Department for Transport

Airspace Modernisation Supporting Documents

NATS Feasibility Report into Airspace Modernisation in the South of the UK and the CAA Assurance into the NATS Feasibility Report

Moving Britain Ahead

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Introduction

1 The UK's airspace is an essential, but invisible, part of our national transport infrastructure, and is also some of the most complex in the world. However it has not undergone significant change since the 1950s and this outdated infrastructure is struggling to keep pace with the growing demand for aviation. We now have an opportunity to take advantage of new technologies to create quicker, quieter, cleaner flights while allowing our airspace to meet this growing demand. If we do nothing, the situation will deteriorate further in the coming years as demand for air travel continues to rise, resulting in delays for passengers of 30 minutes on every 1 in 3 flights by 2030 if no action is taken.

2 In 2017, the government published the Strategic Case for Airspace Modernisation, setting out the major benefits that airspace modernisation can deliver. Through the introduction of technology we expect more efficient flight paths that are optimised to reduce noise for local communities and reduce delay for passengers to be introduced. We can also expect to see a large reduction or the elimination of planes queueing in holding stacks over the UK, bringing noise and environmental benefits for local people.

3 The DfT has now published the Aviation Strategy Green Paper, which sets out our support for the modernisation of UK airspace and the objectives we want modernisation to fulfil. It also proposes policies to support the aviation industry in delivery of modernisation, as well as new proposals for managing aviation noise.

4 Airspace Modernisation is essential across the UK. However, the government recognises that there is a particular and immediate challenge in the South of the UK to coordinate multiple airspace changes across different airports. In 2017 the Secretary of State for Transport asked NATS to produce a report into the technical feasibility of airspace modernisation in the South of the UK.

5 NATS submitted this report to the Secretary of State in May 2018, and submitted a further addendum to this work in July 2018. After receiving the report, the Secretary of State asked the Civil Aviation Authority to undertake a piece of assurance into the report, which was submitted in August 2018. Alongside today's Green Paper, this document also publishes these reports.

6 The CAA will also publish an Airspace Modernisation Strategy (AMS) in December 2018, which will set out more detail on the initiatives that the aviation industry should pursue in order to achieve this modernisation. This will also set out the governance structure for the modernisation programme, which CAA, DfT, NATS and the Infrastructure Projects Authority have developed.

Context

7 Given the level of complexity, the Secretary of State commissioned NATS to undertake a technical feasibility report into airspace modernisation in the South of the UK. The report considered whether there is sufficient capacity in the South of the UK to accommodate airports' potential future demands for airspace, to establish the extent of interdependency between different airports' potential future demands for airspace, and to propose an initial plan for the delivery of airspace change. In doing so, it acknowledged the need for extensive community engagement during the design of the changes.

8 The NATS report sets the context for the future airspace design work by both NATS and the airports. The modelling was undertaken for the purposes of testing feasibility only. Airspace change sponsors (usually airports and Air Navigation Service Providers) are responsible for bringing forward the actual proposals to modernise our airspace. These proposals will be subject to full public consultation under the guidance set out in CAP1616[1], before being submitted to the CAA for consideration. For changes that have the potential to alter traffic patterns below 7,000ft over an inhabited area, this will include consultation with local communities and an assessment of noise impacts. The demand forecasts used in NATS modelling were submitted to NATS by airports under commercial confidentiality agreements and the government has not received this data.

9 Both the NATS and CAA work were submitted to DfT earlier in 2018. In some places, this means that the work has now moved on. For example, the CAA assurance report sets out further work required by NATS to develop their proposals. Some of this work has already taken place since the documents were written. There are also places where the timeline proposed in the NATS report has now moved on, for example we now expect airports to launch consultations later than the August 2020 timeline initially proposed by NATS, which will necessitate subsequent steps in the design and approvals process also moving. We have asked NATS to work with the airports to develop a more detailed deployment plan and timeline by June 2019.

10 It is also important to note that the NATS study is based on data provided by airports, which in some cases results in different estimates of the delay impact of failure to modernise our airspace than was estimated in the DfT 2017 Strategic Rationale for Airspace Modernisation[2]. Furthermore, the modelling is based on estimates for future

1 The CAA's latest guidance on the regulatory process for changing airspace design, including the most recent requirements for community engagement, which came into effect from January 2018 and will apply to changes under the modernisation programme. https://publicapps.caa.co.uk/docs/33/CAP1616%20Airspace%20Design%20non-interactive.pdf

2 This predicted the average delay would be 72 times more than in 2015. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/586871/upgrading-uk-airspace-strategic-rationale.pdf

airspace capacity that may not materialise depending on the outcomes of the airspace changes submitted to the CAA’s airspace change process.

NATS Feasibility Study

Background

11 The feasibility report looks at an area between Birmingham in the north, Bristol in the west, and the UK borders in the North Sea and English Channel to the south and east. Fifteen airports were in scope: Heathrow; Gatwick; Stansted; Luton; Northolt; Biggin Hill; London City; Southend; Bournemouth; Southampton; Bristol; Cardiff; Birmingham; East Midlands; and Farnborough. During this study, NATS received data from 12 of the 15 airports identified above, plus an estimated need for the remaining three, and evaluated whether UK airspace has the capacity to meet the demand of these airports using a network of 3D flight routes, known as tubes.

12 Under NATS proposals, aircraft will be able to follow a flexible number of set routes, defined by the local airport in consultation with their local communities, from take-off up to 7000 feet at which point they would join one of a series of '3D tubes' in the sky. For the purpose of modelling only, airports were asked to suggest their indicative, potential routes to 9000ft. Airports were free to use their existing routes or include possible respite routes as they saw fit. The routes below 9000ft were used to generate the flow of traffic from the runways into airspace. Modelling of feasibility and capacity commenced at 9000ft while allowing sufficient options below 9000ft for airports to offer respite routes where required in their designs.

13 The feasibility study was based on an assumption that there would be an increased use of Performance-Based Navigation (satellite navigation rather than navigation using ground-based markers and beacons), and better data sharing between airports, airlines and air traffic controllers throughout an aircraft's journey.

14 The introduction of Performance Based Navigation is key to achieving the aims of airspace modernisation. It improves the accuracy of where aircraft fly, improving operational performance, reducing delays and providing opportunities to better avoid noise sensitive areas. However, enabling aircraft to follow a more precise route will potentially lead to routes becoming narrower and more concentrated than today. This means that while the overall area subject to noise may reduce, noise may become more concentrated for some. Whether modernised airspace leads to one concentrated route, or utilises multiple routes to provide respite, will depend on local circumstances and be subject to consultation with local communities.

15 NATS collated data from and about the 15 airports in its study to test proposals for all potential routes to 9,000ft (once at 9,000ft aircraft would join one of a number of flight paths designed by NATS in the form of 3D 'tubes', and then would be free to follow their own routes once outside controlled airspace). These proposals are based on an

assumption that:

a. Outbound flights follow airport-designated departure routes from the runway until they reach a new, NATS-designed airspace network at 9,000ft. These lower level routes will be determined through the CAA's airspace change process. From then, they will follow these routes until leaving controlled airspace, descending to land, or leaving UK airspace. This should, in the long term, reduce the amount of tactical management required by air traffic controllers, as aircraft can be sent into different routes depending on their specifications and performance. This proposal is intended to allow aircraft to climb (and descend) continuously, getting into higher airspace more quickly, reducing fuel burn and noise at lower levels.

b. Inbound flights follow Performance-Based Navigation routes until the point of descent, when they will use satellite, rather than ground-based, navigation to move into position for landing. Increased capacity and better data sharing will allow air traffic controllers to slow down the flight of inbound aircraft that may be subject to delays before they arrive in UK airspace, rather than putting them into holding stacks over UK population centres.

Findings

16 NATS found that, with some refinement, the concept proposed could provide the network capacity required to meet airports' potential growth aspirations between now and 2030. It also found that holding stacks may no longer be required, improving fuel efficiency, reducing delays and reducing the noise for those on the ground.

17 The modelling found that some of the airport modelled routes from take-off to 9,000ft still overlap with, or are not sufficiently separated from, those for other airports. These routes will be designed by sponsors in accordance with the CAA's airspace change process. Coordination and compromise will therefore be needed between airports as the design work progresses. NATS believe it will be possible to balance meeting the needs of each airport with routes that are fully separated from each other.

18 NATS proposed that, given the level of co-dependency between the southern airports, all 15 should consult on their individual airspace changes concurrently in a highly coordinated way.

19 The Secretary of State asked NATS to carry out further work, looking at elements of the modelling including interdependency, stacking, noise, and any associated risks. This further work found that at least seven airfields had a level of interdependency with potential airspace changes for the proposed Northwest runway at Heathrow that would require their participation in the modernisation programme in order to deliver its core benefits of capacity, noise and fuel improvements.

20 The further work also found that holding stacks would not need to exist in the same form as present, and would be replaced with contingency stacks at higher altitudes and positioned to minimise impact on local communities. This is based on the use of new systems at Heathrow, which has reduced holding for that airport significantly. The NATS

modelling identified potential noise benefits around each of the airfields involved in the study as a result of modernisation, although these will vary based on the outcome of the modernisation design, and the analysis and consultation that are a requirement of the CAA's process for airspace changes.

CAA Assurance Report

Background

21 The Secretary of State asked the CAA to review the NATS report into the feasibility of its airspace modernisation proposals, and provide assurance for the concepts, modelling, findings and implementation timelines NATS presented. The Secretary of State requested the CAA to look specifically at the following:

a. the technical concepts proposed in the report and the main features of the modelling approach;

b. the NATS finding that the positioning of routes under 9,000ft will not unreasonably constrain airports' flight path options and the distribution of noise;

c. how the concept and modelling can be applied by sponsors with the existing Airspace Change Proposals process and government's Air Navigation Guidance 2017;

d. the minimum group of airports in the South East that must take forward airspace changes to deliver the core benefits of the programme;

e. the feasibility of all airports and NATS undertaking their airspace changes concurrently, compared to an ordered but sequential approach; and

f. the NATS findings about the likely removal of stacking and other noise benefits.

22 The assurance review is limited to the initial report delivered by NATS to the Secretary of State, but does refer to the further work requested by the Secretary of State where possible.

Findings

23 Overall, the CAA found that the NATS concept offers an innovative new approach to tackling the challenges in the South-East airspace. The CAA also set out that further work is needed to prove the concept is feasible. This is understandable, given that the work was submitted in May 2018, far before the proposed implementation date of 2025. The CAA has therefore recommended a series of next steps to progress the proposals further.

24 The CAA set out their view that the higher the number of concurrent airspace changes, the higher the risk to delivery. One change being delayed could delay the whole process, while all 15 airfields developing proposals at once would increase demand for

a limited number of airspace specialists and for the resources of the regulator in overseeing the process. The CAA proposed a phased approach, with the airports divided into smaller groups based on their interdependency with Heathrow's proposals.

25 The CAA recommended a number of actions for NATS to take, to further develop the airspace design concept to a point where the CAA can comfortably form a definitive view. These next steps form the CAA report's recommendations and can be found in Table 1 of the CAA document. NATS have already begun to address these

DfT View and Next Steps

26 The DfT welcomes the work done by NATS and the CAA, which is an important step forward in testing the feasibility of airspace modernisation in the South of the UK. It is also positive that through NATS's new concept, they can deliver major per flight noise reductions and carbon benefits, as well as radically reducing the need for stacking over the UK.

27 It will now be for NATS and the group of airports in the South of the UK to bring forward a coordinated plan for airspace change, as well as to address the recommendations made by the CAA. The DfT and the CAA have therefore commissioned NATS to produce a masterplan of key airspace changes. The masterplan will show where airspace changes are needed to deliver improvements to safety, capacity, noise, air quality, fuel efficiency, access to airspace for users including where controlled airspace is no longer justified, military access, or to the introduction of new technology.

28 Another major finding of NATS's report was that close collaboration and compromise between airports is needed in order to deliver airspace change. NATS have identified a group of at least 8 and up to 15 airports in the south of the UK, who should work closely together and with NATS to develop their airspace change proposals. This includes airspace change for the proposed Northwest runway at Heathrow Airport.

29 The DfT recognise that the CAA and NATS have suggested different approaches with regard to the level of coordination required between different airports. The DfT will work collaboratively with CAA, NATS, airports and other key stakeholders through the new airspace governance structure in order to develop the best approach to this.

Annex A: NATS Feasibility Report

The Feasibility of Airspace Modernisation

A report by NATS for the Secretary of State for Transport on the feasibility of airspace modernisation in South East UK

NATS

V3 1 May 2018

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1. Summary Statement

1.1. Purpose

On behalf of the Secretary of State for Transport, NATS has reviewed the technical feasibility of modernising the capacity constrained airspace in South East UK, from Birmingham in the north and Bristol in the west, across to the UK border with adjoining airspace in the English Channel and North Sea. In particular, we have examined whether the potential future growth aspirations of all 15 airfield participants could be met within a design that provides flexibility in the distribution of aircraft noise, together with procedures which can reduce noise, for those overflown communities near to airports.

NATS has been clear that our objective is that airspace capacity should not be a constraint on aviation growth. Any constraint to growth would instead become the number of runways; or restrictions imposed on the use of those runways by Government or planning authorities as a condition of growth. It is a design requirement that the total volume of controlled airspace does not increase and that where possible, controlled airspace would be released to other airspace users, particularly at lower levels.

This feasibility study will form the framework for airspace design work by both NATS and the 15 airports in the catchment area, leading to public consultation on draft proposals, followed by the submission of formal airspace change proposals, all under the guidance set out in CAP1616. Similar work is already under way in northern UK, although neither the airspace nor the requirements are as complex or as constrained as in the south-east.

1.2. The review

In conducting its review, NATS has collated the latest data and analysis submitted over the past 6 months from the airfields themselves to evaluate the concept of operations that we have proposed to systemise the airspace and to bring about the network improvements in capacity, flight efficiency and environmental impact.

This concept of operations is described within the report but in summary, it makes use of high-precision satellite navigation technology currently available on aircraft to create a systemised network of routes (as compared to the structures we have today that require more tactical management). Aircraft would be able follow a flexible number of set routes, defined by the local airport in consultation with their local communities, from take-off up to Flight Level 70 (FL70 - approximately 7000 feet) at which point they would join one of a series of ‘3D tubes’ in the sky. From here, they could use continuous climb and descent between FL70 and FL305 , after which they would be able to transition to free-routing. For the purpose of modelling only, airports were asked to define their potential routes to FL90. Actual design of routes will be subject to the CAA Airspace Change Process (CAP1616).

1.3. The findings

The major finding of our analysis, covered in this report, is that with refinement, this concept can provide the network capacity required to meet airfields’ growth aspirations as well as not constraining airport choices for the lower level routes, below FL70, over local communities. The reforms would improve flight efficiency and fuel burn, and the improved flight profiles would in turn generally have the effect of reducing noise at lower altitudes

The review has also confirmed that:

- Early modelling shows that some of the airport modelled routes up to FL90 overlap in some instances. Thus there will be a requirement for airports to compromise on their initial proposals and cooperate with other airports and with NATS leading up to and throughout the CAA ACP process. We believe this is achievable while still meeting the needs of the airports.

- The holding stacks used today would no longer be required, significantly improving fuel efficiency and passengers' experience while reducing noise near the ground.
- Innovative data and computer modelling can be used to aid the design of airspace throughout the project to deliver the best possible proposal which would then be subject to the CAP1616 ACP process.
- The Performance-based Navigation (PBN) accuracy on which the concept of operation is predicated is achievable for descending aircraft using current aircraft avionics. Because the performance of climbing aircraft varies considerably (based on the size and weight of the aircraft) it is a more difficult task for climbing aircraft to fly so precisely. However, we believe there are solutions to this constraint.

Any programme of this size and complexity has attendant risks and the document sets these out. We believe these are outweighed by the improvements that can be delivered in terms of noise and environmental benefit for local communities alongside providing capacity to support future growth in the aviation industry. In NATS' view, the risk of doing nothing carries the highest long term cost. Our analysis indicates that not modernising the current system would result in 28 million minutes of delay to aircraft in 2030 at a cost to operators of £1.8bn per annum.

1.4. The implementation timeline

Technically and in pure process terms, implementing a change of this magnitude could be completed by 2025. However this timeline will need to be further assessed against resourcing availability for airspace design expertise, and likely delays due to challenges and appeals during the consultation process. It should be noted that this schedule has not yet been assessed against political timing considerations since it will spread across more than one parliamentary term.

