance

The continuing operational requirement for non-cooperative surveillance suggests an on-going requirement for technical enablers in approximately their current location. The specific coverage area may change however. The discussion above on ATSOCAS provided from aerodrome-based PSRs is important when assessing the possible coverage area of non-cooperative surveillance in the future. Whilst aerodrome radar gives roughly a 60NM coverage zone, distributed systems such as MSPSR could be highly tailored to meet a specific service volume.

Without the drivers from wind farm mitigations and spectrum release, existing civil PSRs would be replaced between 2020 and 2027 dependent on the business case of the alternative solution. For the MoD PSRs, the Project Marshall timeline dictates that new non-cooperative solutions are deployed in the 2015-2021 timeframe, and decided upon at the start of this timeframe. The IAA PSRs will be replaced at the end of their design life.

Where potential interference with non-cooperative surveillance is the constraining factor to gaining approval for the wind farms, a dilemma exists. The introduction of mid-life changes to non-cooperative surveillance solutions may impose additional costs on stakeholders, and potentially multiple changes to technical solutions. It is possible that short-term wind farm mitigations could be deployed in the 2014-2017 timeframe. However, if alternative mitigations are deployed, for example radar upgrades or new in-fill radar solutions, the transition costs on the ANSP may act as a constraint to another change in 2020-2021 for spectrum release benefits.

A single integrated solution could solve both spectrum release and wind farm interference issues: Multi-Static PSR (or multilaterated primary) is thought to address both issues and potentially be more cost-beneficial over its lifetime than equivalent coverage PSRs. However, this will not be available for civil ANS use by 2017. The earliest MSPSR could replace PSRs is 2020, given current development and regulatory timelines.

The timeline for the constraining factors on non-cooperative surveillance is shown in Figure 12 below.

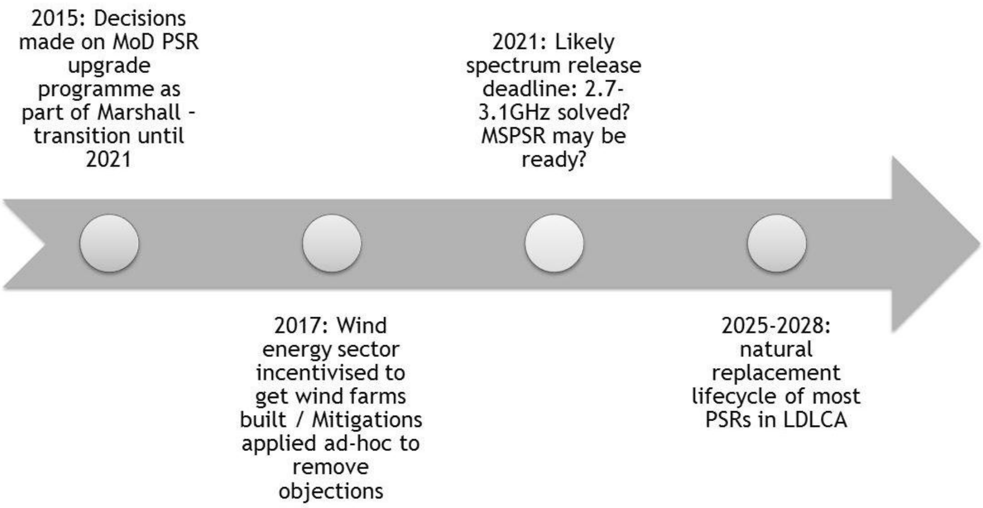



**Figure 12: Non-cooperative surveillance - issues timeline**

At certain locations, assuming the requirement for non-cooperative surveillance is maintained, a radar will be the only option as distributed surveillance may not be feasible. This could be the case for Compass Head and possibly Allanshill, where offshore sensors and communications capability would need to be installed for a distributed surveillance system such as MSPSR (or WAM for cooperative surveillance), something which may not be technically feasible. Oil rigs or even wind farms could be used if available, but would need to be positioned appropriately for the distributed system to be effective.

In the UK, the timelines of the drivers impacting non-cooperative surveillance do not obviously “line-up” to generate a single set of decisions, complicating the evolution of the technical enablers. In particular, the MoD (and the tenderers under Project Marshall) will need to make a decision before contract award (2014/5) for PSR provision to meet Marshall performance requirements by 2021. MSPSR will not be mature enough in the 2015 timeframe; the solution is therefore likely to be PSR-based, with capacity to incorporate wind farm mitigating technology should it be proved viable. There is a question mark whether the PSRs would be compliant with a future spectrum release programme solution in the 2020 timeframe.

Prior to 2017, wind energy companies will also be incentivised to find available mitigations. These are not likely to solve the spectrum release programme, requiring another round of changes in 2020-21 if spectrum release goes ahead.

The UK CAA is working on a Surveillance Strategy to bring together these elements for the UK. The LDLCA regional issues are analogous to the problems faced nationwide, and therefore LDLCA stakeholders should engage with this strategic initiative.

Stakeholders are recommended in the short term to assess which assumptions can be moved in time to align the changes more appropriately, thus avoiding unsynchronised multiple procurements. For example, the business case for wind energy depends on subsidies. These may be able to be moved to apply to a longer timeline (e.g. up to 2022), to ensure enough time to remove wind farm planning objections due to non-cooperative surveillance by using solutions compatible with spectrum release.

Cooperative surveillance (ground)

The issues surrounding cooperative surveillance on the ground and its evolution are less complex than non-cooperative surveillance due to the absence of spectrum release and wind farm mitigation issues. The key drivers are therefore the design lifetime, and potential business case for replacement of MSSRs by cheaper technical enablers.

Elements impacting the decision in LDLCA include:

- The need for some installations to make coordinated decisions with the non-cooperative solution. For example, if a PSR is implemented, it is likely that the cost efficient option would be to install a co-located MSSR at the same time; in a similar manner, it is assumed that MSPSR and WAM/ADS-B sensors could be co-located.
- The characteristics of distributed systems meaning that the eventual costs could be higher than expected due to the difficulty of siting ground stations and the cost of communications from the distributed infrastructure; this may make WAM unfeasible in coastal areas or on small islands.
- The reliance of ADS-B (and WAM timing) on GNSS, and the potential deliberate interference of GNSS by military exercises in the region.

For these reasons, it is likely that the future LDLCA cooperative environment will be a mix of MSSRs and WAM/ADS-B. If Irish stakeholders do move to a nationwide ADS-B infrastructure, there may be value in ensuring full equipage of users, and moving to an ADS-B surveillance layer with light WAM integrity checking, and turning off the Mode S SSRs. For the UK, Inverness may be a possible environment where WAM/ADS-B would work, but the radar has a design life until at least 2024 so without other influences, this decision would be long-term.

The study notes that ADS-B is currently in a transition period, whilst trust in the new system builds. It is likely that as transition issues with deployment are solved, for example the issues around reliance on GNSS, that ADS-B may become a more palatable single-source solution (as in Australia) with significant cost-benefit gains.

Airborne surveillance

For several years, the notion of electronic conspicuity in the cockpit has been proposed for introduction, particularly as a result of two mid-air collisions in the UK in the last decade. In each case, the AAIB recommended that light aircraft and gliders fit with electronic conspicuity solutions. However, the absence of a low cost system market precludes full application of the technology, along with the debate about the true level of risk of mid-air collisions in Class G airspace.

It is not the position of this scoping study to make the recommendations for the Electronic Conspicuity Working Group organised by the CAA. However, it is clear that for the airborne domain, the potential benefits of ADS-B IN/OUT versus those found with transponder-only equipage mean that the business case per aircraft could be more positive assuming a cheap technical solution can be found. The FAA LPSE, NATS LPAT and other specifications give encouragement that the market will move forwards on this issue in the next few years.

For many light aircraft, the use of traffic displays showing ADS-B derived information can bring situational awareness benefits, particularly in Class G when not receiving any other service. This additional risk layer is enhanced as the equipage rate of ADS-B OUT increases, for example through incentivisation of voluntary equipage or through the use of mandatory zones.

The notion of a Surveillance Mandatory Zone has also been introduced in this report, entailing the fitment of ADS-B OUT or a transponder for access to the zone. This allows those GA (and military) aircraft who wish to equip with an ADS-B OUT functionality to benefit from access. It is not likely to be appropriate until widespread equipage of ADS-B OUT is seen in LDLCA, estimated after 2020. Nevertheless, to give clear guidance on the issue and encourage equipage, the CAA policy on mandatory zones could consider this for inclusion as a future option.

### 8.4.4 Other enablers

The application of Remote Towers and centralised approach centres is nearing maturity, and in Europe the first units will be operational in 2014 (LFV in Q1, Avinor in Q4). Airservices Australia is also beginning a four month trial of Remote Towers at Alice Springs in October 2013, and the FAA is deploying functionality in Colorado. Both FIS and ATC services can be provided by a Remote Tower unit.

It will be important that both Tower and Approach services can be provided remotely in LDLCA, as key benefits from pooling controllers would otherwise be lost.

Experience will be gained from the LFV, Avinor, FAA and Airservices installations, and the cost-benefit and safety cases better appreciated. It is fully expected that the principles of transparent charging will lead to pressure to reduce TWR/FIS costs, and that Remote Towers will give a positive business case, even in the case of island-island communications being necessary. The communications cost of Remote Tower solutions will need to be assessed, but many of the latest deployments utilise a compression scheme (e.g. for real-time video) which reduces the bandwidth requirements.

Early engagement with stakeholders and the CAA is recommended to understand the drivers in more detail, and in particular to identify any integration required with other developments (e.g. licensing, SERA etc). This study concluded that the application of Remote Towers could be a cost-effective, safe and appropriate solution for the UK and Irish LDLCA regions in the next 5 years, and consideration towards progressing this option further could be made by the Regulator.

## 8.5 Next steps

The vision for the LDLCA airspace aims to address the challenges from external constraints in a positive and coherent manner, noting that unnecessary services and requirements are not desired in the region. The vision includes RNAV-1 route structures, continued non-cooperative surveillance, a more focused risk-based approach to service provision, and the use of new mitigation layers such as airborne surveillance and enhanced information to provide a safer environment for all users.

The vision will be achieved through a clear strategy laid out for the region at a FAB level, recognising the variance between the UK and Ireland. The strategy should include a stepped deployment approach to dealing with the constraints highlighted in this report, allowing all stakeholders to plan accordingly. Where uncertainties exist, specific actions should be put in place to provide evidence of preferred options. Particular examples where further evidence is required include the non-cooperative surveillance deployment issues, the use of Remote Towers, and the application and effectiveness of mandatory zones for risk mitigation.

This report is provided to the LDLCA Scoping Study's funding partners, and is recommended to be made publicly available, to inform decision making and investment plans.

It is further recommended that the UK CAA SARG and IAA SRD undertake a programme of work, informed by the Scoping Study, to produce a strategy for low density, low complexity airspace types within the UK Ireland FAB, potentially as part of the Future Airspace Strategy.

This strategic approach could include an LDLCA consultative group, overseeing the production of a UK-Ireland FAS LDLCA strategy including industry consultation. Any plan should be complementary to the UK Spectrum Release Programme's published milestones.