A draft timeline for NATS activity has yet to be fully integrated into the timelines of our airport partners and subjected to rigorous external scrutiny; however it already has good synergies with known plans and the next steps include work on an integrated and accepted timeline

Draft Timeline

Design Work	May 2018 to July 2020
Consultations commence	August 2020
ACP Submission	May 2021
ACP Decision	March 2022
LAMP and Airport Deployment 1	Early 2024
LAMP and Airport Deployment 2	Late 2024
LAMP and Airport Deployment 3	Early 2025

1.5. Support for airspace modernisation and consultation

The report provides evidence of widespread support for modernising airspace within the context of Government's ongoing development of a new aviation strategy. This support is, not just within the industry itself. Surveys of MP opinion show overwhelming support, and independent research of public opinion suggests that many people understand the importance of a modern aviation system to the UK. However, such support can easily fade when the details, scale and impact of individual changes to specific constituencies, communities and individuals become clear.

Airspace change regulations require a sponsor of an airspace change proposal to run their own consultation for the airspace/routes for which they are responsible. It is clear however from our review that modernisation cannot be viewed or consulted upon successfully as a series of separate changes across upper and lower airspace. The optimum solution will involve significant dependencies between individual airports and the wider network in which they sit.

As a result, our view is that all participant airports and NATS should be required to undertake concurrent statutory airspace consultations to ensure that designs are complementary, that the public have a coherent design for the airspace in their region to consider and comment on, and that the industry moves forward in a coordinated and committed way. This includes alignment of communications functions across all the stakeholder organisations in order to present to the public, and their representatives, a consultation package which is clear and straightforward to understand. This should also bring benefits in terms of coordinating the resourcing requirements for each step in the process up to and including implementation.

1.6. Stakeholder collaboration

Successful development and delivery of this change programme will require absolute alignment, commitment and transparency across industry as well as considerable political will on the part of the Government over an extended period.

Ensuring commitment of all parties to milestones and deliverables will require effective governance from the DfT level down. It is very welcome that the Government, in response to the first consultation on Aviation Strategy, is ensuring that the right governance roles, structures, powers and incentives are in place.

We also note that the Government will now consider whether further policy is required to support airspace modernisation. There is undoubtedly a policy challenge to coordinate multiple airspace changes across different airports; this report identifies the scale of the challenge. It is also reasonable to assume that regardless of the extent and openness of consultation, there will remain significant opposition to changes. For these reasons, NATS believes the Government should consider the powers that may be required to ensure a modernisation programme is deliverable.

1.7. Activity focus for 2018

NATS:

- In order to increase assurance of the concept, the ATM network design will be refined in order to mitigate the complexities encountered in the initial assessment.
- Also to increase assurance the computational methodologies will be enhanced further to enable the exploration of a variety of concepts of operation such as intermediate changes of track.
- Establishing a robust industry wide governance structure to deliver airspace modernisation across the UK. This includes means of communications alignment between NATS and airports

- Creating an integrated development and delivery roadmap linked to specific stages of the CAA ACP Process

- Developing a clear resourcing and risk management strategy and plan.

Airfields:

- Refinement of airfield requirements to include plans for connecting with the network definition of approach procedures.

- Ensuring progress on design andconsultation planning of routes below FL70, as part of the system-wide consultation process.

2. Introduction

2.1. The Industry Approach to Airspace Modernisation under FAS

Airspace is a critical national infrastructure and a limited resource on which the UK relies to ensure that airline passengers, businesses, the military and leisure flyers enjoy the many benefits that aviation brings.

The basic structure of the UK's airspace was developed more than 50 years ago. Since then there have been huge changes, including a hundredfold increase in demand for aviation. While the airspace structure has expanded, it has remained fundamentally the same which constrains modern aircraft capabilities and performance; modernising it will add capacity, directly supporting the UK GDP, and improve the journey experience for consumers.

Throughout Europe there is a move to simplify and harmonise airspace and air traffic control through the Single European Sky project. The UK is meeting those and other requirements through the Future Airspace Strategy (FAS) which sets out a plan to modernise airspace by 2025. We note that the CAA is revisiting the Future Airspace Strategy in light of new directions from government, and that the new Airspace Modernisation Strategy currently being drafted will set out a strategy and plan to modernise airspace up to 2040, superseding and replacing the FAS. Important aspects of FAS will be retained and rearticulated within a new context that takes into account forthcoming government policy changes and technological developments

Achieving sustainable growth is dependent on improving the way air traffic is managed and moves around the airspace. Advancements in Air Traffic Management (ATM) can generate significant commercial, environmental, societal and safety benefits including:

For communities, consumers and everyone

- Fuel savings and attendant CO_2 savings from more direct tracks and greater flight efficiency.
- Time savings from more direct tracks and the provision of additional capacity when and where required.
- Noise reductions from fewer aircraft holding at low levels and the use of more continuous climbs and descents.

For airports, FAS will deliver:

- Optimised runway efficiency and better management of queuing on the ground.
- Increased flow of information that is shared across airports, strengthening their resilience to unexpected events and poor weather and introducing new operating techniques to better sequence departures.

For airlines, FAS will deliver:

- An airspace structure and route network that enables operators to make the most of the capability of their aircraft to fly more continuous climbs and descents into and out of airports, and allow more direct routes from departure to destination.
- Better fuel efficiency and therefore reduced costs.

For other airspace users, FAS means:

- By implementing continuous climb for commercial traffic departing airports there is the potential to release some lower levels of controlled airspace back to Class G.
- Through adopting and fitting the latest technology there will be opportunities to gain easier access to some levels of controlled airspace – for example for airspace crossings.
- Flexible use of the airspace, for example the Ministry of Defence releasing restricted airspace when it is not in military use, will make more airspace available for more users.

2.2. Political context in May 2018

In its response to the Aviation Strategy Call for Evidence, the Government acknowledged that effective governance would be required to support airspace modernisation, and would consider whether further policy might be required. While the concept of operations is technically feasible, the proposed timescale is challenging and the practical requirements of this long term programme must be overlaid with political realities.

The Government said it 'expects to introduce new arrangements to take forward the delivery of the airspace modernisation programme, including a new governance structure defining and overseeing the overall programme. Airports will need to develop their airspace modernisation proposals in conjunction with each other where there are interdependencies between their airspace designs. This creates a potential issue. Should one airport decide not to progress with an airspace change that has interdependencies with other airspace changes, it could create delays for other airports.' NATS strongly supports this initiative and would welcome a role as stated in the CAA's RP3 Guidance, within the settlement, to coordinate the programme.

The Government will consider whether it needs to take new enforcement powers to 'require airports to take forward, or to hand over to NATS to take forward, particular airspace changes that are important for wider airspace modernisation'. Any enforcement powers would be subject to primary legislation.

NATS believes the Government should consider a strong policy statement to confirm its commitment to modernising the UK's airspace. Modernisation will be difficult; no one underestimates the challenges of addressing capacity requirements alongside the need to ensure that growth in traffic does not create unacceptable noise burden for communities below flight paths. Timescales are critical; a major reason for the UK's airspace not being modernised before now, is that it has not received the right level of support. The support is now there; there must be proper governance in place to ensure all needs are addressed, and the Government must do all it can to ensure the timetable can be met, regardless of the fact that the timetable will cut across successive parliaments so the Government will need to encourage a cross-party consensus on the process and approach

2.3. The Technology Opportunity

2.3.1. PBN Navigation

Core to the Future Airspace Strategy and subsequent Airspace Modernisation Strategy is making airspace more efficient – saving time and fuel and reducing emissions. To achieve this we must improve the accuracy of where aircraft fly which means moving to satellite-based navigation rather than ground-based navigation aids.

The level of accuracy, safety and integrity that these satellite navigation systems must reach is set out in the international requirements for Performance-Based Navigation (PBN).

PBN is being adopted worldwide and countries are expected to develop their airspace to apply it. Indeed there is a Eurocontrol mandate for the adoption of PBN that must be met in the timescale of the UK's airspace modernisation programme. Therefore new designs for airspace, and the routes aircraft fly, will be based on PBN.

The use of PBN means that the envelope of airspace within which each route sits can be narrowed because aircraft are flying the route more accurately (see Para 2.2.2). This in turn means that more routes can be established within the same amount of airspace; while this helps to increase capacity, more importantly it also introduces the concept of noise respite as there is more opportunity to vary the routes flown. This gives airports more choice in designing route options that support local community needs. Each route will be contained in a 'tube' of airspace in which aircraft will be contained until they reach very much higher levels.

This move to PBN will affect both high level airways and lower level arrival and departure routes into and out of airports. In many cases routes will remain very similar to those flown under the current ground-based navigation system but in some cases there may be structural changes to the airspace.

2.3.2. Route spacing

An essential component supporting PBN is the definition of route spacing between proximate departure and/or arrival routes and approach transitions.

The CAA and NATS have worked collaboratively to develop a Loss of Separation Risk Model (LSRM) which assesses what safe spacing between PBN routes should be, in a tactically controlled airspace environment, based on the predicted number of losses of separation.

Based on this work, the CAA has published CAP 1385 'Enhanced route spacing guidance' that provides the background, assumptions and constraints in applying route spacing for nine standard airspace design scenarios which might be applied as building blocks within a terminal airspace design. The guidance document is being continually updated through the FAS funded PBN Research Project, as more data becomes available.

The accuracy of PBN allows the UK to specify new route separation spacing so that the airspace can be utilised more efficiently. Adding Flight Management techniques in the vertical plane, these can become 3-dimensional routes that optimise operations.

2.3.3. Data-Driven Design

The airspace design activity for LAMP will move from the traditional methodology involving expert human designers spending many hours drawing routes on maps, towards evidence-based, data-driven computer generated design. This methodology takes data from all relevant stakeholders in the design process and, through mathematical modelling and computer aided calculations, produces a number of airspace models which are adapted to meet the relevant criteria demanded from the system. This is the first time we have been able to automate the design process.

NATS is developing tools which will take inputs from airports (runways, fleet mix, traffic predictions, destinations, etc.) and analyse these along with inputs from regulations (airspace separation standards, CO_2 implications, noise impact) in order to provide a range of options depending on which criteria are deemed the most important. This allows changes to be made quickly and all impacts to be considered as the tool must take everything into account whilst completing its calculations.

2.4. Previous LAMP Implementations

The LAMP Phase 1A Airspace Change Proposal (ACP) was approved by the CAA in November 2015 and implemented on 4 February 2016. The ACP delivered a small scale modernisation of airspace associated with London City, Stansted, Luton and Northolt traffic. Principally it increased the resilience of the London City procedures, but because it was an isolated modernisation it did not deliver full optimisation for other traffic.

NATS formally restarted the LAMP work in May 2017 when a timetable was established for the publication of Government Guidance and CAA CAP1616. In addition there was a groundswell of industry demand for assured and enhanced future airspace capacity through modernisation. This demand, focused through FAS, not only reflected the anticipated demand created by a proposed Heathrow Runway 3 but also the aspirations of airlines and other commercial airports to prosper and expand.

The NATS strategy for modernisation is based on a principle of 'systemisation' to remove variability as far as possible and instead introduce predictability. It includes a number of key features:

- Exploit the reduced spacing possible through PBN, thereby adding capacity;
- Ensure that airspace is not a constraint to airport capacity growth, the constraint instead becoming the number of runways; any constraint to growth would instead become the number of runways; or restrictions imposed on the use of those runways by Government or planning authorities as a condition of growth.
- Eliminate, where possible, tactical air traffic control so that aircraft depart and land within the airspace covered by this study, following pre-determined PBN 3-dimensional tracks or tubes. This will reduce controller task complexity and therefore increase capacity;
- Create a design with the optimum use of airspace ensuring continuous descents and climbs wherever possible;
- Support airports in removing reliance on traditional VOR navigation and deploy PBN departures;
- Support airports in the deployment of modern approach procedures, such as space-based navigation approaches offering opportunities for curved approaches;
- Support airports in creating more options in low level routing to offer respite;
- Design airspace routes, using machine learning algorithms and fast-time simulations, so that the complexity and multiple solutions that PBN offers can be fully exploited. We aim to avoid the risk that a human designer may focus on preferred options rather than explore all options to identify the optimum. Already our tools have worked 25,000 options in feasibility. This is orders of magnitude beyond the number of options tested in any previous airspace change development in the UK.

In order to deliver data-driven designs it was important to intensify the way NATS and airports work together to create trust, share objectives and to respect commercial confidentiality. NATS worked with 15 airports in the South East to understand their future commercial ambitions, likely schedules and demands for 2030 and beyond. The quality of this data is discussed later in this report, but was sufficient to drive the airspace modelling that our Analytics Team have undertaken for this feasibility report.

Section 4 discusses further the work that industry has undertaken in the last 10 months and in particular the creation of the London Terminal Manoeuvring Area Airports Working Group (LTMA WG). This is a significant development, not seen before, where commercial operations have joined together to ensure that there is a new level of cooperation between airports to achieve optimum solutions to airspace modernisation.

2.5. Proof of Concept Analytics

NATS has taken a data-driven approach to assessing the viability of introducing 3D 'tubes' into UK airspace. This centres on using mathematics and algorithms rather than traditional pen and paper methods for airspace design.

NATS has taken an evidence-based, data-driven approach to modelling and evaluating this concept. Data was requested from the 15 airfields to engage them in what has become known as the Future Airspace Strategy Implementation-South (FASI South) programme as part of the UK Future Airspace

Strategy work. This data included predicted demand out to 2030, letterbox and gateway[1] positions, and positioning of new runways.

The data-driven modelling had two objectives. Firstly to evaluate the delay generated by demand based on the current airspace capacity. Secondly to demonstrate whether UK airspace has the capacity to meet the demand of UK airports until 2030 using the 3D tube concept.

The first objective was satisfied by analysing the potential delay in 2030 based on the airfields' aspirational growth assumptions and the current capacity of UK airspace. The second objective was satisfied by creating a 3D tube network based on the airfields' data assumptions and then using a bespoke tube positioning algorithm to separate the tubes.

Section 5 summarises the Proof of Concept Analytics.

1 Letterboxes are the three dimensional points in space where aircraft transition from airport designed outbound tubes into NATS tubes. Gateways are the inbound transitions from NATS tubes into Airport designed approach procedures

3. Systemisation

3.1. Description of the High Level Concept of Operations

3.1.1. Current Issues

The London TMA is unique in the world in its close concentration of major airfields, route complexity, population density and close proximity to numerous external ANSPs. The airspace has developed slowly and in an evolutionary fashion for the last 50 years.

This has led to routes and procedures that whilst currently safe and fit for purpose will not be able to cope with the forecast growth in air traffic in the next 20 years; Heathrow's proposed Runway 3 alone is forecast to add 240,000 more aircraft per year , approximately 10% of the current annual commercial traffic in the UK. In addition the UK would miss the opportunity to where possible reduce noise and carbon emissions.

Providing a safe air traffic service currently relies heavily on tactical controller intervention rather than leaving aircraft to follow their filed flight plans. At lower levels in particular, there is less electronic support than in the upper airspace, instead relying on the capability of the highly skilled controller workforce. This limits the overall efficiency of the service provided.

Figure 1: The current route structure for the 15 airfields in the FASI-S programme (largely based on historic VOR locations).

Technologically the move to Electronic Strips (EXCDS) in the Terminal Control ops room has brought additional benefits in terms of reducing controller workload, alongside the existing toolset within the operation. However the controlling task is still a fully cerebral one with no decision making tool support and limited data sharing with surrounding units.

Due to their close proximity, nearly all airports in SE England have routes that coincide with others at low level (below 6,000ft). These interactions can prevent traffic at one airfield from departing until traffic from a neighbouring airfield has cleared, leading to unnecessary delays for the airlines, ground complexity for the airports and commercial pressures on the network. It also leads to some aircraft flying at lower levels for extended periods, leading to an increase in environmental effects for local communities and increasing fuel burn.

Nearly all inbound aircraft start their descent earlier than the ideal point in order to meet airspace restrictions or to stream inbound flows from different directions. This leads to increased fuel burn in the descent phase and, again, more controller input.

3.1.2. LAMP Concept

3.1.2.1. Airspace

LAMP aims to deliver a generational level change to the airspace above SE England by completely redesigning the routes that aircraft follow from departure airfield to the exit from UK airspace, and from entry into UK airspace to touchdown. The airspace will be designed to allow all airfields to release aircraft into the network without reference to another.

LAMP1A delivered a degree of systemisation for London City airport through the deployment of PBN routes demonstrating the feasibility of this concept in the horizontal plane. LAMP will now develop and deploy a new concept which will take advantage of better horizontal spacing to constrain paths and appropriate vertical constraints to optimise airspace used by each flight.

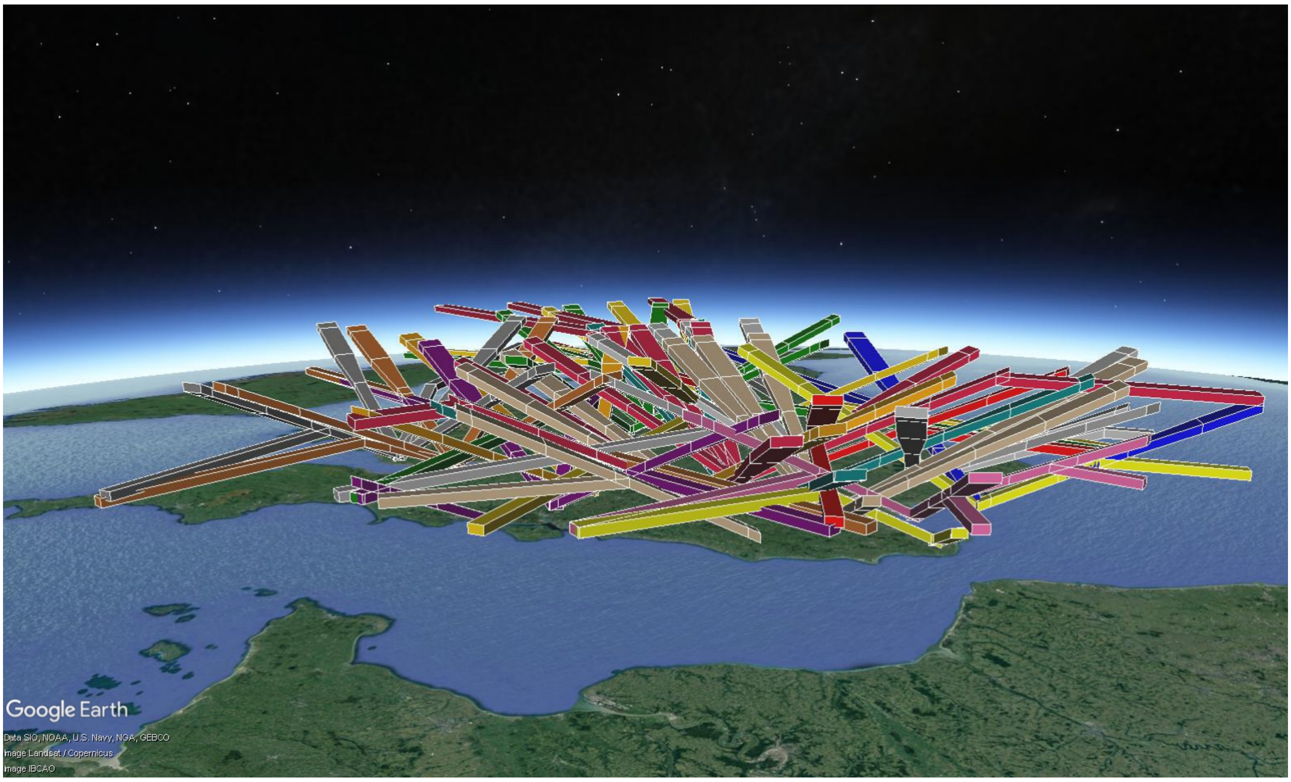
3D ‘tubes’ will be created in the airspace, as detailed below, in order to ensure departures and arrivals from all airports are separated, reducing controller workload and increasing capacity. Efficiency will be improved for airspace users in terms of fuel burn, and environmental benefits will be gained by both users and communities under the airspace.

3.1.2.2. Outbound procedures

Aircraft will leave the runway and follow departure routes, designed and implemented by that airfield in cooperation with LAMP, to an entry point into the new network. From this point the aircraft will follow a highly accurate 2D PBN route, designed to utilise the latest in separation standards that the CAA CAP1385 allows, towards its UK exit point. Controllers will leave the aircraft to follow these routes which will reduce the amount of tactical control needed, reducing workload and improving network efficiency.

By introducing vertical restrictions into these routes it will be possible to create 3D tubes through which aircraft will be able to fly with minimal interference from ATC.

Initially these tubes will need quite broad tolerances to allow for the different performance characteristics of the aircraft using them. Currently the performance of aircraft on departure is less well understood due to the operation of the Flight Management Systems (FMS), meaning that a degree of controller input may still be needed. By utilising an advanced toolset the vertical constraints could be managed by a controller.



Three Dimensional Tubes from 15 Airports climbing from FL90 to FL305

As more understanding is gained, and manufacturers adjust the way an FMS works, it will be possible to utilise vertical constraints on these routes without the need for controller intervention. Ultimately it should be possible to have low and high performance tubes to cater for aircraft with different performance capabilities. For instance, it would be an inefficient use of airspace for a tube to cater for both a heavy transatlantic aircraft and a lighter domestic aircraft as the performance envelopes of these aircraft are vastly different. Giving local communities through ACP consultation and ultimately flight planners more than one option means that most aircraft will be able to fly a more efficient flight profile than today, and some will get continuous climb departures from ground to free route airspace through better flight profile management and with minimal controller intervention. For airport communities greater definition of the vertical profile will make the low level airspace more efficient offering the opportunity where appropriate for greater levels of respite in their designs.

As technology continues to develop and next generation aircraft come into the system it will be possible to introduce tighter level restrictions into these routes, or gradients to fly, allowing the separation between tubes to be reduced. This will further increase the capacity and efficiency of the airspace.

It will be necessary to have a degree of tool-based conformance monitoring to ensure aircraft are staying within the tolerances necessary to fly the PBN routes and to alert controllers when deviations occur. This will be supported by on-board conformance monitoring on the aircraft where they are so equipped.

3.1.2.3. Inbound Procedures

Inbounds will follow 2D PBN routes with vertical level profiles created by level bands at various waypoints. This method of operation is already in operation by other ANSPs and therefore the principle is proven. Further development in aircraft capability will allow for the refinement of these procedures through improved performance and accuracy, as well as flying gradients in descent and allowing tubes to be fully separated in 3 dimensions.

Speed profiles will also be a part of the inbound procedures in order to maintain the spacing created before entering the systemised network. Once on the inbound tracks the aircraft should need few instructions until entering the approach phase of flight, meaning that almost continual descent approaches could be possible from the cruise.

Neighbouring ANSPs and adjacent sectors within the UK will stream arrivals before entering the system in order to provide a steady supply of aircraft to the approach units. This will allow for a massive reduction in the amount of terminal holding in the London area as aircraft will reduce speed earlier, taking more of the delay in the en-route phase and reducing the overall impact of aviation in both environmental and workload terms.

3.1.2.4. Network Management

Tools such as Extended Arrival Management (XMAN) and Systemised Airspace Management (SYSMAN) developed both in-house and through SESAR initiatives, are already helping to improve throughput and the efficiency of the network. Cross border arrival management requires close coordination with neighbouring ANSPs in order to pass on instructions regarding routings, arrival times, speed profiles etc.

Future tools such as Departure Manager (DMAN) will allow tower controllers to depart aircraft into the network in a more efficient manner, and wide scale data sharing through Airport Collaborative Decision Making (A-CDM) will mean any problems at an individual airport can be notified and rectified quickly without affecting the overall network.

3.1.2.5. Airspace Interfaces

It is yet to be decided to what level systemised airspace will operate, this is a key deliverable of the airspace design process between May 2018 and January 2020 when NATS will meet the CAP1616 ACP Gateway for a 'Micro' Design. It is wholly possible that the tubes could terminate at the interface with Free Route Airspace (FL305). This would maximise the benefits of reduced controller intervention and enable more accurate flight planning for airlines. By creating repeatable and consistent routes the network will be easier to understand and manage.

However, this would mean large scale change not only in the London TMA but also in en-route airspace. An interim 'transition' airspace may therefore be needed, where aircraft exit and enter the systemised network at known points but pass into a more 'traditional' type of airspace where controllers handle the traffic giving tool-supported tactical clearances. This airspace would sit between the systemised network from around FL245 to Free Route Airspace above FL305.

Interfaces will also exist with surrounding ANSPs where the tube profile means that the aircraft will never reach FRA in UK airspace. It will be necessary to define the exit and entry points to and from the network at the airspace boundaries at discrete points through which all aircraft must pass in order to maintain separation within the network. This will be beneficial to our neighbours in that they will have a predictable flow of traffic out of the UK, always at the same point and at the same level.

3.1.2.6. Other airspace users

While the vast majority of airspace users with the LAMP network will be from the commercial air transport industry the airspace needs to be open and usable by other stakeholders. The General Aviation community are able to file and fly within controlled airspace and this will continue.

For the military there will be more predictability in terms of being able to avoid civil air traffic as the routes in the network, and intentions of the aircraft, will be better understood. There will likely still be areas, similar to the current radar video corridors, where aircraft can cross controlled airspace in a known manner should they need to.

Should an aircraft not meet the equipage requirements to fly in the network, it will have to route around the area. It may be possible to provide corridors for their use, separated from the network tubes, although these will be less efficient.

Because of the highly accurate nature of the PBN specification it will be possible to design routes for aircraft around military danger areas with more predictability than current methods allow. It may even be possible to have routes which pass through active danger areas in a reflection of the radar video corridors seen in controlled airspace.

It is a design requirement that the total volume of controlled airspace does not increase, initial analysis would indicate that there may be opportunities to release controlled airspace to other airspace users, particularly at lower levels.

3.2. Description of the Projected Benefits Over Current Operations

3.2.1.1. Reduction in Complexity

The current airspace was designed when the only means of navigation was through means of radio direction using VHF beacons (known as VORs). There were far fewer aircraft than today, and capacity far exceeded demand, with aircraft from various airports filing flight plans to fly almost identical routes. This means that individual aircraft need controller intervention almost from take-off in order to provide the capacity required.

Clearly this tactical operation has reached its limits. In 2017 there were 261,000 minutes of delay due to airspace capacity (C2); if we change nothing and traffic increases in line with airports' ambitions it will generate more than 100 times this level of delay by 2030.

3.2.1.2. Increase in Airspace Capacity

The concept of operations will deliver routes from each runway to each systemisation exit point, and routes from top of descent to each airport's approach procedure. Spacing on the route is achieved by the runway and by Arrival Management Tools. This concept generates a significant increase in capacity that more than meets the increase in demand expected by 2030 in the South East (see Section 5 for details).

3.2.1.3. Environmental Improvement

A central objective of the tube concept is that wherever practicable aircraft are able to climb and descend continuously. If desired airports have the opportunity to impose greater climb gradients than the nominal 4% today. This has environmental benefit as fuel burn, and therefore CO_2, is reduced. In addition the concept of operation does not rely on vertical holding at low levels close to airports and so further reduces CO_2 emissions. This is achieved through the principals of advanced flow management and strategic sequencing techniques.

3.2.1.4. Reduction in Forecast Delay

Airport data indicates a level of forecast delay in 2030 of 27.6 million minutes, equating to a cost of £1.8bn to airlines. The reality is that such enormous levels of delay would result in a much lower level of schedule to a level of delay that airports and airlines could tolerate commercially; either way this would jeopardise UK ambitions for growth.

3.2.1.5. Foundation for Future Technologies

A systemised airspace without the need for tactical intervention means that the airport, airline and airspace can 'operate to plan'. Systemisation allows better punctuality, which means that the arrival time of an aircraft can be planned and known in advance by all stakeholders and resources fine-tuned to manage the operation e.g. the arrival gate is ready just in time, the tug arrives just in time, the capacity of baggage, customs etc. can be matched to the known schedule and plan.

We are investing in Air Traffic Management Planning tools to optimise and stream traffic inbound to airports through airspace that is designed to facilitate streaming and spacing. This will maximise environmental and fuel saving whilst delivering stable high capacity flows.

3.2.1.6. Strategic Project Requirements

LAMP has been established to modernise the airspace to deliver significant improvement in safety, capacity, environment and noise. Whilst at an early stage, our analysis has indicated that aspirational targets to deliver the economic and environmental benefits shall be in the region of:

- The capacity increase to deal with expected levels of growth Through offering airports the opportunity to modify their routes below FL70 with the use of PBN and climb profiles there may be opportunities to improve noise over the ground of each flight. These benefits would be quantified through the Airports ACP submissions.

- Enabled fuel savings of between 90kT and 180kT of aviation fuel per annum, within the affected south east airspace which equates to a 10-20% improvement in fuel burn and CO2

- Deliver a 5% improvement in safety performance

4. Scope of the FASI-S Programme

4.1. Airports Participating in the Programme

LAMP is the network airspace modernisation project to be carried out by NATS as part of the wider FASI-S Programme. NATS has engaged with the following airports to generate an alliance of stakeholders committed to the need for airspace modernisation to meet the economic priorities of the UK and to ensure that even with Heathrow growth other airports can also grow. NATS has not communicated the details of this report to these stakeholders but we have shared broad analytical findings with airports and airlines through FAS and Operational Partnership meetings.

Heathrow – including proposed runway 3 **

Gatwick **

Stansted **

Luton **

Northolt (through DAATM/MoD Brize Norton) **

Biggin Hill **

London City **

Southend

Bournemouth

Southampton

Bristol

Cardiff

Birmingham

East Midlands

Farnborough **

** London TMA Working Group Members

4.2. London TMA Airports Working Group

The primary purpose of the London TMA (LTMA) Airports Working Group is to support the coordination of airspace change and provide a forum through which discussions can take place to determine the optimum methods to manage shared dependencies and risks, and secure balanced outcomes. Its secondary purpose is to act as an advisory group to Department for Transport (DfT) and senior airspace governance groups), and offer common views on the strategic risks impacting on the lead up to, and during the implementation of, the significant changes envisaged.

The objectives of the LTMA Airports Working Group are to:

- Mutually support the coordination and integration of strategic level airspace change within or immediately local to the LTMA.
- Advise senior airspace governance groups and the DfT on areas of perceived strategic risk or significant impact to major airspace change programmes/initiatives impacting on the LTMA.

For the purposes of this group, 'strategic' is defined as a combination of at least 2 of the following:

- Involving at least 2 major London airports.
- Involving significant IFR daily movements.
- Where the nature of airspace change is critical to the development and deployment of FASI-S Programme.

The Group will focus primarily on the following areas in relation to the LTMA:

- Airspace Design. Sharing information about design principles and agreeing system-wide principles to support local principles, where appropriate
- The identification and management of the interactions between the major airports.
- Consultation. Identification and coordination of airspace change consultation activities which are common to multiple airports.
- Regulatory Engagement, Validation and Approvals. Develop and maintain an integrated timetable for regulatory engagement, validation of design and approval of multiple linked Airspace Change Proposals (ACPs).
- Communication: Develop and disseminate agreed points of view on concerns facing airspace changes within, and local to, the LTMA.
- Implementation. Creation and maintenance of a timetable and optimised sequence for the implementation of approved ACPs.

The Group will not normally concern itself with the following:

- Detailed technical design of ACPs.
- ACPs of relevance to only one major airport.
- Other matters that fall within the agreed responsibilities of the FAS Industry Implementation Group (FASIIG) and FASI-South Programme Board (or equivalent body), when it is established.

The group is established, with good representation across the London TMA Airports and NATS, and will be accelerating its work from May 2018 onwards as the programme enters the design phase. The group has 50% funding from FAS Small Gaps Fund.

4.3. FAS Governance Structure (including Roles, Responsibilities and Risk Management)

The FAS Structure and responsibilities are being expanded and redefined by the DFT, CAA and NATS into an Airspace Modernisation Strategy (AMS). The AMS will oversee and direct a modernisation of UK airspace. These revisions will enable the highest level of governance to ensure that the programme is delivered and stakeholders remain committed.

The revised structure and terms of reference are detailed in Section 8.

4.4. FASI-S Programme Requirements and Scope

The FASI-S programme will modernise the airspace in SE England to include the London Area Airports as well as the interfaces and appropriate routes from Cardiff, Bristol, Bournemouth, Southampton, Brize Norton, Birmingham, East Midlands and Southend.

The programme will only deliver the optimum solution if airports and NATS collaborate and integrate a programme plan that delivers airspace consultation and ultimate change in a coordinated way.

The principal requirements expected of the FASI-S programme are detailed in the objectives and scope of the London TMA Working Group in Section 4.2 of this report.

5. Analytics

The NATS design requirement for the systemisation of the UK airspace network is that airspace will not be a capacity constraint on existing and planned runways. In order to meet this requirement, NATS has evaluated the potential use of 3D 'tubes' between FL90 and FL305 in SE England. It is assumed that below FL90 the airfields have responsibility for the positioning of routes. It is also assumed that, above FL305, Free Route Airspace will be deployed.