# A Acronyms

| | |
|---|---|
| ACARS | Aircraft Communication And Reporting System |
| ACAS | Airborne Collision Avoidance System |
| ADR | Advisory Route |
| ADS | Air Discount Scheme |
| ADS-B | Automatic Dependent Surveillance – Broadcast |
| ADS-C | Automatic Dependent Surveillance – Contract |
| AIM | Aeronautical Information Management |
| AMSS | Aeronautical Mobile Satellite Services |
| ANC/12 | ICAO 12th Air Navigation Conference |
| ANSP | Air Navigation Service Provider |
| APP | Approach Control |
| APV | Approach with Vertical guidance |
| ATCO | Air Traffic Controller |
| ATM | Air Traffic Management |
| ATM | Air Transport Movement |
| ATS | Air Traffic Service |
| ATSOCAS | Air Traffic Service Outside Controlled Airspace |
| BA | Business Aviation |
| CAA | Civil Aviation Authority (UK) |
| CAS | Controlled Air Space |
| CAT | Commercial Air Traffic |
| CCO | Continuous Climb Operations |
| CDA | Continuous Descent Approach |
| CDO | Continuous Descent Operations |
| CFIT | Controlled Flight Into Terrain |
| CNS | Communication, Navigation, Surveillance |
| COTS | Commercial Off The Shelf |
| CTA | Control Area |
| CTA | Controlled Time of Arrival |
| CTR | Control Zone |
| DAP | CAA Directorate of Airspace Policy |
| DfT | (UK) Department for Transport |
| DoT | (Irish) Department of Transport |

| | |
|---|---|
| DME | Distance Measuring Equipment |
| EASA | European Aviation Safety Agency |
| ECAC | European Civil Aviation Conference |
| EPP | Extended Projected Profile |
| FAB | Functional Airspace Block |
| FAS | Future Airspace Strategy |
| FIR | Flight Information Region |
| FIS | Flight Information Service |
| FISO | Flight Information Service Officer |
| FMARS | Future Military Area Radar Services |
| GA | General Aviation |
| GBAS | Ground Based Augmentation System |
| GLS | GNSS Landing System |
| GNSS | Global Navigation Satellite System |
| HIAL | Highlands and Islands Airports Ltd |
| IAA | Irish Aviation Authority |
| IFP | Instrument Flight Procedure |
| IFR | Instrument Flight Rules |
| IR | Implementing Rule |
| JMATS | Joint Military Air Traffic Services |
| KPA | Key Performance Area |
| LARS | Lower Airspace Radar Service |
| LDLCA | Low Density Low Complexity Area |
| LPAT | Low Power ADS-B Transceiver (NATS) |
| LPSE | Low Power Surveillance Equipment (FAA) |
| LPV | Lateral Precision with Vertical Guidance Approach |
| MAC | Mid Air Collision |
| MoD | (UK) Ministry of Defence |
| MSPSR | Multi Static Primary Surveillance Radar |
| MSSR | Monopulse Secondary Surveillance Radar |
| NDB | Non-Directional Beacon |
| NERL | NATS En Route Limited |
| NPA | Non Precision Approach |
| NSA | National Supervisory Authority |

| | |
|---|---|
| NSL | NATS Services Limited |
| PAR | Precision Approach Radar |
| PBN | Performance Based Navigation |
| PSO | Public Service Obligation |
| PSR | Primary Surveillance Radar |
| RDF | Route Development Fund |
| RMZ | Radio Mandatory Zone |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RPAS | Remotely Piloted Air System |
| SAR | Search and Rescue |
| SBAS | Space Based Augmentation System |
| ScATCC | Scottish Air Traffic Control Centre |
| SERA | Standardised European Rules of the Air |
| SES | Single European Sky |
| SESAR | SES ATM Research |
| SID | Standard Instrument Departure |
| SMZ | Surveillance Mandatory Zone |
| SRD | Safety Regulation Division |
| SSR | Secondary Surveillance Radar |
| STAR | Standard Instrument Arrival |
| SUR | Surveillance |
| SWIM | System Wide Information Management |
| TMA | Terminal Control Area |
| TMZ | Transponder Mandatory Zone |
| TSAA | Traffic Situational Awareness with Alerts |
| TWR | Tower Control |
| VDL | Very High Frequency Data Link |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| VNAV | Vertical Navigation |
| VOR | VHF Omni-directional Range |
| WAM | Wide Area Multilateration |

# B References


| | |
|---|---|
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| 2. | COMMISSION IMPLEMENTING REGULATION (EU) No 1035/2011 of 17 October 2011 laying down common requirements for the provision of air navigation services |
| 3. | UK CAP774 Flight Information Services |
| 4. | http://www.eurocontrol.int/articles/performance-based-navigation-pbn-mandate |
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| 7. | Policy for the Application of Performance-based Navigation in UK/Irish Airspace, UK CAA / IAA, October 2011 |
| 8. | Irish Statutory Instrument (S.I.) 856 of 2004 |
| 9. | AIC Y 023/2012: Application of Performance Based Navigation in UK Airspace, 22 Mar 2012 |
| 10. | Noise Considerations at GA Aerodromes, CAA, November 2012 |
| 11. | UK Ireland FAB – Plan 2012-2015, 31 May 2012 |
| 12. | UK Ireland FAB – ANSP Report for 2012, 18 June 2013 |
| 13. | UK CAP670 Air Traffic Services Safety Requirements |
| 14. | The Air Navigation (Amendment) Order 2012, Statutory Instrument 2012 No. 1751 |
| 15. | ICAO WP ASP14-18, Status of multi-static primary surveillance systems and draft guidance material on the use of MSPSR systems for ATC, 27 March 2013 |
| 16. | UK CAA Policy on Transponder Mandatory Zones, April 2009 |
| 17. | UK CAA Policy on Radio Mandatory Zones, August 2013 |
| 18. | EASA EU OPS |
| 19. | Class G in the 21st Century, part of the Future Airspace Strategy, March 2012 |
| 20. | Final four year EASA rulemaking programme 2014-2017 |
| 21. | CAA presentation to ATS Safety Regulation Advisory Committee (ATSSRAC) 34 – May 2013 |

# C Background data on current situation

## C.1 Validated airport data

Using CAA statistics for 2011, the traffic in the relevant UK airports can be divided into commercial and non-commercial. Commercial aircraft movements can be subdivided into air transport, positioning flights and local movements. As far as non-commercial movements are concerned, those can broadly be subdivided into test and training, aero club, private flights, official, military and business aviation. For each airport, the following tables present number of passengers for 2011 and 2006, and aircraft movements by type of movement for 2011.

For the Irish airports, detailed data is not gathered centrally, but instead by the individual airports. This also means that data is not always gathered, shared, or it is gathered and presented in a way that is not consistent for different airports. Only validated data has been included in this section. See Table 2 in section 3 for estimated movement data for Irish airports, which is not validated by the individual airports.

| Airport | Terminal passengers 2011 | Terminal passengers 2006 | Aircraft movements 2011 | Aircraft movements 2006 |
|---|---|---|---|---|
| **UK** | | | | |
| **BARRA** | 10,482 | 9,808 | 1,258 | 1,321 |
| **BENBECULA** | 34,240 | 33,433 | 4,366 | 4,462 |
| **CAMPBELTOWN** | 9,201 | 8,928 | 1,993 | 3,837 |
| **CITY OF DERRY (EGLINTON)** | 405,568 | 341,531 | 8,464 | 11,941 |
| **INVERNESS** | 579,123 | 670,894 | 30,755 | 40,826 |
| **ISLAY** | 25,784 | 26,218 | 3,003 | 2,558 |
| **KIRKWALL** | 133,930 | 116,837 | 14,131 | 14,719 |
| **LERWICK (TINGWALL)** | 5,181 | 4,438 | 1,926 | 2,131 |
| **SCATSTA** | 288,225 | 255,147 | 14,475 | 12,335 |
| **STORNOWAY** | 122,439 | 120,288 | 11,255 | 12,363 |
| **SUMBURGH** | 142,615 | 128,233 | 12,228 | 12,185 |
| **TIREE** | 8,310 | 7,016 | 1,111 | 858 |
| **WICK** | 24,262 | 19,538 | 4,734 | 6,721 |
| **Ireland** | | | | |
| **DONEGAL** | 40,102 | 56,731 | 2,857 | 3,233 |
| **GALWAY** | Not available | 248,972 | 12,233 | 16,088 |
| **IRELAND WEST / KNOCK** | 654,553 | 621,171 | 8,808 | 8,771 |
| **SHANNON** | | | 27,828 | |

**Table 18: Size of airports 2011 - comparison with 2006**

| | Commercial movements | | |
|---|---|---|---|
| **Airport** | **Air transport** | **Positioning flights** | **Local movements** |
| **UK** | | | |
| **BARRA** | 1,183 | 3 | 0 |
| **BENBECULA** | 3,912 | 282 | 0 |
| **CAMPBELTOWN** | 1,133 | 93 | 0 |
| **CITY OF DERRY (EGLINTON)** | 4,026 | 57 | 2 |
| **INVERNESS** | 15,097 | 1,620 | 15 |
| **ISLAY** | 2,004 | 196 | 2 |
| **KIRKWALL** | 12,599 | 593 | 9 |
| **LERWICK (TINGWALL)** | 1,817 | 54 | 12 |
| **SCATSTA** | 13,199 | 929 | 0 |
| **STORNOWAY** | 9,190 | 355 | 219 |
| **SUMBURGH** | 9,156 | 945 | 198 |
| **TIREE** | 1,019 | 12 | 0 |
| **WICK** | 2,416 | 941 | 2 |
| **Ireland** | | | |
| **DONEGAL** | Scheduled commercial: 1685<br>Non-scheduled commercial: 555 | | |
| **GALWAY** | Scheduled commercial: 3541<br>Non-scheduled commercial: 296 | | |
| **IRELAND WEST / KNOCK** | 6,101 | 68 | 28 |

**Table 19: Commercial movements 2011**

| | Non-Commercial movements | | | | |
|---|---|---|---|---|---|
| **Airport** | **Training** | **Aero club** | **Private** | **Military** | **Business** |
| **UK** | | | | | |
| **BARRA** | 2 | 0 | 70 | 0 | 0 |
| **BENBECULA** | 3 | 17 | 81 | 65 | 4 |
| **CAMPBELTOWN** | 90 | 67 | 163 | 447 | 0 |
| **CITY OF DERRY (EGLINTON)** | 2,070 | 1,118 | 1,126 | 44 | 14 |
| **INVERNESS** | 1,058 | 11,041 | 1,186 | 69 | 547 |
| **ISLAY** | 0 | 75 | 602 | 120 | 4 |
| **KIRKWALL** | 166 | 349 | 358 | 16 | 22 |
| **LERWICK (TINGWALL)** | 2 | 28 | 9 | 0 | 0 |
| **SCATSTA** | 323 | 0 | 0 | 0 | 0 |
| **STORNOWAY** | 1,061 | 30 | 251 | 109 | 0 |
| **SUMBURGH** | 1,773 | 5 | 64 | 20 | 0 |
| **TIREE** | 2 | 14 | 63 | 0 | 0 |
| **WICK** | 261 | 152 | 900 | 40 | 22 |
| **Ireland** | | | | | |
| **DONEGAL** | 497 | | | 120 | |
| **GALWAY** | 5,402 | | | 131 | |
| **IRELAND WEST / KNOCK** | 1,294 | | 662 | 115 | 74 |

**Table 20: Non-commercial movements 2011**

A number of aerodromes of interest have a significant proportion of rotary wing aircraft movements. This fact renders the nature of operations more complicated, meaning that specific operational challenges exist in this group of airports. The following table presents rotary wing aircraft passenger and air transport movements for these airports in 2011:

| **Airport** | **Passengers- Total terminal and transit 2011** | **Passengers- Total terminal and transit 2010** | **Air transport movements 2011** | **Air transport movements 2010** |
|---|---|---|---|---|
| **UK** | | | | |

| | | | | |
|---|---|---|---|---|
| **INVERNESS** | 0 | 39 | 0 | 4 |
| **KIRKWALL** | 160 | 25 | 26 | 10 |
| **LERWICK (TINGWALL)** | 61 | 15 | 26 | 10 |
| **SCATSTA** | 135,116 | 131,760 | 8,331 | 8,165 |
| **STORNOWAY** | 3 | 19 | 15 | 48 |
| **SUMBURGH** | 4,042 | 4,170 | 437 | 476 |
| **TIREE** | 0 | 1 | 0 | 1 |
| **WICK** | 579 | 389 | 137 | 159 |
| **Ireland** | | | | |
| **DONEGAL** | 2,664 | | 516 | |

**Table 21: Rotary wing passengers and air transport movements at relevant airports**

Scatsta, Sumburgh and Wick stand out from the previous table as having a much larger number of rotary wing aircraft passengers and air transport movements from the rest of the group. Combining information from the previous table and Table 19, Scatsta's share of rotary wing to total air transport movements in 2011 was approximately 63%, while the same figures for Sumburgh and Wick were approximately 5% and 6% respectively.