The concept of operations explored in this assessment is a fully systemised 3D PBN environment. The 3D tubes provide continuous climb and descent between FL90 and FL305 and, to enable the free-flow of traffic to and from airfields, the tubes are all procedurally separated.

NATS has taken an evidence-based, data-driven approach to evaluating this concept using data from the 15 airfields engaged in the FASI-S programme. This data included predicted demand out to 2030, letterbox and gateway positions, and positioning of new runways. This data then formed the basis of the modelling exercise.

The modelling had two objectives:

- To evaluate the delay generated by the demand stated by airports based on the current airspace capacity. Based on current capacity levels, the UK would generate 27.6 million minutes of delay in 2030. The cost of this delay to the airlines would 1.8bn. Note: This forecast was made in May 2018 and is different to the DfT published Strategic Case.

- To demonstrate whether UK airspace could have the capacity to meet the potential future demand of UK airports until 2030 using the 3D tube concept.

In order to evaluate the 3D tube concept, NATS Analytics created two conceptual models. The first optimised model contained 915 tubes in easterly runway operations and 908 tubes in westerly operations. The revised model, created after analysis of the first model determined the need to reduce the number of tubes in the system, contained 667 and 658 tubes respectively.

The models demonstrated that the letterboxes and gateways submitted by the airfields were not spaced sufficiently to provide the separation required for systemised PBN airspace. The analysis concluded that further coordination between proximate airfields would be required in order to enable the concept to be viable.

The modelling further concluded that the airfield submissions created significant complexity in the network. The complexity was particularly prevalent in low level airspace between FL90 and FL160. High levels of complexity were also identified in areas around the LTMA.

The occupancy of each tube was assessed to understand whether the tube networks modelled delivered the capacity required by the airfields. In both models, the tubes delivered significantly more capacity than was required. It was determined that each tube could handle approximately 30 flights per hour, totalling 510 flights per day. The maximum tube occupancy in the revised model was 192 although 68% of tubes contained fewer than 10 flights.

In order to ensure that all tubes were procedurally separated, NATS Analytics created a bespoke tube positioning algorithm to analyse the model, identify intersections between tubes, and reduce the number of intersections by altering the position, climb gradient, and altitude of the tubes. The algorithm proved that a machine-based methodology can be used to reduce tube intersections. The limit for improvement was reached after approximately 25,000 iterations with approximately one third of the total intersections removed. However the model was not able to separate all tubes due to the complexities stated above.

Based on this study, it has been concluded that further refinement to the gateway and letterbox positions, the concept of operations, and the tube positioning algorithm are required to successfully demonstrate whether future UK airspace demand can be met with this concept. In order to achieve this, the following is recommended:

- Refinement of the letterbox and gateway requirements of airfields:
  - Airfields to submit letterboxes and gateways at FL70, enabling the network greater freedom to manoeuvre and separate the tubes at low levels; this will be defined and become more certain during the coordinated multi airport and NATS design and ACP process.
  - The FASI-S programme to work together to understand the volume of letterboxes and gateways required by each airfield based on their growth aspirations in order to limit the demand for under-used tubes;
  - The FASI-S programme to collaborate to ensure that letterboxes and gateways are separated.
- Analytics modelling to be refined further to consider a variety of concepts of operation.
- Definition of the CAA Safety & Regulatory process for the approval of the concept, acknowledging that much of the concept is already published in existing ATM Regulations or UK CAP1385.
- The tube positioning algorithm to be further developed to include (but not be limited to):
  - Movement of initial letterbox and gateway positions;
  - Merging of low demand tubes in network airspace;
  - Enabling tubes to turn;
  - Enabling level-offs in tubes.

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6. Future Programme Plan

6.1. NATS London Airspace Modernisation Project

6.1.1. Design Process

The data-driven design concept used in this feasibility study will be carried forward into the design process. Previously design teams would be dominated by controllers and it would be their expertise only that would influence the airspace design. Whilst operational experience and input is still vital, of equal importance will be the data and machine learning capabilities to design the optimum solution.

Design will be a collaborative exercise. This feasibility study has demonstrated that neither the NATS LAMP ACP nor any airport ACP could be designed or developed in isolation. There are significant dependencies between designs. Permitting airspace to be segregated for a particular airport is no longer possible if capacity is to be maximised.

We are recruiting and creating teams across NATS to deliver airspace change in a new way.

Stakeholders that will be required to participate in the design process include:

- Major airports beneath the LTMA with a high proportion of commercial jet traffic
- Large airports outside the LTMA with commercial air traffic that feeds into the airspace
- Airlines
- General Aviation Users
- Neighbouring ANSPs and States
- Military Airspace Users
- General Public through Airports and NATS Public Engagement.

Design priorities will be developed collaboratively between the airports and NATS and will fully reflect UK policy on noise and environment with respect to airspace design.

6.1.2. Training Considerations

Air traffic controllers will still be the decision makers in LAMP airspace in order to provide resilience in times of bad weather, system degradation or emergency situations. However the normality of their current job will change to a degree that means a large amount of training will be necessary. This will be not only to understand and learn the new airspace structures, toolsets and procedures but also to practice fall-backs in the event of an incident.

Supervisory, engineering and support staff will also need to undergo training, as well as colleagues at the airports and in other ANSPs. This is all part of a large scale airspace change.

Pilots flying commercially should be familiar with the changes through the usual channels such as AIRAC cycles, NOTAMS etc. However it would be prudent to engage in a high profile information sharing exercise before the changes come into force, aimed at the largest users of UK airspace in terms of airlines, general aviation and military. This would help to alleviate any problems with such a large change.

6.2. FASI-S Programme Implementations - Sequential or Coordinated?

In order to deliver a comprehensive airspace modernisation the industry must deploy an airspace change that includes at least the core TMA airports[2]. Removing the inefficiencies of the current airspace design can only be achieved if all airports in scope participate. The optimum design will require compromise, coordination and integration.

The industry will need to deliver up to 15 separate airport ACPs in support of the FASI-S programme.

Analysis of the initial feasibility designs has demonstrated that no airport can change airspace in isolation and that, as a consequence, statutory consultation in isolation would be cumbersome, potentially unworkable and arguably unfair to communities and stakeholders.

Sequential or uncoordinated ACPs would result in early ACPs having to demonstrate how theirs fitted with future ACPs. Subsequent consultation and regulatory approval would then restrict the options available to ACPs from other airports to respond to consultation feedback. It is also clear that some communities will be overflown by aircraft from more than one airport, particularly above 4,000ft, and that they should be able to consider the implications in the round.

There is also a decision to be made on the design criteria for the airspace. An initial assumption is to design to RNAV1 specification. Airports have expressed a strong view that the design should be future proofed and take advantage of aircraft capability and deploy RNP1 designs where aircraft conformance in the cockpit can be relied upon. RNP 1 would mean that the aircraft would also have the capability to monitor conformance to the PBN route, thereby contributing to the systems safety case.

NATS therefore recommends that:

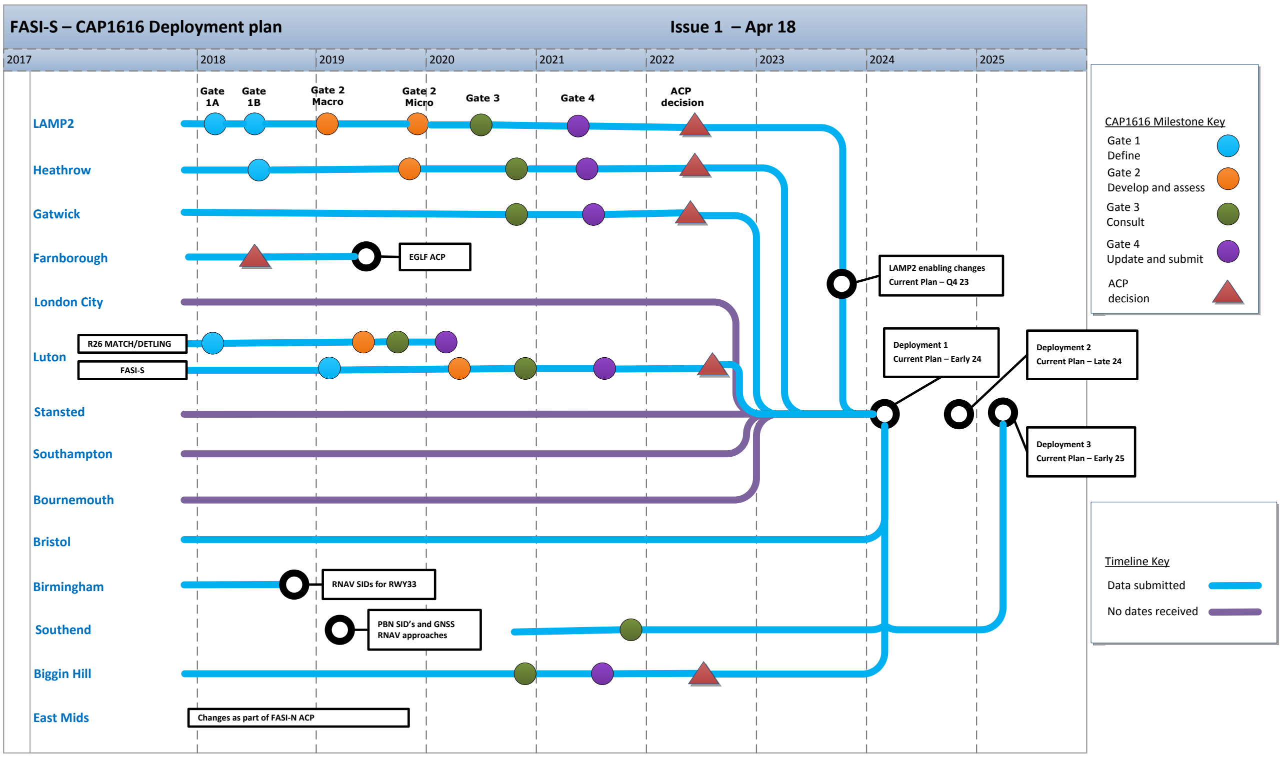
- Development of airspace designs is fully coordinated across the FASI-S programme airports including the design criteria. This will include sharing, compromising and articulating the reasoning behind compromise in a coherent and clear way. Initially we will seek to coordinate communications, project management and technical design across the FASI South partners.
- Formal consultations are undertaken in a fully coordinated and coincident way
- The CAA and ultimately the Secretary of State, if called in, are presented with a single combined proposal.

6.3. Combined Draft Deployment Plan

The next stage of the process is for a credible and deployable programme of work to deliver a robust ACP on which the CAA, and if called in, The Secretary of State can base a consent decision. NATS is committed to completing the bulk of the airspace change, in concert with the airports, by the end of 2024.

Such a complex programme will require significant investment in planning and programme management to ensure success. NATS is proposing to undertake this role within the revised FAS Governance structure .

2 Core TMA Airports are Heathrow, Gatwick, Stansted,, Luton, London City and Northolt



FASI South Deployment Indicative Timeline

The diagram above illustrates a possible future deployment plan mapped against the CAP1616 architecture. A number of airports are yet to declare their precise deployment plans; this activity will be a key deliverable in 2018. In order to deliver a coordinated and integrated ACP FASI South participants will need to ensure that Gate 4 is coincident across airports where there are dependencies.

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7. Risks and Residual Issues and Concerns

This feasibility study demonstrates that in operational and mathematical terms systemisation is a concept that can deliver significant capacity and opportunity for the UK. There are however a number of technical and institutional issues that must be managed.

7.1. Governance of FAS

It is vital that the current stakeholders remain committed to modernisation. The industry has made a good start, demonstrating openness and willingness to collaborate and coordinate. This recognises that each airport is a commercial entity and will face challenges when the optimum solution for the wider programme may not precisely meet their own business priority.

In order to deliver the optimum UK solution with the appropriate level of Ministerial oversight and direction a revised FAS structure and accountability is being developed.

This governance needs to ensure that FAS delivers the airspace modernisation in accordance with the direction of the Government and the UK Aviation Strategy ensuring that benefits of modernisation are shared across stakeholders.

7.2. PBN Vertical Constraints

While significant progress has been made in understanding aircraft capability to be profile constrained in climb and descent, there is more work to be done. Initial industry scepticism on the compromises required in aircraft performance in constrained operations has been replaced by a will to develop optimum solutions to constrain.

NATS and the CAA are working with partners to identify these constraint techniques that can then be built into the airspace design.

7.3. Airport and LAMP coordination and synchronisation

A key conclusion of this feasibility study is that the scope of change cannot be successfully delivered if individual ACPs proceed in isolation. In order to gain efficiencies, airports' airspace designs will overlap and have significant dependencies. The CAP1616 process requires consultation and evolution as designs go through the process and, critically, that they take into account consultation feedback as they progress to the next stage. Unless designs and consultations are coordinated this will result in public confusion; designs will be played off against each other by consultees, resulting in lack of clarity for decision makers.

NATS is convinced that the only way to successfully deliver the scale of change needed is for the industry to integrate designs, to coordinate consultation content and to seek ACP approval together.

Skilled resource, notably airspace design expertise, is limited and the programme will need careful planning to ensure that airports are not fighting simultaneously for the same resource.

This will require leadership at the highest levels across the industry, as well as strict project management and coordination. There is a critical path to 2024 deployment and activity must start immediately.

7.4. Engaging with the Silent Majority

NATS and airports will be seeking to elevate public awareness and discussion of the principles of airspace modernisation and the need for change.

7.5. CAP1616 application to a synchronised ACP

The view of FASI-S programme stakeholders is that the current edition of CAP1616 lacks clarity on how it would be used for a very large airspace change. The industry is working with the CAA to produce case studies of the issue and to demonstrate what is required for the modernisation programme to fit the ACP Process.

7.6. Further Development of Airspace Design Tools

The current fast-time Model and tools do not yet have the capability to identify and resolve all conflicts within the model. Section 5.5 of this report discusses the required developments and NATS is already progressing this work. This report also details the actions expected at a FASI-S programme level to integrate designs and coordinate solutions. This work has also been commissioned and workshops started in April.

7.7. Dependencies on NATS Technical Deployments

In parallel to airspace change, NATS will be deploying new technologies during 2020 to 2025. This includes the Deploying SESAR technical change to en-route operations at Swanwick and Prestwick, followed by the lower level TMA operations at both centres transitioning to the same iTEC platform and a common electronic data system. This will achieve legacy escape and place our ATM systems on a single common platform.

Systemisation offers the ability to increase capacity and reduce ATC complexity. Reduction in controller and Air Traffic Management complexity by reducing the need for vectoring is matched by an increase in the overall route complexity. In order for ATC to identify non-conformance to the plan we may need to deploy conformance monitoring tools. Similar capability exists already in our en-route system and, if safety analysis requires, these will be deployed in lower airspace.

Inbound flows will be streamed to avoid the need for extensive vertical holding close to airports. We have already deployed arrival management tools that have demonstrated their capability and are working with industry partners and neighbouring ANSPs to enhance this capability.

7.8. Do Nothing

Any programme of this size and complexity will include various and significant risks, as above. In NATS' view the risk of doing nothing carries the highest long-term cost, in terms both of introducing noise and other environmental benefit for local communities, and providing capacity to support future growth in the aviation industry. The timetable for the AMS programme straddles the next Parliament and it therefore requires strong cross-party support and Government commitment to seeing it through. The risk of the programme being undone with the result that we do nothing means that the aviation system will not be able to support the objectives of the programme.

8. Future Airspace Strategy Structure and Terms of Reference

It is clear from the initial results of the feasibility study that modernisation cannot be viewed as a single NATS Airspace change and up to 15 separate airport changes. There are significant dependencies between neighbouring airports in order to achieve optimum solutions. The current concept of operations gives a certain degree of autonomy for each airport.

On the basis of the feasibility study, NATS, in discussion with the CAA and stakeholders, will be seeking views on a proposal for all airports and NATS to undertake statutory ACP consultation at the same time. There is significant overlap of individual airport design and unless the consultations are kept in step with each other they risk being subject to an endless cycle of change to adapt to each other's changes. This would ensure that designs are complementary, that the public have a single final consultation to consider and that the industry moves forward in a coordinated and committed way (noting that NATS and each airport may well individually engage as appropriate with their stakeholders throughout the development of the final design for consultation). If approved the change can then be deployed in modules.

Strong industry support is required for development and delivery of the roadmap and absolute transparency in executing the changes at airports and NATS. There is a need for commitment and monitoring of milestones and deliverables through effective governance to DfT level.