## C.2 Services

The following tables provide further details on the main airports that are covered within the scope of this study. Data has been taken from the UK and Irish AIPs. The table focuses on those airports with a Flight Information Service or Air Traffic Control service. If the airport only has an Air/Ground Radio service, it is shown in less detail in section C.3.

| Airport | Operator | Traffic | AIS | ARO | MET | ATS | Remarks |
|---|---|---|---|---|---|---|---|
| **BARRA** | HIAL | VFR | No | No | No | Yes | Nil |
| **BENBECULA** | HIAL | IFR/VFR | No | No | Yes (Aberdeen) | Yes | The aerodrome is PPR. 3 hrs notice by telephone or fax |
| **CAMPBELTOWN** | HIAL | VFR | No | No | No | Yes | The aerodrome is strictly PPR and arrival/departure times may be allocated. |
| **CITY OF DERRY (EGLINTON)** | City of Derry Airport Operations Ltd | IFR/VFR | Yes (As AD hours). Self- Briefing | No | Yes (Via ATC). Associated Met Office Belfast. | Yes (As AD hours). | The aerodrome is not available for aircraft not able to communicate with ATC radio. Local aircraft movements to the north of the aerodrome are restricted. |
| **INVERNESS** | HIAL | IFR/VFR | Yes (As AD hours) | No | Yes (As AIS briefing hours). Associated MET Office Aberdeen. | Yes (As AD hours) | The aerodrome is PPR. |
| **ISLAY** | HIAL | VFR | No | No | No | Yes (As AD hours) | The aerodrome is PPR by telephone. 3 hours' notice required. |
| **KIRKWALL** | HIAL | IFR/VFR | No | No | Yes (As AD hours). Associated MET Office Aberdeen. | Yes | Tingwall aerodrome is PPR, Minimum of phone call or email to Duty FISO |
| **LERWICK (TINGWALL)** | Shetland Islands Council | VFR | No | No | No | Yes (As AD hours)-Basic Flight Information Service (FIS) | The aerodrome is PPR by telephone with ATC/Airport Operations. Aerodrome Operator: See latest NOTAM for details. |

| Airport | Operator | Traffic | AIS | ARO | MET | ATS | Remarks |
|---|---|---|---|---|---|---|---|
| **SCATSTA** | Serco Defence, Science and Nuclear on behalf of BP Ltd | IFR/VFR | Yes (Via ATC) | Yes (As AD hours) | Yes (Via ATC). Associated MET Office Aberdeen. | Yes. And as notified by NOTAM | The aerodrome is PPR (2 hrs notice). Airport extension requests made to SERCO. |
| **STORNOWAY** | HIAL | IFR/VFR | No | No | No. Associated MET Office Aberdeen | Yes | The aerodrome is PPR. To cover the possibility of an aircraft which departs from within 15 mins of normal closing time having to return, the Aerodrome will normally retain sufficient services and equipment for 15 mins after the time of actual departure. |
| **SUMBURGH** | HIAL | IFR/VFR | Yes (As AD hours) | Yes (As AD hours) | Yes. Associated MET Office Aberdeen | Yes (As AD hours). | Request for extension of hours should be made to HIAL, Sumburgh. |
| **TIREE** | HIAL | VFR | No | No | No | Yes (As AD hours) | The aerodrome is PPR. |
| **WICK** | HIAL | IFR/VFR | No | No | No. Associated MET Office Aberdeen | Yes (As AD hours). | The aerodrome is PPR. |

**Table 22: UK airport basic information**

| Airport | Operator | Traffic | AIS | ARO | MET | ATS | Remarks |
|---|---|---|---|---|---|---|---|
| **CONNEMERA** | Galway Aviation Services Ltd | VFR | See Remarks | See Remarks | See Remarks | No | "PPR Minimum 3 hours with restrictions, PIB AVBL from AIS, Shannon, ARO service is AVBL H24 from AIS Shannon, Met briefing AVBL from Central Aviation Office, Shannon Airport |
| **CORK** | Dublin Airport Authority plc | IFR/VFR | Yes (H24 in conjunction with AIS Shannon) | Yes (H24 in conjunction with AIS Shannon) | Yes (H24) | Yes (H24) | Airport closed on Christmas Day. Exact HR advised by NOTAM |
| **DONEGAL** | Donegal Airport Co | IFR/VFR | Yes (See Remarks) | Yes (As ATS) | Yes (Associated Office: Central Aviation Office, Shannon Airport ) | Yes | PIB AVBL from AIS, Shannon |
| **GALWAY** | Galway Airport | IFR/VFR | See remarks | As ATS | See remarks | See remarks | NOTAM for ATS Operational Hours. AVBL outside published HR, 24HR PN to AD administration. PIB AVBL from AIS, Shannon. MET briefing AVBL from Central Aviation Office, Shannon Airport. METAR AVBL as per ATS. |
| **INISHEER** | Galway Aviation Services Ltd | VFR | See remarks | See remarks | See remarks | No | See Connemera |
| **INISHMAAN** | Galway Aviation Services Ltd | VFR | See remarks | See remarks | See remarks | No | See Connemera |
| **INISHMORE** | Galway Aviation Services Ltd | VFR | See remarks | See remarks | See remarks | No | See Connemera |
| **IRELAND WEST / KNOCK** | Development Co. Ltd., Charlestown Co. Mayor | IFR/VFR | See remarks | Yes (As per AD ADMIN) | Yes (Associated MET Office Ireland West Airport Knock) | Yes (As per AD ADMIN) | "ATS AVBL outside published HR, 24 HR PN to AD ADMIN. PIB AVBL from AIS, Shannon. PPR required in advance for all flights |

| Airport | Operator | Traffic | AIS | ARO | MET | ATS | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | (24HR if possible) |
| **KERRY** | Kerry Airport Plc. | IFR/VFR | Yes | Yes(As ATS) | Yes (Associated Office: Central Aviation Office, Shannon Airport ) | Yes (0700-1900 LCT) | PIB AVBL from AIS, Shannon |
| **SHANNON** | Dublin Airport Authority | IFR/VFR | Yes (H24) | Yes (H24) | Yes (H24) | Yes (H24) | Nil |
| **SLIGO** | Sligo Northwest Airport Co | IFR/VFR | Yes (See Remarks) | Yes (As ATS) | Yes (Associated Office: Central Aviation Office, Shannon Airport ) | Yes (07 30 - 21 00) | PIB AVBL from AIS, Shannon |
| **WATERFORD** | Waterford Airport Killowen Co | IFR/VFR | See Remarks | Yes (As per AD ADMIN) | Yes (Associated Office: Central Aviation Office, Shannon Airport ) | Yes (As per AD ADMIN) | "ATS AVBL outside published HR, 24 HR PN to AD ADMIN. PIB AVBL from AIS, Shannon<br>MET briefing AVBL from Central Aviation Office, Shannon Airport |

**Table 23: Irish airports basic information**

| | Airport Services | | | | |
|---|---|---|---|---|---|
| **Airport** | **AFIS** | **ATIS** | **APP** | **TWR** | **RAD** |
| **BARRA** | x | | | | |
| **BENBECULA** | x | x | x | x | |
| **CAMPBELTOWN** | x | | | | |
| **CITY OF DERRY (EGLINTON)** | | | x | x | |
| **INVERNESS** | | x | x | x | x |
| **ISLAY** | x | | | | |
| **KIRKWALL** | x | x | x | x | |
| **LERWICK (TINGWALL)** | x | | | | |
| **SCATSTA** | | x | x | x | x |
| **STORNOWAY** | x | x | x | x | |
| **SUMBURGH** | | x | | x | x |
| **TIREE** | x | | | | |
| **WICK** | x | x | x | x | |

**Table 24: UK airport services**

| | Airport Services | | | | |
|---|---|---|---|---|---|
| **Airport** | **AFIS** | **ATIS** | **APP** | **TWR** | **RAD** |
| **CORK** | | x | x | x | x |
| **DONEGAL** | | x | x | x | |
| **GALWAY** | | x | x | x | |
| **IRELAND WEST / KNOCK** | | | x | x | |
| **KERRY** | | x | x | x | |
| **SHANNON** | | x | x | x | x |
| **SLIGO** | x | | x | x | |
| **WATERFORD** | x | x | x | x | |

**Table 25: Irish airport services**

## C.3 Other airfields in the reference LDLCA environment

The table below provides an overview of other licensed and unlicensed airfields in the reference LDLCA environment considered in this study, mainly corresponding to those without an AFIS, ATIS or ATC service. This list is meant to illustrate the wider scope of aviation in the area (beyond the airports with commercial operations listed above); the list should not be considered comprehensive, since it does not include many farm strips or small helipads.