In order to deliver the required level of capacity, the letterboxes and gateways for each airport will need to be designed to complement those of neighbouring airports. NATS is looking at opportunities to reduce the height of the network interface to FL70 in some areas which we believe will help reduce the amount of interaction between neighbouring airports. However, in order to prevent noise concentration, it is recognised that this will need to be limited on letterboxes/gateways where there is a confluence of low level respite routes.

In response to the first consultation on Aviation Strategy, the Government has committed to ensuring that the right roles, structures, powers and incentives are in place to successfully deliver this modernisation.

We welcome that, as part of the Aviation Strategy, the Government will now consider whether further policy is required to support airspace modernisation and the recognition that there is a policy challenge to coordinate multiple different airspace changes across different airports, with this report identifying the scale of the challenge

The Government has said that it 'expects to introduce new arrangements to take forward the delivery of the airspace modernisation programme, including a new governance structure defining and overseeing the overall programme. Airports will need to develop their airspace modernisation proposals in conjunction with each other where there are interdependencies between their airspace designs. This creates a potential issue. Should one airport decide not to progress with an airspace change that has interdependencies with other airspace changes, it could create delays for other airports'. NATS strongly supports this initiative and would welcome a role, within the RP3 settlement, to coordinate the programme.

The Government will consider whether it needs to take new enforcement powers to 'require airports to take forward, or to hand over to NATS to take forward, particular airspace changes that are important for wider airspace modernisation'. Any enforcement powers would be subject to primary legislation.

8.1. NATS Coordination role in the FASI-S Programme

NATS expects to lead the coordination and management of the FASI-S programme. This role will include designing, implementing and consulting on the network airspace to support future capacity and working with the airports to connect their low level designs into the network, following the CAA's CAP1616 process.

We will take on the project management of the overall modernisation programme including planning the implementation and monitoring and reporting on progress of each of the stakeholder elements. We expect to take a role in coordinating and supporting the public consultations on airspace change to ensure a coherent outcome but would expect the airports to be responsible for their own designs, consultation and implementation elements of their parts of the plan.

8.2. Airspace Modernisation Strategy (AMS) Governance

The AMS Governance Structure that sets out the overall governance of airspace modernisation and other initiatives under FAS is nearing completion.

9. Appendix A - Analytics

9.1. Executive Summary

The Future Airspace Strategy Implementation – South (FASI-S) programme was initiated to address the critical need to modernise the airspace in the south of the UK in order to meet future demand. The NATS design requirement for the systemisation of the airspace network is that airspace will not be a capacity constraint on existing and planned runways. In order to meet this requirement, NATS has evaluated the potential use of 3D 'tubes' between FL90 and FL305 in the South of England. For this analysis only it was assumed that below FL90 the airfields have responsibility for the positioning of routes, although UK strategy refers to 7000 feet. It is also assumed that, above FL305, Free Route Airspace will be deployed.

The concept of operations explored in this assessment is a fully systemised 3D Performance Based Navigation (PBN) environment. The 3D tubes provide continuous climb and descent between FL90 and FL305 and, to enable the free-flow of traffic to and from airfields, the tubes are all procedurally separated.

NATS have taken an evidence-based, data-driven approach to evaluating this concept. Data was requested from the 15 airfields engaged in the FASI-S programme. This data included predicted demand out to 2030, letterbox and gateway positions, and positioning of new runways. This data then formed the basis of the modelling exercise.

The modelling had two objectives. The first was to evaluate the delay generated by the demand based on the current airspace capacity. Based on current capacity levels, the UK would generate 27.6 million minutes of delay in 2030. The cost of this delay to the airlines would be £1.8bn. Note: This forecast was made in May 2018 and is different to the DfT published Strategic Case.

The second objective was to demonstrate whether UK airspace could have the capacity to meet the potential future demand of UK airports until 2030 using the 3D tube concept.

In order to evaluate the 3D tube concept, NATS Analytics created two conceptual models. The first optimised model contained 915 tubes in easterly runway operations and 908 tubes in westerly operations. The revised model, which was created after analysis of the first model determined the need to reduce the number of tubes in the system, contained 667 and 658 tubes respectively.

The models demonstrated that the letterboxes and gateways submitted by the airfields were not spaced sufficiently to provide the separation required for systemised PBN airspace. The analysis concluded that further coordination between proximate airfields would be required in order to enable the concept to be viable.

The modelling further concluded that the airfield submissions created significant complexity in the network. The complexity was particularly prevalent in low level airspace between FL90 and FL160. High levels of complexity were also identified in areas around the London Terminal Manoeuvring Area (LTMA).

The occupancy of each tube was assessed to understand whether the tube networks modelled delivered the capacity required by the airfields. In both models, the tubes delivered significantly more capacity than was required by the demand predictions submitted by the airfields. It was determined by NATS Analytics that each tube could handle approximately 30 flights per hour, totalling 510 flights per day. The maximum tube occupancy in the revised model was 192 but with 68% of tubes contained fewer than 10 flights.

In order to ensure that all tubes were procedurally separated, NATS Analytics created a bespoke tube positioning algorithm to analyse the model, identify intersections between tubes, and reduce the number of intersections by altering the position, climb gradient, and altitude of the tubes. The algorithm proved that a machine-based methodology can be used to reduce tube intersections. The limit for improvement was reached after approximately 25,000 iterations with approximately one third of the total intersections removed. However the model was not able to separate all tubes due to the complexities stated above.

Based on this study, it has been concluded that further refinement to the gateway and letterbox positions, the concept of operations, and the tube positioning algorithm are required to successfully demonstrate whether future UK airspace demand can be met with this concept. In order to achieve this, the following is recommended:

- Refinement of the letterbox and gateway requirements of airfields:
  - Airfields to submit letterboxes and gateways at FL70, enabling the network greater freedom to manoeuvre and separate the tubes at low levels;
  - The FASI-S programme to work together to understand the volume of letterboxes and gateways required by each airfield based on their growth aspirations in order to limit the demand for under-used tubes;
  - The FASI-S programme to collaborate to ensure that letterboxes and gateways are separated.
- Analytics modelling to be refined further to consider a variety of concepts of operation.
- The tube positioning algorithm to be further developed to include (but not be limited to):
  - Movement of initial letterbox and gateway positions;
  - Merging of low demand tubes in network airspace;
  - Enabling tubes to turn;
  - Enabling level-offs in tubes.

NATS

Secretary of State Feasibility Report Addendum

Significant modernisation of the airspace in South East England is required, independent of major ground infrastructure projects, to accommodate forecast growth in the aviation sector out to 2030. The overarching case for modernisation was set out in NATS' draft Feasibility Report for the Secretary of State in May 2018.

Following initial consideration of the draft Report, the Secretary of State made the following requests of NATS:

- To provide detail on the likely level of interdependency between different airports' airspace proposals and where conflicts may exist. This should include establishing the minimum group of airports in the South East that is strictly needed to deliver the essential core benefits of the airspace change programme.
- Further detail to underpin NATS' findings about the likely removal of stacking and other noise benefits brought about by modernisation.
- To clarify and evidence NATS' conclusion that the positioning of the letterboxes will not unreasonably constrain airports' flight path options and therefore the distribution of noise on the ground, the establishment of which is an essential component of the CAA's airspace change process and the government's Air Navigation Guidance.
- To provide further evidence about the potential noise benefits associated with the airspace reform.
- To set out and test the realism and risks associated with the assumptions underpinning NATS' modelling and the novel technical concepts proposed.

In answering the questions, below, NATS has taken the opportunity to include more information on the goal plan and engagement plan which has also evolved since the draft Report was submitted.

Q1: Provide detail on the likely level of interdependency between different airports' airspace proposals and where conflicts may exist. This should include establishing the minimum group of airports in the South East that is strictly needed to deliver the essential core benefits of the airspace change programme.

NATS has assessed the interdependencies between airports within the FASI-S programme by analysing interactions between the routes into and out of the individual airports. For the purposes of this modelling, an indicative Heathrow 3 Runway operation was compared to the current routes at all other participating airfields. It should be noted that no designs exist at this time and that Heathrow does not have designs that could be relied upon this early in the CAP1616 process. We can only demonstrates the scale of impact on other airports by creating new procedures at Heathrow to facilitate a new runway.

Airport	Estimate of route interaction with Heathrow indicative growth
Luton	Very High
Gatwick	Very High

Farnborough	**Very High**
Southend	**High**
London City	**High**
Stansted	**High**
Northolt	**Medium**

Southampton	High
Bournemouth	Medium
East Midlands	Low
Biggin Hill	Low
Birmingham	Low
Cardiff	Low
Bristol	Low

The table above shows the airports that have route interactions with Heathrow. The participation of all these airports is required to realise the full capacity benefits from the programme, meaning that airspace will not be a constraint to the growth plans of all airports.

However, to deliver the essential core benefits, including the movements associated with Heathrow Runway 3, the participation of the seven highlighted airfields is essential. As well as facilitating the movements for R3 this would also deliver the capacity, noise and fuel benefits for those seven airfields that they have indicated form part of their long term plans. It is difficult to quantify at this stage the impact of any one or more of the seven above not participating in the programme, however, this is an area that we can continue to refine as designs progress.

In addition, Biggin Hill will benefit significantly from participating in the programme due to its proximate location to Heathrow and improved climb profiles that the redesign could provide.

The more distant location of the other airports should make interactions with Heathrow easier to solve. Participating in the programme will yield noise and CO_2 benefits and, as significant airports with growth strategies, it makes sense for them to modernise their airspace in line with the programme; their absence from the programme would leave large swathes of airspace unmodernised, and their growth plans would be unrealisable.

It is NATS' assessment that if none of the 14 airports other than Heathrow participate fully in the programme, the likely outcome will be similar to the "do nothing" scenario outlined in the Feasibility Report; the likely impact would be more than one in three flights delayed by more than 30 minutes by 2030, with consequent negative impact on CO_2 emissions

In the next stage of the design process (from November 2018 to the end of 2019) the airports and NATS will work together to develop an optimum design for FASI-S.

Q2: Further detail to underpin NATS' findings about the likely removal of stacking and other noise benefits brought about by modernisation.

The current airspace in SE England utilises orbital holds at low levels and close to the airports, combined with arrival management systems, to maintain a constant stream of arrivals to UK runways. This is highly inefficient in terms of airline fuel burn and CO_2 emissions but maximises the use of the most constrained asset, the runways themselves.

The new structure will not require orbital stacking in the same way as today. While orbital holds will still need to be designed in for contingency purposes (for instance, to manage extreme events, or bad weather) these will be at much higher altitudes than today, and positioned to minimise impact on local communities.

Arrival management systems, already in use today, will increasingly enable delay to be absorbed in the cruising part of a flight. Extended Arrival Manager (XMAN), Demand-Capacity Balancing (DCB) and Queue Management, in combination with a much more efficient airspace design, will yield significant benefits in terms of reduced holding and associated fuel burn/CO_2.

Use of arrival management systems is already reducing holding at Heathrow by 120,000 minutes per year. Extending this use to other airfields within the FASI-S programme, alongside significant improvements to our systems, is expected to yield further benefit. Other forms of managing delay that do not require aircraft to circle will also replace traditional orbital holding in normal operations.

NATS is developing a programme with industry partners to enhance arrival management to stream traffic into SE England before an aircraft starts descending. By planning systemised airspace entry times and trajectories in advance, aircraft can plan their arrival time to their inbound descent point and eliminate the need for significant holding. Initial enhancements to streaming of traffic will be delivered early in RP3 with final delivery at the end of 2023 before deployment of systemised airspace and revised airspace use.

Q3: Clarify and evidence NATS' conclusion that the positioning of the letterboxes will not unreasonably constrain airports' flight path options and therefore the distribution of noise on the ground, the establishment of which is an essential component of the CAA's airspace change process and the government 's Air Navigation Guidance.

During the summer of 2017, NATS staff visited the 15 FASI-S airports to introduce the programme and request data on forecast movements, fleet types, and departure/arrival strategies as well as initial positioning of letterboxes for both inbounds and outbounds.

The positioning of these letterboxes is largely at the discretion of the airfields. This enables the airfield to design flight path options at low levels that will provide maximum benefit to their stakeholders. The FASI-S governance structure will include mechanisms for the repositioning of letterboxes where conflicts occur between two or more airfields. Some constraints may arise because of the complexity of the airspace and proximity of the airfields, which NATS will work directly with the airports to resolve.

NATS' design work will initially commence at FL90 (9000 feet) so that progress can be made in the high level design process while airports consider their detailed requirements at lower levels. We expect airports to provide letterbox positions at 7000' in 2018 in general terms (i.e. plus or minus 4 miles) and these will then be refined to a fixed point following the airports' own design and consultation process. Airports will be free to implement multiple dispersed letterboxes at 7000' for noise abatement purposes, which will then converge at FL90 to feed into the network.

Q4: Provide further evidence about the potential noise benefits associated with the airspace reform.

NATS has conducted a noise study on 8 of the 15 airfields participating in the FASI-S programme. These airports all have Standard Instrument Departure routes (SIDs) which are necessary to be able to measure noise at a given position from the runway. Within the initial timeframe it has not been possible to conduct a study on the other 7 airfields which do not have SIDs. The study compares the modelled noise footprints of a the most common aircraft type at each airfield following (a) a typical current procedure and (b) a continuous climb procedure that could be achieved by an optimised airspace design. The percentage of aircraft which currently receive continuous climbs in the current operation has been considered in the analysis to provide a more realistic view of the likely benefits at each airfield.

The table below summarises the potential noise benefits for the participating airfields based on a 55dB footprint and based on the above assumptions. The table does not reflect expectations or targets for noise outcomes, but suggests potential outcomes under one optimised scenario. Actual noise outcomes will depend on a range of factors, including the final airspace design approved by the CAA and the volume of traffic.

	Potential % Reduction in Size of Noise Footprint per Flight at 55dB
Birmingham	10.3%
Cardiff	3.1%
Bristol	0.6%
Luton	27.8%
Gatwick	20.8%
London City	70.2%
Heathrow	34.2%
East Midlands	5.2%
Stansted	19.3%

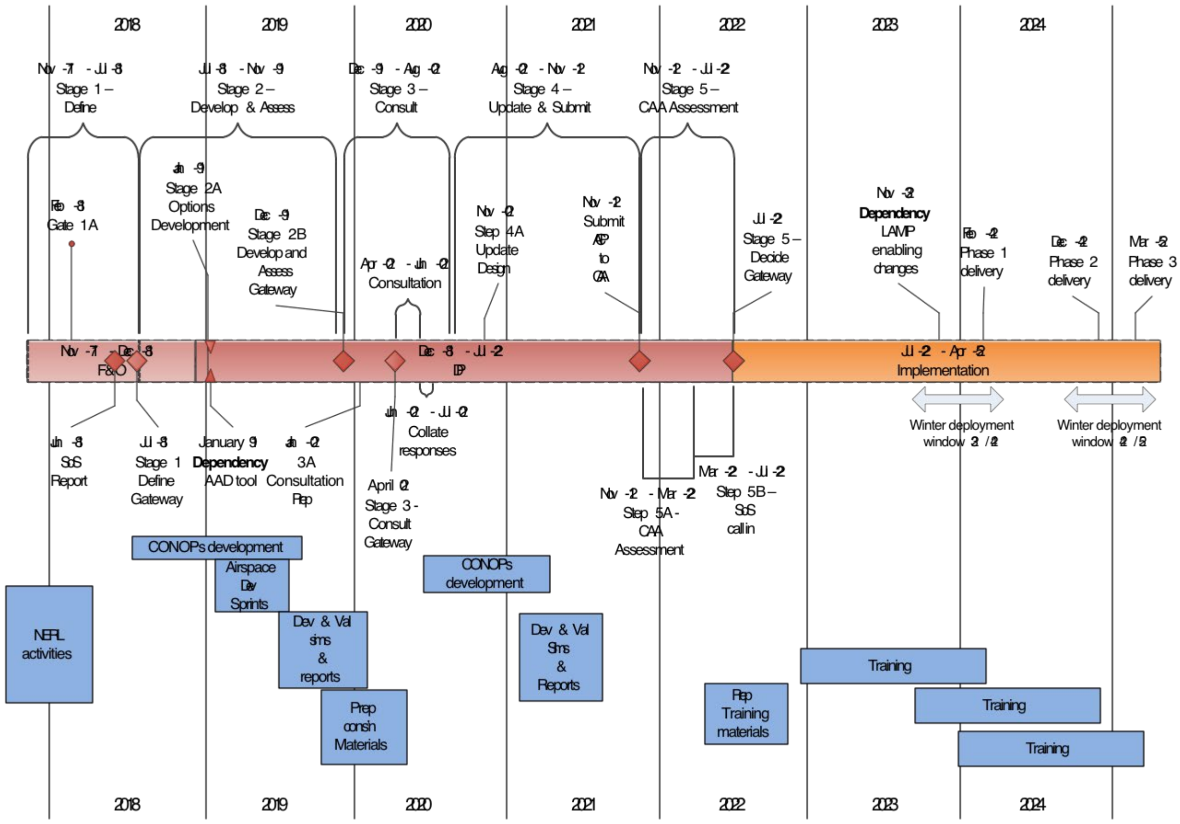
Q5: Set out and test the realism and risks associated with the assumptions underpinning your modelling and the novel technical concepts proposed.