| Airfield | Runway length (ft) | Runway surface |
|---|---|---|
| | **Scotland** | |
| **Broadford Airfield** | 2,602 | Grass |
| **Coll Airport** | 1,640 | Asphalt |
| **Colonsay Airport** | 1,644 | Asphalt |
| **Eday Airport** | 07/25: 1,729<br>18/36: 1,699 | Graded hardcore/Grass |
| **Fair Isle Airport** | 1,762 | Gravel |
| **North Ronaldsay Airport** | 03/21: 1,083<br>10/28: 1,729<br>14/32: 1,240 | Graded hardcore/Graded hardcore/Grass |
| **Oban Airport** | 4,144 | Asphalt |
| **Outer Skerries Airport** | | |
| **Papa Stour Airport** | | |
| **Papa Westray Airport** | 02/22: 1,729<br>07/25: 1,096<br>18/36: 1,125 | Graded hardcore/Graded hardcore/Grass |
| **Sanday Airport** | 03/21: 1,729<br>11/29: 1,398<br>17/35: 1,266 | Graded hardcore/Grass/Grass |
| **Stronsay Airport** | 02/20: 1,690<br>06/24: 1,348<br>10/28: 1,325 | Graded hardcore/Grass/Grass |
| **Westray Airport** | 01/19: 954<br>09/27: 1,729<br>13/31: 1,381 | Grass/Graded hardcode/Grass |
| **Whalsay Airport** | 1,499 | Asphalt |
| **Dornoch** | 2,540 | Grass |
| **Feshie Airstrip (Feshiebridge)** | 2,950 | Grass |
| **Knockbain Airstrip** | 2,000 | Grass |
| **Plockton Airfield** | 1,960 | Asphalt |
| **Glenforsa/Mull Airfield** | 2,560 | Grass |
| **Easter Airfield** | 2,130 | Grass |
| **Lamb Holm Airfield** | 06/24: 2,100 | Grass |

| Airfield | Runway length (ft) | Runway surface |
|---|---|---|
| | 15/33: 1,115 | |
| **Easterton Airfield** | 3,116 | Grass |
| **Aboyne Airfield** | | Asphalt/Grass |
| **Unst Airport** | 2,100 | Asphalt |
| | **Northern Ireland** | |
| **Enniskillen/St Angelo Airport** | 4,350 | Asphalt |
| **Bally Kelly Airport** | | Asphalt |
| **Ballarena Airport** | | Grass |
| **Benone Strand** | | Gravel |
| **Movenis (Mcmasters Farm) Airfield** | 1,200 | Grass |
| | **Ireland** | |
| **Abbeyfeale** | | |
| **Abbeyshrule** | 2,592 | Asphalt |
| **Ballyboy Airfield** | 1,860 | Grass |
| **Bantry** | 1,280 | Tarmac |
| **Belmullet** | 1,476 | Grass |
| **Birr** | 1,870 | Grass |
| **Coonagh** | 1,365 | Asphalt |
| **Erinagh** | 11/29: 1,804<br>01/19: 1,988 | |
| **Kilkenny** | 3,051 | Grass |
| **Kilrush** | | Grass |
| **Mountshannon** | 8,202 | Water |
| **Newcastle** | 2,264 | Grass |
| **Rathcoole** | 1,476 | Grass |
| **Trevet Farm, Dunshaughlin** | 2,133 | Grass |
| **Trim** | 1,837 | Grass |
| **Castleforbs** | | |
| **Killenaule airport** | | |
| **Letterkenny** | 1,886 | Grass/Tarmac |
| **Spanish Point** | | |
| **Moyne** | 1,165 | Grass |
| **Finner Camp** | | |

**Table 26: Other airfields in the reference LDLCA environment**

# D Airspace classifications

The following table provides the AIP description of relevant airspace Classes for the UK and Ireland respectively:

| **Class F** | **IFR** | **VFR** |
|---|---|---|
| Service | Deconfliction or procedural service to participating aircraft | UK flight information services as required (basic, traffic, deconfliction, procedural service |
| Separation | Separation provided in so far as possible, between aircraft that have flight planned to operate IFR on ADRs. Additionally, under a deconfliction service, advice is provided on unknown traffic. The deconfliction service aims to achieve planned deconfliction minima. | ATC separation cannot be provided due to the nature of the unknown Class F traffic environment. Deconfliction advice is provided against participating aircraft under a procedural service or against participating and non-participating traffic (unknown traffic) under a deconfliction service. Both procedural and deconfliction services aim to achieve planned deconfliction minima. |
| ATC Rules | Participating flights; flight plan required; ATC clearance required; Radio Comm required; ATC instructions are mandatory | Instructions issued by controllers to pilots operating outside controlled airspace are not mandatory; however, the services rely upon pilot compliance with the specified terms and conditions so as to promote a safer operating environment for all airspace users. |
| VMC minima | Not applicable | Varying by flight level |
| Speed limitation | Below FL 100: 250 kt IAS or lower when published in procedures or instructed by ATC. | |
| **Class G** | **IFR** | **VFR** |
| Service | UK flight information services as required (basic, traffic, deconfliction, procedural service). | |
| Separation | ATC separation cannot be provided due to the nature of the unknown Class G traffic environment. Deconfliction advice is provided against participating aircraft under a procedural service or against participating and non-participating traffic (unknown traffic) under a deconfliction service. Both procedural and deconfliction services aim to achieve planned deconfliction minima. | |
| ATC Rules | Instructions issued by controllers to pilots operating outside controlled airspace are not mandatory; however, the services rely upon pilot compliance with the specified terms and conditions so as to promote a safer operating environment for all airspace users. | |
| VMC minima | Not applicable | Varying by flight level |
| Speed limitation | Below FL 100: 250 kt IAS or lower when published in procedures or instructed by ATC. | |

**Table 27: UK Class F and G airspace characteristics**

| Class C | IFR | VFR |
|---|---|---|
| Service | Air traffic control service | Air traffic control service for separation from IFR. VFR Traffic information and traffic avoidance advice on request |
| Separation | All aircraft | VFR from IFR |
| ATC Rules | All movements subject to ATC clearance | |
| VMC minima | Not applicable | At and above FL100: 8km visibility, 1500m horizontal and 1000ft vertical from cloud.<br>Below FL100: 5km visibility, 1500m horizontal and 1000ft vertical from cloud. |
| Speed limitation | Not applicable | 250kts IAS below FL100 |
| Radio communication requirement | Continuous two-way | |
| **Class G** | **IFR** | **VFR** |
| Service | Flight information services if required | |
| Separation | No separation provided | |
| ATC Rules | No ATC clearance required | |
| VMC minima | Not applicable | At and above FL100: 8km visibility, 1500m horizontal and 1000ft vertical from cloud.<br>Below FL100: 5km visibility, 1500m horizontal and 1000ft vertical from cloud. OR At and below 3000ft AMSL or 1000ft above terrain, whichever is higher: 5km (3km for flight at IAS 140kts<br>or less) visibility. Clear of cloud, in sight of surface.<br>Helicopters may be flown below 300m (1000ft) above terrain in flight visibility not less than 1000m if manoeuvred at a speed which would give the pilot in command adequate opportunity to observe other traffic or obstacles in good time to avoid collision |
| Speed limitation | Not applicable | 250kts IAS below FL100 |
| Radio communication requirement | Not required | |

**Table 28: Ireland Class C and G airspace characteristics**

# E UK/Ireland FAB initiatives

This annex outlines the key FAB initiatives which could have an impact on the airspace and provision of ATS in the LDLCA region. It focuses on the services in the near-term, contained in the FAB business plan 2012-2015 [11], with relevant status updates taken from the FAB ANSP Report 2012 [12].

### Network management evolution plan

The network management evolution plan will develop towards the SES aspirations, including SESAR concepts and the Network Management Function. Key principles relevant to LDLCA are listed below:

- Increased and better use of existing network capacity through the advanced flexible use of airspace and dynamic sectorisation in order to reduce complexity, whilst facilitating the sharing of airspace between civil and military users (Flexible Use of Airspace).
- If ATM constraints are necessary, the preferred way to integrate them is through a collaborative process with airspace users and airports in order to achieve the best business or mission outcome.
- The evolution from current fixed route structures to a performance-based operations environment based upon user preferred trajectories and users business needs

Work on the plan is currently focussing on capacity management in the 2015-2019 timeframe.

### Technology Coordination Group

<u>Datalink infrastructure (ARINC/SITA)</u>

NATS and IAA will benefit from a joint approach in the implementation of VDL Mode 2 infrastructure to support the Data linking Mandate planned for 2013. The implementation projects will seek to deliver value in the provision of the infrastructure and cost avoidance.

NATS and IAA worked on a joint approach which led to costs being avoided. This was followed by the production of a commercial framework agreement which will be used in future projects.

### Technology convergence strategy

This project assesses the potential for FAB wide surveillance and infrastructure services. The first draft Technical Convergence Plan has been completed, which provides short, medium and long-terms options.

Whilst the focus in the strategy is on the medium-high density areas and the technical support to the provision of services in these areas, there may also be applications in the LDLCA region. Specifically, one of the short term initiatives supports rationalisation of navigation facilities.

### Service Provision Working Group

<u>CPDLC ConOps alignment/Benefit led use of CPDLC from 2013 onwards</u>

IAA and NATS have elected to implement CPDLC (FANS-1/A and ATN) at different stages during 2013 and 2014. Although the implementation process has not been aligned, there will be opportunities in the future to secure the usage of CPDLC is maximised across the FAB.

**Airspace Design Working Group**

FAB free route airspace

Effort to extend the free route airspace volume over the less complex parts of the FAB will take place to enable fuel emissions savings whilst protecting the capacity that a systemised route structure delivers in the denser more complex parts of the airspace.

The current airspace management arrangements will evolve in an agreed manner to allow civil/military coexistence in route free airspace. The long-term plans are to deliver free route across the entire FAB in line with SESAR expectations.

Whilst this looks at Upper Airspace primarily, similar concepts could be applied below FL195.

**Safety Working Group**

SMS harmonisation

The objective of this project is to harmonise on a Safety Management Manual (SMM) which will ensure the application of a common safety policy and principles within the FAB whilst providing for variability in implementation procedures.

Benefits are expected from elimination of inconsistencies in SMS implementation enabling wider integration and technical convergence between the two organisations, potential for concurrent ANSP and regulatory harmonisation resulting in better value from the regulatory processes and Synergies in documentation, training, application and so on.

A draft SMM was developed by the ANSPs and shared with the NSAs in 2012. Discussions are being finalised between the ANSPs and NSAs regarding the approach to safety accountabilities, this being a statement that assurance by the Irish/UK NSAs will be mutually recognised. This will then be referenced or included in the FAB SMM.

# F Stakeholder expectations from consultation

## F.1 Airspace users – Commercial Air Transport

**Performance**

- Safety of operations remains paramount; with improvement in Class G and around aerodromes. There should be a level of awareness in and around aerodromes to ensure safety (though this may not need to be full ATC service)
- Resilience (capacity / robustness) – ensuring operations are not affected by adverse conditions to the maximum extent possible
- Capacity (during bunching of flights) – appropriate use of services and procedures to avoid any flight inefficiencies

**Operations**

- Ability to access aerodromes during all weather conditions
- Ability to fly preferred trajectory, including direct routing (with unlimited direct leg length) and CDOs with efficient approach paths
- Military exercises must be better coordinated in the area, particularly with respect to airspace boundaries and GPS jamming

**Technical**

- Investment plans in response to regulation must be shown to be cost-effective for all fleet types which will remain operative in the medium-term
- Allowing ACAS to work against all traffic (equipping traffic through a mandatory zone), possibly including RPAS in non-segregated airspace = electronic conspicuity
- Integration of PBN capability varies per fleet type – this must be taken into account in any strategy

**Commercial and financial**

- Positive NPV for any investment
- Recognition of thin/nil margins in the region – cost drivers are important
- Cost effective ATS must be emphasised (particularly where ATS is a regulatory/legislative requirement)

## F.2 Airspace users – General Aviation

**Performance**

- Maintain ability to operate in airspace, to/from aerodromes, and to unlicensed fields as required
- Minimise all costs (any additional cost tends to be high as a proportion of overall)
- Remain interoperable as far as possible
- Maintain safety levels based on evidence - i.e. if there really is a problem with airprox / mid-airs in LDLCA, then apply solutions, but if the data does not support this, then think hard before any regulatory action
- Resilience (through new instrument approaches) is useful for the higher end of GA

**Operations**

- In some ways, maintaining the status quo is the ideal
- Electronic conspicuity may have benefits, but should not be mandated (since this would block e.g. some microlights or gliders from the airspace)
- PBN should only be introduced on a performance basis (i.e. as with airspace, keep to the "lowest level necessary")
- If controlled airspace is necessary, VFR flights should still be accommodated (allowed entry in reasonable time)
- Real time weather information would be of great use - ideally via 3G/4G

**Technical**

- Appropriate technical solutions for GA must be available on the market prior to any new CNS-ATM technical concept being introduced – e.g. surveillance, PBN
- Solutions should be modular and use COTS where possible (including iPad / tablet based output)
- Ideally, lower certification level technical solutions should be available for use (e.g. 8.33kHz iCom handheld radios, non-certified GPS for ADS-B), where shown to be acceptably safe
- As the RPAS market develops, new (interoperable) technical solutions may become available from that domain

**Commercial and financial**

- Cost will remain a huge driver - any estimate must include all aspects, for example purchase, installation, and training
- Most GA "does not need an ATS" - it exists for the benefit of the commercial users, and should be paid for by them

## F.3 Military

**Performance**

- Military want freedom to operate in all areas and under all weather conditions
- Safety of military and other users should be maintained as appropriate

**Operations**

- Low flying zones and 'train as you fight' will continue to be essential
- Military do not want serious airspace constraints – not more regulated (controlled) airspace but also not more segregated airspace; the military will remove their own constraints when airspace is not used applying the principles of flexible use
- Airspace should support activity, not vice versa; making classification time dependent could be a way forward
- Expansion of aerodrome ATZs may have an impact on military operations in the area - this must be considered in any change proposal
- Provision of the LARS service (primarily helicopter operations) is carried out by the military - the expectation is that this may change in the future (subject of a current study)
- Military GPS jamming may increase in the future, for example during live exercises

**Technical**

- MOD has defined future requirements, performance levels and coverage volumes for ATM and CNS through Project Marshall, but not which technology should be used; remote towers, approach guidance systems and primary surveillance radar are all areas where various options exist
- MOD is working on wind farm tolerant surveillance, but has not yet seen definitive solution/s to move forwards
- CNS needs to be able to accommodate changes to location of bases and assets, and to types of training and testing

**Commercial and financial**

- Much of the future military CNS-ATM environment will be determined by Project Marshall - in the early timeframe, the suppliers may not be willing to increase risk by innovating technically
- Appreciation should also be taken of the training cost to the Military (flight crew and ATCOs) for any change made in LDLCA

## F.4 ANSPs (En-Route)

**Performance**

- Cost efficiency; the en-route ANSP wants to manage the ground infrastructure based on requirements of the airspace under its responsibility, and of any paying users outside this airspace
- Safety; developments in LDLCA (such as wind farms) should not have a negative impact on safe functioning of the CNS infrastructure

**Operations**

- The en-route ANSP can have a role in LDLCA; this varies with airspace classification and structure and areas of responsibility - changes to airspace need to consider impact on ANSP
- Equipage levels have to be sufficiently high to use mandatory zones (as safety tools); without wide-spread equipage, too many exemptions will be required

**Technical**

- Ability to implement the best, most cost-efficient solution going forward when the lifetime of current equipment runs out (navigation, surveillance); this depends on both maturity of new concepts, and whether shortcomings of new concepts for some stakeholders can be mitigated

**Commercial and financial**

- Users should pay for the service received and/or the infrastructure used

## F.5 Aerodrome ANSPs (and operators)

**Performance**

- Safety maintained or improved; key risk areas mitigated through the use of appropriate operational or technical solutions
- Cost effective provision of services
- Resilience

**Operations**

- CAT operations need to be provided with an appropriate level of protection
- Service provision and CNS infrastructure should be considered separately; the need for service provision is a business case or safety issue, CNS requirements follow from this (and should be part of the business case) – not the other way around
- Guidance is required on how to separate aircraft on GNSS and conventional approaches
- VOR rationalisation can be addressed through alternative navigation concepts (GNSS); surveillance; or service degradation and procedural control

**Technical**

- System updates , whether direct replacements or changes to new technology, require a feasible timeline

**Commercial and financial**

- Aerodromes aim to increase user numbers, attracting commercial routes where possible
- Where possible, aim to rationalise the asset base
- Level of service must balance safety of paying passengers and cost of provision
- Centralised services must balance cost efficiency and need for competition
- Regulatory burden must be proportionate, and regulation must be appropriate for regional airports
- The level of charging for data provided by third parties (e.g. surveillance data) must be balanced with how safety-critical the data is

## F.6 Regulators

**Performance**

- Maintain acceptable levels of safety across the LDLCA airspace
- Enable appropriate access and cost-efficiency for users through policy and airspace change processes

**Operations**

- Only introduce the services and the constraints into the airspace that traffic requires
- Allow continued GA operations without unduly hindering CAT
- Operation of RPAS beyond line of sight is only acceptable if they show equivalence – the same rules and requirements will be applied to both manned and unmanned aircraft
- APV+FISO could be a cost efficient option for very low density airports
- We need strategic solutions , not interim solutions, to ensure safe operations when the infrastructure changes

**Technical**

- Surveillance system needs to be layered, and less spectrum-demanding; also recognising that one size does not fit all
- Non-cooperative surveillance needs to be argued on a case by case basis: where is it required, and why
- Wind farm mitigation options include filters; in-fill surveillance; and new technology
- MSPSR with co-located WAM benefits both wind farm development and spectrum release

**Commercial and financial**

- An acceptable, affordable solution for GA transponder equipage must be found, e.g. a modular approach
- Consider subsidies (similar to ACCEPTA) to address issues resulting from VOR rationalisation
- Consider incentivisation to enable timely transition to new surveillance technology – benefit of spectrum release may be greater than cost of surveillance transition; this may require centralised decision making on a surveillance strategy

## F.7 Other industries

**Performance**

- Safety: Ability to manage aviation risk arising from wind farms, allowing wind farm projects to proceed
- Cost-effectiveness: Solutions to wind farm mitigations are competitive and cost-effective

**Operations**

- Renewable industry: Requires an understanding of new approach procedures and impact on safeguarding

**Technical**

- Technical solutions introduced onto the market as commonplace to mitigate impact of wind farms on surveillance, ideally integrated into the default technology
- Surveillance solutions allow for increased wind farm development, including integrating processing for unlimited wind turbines or farms into a single processor/integrator (i.e. no constraint)
- Mitigations applied to all potential primary surveillance means (PSR, MSPSR, PAR)

**Commercial and financial**

- Aviation to contribute to introduction of wind farm mitigations, once mature - wind farms no longer considered as a "special case" for mitigation measures

# G Dependency assessment

In order to understand the issues leading to individual implementation decisions, and the impact of those decisions, a dependency assessment was carried out, using the material gathered during the information collection phase and stakeholder consultations.

The dependencies identified were used to inform the development of scenarios, ensuring clearly linked decisions were included.

The results of the assessment are shown below, with each row representing one of the variables (shown in the prioritisation order as in section 4.3.8).

Pre-cursors = what would influence the decision to move to {Variable X} or not?

Impact = what would the decision to move to {Variable X} or not influence?

| Priority | Pre-cursors | Variable | Impact |
|---|---|---|---|
| **1** | Availability of cheap equipment (modular, COTS)<br>Acceptance of users<br>Clear application (e.g. ground, air-to-air)<br>Voluntary vs mandate<br>Reduced certification costs<br>Need to see all traffic not picked up by primary radar<br>Availability of non-cooperative alternatives such as MSPSR | Electronic conspicuity | Use of TMZ/SMZs<br>Removal of need for non-cooperative SUR?<br>Extra mitigation layer in "Big Sky" Class G |
| **2** | Strong business case<br>Government policy<br>End of recession<br>Need for resilience | Centralised (government) funding | Synchronised and potentially early transition to new concepts |
| **3** | Fleet equipage<br>Regulatory guidance<br>Centralised monitoring of satellite performance for SBAS<br>Funding | Implementation of APV approaches | Resilience (through lower minima)<br>Tailored approaches (noise, CDAs)<br>Potential larger benefits case for fleet upgrades (i.e. good for PBN timelines more widely) |
| **4** | Availability of standards<br>Regulatory approval<br>User confidence / risk perception<br>Life cycle of existing radars<br>Resolution of coastal issues<br>COTS availability to limit cost of transition | Introduction of MSPSR | Wind farm mitigation<br>Cost reduction (capex and opex)<br>Low level coverage<br>Spectrum release |
| **5** | Risk assessment – equivalent level of safety required<br>Benefits to users from change (e.g. reduction in CAS volume)<br>Benefits to airport in getting more (GA) traffic in | Level of protection around aerodrome | "Performance-based" airspace<br>GA benefits from access |
| **6** | IAA/additional conditions will be required to show equivalent safety<br>Change of legislation<br>Risk assessment on a local level (traffic, complexity, context)<br>Current and forecast traffic levels | CAT using a FIS at an aerodrome | Perceived cost benefit<br>Availability? |
| **7** | Lifecycle upgrade of Mode S SSRs<br>Increased surveillance ATS provided (traffic increase?)<br>Funding<br>Training – procedural APP ATCO doesn't use SUR data | Secondary surveillance deployment (ADS-B & WAM) | Cost-effective surveillance?<br>Layer of risk mitigation in Class G (via ATSOCAS)<br>Use of surveillance zones around aerodromes (electronic conspicuity)<br>Safety net through downlinking of aircraft parameters |

| Priority | Pre-cursors | Variable | Impact |
|---|---|---|---|
| **8** | User need (traffic density, airspace complexity)<br>Ease of transition to new solution<br>Risk tolerability<br>Cost<br>Need for sufficient alternative means of navigation (avoiding over-reliance on e.g. GNSS) | Next steps in VOR rationalisation | Future NAV or SUR plans<br>User benefits<br>Integration with other airspace (e.g. MIL) |
| **9** | Availability of equipment (e.g. modular)<br>Perceived benefits<br>Electronic conspicuity | Use of air-to-air surveillance in mitigating risk | Additional layer of protection e.g. around aerodromes with TMZ/SMZ<br>Self-separation |
| **10** | Regulatory approval<br>Cost-efficient solution<br>Cheap band-width<br>Clarity of structure and service<br>Individual airports' interests<br>Accurate traffic predictions | Remote TWR or FIS | Cost reduction? (to be proven)<br>Service availability – both in geographical scope and hours |
| **11** | Depends on ability to meet political goal (e.g. equipment available)<br>Confidence in maturity and stability of future technology used in the air transport industry<br>EU pressure (e.g. green energy targets) | Timing of assumptions | Depends on synchronisation<br>Cost and resource required to respond to impact (e.g. increased wind farm applications) |
| **12** | Dependent on environment<br>New, affordable technology that leads to wide-spread equipage of secondary SUR means<br>Change of regulatory requirements for primary radar coverage<br>Recognition or acceptance of shortcomings of non-cooperative SUR (unable to detect gliders, microlights, low-flying mil)<br>Need to deal with aircraft from other States<br>Appropriate contingency for aircraft system failure<br>Government willingness to contribute to equipage funding<br>Introduction of electronic conspicuity<br>ATC ability to deal with high volume of information in higher density areas<br>Confidence in synchronisation of air and ground systems<br>Future concept of ATSOCAS | The need for non-cooperative surveillance | Expanded use of TMZ/SMZs<br>Spectrum release programme benefits<br>Planning permission (removal of objections or conditions) for wind farms<br>Cost-efficiency for ANS through removal of expensive primary radars |
| **13** | Willingness to cooperate | Centralised | Cost? |

| Priority | Pre-cursors | Variable | Impact |
|---|---|---|---|
| | Recognition that ATS is not a competitive advantage when it is a regulatory requirement<br>ATC availability requirements from users<br>Possibly needs centralised govt funding | APP operations | Availability of service |
| **14** | Introduction of SWIM<br>Introduction of new apps (e.g. weather)<br>Introduction of trajectory sharing (strategic)<br>Means of introduction that avoids info overload | Enhanced AIM | Additional risk mitigations (through information)<br>Strategic conflict avoidance by making VFR aware of IFR arrivals/ departures |
| **15** | Benefits case<br>Fleet equipage<br>Regulatory support (incl SES mandate) | Application of RNAV Instrument Flight Procedures | More closely spaced routes<br>More efficient SID/STAR system through increased design freedom |

**Table 29: Dependency assessment outcomes**

# H Regulatory changes impacting upon LDLCA

## H.1 Introduction

This section outlines the potential regulatory and deployment changes which may impact upon the LDLCA environment. It includes existing European regulations (Implementing Rules or IRs) that are still being implemented (e.g. those that have requirements with deadlines to be met by 2014 or beyond); expected upcoming European IRs; and the ICAO Aviation System Block Upgrades (ASBUs).