NATS is using the latest available technologies to maximise the benefits delivered by the FASI-S programme. This includes modelling using mathematical algorithms which produces more options than conventional modelling, which can then be tested. Due to the unprecedented level of complexity involved in redesigning the airspace in SE England, computer simulations are essential to finding the best possible solution for all stakeholders, balancing efficiency, capacity and emissions. The design process itself will be computer-based rather than pen-and-paper which will require an entirely different approach from the past, essentially enabling designers to start with a blank piece of paper rather than being constrained by their appreciation of current structures.

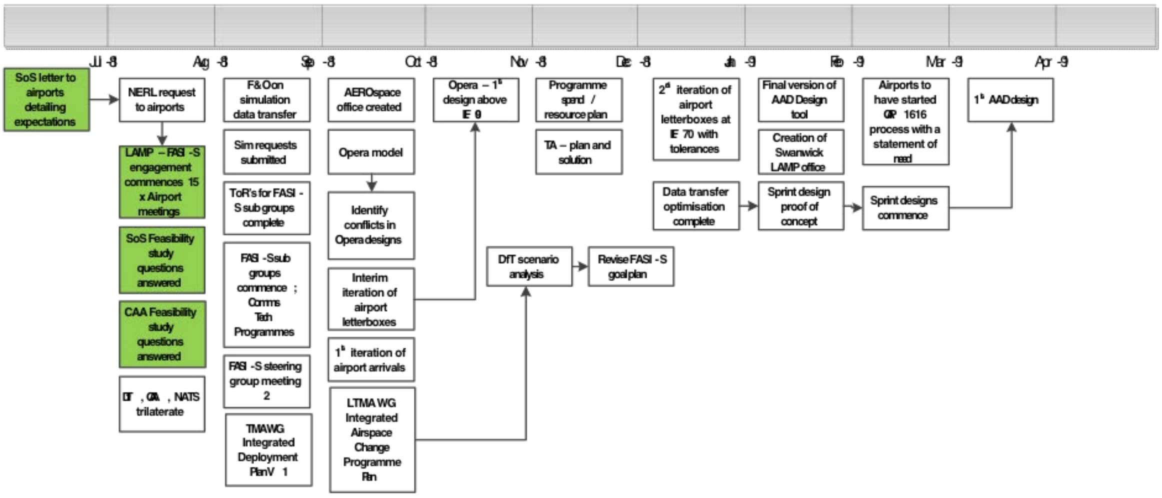
This is a world-leading approach and the most robust that NATS has ever undertaken for an airspace design project which we believe is necessary for a project of this size and complexity. These processes are by their nature iterative and will be refined and validated as we go; there will be significant simulator time invested to test all options to help identify the most robust. The risks associated with new technologies have been captured in the project's risk register and will be monitored and assessed at regular intervals as the project progresses.

Goal plans, timelines & key dates

The LAMP high-level timeline is provided below:



In addition, the project also has the following short-term milestones which are continually reviewed and added to in order to maintain the delivery momentum/oversight required for a project at this stage of delivery:



Detailed engagement plans (high level and low level) that are taking place between NATS/airports/CAA/DfT

Airspace modernisation is a complex political and technical issue that requires significant investment in engagement. CAP1616 alone significantly increases the requirement for consultation at multiple gateways throughout the process as well as high levels of stakeholder engagement. The challenge for all participants is to deliver the airspace modernisation on time whilst also complying fully with the processes.

The biggest challenge for the FASI-S Programme is bringing together the 15 airports and NATS En-Route into a coordinated and synchronised airspace change. This programme, as well as providing high level commitment and governance, will also address communications, project management and technical issues across the range of 16 projects.

The Programme Steering Board met in June with the three initial subgroups (Project Management, Technical Resolution and Communications) now forming. NATS is seeking RP3 funding to coordinate and deliver the programme.

DfT, CAA and NATS have been working on the structure of the wider Airspace Modernisation Strategy Governance, of which FASI-S will be part of the delivery arm. NATS is creating a Project Management Office (PMO) function which will primarily be responsible for the coordination and the implementation of the delivery plan including airports' and NATS' requirements.

The PMO will share, adopt or agree (dependent on policy ownership) and thereafter own, design principles applied by ACP Sponsors within the Programme i.e. 15 Airports and NATS En-Route. This includes, but is not limited to, airport runway usage constraints, climb and descent gradient policy, PBN design separations and approach procedure strategies. The purpose of these policies and strategies is to optimise the usage of airspace and give certainty to dependent airspace designs. Airports will retain ownership of low level airspace designs and the relationship with their local communities and NATS En-Route will retain ownership of the Network Airspace change.

Within the Programme NATS will work bi-laterally with each of the airports to establish their project requirements and data as well as the shared timeline towards programme deployment. The objective is that NATS helps airports to commence their CAP1616 process by February 2019 with a Gateway 1A Statement of Need and that the programme achieves synchronisation at Gateway 2B at the end of 2019. This bilateral work has already begun, in July 2018.

The design of higher level governance is approaching conclusion with a round table consultation with non-industry stakeholders scheduled for 27 July 2018.

The key objectives for the rest of 2018 are:

- Establishment of and airport commitment to a full FASI-S programme board and subgroups on Project Management, Technical Resolution and Communications;
- Completion of the next phase of Analytics algorithms for fast-time modelling to create a mathematical model of airspace above FL90 to feed into Airspace Design;
- Delivery of the airspace design tool and creation of the 2019 fast-time and real-time development and simulation plan;
- Engagement with Airports for their next iteration of outbound letterboxes and first iteration of approach procedures and letterboxes.

Annex B: CAA Assurance Report

The Feasibility of Airspace Modernisation in the South East

CAA Assurance Review

Version 1.9, November 2018

Published by the Civil Aviation Authority, 2018
Civil Aviation Authority
Aviation House
Gatwick Airport South
West Sussex
RH6 0YR

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Contents

Executive Summary

Implementing a new network of arrival and departure routes for airports in the South East has been a key goal of the UK's airspace strategy for over a decade because it offers the opportunity to significantly increase capacity, efficiency and environmental performance. As traffic levels continue to grow, airspace modernisation in the South East has become less of an opportunity and more of an urgent requirement. Delays are forecast to grow sharply if more airspace capacity is not added in the next ten years. Plans supported by the government to expand Heathrow and allow other airports to grow rely greatly on airspace modernisation.

The NATS report on the feasibility of airspace modernisation in the South East describes a commendably ambitious concept for the design and implementation of a new route network. The concept looks to add airspace capacity by offering every airport a set of dedicated arrival and departure routes. All the routes are designed using horizontal and vertical restrictions that contain flights within a 3D tube. The tube concept has the potential to add significantly more airspace capacity because the aircraft using the tubes would fly more direct routes, climbing and descending continuously and would no longer need to be managed tactically by air traffic controllers. We welcome the opportunity to review the report and are encouraged by the progress that has been made so far:

- The concept offers an innovative new approach to tackling the challenges in the South-East airspace.
- The use of computer modelling to optimise the new route network has the potential to generate more balanced outcomes by gathering inputs from a wide range of stakeholders.
- The engagement with airports in the South East to develop the concept has established the foundations of the collaborative working arrangements that will become essential for the industry to deliver airspace modernisation and share the costs and benefits effectively. A wider mix of stakeholder groups including airspace users from the Commercial, Military and General Aviation sectors must be engaged in the next phase of work to validate and refine the concept.

We understand that the report was drafted in May 2018, when the work to prove that the concept is feasible and that a variant of it can be implemented by 2025 was still not fully mature. The next phase of work is already underway and will need to demonstrate that some of the key assumptions highlighted in our review (and often recognised in the report itself) are reliable. The most important details we would hope to see at this stage are set out below:

- All tubes must be safely separated from one another for the new network to deliver the assumed capacity improvements. The modelling developed to separate the tubes has so far only managed to isolate 30 of the 600+ required. The current model does not allow for the tubes to turn or level off, which will constrain the process of tube separation and network optimisation until the model is developed. Demonstrating that a network can be established (albeit hypothetically) where all tubes are safely separated and deliver the required capacity will be a top priority for the next phase of work because all other features of the concept and all future airspace design activities assume that the new routes won't interact with each other.

- One of the challenges of airspace modernisation, particularly when it includes implementing a new network, is that the responsibility for design is split between NATS and the airports. The report shows that it is not possible to meet all the airports airspace design requirements simultaneously. NATS is clear that the success of the new concept will rely on airports reaching efficient compromises on the airspace designs for which they are responsible. In practice, these compromises may be difficult to agree because of the environmental, commercial and reputational impacts for the airports of moving flight paths at low altitudes. The next phase of work should investigate and identify the potential compromises. It may be the case that government policy changes are needed to i) help solve the compromises and ii) establish stronger mechanisms that commit the airports to making the necessary airspace changes in the timescales required (a policy the government announced it was considering in its Next Steps document on its forthcoming Aviation Strategy).
- This concept appropriately looks to the future, but this means that current fleet and procedures will also need to be developed. Aircraft in today's fleet do not currently have the avionics capability needed to fly safely within a tube. Specifically, they cannot deliver the consistent climb performance required to conform to the vertical profile of the tube. The timescales for manufactures to develop and deploy new avionics that can is unclear. We expect it will be over ten years before most of the fleet are capable. The report suggests that controllers could be retained in the short term to manage the aircrafts' vertical profile within the tubes tactically. This could be a workable solution but, as a variant of the concept, it must be examined in more detail during the next phase of work to quantify the capacity, efficiency and environmental improvements it can deliver.
- Noise is a complex issue. Design and operational solutions for one community may introduce or increase noise for others. The potential to deliver general reductions in aircraft noise as the new network is deployed are described in the report but the specific measures and evidence of their impacts should be examined in more detail during the next phase of work. The addendum NATS delivered on 30 July 2018 suggested that NATS will design routes from 9000 feet and airports will design the letterboxes at 7000 feet. Given noise is the environmental priority below 7000 feet (and therefore determines whether an airspace change is a 'Level 1' change to include consulting communities on the ground) it is important to understand the interplay between these two design areas. We would like to see more detail and supporting evidence on how the design at 9000 feet and the letterbox positions at 7000 feet will be developed together without one prejudging the other (i.e. without the design at 9000 feet undermining the airports' engagement process in designing the letterboxes).
- We understand why NATS suggest that all the South-East airports and NATS should develop and consult on their airspace change proposals concurrently, but we do not think this will be achievable in practice. The addendum NATS delivered on 30 July 2018 suggested that of the 15 airports where airspace change is needed, seven of these are essential for Heathrow's expansion programme (meaning nine airspace changes in total, including Heathrow's own and NATS'). The next phase of work must ensure that the schedule of activities and major milestones to deliver the new network by 2025 are set out in detail, agreed across all the key stakeholders and integrated into a common timeline. The governance arrangements referred to in the report to oversee the programme of airspace modernisation in the South East can then use this integrated schedule and milestones to actively manage the risks, issues and dependencies that may impact on delivery. The programmes for controller retraining and the implementation of new systems and tools required to support the concept should be set out as part of the

schedule and milestones and the entire programme should be tested against the available resources and funding to provide assurance that a 2025 deployment date is truly feasible. Crucially, this work is an essential enabler for Heathrow expansion. A clear timetable as to which airspace changes are necessary for Heathrow's new runway to be operable is essential well in advance of Heathrow's Development Consent Order application.

Table 1 summarises the main recommendations identified by our review organised by theme.

Theme	Recommendation
The concept	a) We recommend that NATS complete the computer modelling as soon as possible to provide a mature demonstration that a new network of fully separated arrival and departure tubes is feasible in the South-East airspace and delivers the required capacity gains. b) We recommend NATS commence a comprehensive programme of engagement with airspace users from the Commercial, Military and General Aviation (GA) sectors and with aircraft manufacturers to test the main features of the concept and the implementation timelines from a flight operations perspective.
	c) We recommend that NATS work with the airports, airspace users and the CAA to consider what other concepts exist that may be deployed to add airspace capacity sufficient to meet the airports growth aspirations, in case the proposed tube network cannot be adequately separated.
The modelling	d) We recommend that the modelling used to optimise and separate the tubes is updated to allow the tubes to turn and level off.
	e) We recommend that the modelling is updated to include a broader and more qualitative set of inputs, such as data from different airspace user groups about their requirements for access to the airspace (and, at a later stage, the design principles that sponsors must develop by engaging stakeholders at stage 1 of the airspace change process)
Vertical containment within a tube	f) We recommend that the description and implementation timelines for the concept should be updated to reflect the dependency on new aircraft avionics that support vertical containment within a tube and that more details are included about the short-term mitigation strategies that enable vertical containment through controller intervention and dedicated support tools.
Airport engagement and compromises	g) We recommend that NATS undertake further work to set out the compromises that airports might need to make, so that the government and CAA can determine whether additional policy will be necessary. NATS should also continue to work with ourselves and the government as the government develops new policy concerning mechanisms to commit all stakeholders to developing the necessary airspace change proposals in the timescales required.

Theme	Recommendation
Environmental impacts	h) We recommend that the potential positive and negative impacts of the concept are evaluated, further noting that the noise or environmental impacts of the concept must be demonstrated as part of the concept implementation through the CAA Airspace Change Process. Evidence should be produced about whether the airspace design at 9000 feet will have any impact on airspace design (and noise) at and below 7000 feet.
Implementation timeline	i) We recommend that NATS work with the airports to create an integrated schedule of activities and milestones for the development and implementation of the new network and test it against the available resources and funding.

Table 1: Summary of recommendations from the assurance review

Figure 2 Type caption here

The CAA would like to thank NATS for its engagement with us for the purpose of preparing this assurance report. We recognise the task requested is difficult and novel and we are encouraged with how NATS has started the conceptual and analytical process required. We are keen to continue to work together closely in our respective roles to make airspace modernisation a reality.

1. Introduction and scope of the review

Introduction

1.1. This document describes the outputs of a review conducted by the CAA into a report on the Feasibility of Airspace Modernisation produced by NATS.[1] The feasibility report was commissioned by the Secretary of State (SoS) for Transport to understand whether there is sufficient airspace capacity in the South-East to meet the forecast demand for aviation in the region and the growth aspirations of the airports that operate there. A draft version of the report was submitted to the SoS in May 2018.

1.2. The CAA has been asked by the SoS to review the report and consider the level of assurance that can be attached to the main findings, technical concepts, modelling and implementation timelines.

1.3. The NATS feasibility report includes a description of:

- The information gathered for 15 airports[2] in the South East about their growth aspirations and future airspace requirements at lower altitudes;
- Modelling conducted to examine the air traffic delays that may occur if the growth predicted by the airports is not met by additional airspace capacity;
- A new concept for the South-East airspace network above 9000 feet to add more capacity by deploying a large number of arrival and departure routes that are safely separated from one another by design and connect to each airports' local airspace at pre-defined letterbox points. Aircraft would use satellite navigation to fly the routes following a series of horizontal and vertical restrictions that effectively contain their flight paths within dedicated 3-dimensional tubes;
- Modelling conducted to optimise the position of the tubes, ensure they can all be safely separated and examine the levels of airspace capacity that they can deliver;
- A programme plan proposed by NATS for the next phase of work to refine the concept, enhance the modelling and collaborate with the airports to implement the airspace changes. The plan includes an indicative timeline and governance arrangements that start to consider how such a large set of co-dependent airspace changes could be coordinated, sequenced and overseen between now and 2025.

1.4. Our assurance review is limited to the content of the May 2018 report and the feedback provided by NATS to clarification questions we have asked about the report. Where possible we refer to the addendum provided by NATS on 30 July 2018. The report considers the concepts and modelling in non-technical detail, evaluating the proposal in high-level terms. Some of the assumptions and issues raised in our review may be well known to NATS but were not included in the report because of their detailed technical or operational nature.

[1] The Feasibility of Airspace Modernisation: a report by NATS for the Secretary of State for Transport on the feasibility of airspace modernisation in the South-East UK, version 2, 1st May 2018.