## H.2 Existing Implementing Rules

The following existing Implementing Rules are currently being implemented and may be relevant to operations in LDLCA, particularly where IFR data must be interoperable:

- Requirements for automatic systems for the exchange of flight data for the purpose of notification, coordination and transfer of flights between air traffic control units – the 'COTR IR' – Commission Regulation (EC) No 1032/2006
- Requirements for the performance and the interoperability of surveillance for the Single European Sky – the 'SPI IR' – Commission Implementing Regulation (EU) No 1207/2011
- Requirements on aircraft identification for surveillance of the Single European Sky – the 'ACID IR' – Commission Implementing Regulation (EU) No 1206/2011
- Requirements on the quality of aeronautical data and aeronautical information for the Single European Sky – the 'ADQ IR' – Commission Regulation (EU) N° 73/2010 of 26 January 2010
- Requirements for the application of a flight message transfer protocol used for the purpose of notification, coordination and transfer of flights between air traffic control units – the 'FMTP IR' – Commission Regulation (EC) N° 633/2007
- Requirements on procedures for flight plans in the pre-flight phase for the Single European Sky – the 'IFPL IR' – Commission Regulation (EC) No 1033/2006

## H.3 Upcoming Implementing Rules

The following are the expected future aviation regulations, including those planned by EASA and included in its four year rulemaking programme:

- Standardised European Rules of the Air (SERA) – due 2014
- Harmonised Transition Altitude (opinion due 2015, decision 2017)
- Performance Based Navigation (PBN) Implementing Rule
- Surveillance Performance and Interoperability (SPI) Implementing Rule
- System Wide Information Management (SWIM) organisational requirements, with opinion due in 2016 and decision by 2017
- Remote TWR operations Implementing Rule, with opinion due in 2016 and decision by 2017

- Technical requirements and operational procedures for:
  - Airspace design including procedural design
  - AIS/AIM
  - CNS
  - Provision of data for airspace users for the purposes of air navigation

Other regulatory plans from EASA include Implementing Rules on initial 4D trajectories, and advanced datalink operations. These are not thought to impact the LDLCA area, since they are primarily for CAT in medium-high density and oceanic environments.

## H.4 ICAO Aviation System Block Upgrades

ICAO describes its block upgrades as follows: '*An ASBU designates a set of improvements that can be implemented globally from a defined point in time to enhance the performance of the ATM System.*' Each block is made up of modules which aim to combine to deliver improvements. The aim is to enable harmonised functional improvements world-wide, dependent on the performance need.

Below, the modules that are most relevant to LDLCA are described[14]. A module is a deployable package (performance) or capability that will offer an understandable performance benefit, related to a change in operations, supported by procedures, technology, regulation/standards as necessary, and a business case.

| **Module title** | **Description** |
|---|---|
| Optimisation of approach procedures including vertical guidance | The use of performance-based navigation (PBN) and ground-based augmentation system (GBAS) landing system (GLS) procedures will enhance the reliability and predictability of approaches to runways, thus increasing safety, accessibility and efficiency. This is possible through the application of Basic global navigation satellite system (GNSS), Baro vertical navigation (VNAV), satellite-based augmentation system (SBAS) and GLS. The flexibility inherent in PBN approach design can be exploited to increase runway capacity. |

[14] A complete overview of modules can be found at http://www.icao.int/Meetings/anconf12/Pages/Module-Library-of-the-Aviation-System-Block-Upgrades.aspx

| Module title | Description |
|---|---|
| Meteorological information supporting enhanced operational efficiency and safety | Global, regional and local meteorological information:<br>a) forecasts provided by world area forecast centres (WAFC), volcanic ash advisory centres (VAAC) and tropical cyclone advisory centres (TCAC);<br>b) aerodrome warnings to give concise information of meteorological conditions that could adversely affect all aircraft at an aerodrome including wind shear; and<br>c)SIGMETs to provide information on occurrence or expected occurrence of specific en-route weather phenomena which may affect the safety of aircraft operations.<br>This information supports flexible airspace management, improved situational awareness and collaborative decision making, and dynamically-optimized flight trajectory planning.<br>This module includes elements which should be viewed as a subset of all available meteorological information that can be used to support enhanced operational efficiency and safety. |
| Performance Improvement through the application of System-Wide Information Management (SWIM) | Implementation of system-wide information management (SWIM) services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximize interoperability. |
| Remotely Operated Aerodrome Control | To provide a safe and cost effective ATS from a remote facility, to one or more aerodromes where dedicated, local ATS is no longer sustainable or cost effective, but there is a local economic and social benefit from aviation. This can also be applied to contingency situations and depends on enhanced situational awareness of the aerodrome under remote control. |
| Initial Integration of Remotely Piloted Aircraft (RPA) into non-segregated airspace | Implementation of basic procedures for operating remotely piloted aircraft (RPA) in non-segregated airspace including detect and avoid.<br>*Note: this was considered long-term in LDLCA (i.e. 2025+)* |
| Airborne Self-Separation (SSEP) | Creation of operational benefits through total delegation of responsibility to the flight deck for separation provision between suitably equipped aircraft in designated airspace, thus reducing the need for conflict resolution. Benefits will include reduced separation minima, reduction of controller workload, optimum flight trajectories and lower fuel consumption. |
| Initial capability for ground surveillance | This module provides initial capability for lower cost ground surveillance supported by new technologies such as ADS-B OUT and wide area multilateration (MLAT) systems. This capability will be expressed in various ATM services, e.g. traffic information, search and rescue and separation provision. |

**Table 30: Relevant modules from ICAO ASBUs**

# I Note on safety data

The ability to collect clear evidence on incidents and safety-related events in the LDLCA region is compromised by a lack of central data availability. This has been recognised in a number of recent reports including the Class G airspace in the 21st century [19]. Attempts to gather radar data to understand conflicts resulted in limited value due to mixed transponder equipage and poor low level surveillance coverage. The General Aviation Alliance carried out a risk study referenced in [19], which appears to give an indication of the concentration of risk and may give more detail on accident causation.

The problem with using accident data is that a) it is thankfully rare and thus less statistically significant and b) it hides the instances where providence prevented a collision. The incidents where providence prevents a collision can be reported when under a control service (particularly where surveillance exists), but are rarely reported in Class G unless deconfliction services are being provided.

There are two primary categories of occurrence under the ICAO ADREP taxonomy which are related to the ATM and airspace system in LDLCA: the risk of Mid Air Collision (MAC), and the risk of Controlled Flight Into Terrain (CFIT). Three secondary occurrence categories can be defined: Unintended flight into IMC (UIMC), ATM/CNS, and possibly Low Altitude Operations (LALT).

The lagging data available on MAC risk in LDLCA is generally split into two categories: accident reports (AAIB) and airprox reports, captured by the UK Airprox Board.

The GA Alliance study studied the last 37 years of accident reports. This may assist in capturing the causal factors for accidents in LDLCA, assuming a database is available to filter accidents by geographical location.

Understanding the link between accident levels and airprox levels is useful in linking the data-sets. In general, in a safety critical system, there is a probability-based relationship between accidents, serious incidents and minor events. This relationship was hypothesised and confirmed through studies over multiple safety critical industries, and states that for every accident, there are approximately 30 serious incidents and 300 minor incidents.

The airprox data, if it were complete, could therefore be linked to the accident data to understand overall risk levels from the available data. Note that the airprox data will not generally include GA-GA occurrences. Fewer GA-GA airproxes are reported, but this is mainly due to reporting mechanisms and also their flying culture – they are relatively slow moving and are generally much more comfortable with nearby traffic as long as they can see it clearly'

It is not the purpose of this study to judge whether or not the existing system has an appropriate risk level. The UK CAA is launching a study to look at potential indicators for Class G airspace risks, which may help develop a fuller picture of the achieved risk level.

The figure below shows a plot of the UKAB data for the last ten years across the LDLCA area. MIL-MIL incidents have been filtered, as they were not the focus of this study.


**Figure 13: Initial plot of airproxes in LDLCA (2003-13)**

# J Cost model outputs per stakeholder

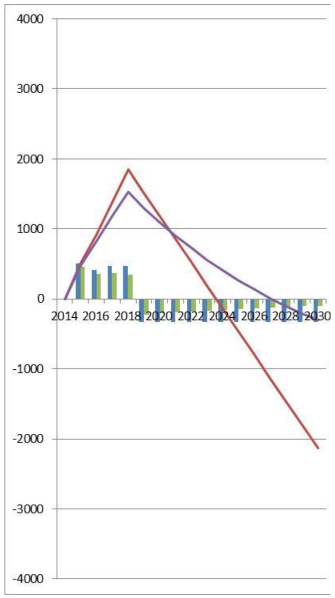
## J.1 Introduction

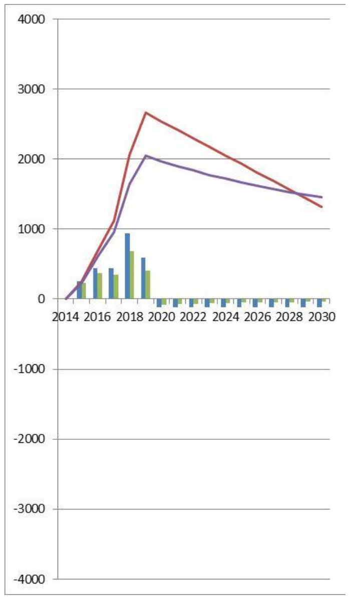
This annex shows the outputs from the cost model on a per stakeholder basis. The five scenarios are shown together to invite comparison. Common axis are used across a single stakeholder to assist in this comparison, but each stakeholder has different axis.

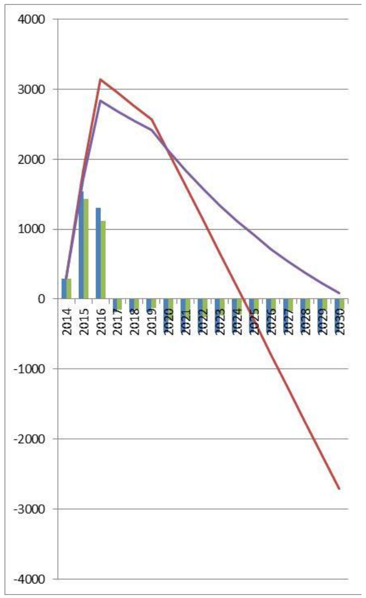
It is stressed that the model outputs are purely a reflection of the input costs, and should not be taken as indicative of a business case or policy. It is solely a high level view of the scenarios modelled and their impact.

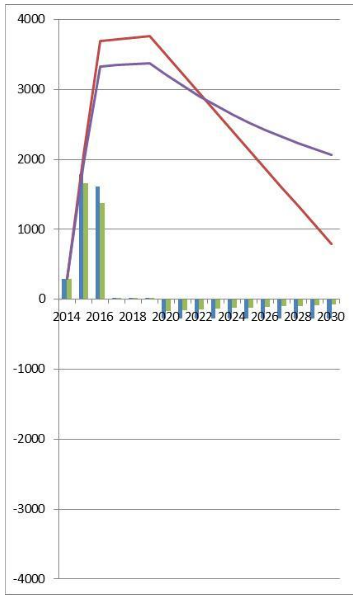
## J.2 Commercial Air Transport (CAT)

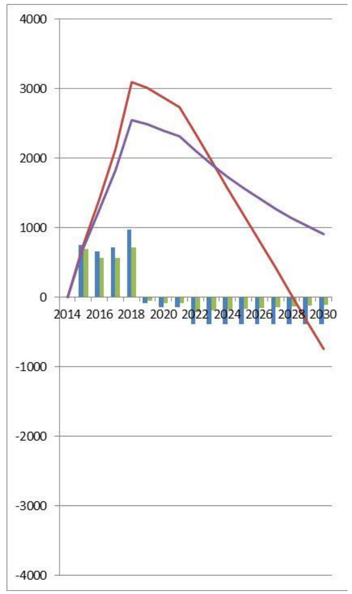
| Scenario 1: Do the minimum necessary | Scenario 2: Cost minimisation | Scenario 3: Safety enhanced | Scenario 4: Modernisation with limited synchronisation | Scenario 5: Coordinated funding |
|---|---|---|---|---|
| NPV (CAT) = +£0.31m | NPV (CAT) = -£1.46m | NPV (CAT) = +£0.09m | NPV (CAT) = -£2.07m | NPV (CAT) = -£0.91m |



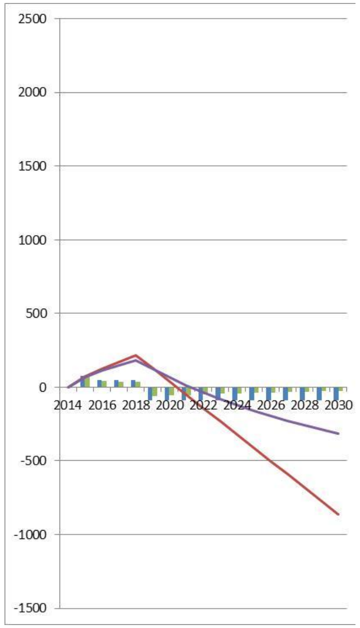
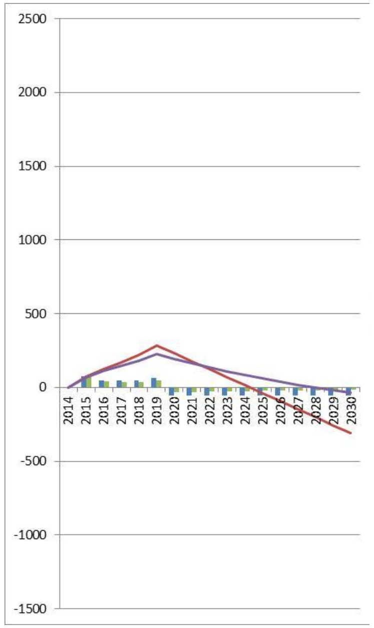
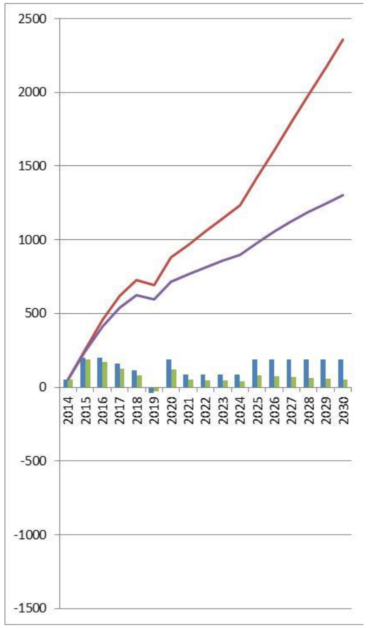
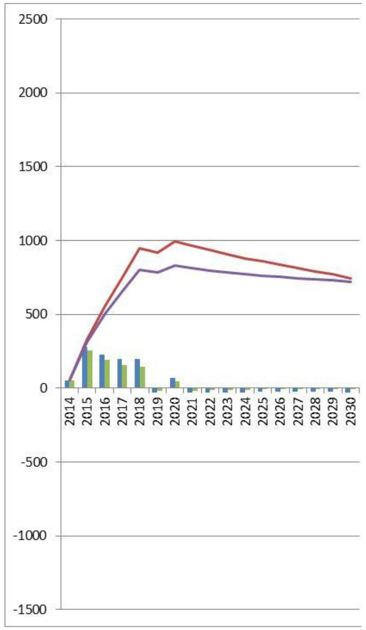
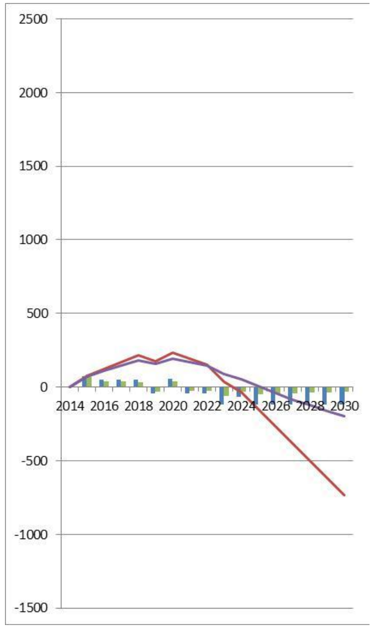



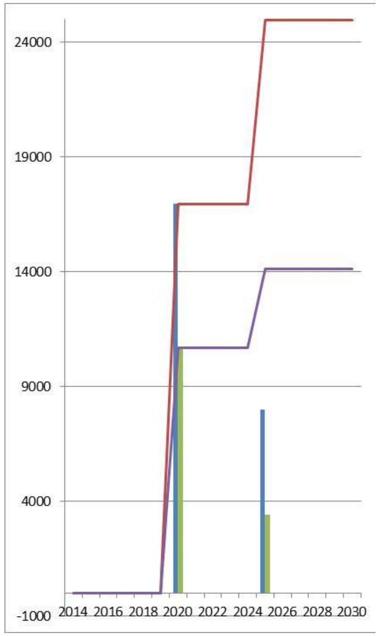
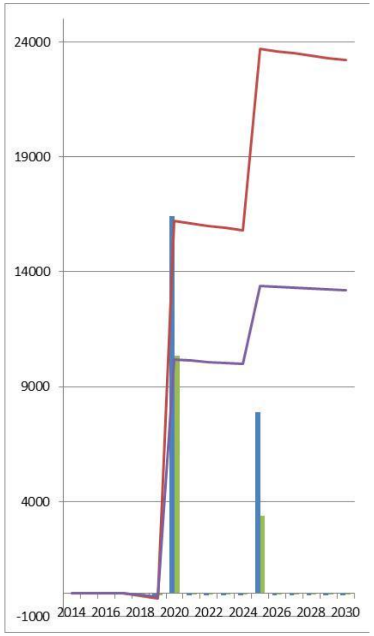
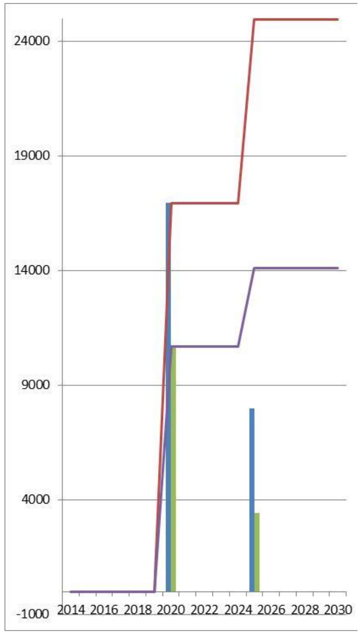
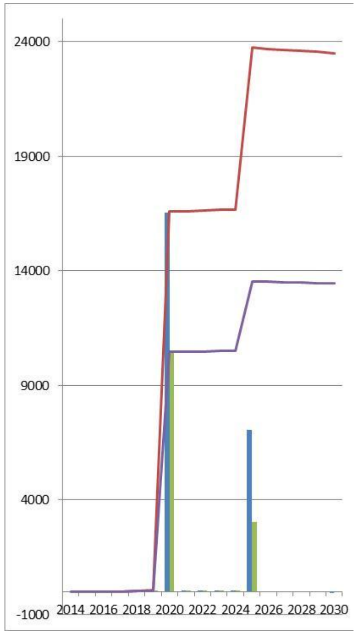
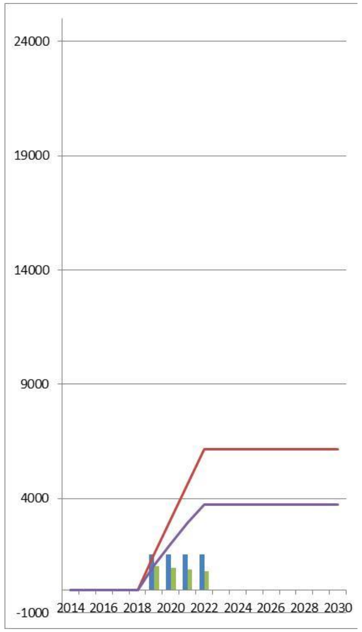



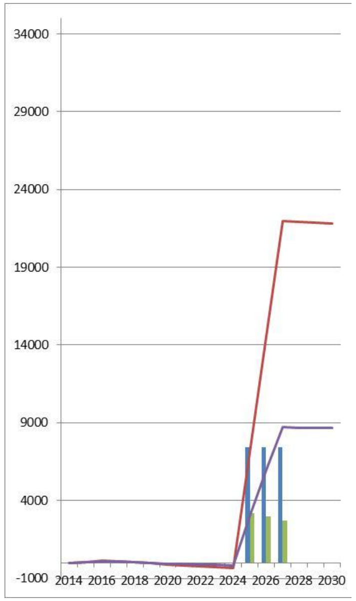
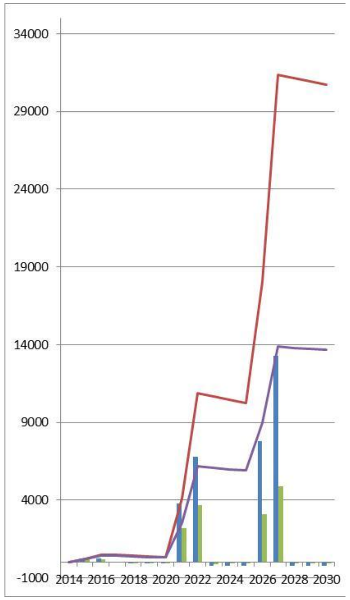
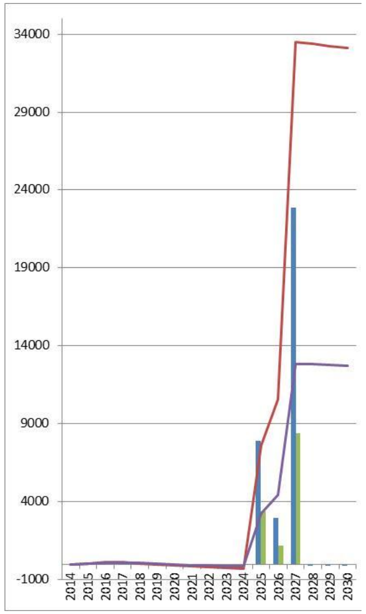
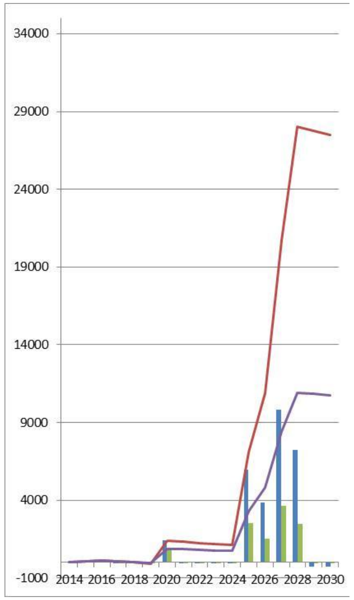
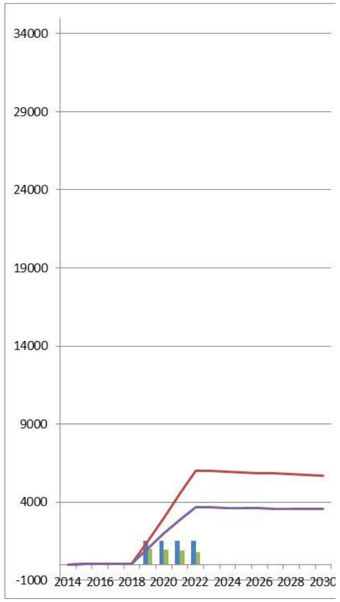
## J.3 General Aviation