[2] NATS requested information from 15 airports: Heathrow, Gatwick, Stansted, Luton, London City, RAF Northolt, Biggin Hill, Farnborough, Southend, Southampton, Bournemouth, Cardiff, Bristol, Birmingham and East Midlands. Northolt, Birmingham and Farnborough did not provide any information so NATS made growth assumptions on their behalf.

1.5. We are aware that the next phase of work is already underway and NATS is engaging with the airports to refine the information they have provided. As a result, some of the recommendations and observations raised by our review may already be addressed or under consideration.

Scope

1.6. The scope of our assurance review is grouped into sections that were decided in collaboration with the Department for Transport (DfT). Section 2 summarises our overall view of the report and the key assumptions on which the concept and modelling are based. Sections 3 to 8 provide our views on some specific questions raised by the DfT that are summarised in table 2. Section 9 offers some concluding comments and other observations on the report that we would like to raise following our review, which may be of use to NATS in the next phase of work.

DfT's question (section of this review)	**Our view**
What is our view of the novel technical concepts proposed in the report and the main features of the modelling approach? (3)	The concept is an innovative new approach to tackling the challenges in the South-East airspace. The modelling to optimise the new routes has the potential to generate more balanced outcomes. As the model has been developed in-house following a data driven approach, it is important that NATS provides assurance that a robust validation process is being been carried out. Consideration should be given to how data integrity is ensured and what quality checks are performed.
What is our view on NATS findings that the positioning of the letterboxes will not unreasonably constrain airports' flight path options and the distribution of noise? (4)	Letterboxes offer airports flexibility regarding the design of flight paths below 7000 feet, where noise is the environmental priority. The final number and location of letterboxes will be determined by the output of stakeholder engagement, options appraisals and consultations conducted as part of the airspace change process. NATS should progress on the understanding that the final positioning of letterboxes cannot be fixed until the airspace change process results in an approved proposal. The report highlights that collaboration and compromise between airports will be needed to accommodate all the letterboxes. It is reasonable to assume the preferred position of some airports' letterboxes may constrain certain flight path options for other airports. Policy intervention may be needed to help determine the outcome of compromises. If NATS' network airspace design applies any constraints on how airspace below 7000 feet will be designed, then NATS will be designing a Level 1 airspace change.

What is our view on how the concept and modelling can be applied by sponsors with the existing ACP process and government's Air Navigation Guidance 2017? (5)	We believe that the report is in principle compatible with the government's policies on noise, but, in practice, the proposed concept may have to be a Level 1 airspace change proposal (including detailed noise evidence and community consultation) in order to be compatible with the government's policies on noise, and therefore the CAA's airspace change process. We would need NATS and the airports to consider how such a data driven, iterative design process remains aligned with the airspace change process, that must be met for any of the individual airspace change proposals to progress.
What is our view on the minimum group of airports in the South East that must take forward airspace changes to deliver the core benefits of the programme? (6)	Our view is aligned with that provided by NATS in the 30 July addendum that eight airports must take forward airspace changes alongside NATS to deliver the core benefits of the programme – specifically; Heathrow, Gatwick, Stansted, Luton, London City, RAF Northolt, Farnborough and Southend.
What is our view of the feasibility of all airports and NATS undertaking their airspace changes concurrently, compared to a ordered but sequential approach? (7)	We understand the assertion that 'as a result of these dependencies all airports and NATS should be required to conduct statutory airspace consultations concurrently and submit one single ACP', but believe it will be impractical and suggest other solutions should be considered. The greater the number of airspace changes that are co-dependent and happening in unison, the greater the risk is to delivery. We think that airspace changes should be broken down into groups or modules and ordered into a sequence, with those that are key enablers for Heathrow expansion, being noted as critical.
What is our view on NATS findings about the likely removal of stacking and other noise benefits brought about by modernisation? (8)	The Arrival Management concepts that are relied upon in the concept to remove stack holding require the cooperation of neighbouring States' ANSPs to help manage inbound traffic flows. We would like to understand how mature the engagement with neighbouring States' ANSPs is and what formal agreements need to be in place. The expected reduction in the operational need for stack holding is likely to have beneficial noise impacts however, the main noise benefits (and dis-benefits) associated with the concept come from the repositioning of flight paths at lower altitudes. The extent of environmental benefits generated by the removal of stack holding is still to be quantified.

Table 2: Summary of the questions asked by DfT as part of the assurance review and our views

2. CAA's overall view of the report

General overview

2.1. Our overall view of the report is that NATS has engaged well with the airports and developed an innovative new concept to tackle the airspace capacity challenges facing the South East, which could deliver many positive outcomes. NATS has usefully commenced a complex piece of work. At this early stage and based on the evidence provided in the report, we cannot fully assure that the concept is deliverable. We have therefore recommended next steps for NATS (summarised in table 1 above) that we believe, working in collaboration with the airports, would help produce a more mature concept on which we could provide more definitive assurance.

2.2. The main technical features of the concept are closely aligned with the UK's draft Airspace Modernisation Strategy (AMS) and the Single European Sky initiative. The widespread use of Performance-based Navigation (PBN), greater systemisation to minimise tactical air traffic control and the reliance on sequencing tools to space traffic are considered essential steps in the modernisation of the busy terminal airspace.

2.3. The report's major finding is that with further refinement, a future version of the concept "<u>can</u> provide the airspace capacity required to meet airports' growth aspirations." This is certainly supported by the estimates in the report about the capacity gains that could be delivered by the tube concept in relation to airports' 2030 growth aspirations. However, we tend to agree more with the Analytics section of the report that is more cautious, concluding that ''further refinement to the letterbox positions, the concept of operations, and the tube positioning algorithm are required to successfully demonstrate <u>whether</u> future UK airspace demand can be met with this concept."

2.4. The concept aims to redesign the South-East airspace so that aircraft can automatically follow a large number of dedicated arrival and departure routes between 9000 feet and either the boundary of UK airspace or the proposed base of Free Route Airspace (assumed to be at FL310).

2.5. The concept requires that all routes are procedurally separated and do not interact with one another so that:

- All airports can release traffic into the network without reference to, or dependency on any other airport (known as free flow departures); and
- In normal operations, controllers are not required to manage the airspace tactically (i.e. by routinely directing pilots to vector aircraft as they do today).

2.6. We agree that free flow departures from all airports should be a key objective of the airspace modernisation programme. Removing tactical interventions and designing a network with such refinement that all routes are isolated from any interaction with one another is known as 'systemisation'. Aircraft would use their navigation capabilities to accurately fly the routes following a series of horizontal and vertical restrictions that effectively contain their flight paths within dedicated 3D tubes. The tubes would be designed to climb and descend continuously, generating per flight fuel burn and emissions savings, providing there is no increase in total track miles.

2.7. The concept allows airports to take full responsibility for designing their local arrival and departure routes from the ground to 9000 feet, to include the airspace up to 7000 feet as they have in the past but also to include another 2000 feet, i.e. the airspace in which these routes interface with the tube network design. These interfaces, known as letterboxes, provide a method of managing the airspace design requirements of individual airports. The size of some letterboxes may be reduced and others may be removed in future iterations of the concept as airports coordinate their low-level airspace designs and route options between the ground and the tube network become clear.

2.8. The overall goal of the concept is that airspace capacity should not be a constraint to aviation growth and that any limitations would instead come from the number of runways and the restrictions on their usage. The extent to which the concept is future proof in terms of increasing runway capacity should be made clear as, once it is in place, all future developments to airspace infrastructure that impact the South-East airspace will need to build upon it. For example, should a new runway receive planning permission between now and 2030 to be built in future years, it is unclear whether the associated traffic would be able to feed seamlessly into the tube network or if another network-level airspace change would be required.

2.9. The progress made by NATS to apply a data driven approach to large scale, network level airspace changes, is encouraging. We agree that computer modelling can be used to enhance network level airspace change proposals by adapting and optimising many potential options based on a broad range of stakeholder inputs and criteria. Traffic demand data and route separation criteria are the main inputs used in the modelling presented in the report. In the next phase of work, a broader and more qualitative set of inputs will need to be added, including data from different airspace users about their requirements for access to the airspace, and the design principles that sponsors must develop through engagement with stakeholders in stage 1 of the airspace change process. It should be recognised that some airspace users are likely to have conflicting requirements, leading to difficult trade-off decisions about the use of airspace that cannot be fully resolved through a mathematical model.

2.10. We believe that NATS' engagement with the airports during the production of the report has helped to strengthen the industry's commitment to work together and understand their respective roles in airspace modernisation. The use of letterboxes to connect the airports' local routes with the wider tube network may ultimately become a constraint to optimising the performance of the overall airspace (see section 4 of this review). However, the request for airports to consider the initial position of their letterboxes has become an important aspect of the engagement process, prompting airports to consider the impacts that airspace modernisation will have on their operations at lower altitudes and the compromises that will be needed in the next phase of work. The progress made by the London TMA Airports Working Group[3] that NATS have worked with closely to develop the concept, is evidence of a more expansive and collaborative approach to airspace design.

2.11. We would like to see similar levels of engagement with the airspace user community. Commercial, Military and GA and airspace users are identified as stakeholders that will

[3] The LTMA Airports Working Group is attended by Heathrow, Gatwick, Stansted, Luton, London City, RAF Northolt, Biggin Hill, Farnborough and Southend airports and NATS

be required to participate in the airspace design process. For Level 1 changes (those that will affect the distribution of traffic below 7000 feet) communities must also be engaged and consulted. It is critically important that NATS gather feedback from all airspace users on the key features of the concept before moving into the design phase. Some of the standard procedures and avionics that commercial users have relied on for many years to operate safely and efficiently in the busy South-East airspace will need to change to support the concept. *We suggest that the chief technical pilots from leading UK and international airlines are engaged as a priority to validate the concept from a flight operations perspective*.

2.12. The South East is home to a thriving GA sector. The concepts proposed in the report may have a range of impacts on GA activities, for example light aircraft wishing to transit controlled airspace, sports parachuting that requires pre-notification of segregated airspace and gliding activities that routinely operate at higher altitudes. *We suggest that the GA community are engaged as a priority to better understand the impact of the concept on their operations.*

2.13. More advanced GA and Business Jet operators may require access to the tube network. The report briefly refers to minimum equipment specifications necessary to use the tube network and the possibility of providing less efficient corridors for aircraft that are not adequately equipped. *We suggest the concept should be underpinned by a clearer description of the expected avionics capability of the airspace users wishing to use the tube network from 2025 onwards and greater clarity on minimum equipage standards.*

2.14. NATS is working closely with the CAA and MoD to ensure that Military users retain access to suitably sized and sited areas of segregated airspace to conduct their operations. The report mentions that the tubes will route around segregated areas used by the Military (and possibly through them), but it is not clear if this has been incorporated into the current model. *We suggest the next phase of work includes a close examination of the implications for the tube network in avoiding segregated areas that can be activated and deactivated by the Military at short notice, and the effects on Military users transiting to and from those segregated areas.*

2.15. The report suggests that, if approved, the concept should form the framework for airspace design work to be undertaken by NATS and the airports. Although we agree that the concept should form the basis of such design work, before any form of approval is given we think it is necessary to evidence and validate clearly some of the key assumptions underpinning the concept before the Government or the CAA could provide any form of "approval". From a regulatory perspective, it will be the airspace change process which would have to be followed in the next phase of work, that will ultimately result in a regulatory decision on approval to deploy all or part of the concept.

Key assumptions

2.16. Our assurance review has identified five key assumptions that underpin the concept and modelling, which we think require further analysis in the next phase of work to demonstrate that they are reliable. Our view of these assumptions is described below.

Assumption 1: That the 3D tube concept can deliver the additional capacity required to meet airports' growth aspirations by procedurally separating all tubes.

2.17. We believe that further development is needed before the model can be proven to meet this assumption. NATS created two variants of the model. One for easterly operations and one for westerly. In the first round of modelling, none of the easterly tubes and only three of the westerly tubes were procedurally separated. In total, there were around 40,000 intersections between tubes. The objective of the concept is zero intersections. A very high density of tube intersections occurred between 9000 feet and 16,000 feet because of the complexity caused by the positioning of airports' letterboxes. In the second round the model was revised to reduce the overall number of tubes by grouping those with similar entry and exit points. The number of easterly tubes was reduced from 915 to 667 and the number of westerly tubes from 908 to 658. As a result, the total number of intersections was broadly halved to around 20,000, but only a small number of tubes (c.30 out of 600+) were separated by design. We believe it is NATS' intention to continue refining the model so that it can separate many more tubes. We welcome this work, as one key aspect of it will be essential to prove the concept. Namely, the current model does not allow for the tubes to turn or to level off – these are major constraints to the algorithm used to separate the tubes and optimise the network and should be addressed as a priority in the next phase of work. Our view of the modelling approach is explained in more detail in section 3.

2.18. The report concludes that the number and capacity of the tubes in the revised model is more than sufficient to meet the forecast demand. We believe it should be clearly stated that this calculation assumes that all tubes will be separated during a further phase of work that was not complete when the report was delivered.

Assumption 2: That the letterbox positions determined by the airports to connect their local routes below 7000 feet with the tube network from 9000 feet upwards can be safely and efficiently separated.

2.19. This assumption has yet to be proven because several of the airports' preferences for the positioning of their letterboxes to support the model could not be accommodated. Over 60 (32%) of the letterbox locations provided by the airports to inform the modelling were not adequately separated from other letterboxes (i.e. by more than 4 miles horizontally). As a result, around 28 (14%) of the letterboxes were moved manually by NATS analysts and four (2%) were removed from the modelling altogether. We understand that at this early stage in the programme that the airports determined their letterbox positions in isolation and with little knowledge of the other airports' requirements, or with the appropriate stakeholder engagement required by the airspace change process. The report highlights the importance of collaboration between the airports and the likely need for compromises to be made regarding the final positioning of letterboxes to ensure that they can all be accommodated. It is unclear at this stage whether the collaborative approach will be enough to reach a compromise agreement on letterbox locations that are environmentally sustainable, operationally efficient and commercially viable for the airports and suitably reflect the views of those stakeholders engaged through the airspace change process. Our view of the positioning of letterboxes is explained more fully in section 4.

Assumption 3: The assumption that aircraft flight paths can be vertically contained within a 3D tube.

2.20. We think that more information is required to demonstrate the reliability of this assumption. The concept described in the report could go further to specify what a 3D tube *is* in terms of aircraft avionics, instrument flight procedures or flight planning. We assume that a 3D tube is a defined geometric path. For example, on a Final Approach procedure a geometric path is defined using a Vertical Path Angle (VPA) whereby an aircraft's Flight Management System (FMS) is coded to descend at a certain gradient.

It is our understanding that avionics will need to be developed to allow for the coding of descent gradients in this way outside of the Final Approach procedure. This is also the case for avionics capability to define a geometric path for a departure procedure.

2.21. NATS has advised us that it is possible for an aircraft's FMS to fly a defined geometric path on departure, and it is useful that NATS has started discussions with aircraft manufacturers to better understand the limitations of the existing fleet's avionics and the timescales for making improvements. The vertical aspect of the tubes will need broad tolerances on departure to allow for differences in climb performance and FMS operations across aircraft types, which the report acknowledges is currently poorly understood. As technology develops and FMS operations are better understood, the report expects that it will be possible to systemise vertical constraints without the need for controller intervention and allow the separation between tubes to be reduced. *We think that the report should offer further detail about how the dependency on new aircraft avionics that support vertical containment within a tube will be managed. This should include more details about short-term mitigation strategies that may enable vertical containment by other means*. Further details on the management of vertical containment should include how vertical restrictions will be implemented, the expectations on aircraft conformance to multiple standard constraints, and how the use of speed constraints would work within the concept because of their potential to add to the difficulties of vertical containment.

2.22. The report could also go further to describe how the management of an aircraft's vertical reference below, through or above the Transition Altitude (TA) will be achieved in the concept. A joint project conducted by the CAA, NATS and MoD in 2014 concluded that harmonisation of the Transition Altitude at a significantly higher level (e.g. 18,000 feet) was necessary for airspace modernisation in the South East to manage the complexities and route interactions. *We would like further detail as to whether harmonisation of the TA at a higher level is still a requirement in the concept proposed in the report. If not, the report could be updated to include a description of how an aircraft's vertical reference below, through or above the TA will be managed at the existing level of 6000 feet.*

Assumption 4: That deployment of the concept will have the general effect of reducing noise at lower altitudes and generate environmental benefits for local communities.