| Scenario 1: Do the minimum necessary | Scenario 2: Cost minimisation | Scenario 3: Safety enhanced | Scenario 4: Modernisation with limited synchronisation | Scenario 5: Coordinated funding |
|---|---|---|---|---|
| NPV (GA) = +£0.32m | NPV (GA) = +£0.03m | NPV (GA) = -£1.30m | NPV (GA) = -£0.72m | NPV (GA) = +£0.20m |
|  |  |  |  |  |

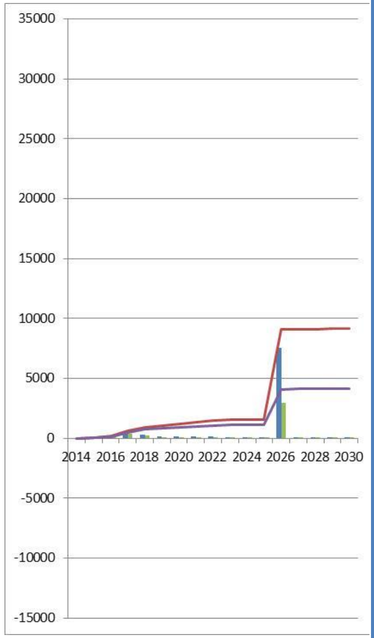
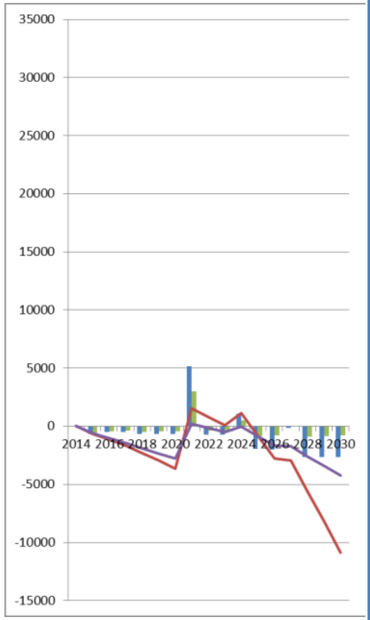
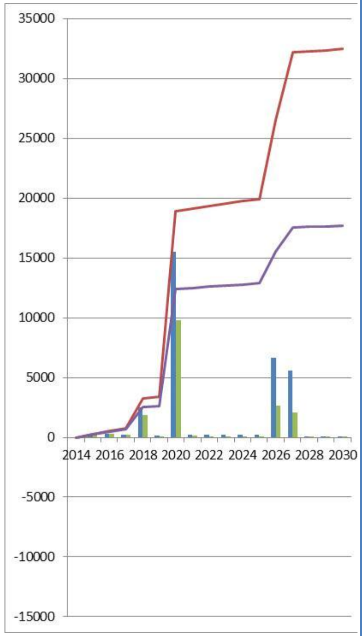
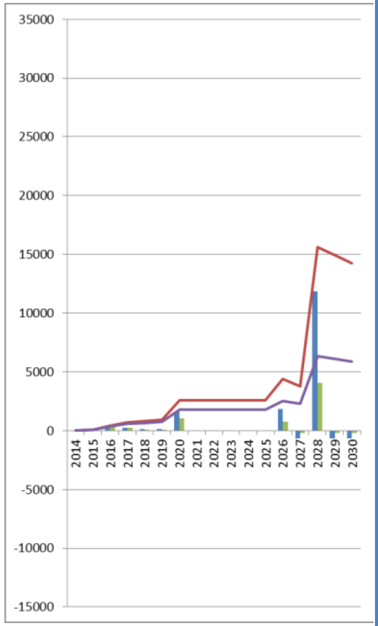
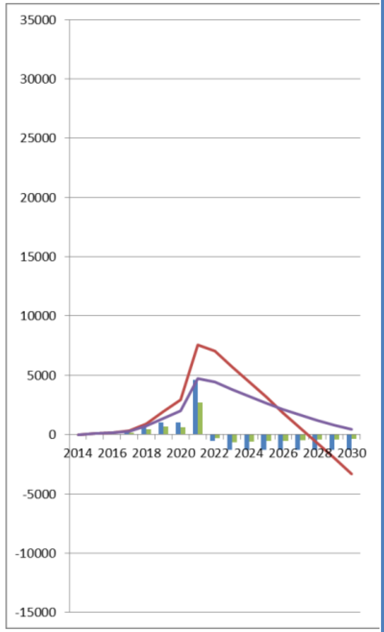
## J.4 Military

| Scenario 1: Do the minimum necessary | Scenario 2: Cost minimisation | Scenario 3: Safety enhanced | Scenario 4: Modernisation with limited synchronisation | Scenario 5: Coordinated funding |
|---|---|---|---|---|
| NPV (MIL) = -£14.1m | NPV (MIL) = -£13.2m | NPV (MIL) = -£14.1m | NPV (MIL) = -£13.4m | NPV (MIL) = -£3.75m |
|  |  |  |  |  |

## J.5 En-route ANSPs

| Scenario 1: Do the minimum necessary | Scenario 2: Cost minimisation | Scenario 3: Safety enhanced | Scenario 4: Modernisation with limited synchronisation | Scenario 5: Coordinated funding |
|---|---|---|---|---|
| NPV (ENR) = -£8.65m | NPV (ENR) = -£13.7m | NPV (ENR) = -£12.7m | NPV (ENR) = -£10.8m | NPV (ENR) = -£3.55m |
|  |  |  |  |  |

## J.6 Aerodrome ANSPs

| Scenario 1: Do the minimum necessary | Scenario 2: Cost minimisation | Scenario 3: Safety enhanced | Scenario 4: Modernisation with limited synchronisation | Scenario 5: Coordinated funding |
|---|---|---|---|---|
| NPV (AD) = -£4.13m | NPV (AD) = +£4.20m | NPV (AD) = -£17.7m | NPV (AD) = -£5.89m | NPV (AD) = -£0.04m |
|  |  |  |  |  |

## J.7 Other industry

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<tr><td>NPV (IND) = -£0.82m</td><td>NPV (IND) = -£0.21m</td><td>NPV (IND) = -£0.82m</td><td>NPV (IND) = -£0.82m</td><td>NPV (IND) = -£0.43m</td></tr>
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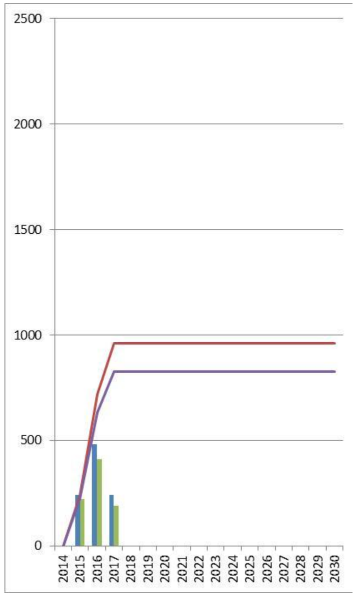
<td>
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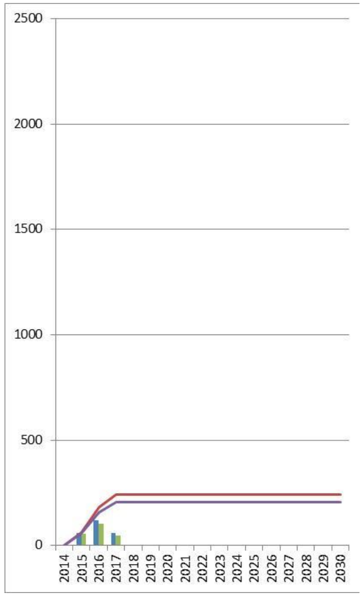
<td>
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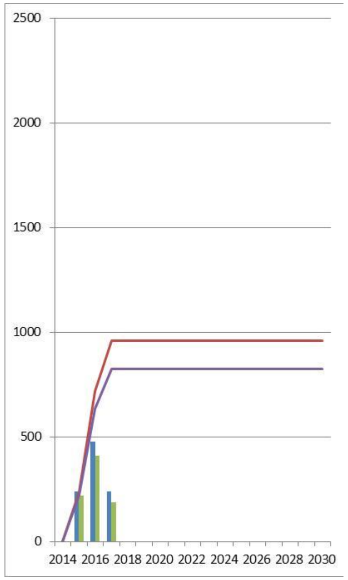
<td>
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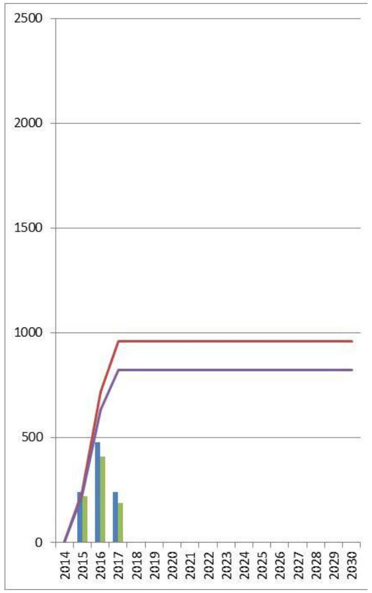
<td>
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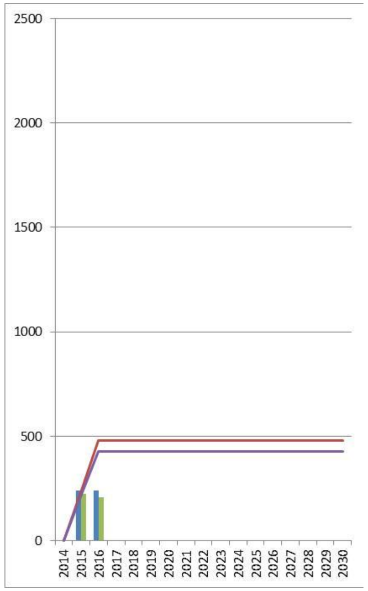
<td>
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