2.23. The assumptions made in the report about noise and environmental benefits show that environmental considerations have fed into NATS' thinking. We would like to see more evidence on the specific nature of the benefits, and we think that to be transparent, it is important that a description of the benefits be balanced with a description of the potential for airspace modernisation to create negative environmental impacts. The main goal of the concept is to increase airspace capacity to meet airports' growth aspirations. The report should be clear that the assumptions about aircraft noise and emissions savings are made on a 'per flight' basis. Although the concept offers new opportunities to mitigate some of the environmental impacts of aviation, the absolute levels of aircraft noise and emissions may increase with airspace modernisation because it enables traffic growth that would not otherwise occur. We say 'may' increase because evidence about the nature of the future fleet and its noise and emissions levels may show otherwise – further analysis would be helpful in this respect.

2.24. The report suggests that the risks associated with implementing the concept are "outweighed by the improvements that can be delivered in terms of noise and environmental benefit for local communities". The assumed noise or environmental impacts linked to the concept or the modelling must be demonstrated as part of the concept implementation through the CAA Airspace Change Process. A high-level target is included for fuel savings which equates to a 10% to 20% improvement in emissions, but it is not clear on how the figures are derived. We agree that the concept is likely to enable more environmentally efficient continuous climbs and descents, but it is unclear to what extent the procedural separation of tubes aligned to letterbox locations will result in additional track miles for aircraft.

2.25. The concept proposed is based on the widespread use of PBN routes that improve aircrafts' track keeping accuracy and allows more routes to be established in the same volume of airspace – supporting the introduction of additional capacity. The report refers to the use of PBN offering the airports "more choice in designing route options that support local community needs." We agree with NATS that the precision and flexibility offered by PBN creates opportunities to design routes that avoid population centres and noise sensitive areas. PBN also supports the provision of noise respite by increasing the potential to vary the routes flown at lower altitudes. However, the assumptions about the environmental benefits enabled by PBN must include a consideration of the potential to cause redistribution or concentration of aircraft noise that can have a negative impact on the communities effected – even when the goal of the change is simply to replicate a long-established route centreline.

Assumption 5: That a version of the concept proposed in the report can be implemented in the South East between now and 2025 by all airports and NATS working concurrently.

2.26. The report could be more explicit about the version of the concept that is proposed for deployment in 2025. Some features of the concept are linked to the next generation of aircraft and avionics that may take longer than six years to reach maturity. Any concept deployed in 2025 will need to include a new network of arrival and departure routes above 9000 feet that can turn and level off and are procedurally separated in the horizontal plain using PBN. The concept in NATS' report does not yet deliver this, although we understand that further work is in progress. To make the concept work, vertical separations between the routes would be achieved by controllers tactically managing the climb profiles of each departure. Inbound traffic would need to be sequenced more effectively into the tube network through the wider use of Arrival Management (AMAN) tools beyond Heathrow. Based on the current approach in the report, we think that some airborne holding will still be required in normal operations to maximise runway throughput at increasingly capacity constrained airports. The timescales and dependencies associated with deployment of conformance monitoring tools to support the tactical management of vertical separations and AMAN tools to support the sequencing of inbound traffic are not described in the report. *We think that the next phase of work should explain all the features of the concept to be deployed in 2025 in full and set out the requirements for airspace design, new systems and tools, changes to operational procedures and controller retraining as a single joined-up programme.*

2.27. The report suggests that all relevant airports and NATS should work concurrently to develop and deploy the required airspace changes by 2025, meaning they would all undertake the design phase and the consultation phase at once, resulting in one package of coordinated airspace change proposals submitted to the CAA. We assume this means that implementation would not be concurrent, i.e. the changes will be phased in, but would all be approved in advance of the first phase. The report did originally say which of the airports must undertake airspace changes to specifically enable Heathrow expansion or the implementation of an efficient tube network more broadly. The addendum NATS delivered on 30 July 2018 suggested that of the 15 airports where airspace change is needed, seven of these are essential to Heathrow's third runway (meaning nine airspace changes in total, including Heathrow's own and NATS'). It is important that there is a coordinated approach to presentation of proposals to impacted stakeholders and we welcome the ambition of coordination in NATS' report. However, the greater the number of airspace changes that are co-dependent and happening in unison, the greater the risk is to delivery – as any one airspace change could hold up all the others. We are concerned that if one airspace change sponsor fails any individual regulatory gateway, all the changes will be held up. If such a delay were to continue for an extended period of time or lead to significant rework, those sponsors that did pass the gateway may be asked to revisit their work. We think that the sequencing of airspace changes should be broken down into groups or modules, with those that are key enablers for Heathrow expansion, being noted as critical.

2.28. We also believe there is a risk that the resources and capabilities required to design airspace are in limited supply. A concurrent approach would exacerbate the peaks in demand for resources by concentrating the dependencies on a limited number of airspace specialists into the same time windows. A sequential approach, with all airports and NATS working to a common timeline, may be more effective at spreading the peaks in demand for specialists. A sequential approach may also be used to better manage the dependencies on regulatory resources, who are required to assess consultation materials and validate proposals from all sponsors.

3. Our view of the modelling approach

3.1. We have reviewed the modelling approach undertaken to develop the concept so far and test the associated capacity improvements.

3.2. NATS Analytics modelled the tube network using data requested from 15 airports. The airports were asked to predict their growth rates out to 2030 and provide data based on this forecast, including letterbox positions, runway positions and departure and arrival schedules. For airports that did not provide 2030 schedule data, the busiest date over the summer period was identified and grown either by the forecast growth rate, airport master plan or NATS internal forecast. If letterbox positions were not provided by the airport, then locations were chosen based on the airport's current route structure. Any letterbox position found to be in close proximity with other airports was manually relocated to be at least 4 miles apart. If this could not be achieved, they were removed from the model.

3.3. The report outlines that data was received from 12 of the 15 airports and this data was deemed to be of sufficient quality. As a data driven approach has been used to assess the viability of the concept, it will be important to define what "sufficient" means and in due course to explain the process used to assess the quality of the data. In the next phase of work, it may also be useful to include details of:

- Any guidelines/templates issued to the airports, which would help ensure data was received in a common format and was to a pre-determined level of accuracy;
- An explanation as to how the airports decided on the position of their letterboxes and how these positions were validated by NATS; and
- The methodology used to determine letterbox positions for the airports that failed to provide data.

3.4. It is also worth noting that whilst this data driven approach is an effective way of testing a concept, the actual design and positioning of the letterboxes will not be driven by traffic data alone. One of the earliest activities in the CAA's airspace change process is the development of qualitative design principles, which must be developed through two-way engagement with stakeholders. Where an airspace change is expected to change traffic patterns below 7000 feet, noise is an environmental priority (as per the Air Navigation Guidance 2017) and the CAA requires that communities are engaged.

3.5. For the 15 airports combined, the report states that the modelling sample provided a 4.1% average annual growth, which is higher than the NATS 2017 UK Base Case Forecast of 1.2% per annum and the DfT's 2017 UK Aviation Forecast of 1.1% p.a. over the same period. This is explained by the much smaller number of airports included on the forecast sample and is based on airport's own growth aspirations.

3.6. The vertical profile of the tubes in the network model was determined by analysing aircraft performance using EUROCONTROL's Base of Aircraft Data (BADA). The tubes were grouped into three categories; low, medium and high performance.

3.7. NATS Analytics then developed a tube positioning algorithm called the BATTENBERG to separate the tubes vertically and laterally. The BATTENBERG algorithm consists of three modules; a tube model builder, an intersection test and the tube positioning algorithm. As the BATTENBERG tool has been developed in-house it is important that

NATS provides assurance that a robust validation process has been carried out. Consideration should also be given to demonstrate how data integrity is ensured and what quality checks are performed. We think a flow diagram might help to show the analytical process and clarify what each BATTENBERG module is used for and how they interrelate. In addition, all diagrams, charts and maps in Annex A and Annex A.3 should be enlarged and enhanced with data tables if necessary. For example, Figure 8 and Figure 14 are difficult to read. It would be clearer if the results of the BATTENBERG runs were displayed in a table.

3.8. The BATTENBERG tool uses an iterative method to make changes to the model from a pre-defined set of movements until no further improvements can be made. We think the report should include evidence to show that an adequate audit trail is recorded, and to explain which, if any, of the iterative designs are accessible for review.

3.9. A spatial analysis package (SHAPELY) is used to construct the polygons that support the modelling. This is done in the cartesian plane.[4] Transformation errors may occur when converting from *cartesian (2D)* to *geographic (3D) environment*. It should therefore be made clear in the report that the modelling is used purely for proof of concept and that a rigorous safety process will be undertaken to ensure all routes are safely separated before being implemented.

3.10. We understand that NATS is currently making several changes to the model to prove the concept that a procedurally separated tube network can accommodate the forecast traffic demand and airspace will no longer be a capacity constraint. The changes include:

- Introducing additional functionality that allows the tubes to turn and level off.
- Lowering the position of some of the letterboxes to 7000 feet and introducing a waypoint at 9000 feet that can be moved to introduce more flexibility.
- Merging lower demand tubes (77% of the tubes in the current model would serve fewer than 10 flights per day).

3.11. The report states that the methodology used to prove the concept started with the optimum number of tubes and then proceeded to separate them. This is clearly a very complex task and to date has not been completed. We think it would be useful to include details of any other methodologies that were considered to prove the concept and the reasons why they were discounted. For example, was an option considered to start with the minimum number of tubes required to meet the forecast demand and then to increase the tubes until they can no longer be separated?

[4] A Cartesian plane simply specifies each point uniquely in a 2D plane using a pair of numerical coordinates.

3.12. As the model is developed further it will become more complex. *Decisions made using the analytical modelling outputs and the implications of those decisions should be supported by a clear audit trail, especially where there are inputs from multiple airspace change sponsors. We also think the model's functionality, maintenance and the translation of its outputs will need to be well-resourced by NATS during the next phase of work, particularly if the airports are to become more reliant on its use to inform their own airspace developments.*

4. Our view of letterboxes and their impact on flight path options

4.1. This section considers NATS' conclusion that the positioning of letterboxes would not unreasonably constrain airports' flight path options and therefore the distribution of noise on the ground. The goal of the concept is to introduce the airspace capacity required to meet airports' growth aspirations without constraining the choices available for routes at lower altitudes below 7000 feet, where noise is the main environmental concern. The modelling shows that some of the airport's preferred routes up to 9000 feet overlap and imply the need for some compromise on the initial proposals. The report could further elaborate on the scope and nature of these compromises and how they should be achieved.

4.2. All airspace change sponsors are bound by the same requirement that noise must be the primary environmental factor of concern below 7000 feet. This means that any airspace change – at any height, from any sponsor – that impacts on traffic patterns below 7000 feet is a 'Level 1' change. Level 1 changes must be designed i) through engagement and consultation with a wider range of stakeholders, including communities and ii) with regard to noise data and WebTAG analysis that should compare the total adverse health effects of the different design options. If NATS' network airspace design applies any constraints on how airspace below 7000 feet will be designed, then NATS will be designing a Level 1 airspace change. The inclusion of the letterbox feature in the concept aims to introduce a buffer between the network design above 9000 feet and routes designs below 7000 feet. Airports will be required to develop airspace change proposals to connect routes through the letterboxes with the tube network using new PBN procedures. Airports will design how best to deploy PBN routes. Airports may decide to replicate existing routes, design new routes, or deploy multiple route options to offer noise respite to some communities. We understand from NATS feedback that when the network and airport designs are finalised the intention is to link the two, by aircraft flying on a continuous climb or descent connecting route between the end of the airport routes at 7000 feet and the relevant network tube starting at 9000 feet.

4.3. We expect that the final number and location of letterboxes that connect each airport's routes will ultimately be determined by the output of stakeholder engagement, options appraisals and consultations on flight path options conducted as part of the airspace change process. The information submitted to NATS by the airports about the numbers and locations of letterboxes that they expect will be required by 2030 is therefore indicative, and provided only to inform the modelling. We are aware that airports have been asked to provide more information about the numbers and locations of letterboxes that connect their routes below 7000 feet with the tube concept to inform the next phase of modelling. However, we would emphasise that the airspace change process is an iterative one, and the actual routes and therefore letterbox locations will not be known until stage 5 of the process (at which the CAA makes a decision based on a firm proposal) is complete and the change approved. Airports should be aware that their process for changes below 7000 feet may be put at risk if airspace design information provided in advance of the proposal has the effect of fixing letterbox locations for the routes in question.

4.4. The sequential relationship between designs above and below 9000 feet will require careful management. NATS should progress the concept and modelling on the understanding that the final positioning of letterboxes cannot be fixed until the iterative airspace change process results in an approved proposal. We understand that NATS hoped to avoid this sequential challenge by working with sponsors to develop all airspace changes at once, but that approach presents other challenges, as noted in this report.

4.5. It is reasonable to assume that as the concept is refined, the preferred position of some airports' letterboxes may constrain certain flight path options for other airports. We understand from NATS that the next stage of modelling will include reducing the height of the letterboxes to 7000 feet to reduce the potential for interactions between neighbouring airports. But the report notes that, 'in order to prevent noise concentration' limitations will need to be placed on letterbox locations where there is a confluence of low level routes.

4.6. The position of letterboxes and flight path options may also be constrained by the design requirement proposed in the report that the total volume of controlled airspace will not increase through modernisation. It is conceivable that some routes and associated letterboxes may require the introduction of additional controlled airspace. Should this result in an increase in the total volume of controlled airspace, there will need to be a trade-off between different airspace users..

5. Alignment with the airspace change process and Air Navigation Guidance

5.1. This section considers how the concept can be applied by airspace change sponsors with the existing airspace change process (sometimes called the ACP process), including following the government's Air Navigation Guidance 2017.

5.2. The report suggests that 'innovative data and computer modelling' should be used to support airspace design activities and 'deliver the best possible proposal that will then be subject to the ACP process.' It is our view that the best possible proposal will be established *through* the airspace change process, rather than be subject to it once delivered. This is an important distinction. The airspace change process is an iterative design process, in which options are refined and reduced in number through stakeholder engagement and an increasingly detailed evidence base. At this stage, it is unclear what inputs the airspace change sponsors will need to provide into the computer modelling and how this approach will align with the requirements for ongoing stakeholder engagement, options appraisal and consultation set out in the process.

5.3. In general terms, the airspace change process guides sponsors to create a broad range of high-level airspace design options. These options are evaluated against design principles which have been pre-agreed with local communities and aviation stakeholders. The options are also refined through initial, full and final appraisals that take an economic approach to capturing the broad range of costs and benefits, including the health impacts of noise. The CAA checks that the sponsor is adhering to the process by requiring evidence at key 'gateways', which can only be passed when the CAA is satisfied by the evidence.

5.4. The data driven approach proposed in the report focuses on quickly refining successive iterations of a computer-generated design by regularly refreshing the inputs from the sponsors through monthly 'design sprints' until a final design begins to form. This is an innovative approach that we believe has the potential to strengthen the airspace change process and its outcomes. However, we do advise NATS and the airports to carefully consider how such a data driven, sprint based, iterative design process remains aligned with the airspace change process requirements, that must be met for any of the individual airspace change proposals to progress.

5.5. The report refers to 'Macro' and 'Micro' gateways that do not currently feature in the process and are described as 'beyond' the current requirements. We would like to see further detail on the purpose of these additional gateways and whether they have potential to limit flight path options at later stages in the process. The report suggests that approach transitions are to be included in the Macro gateway and departure procedures in the Micro gateway. We would like to understand how the options appraisals required by the airspace change process will be used to support the submissions at either a Macro or Micro gateway. The rationale for separating arrival and departure procedures into separate gateways is not provided.

5.6. The report notes that there will be noise reductions from fewer aircraft being held at lower levels, and through continuous descent and climb operations. The report also notes that airports will be able to design a number of flexible routes that take aircraft up to 9000 feet. The potential for a flexible number of routes means that respite routes may be possible. Together, these changes <u>in principle</u> support current government policy set out in the Air Navigation Guidance on limiting and where possible reducing the number of people significantly affected by noise. For the policy to be met in practice as well as principle, further work is needed. There are two further considerations:

- The increase in traffic might mitigate the noise improvements offered by the concept. Further work would need to be done to determine this. The government is aware that growth in traffic may increase noise and is considering this through its Aviation Strategy.
- As the concept is developed, if the design of the tube network does create the potential to generate noise impacts below 7000ft, for example by constraining one or more of the letterbox locations, NATS will need to accompany the airports in consulting with affected communities, as part of a Level 1 change explained in section 4 above.

5.7. Finally, designing and regulating a high number of airspace changes in unison will create new risks that would not apply to individual changes. This is discussed in more detail elsewhere in this report.

6. Core airports required to change

6.1. This section summarises our view on the minimum group of core airports’ in the South East that must take forward airspace changes to deliver the core benefits of the programme.

6.2. The report concludes that the densest area of tube intersections occurs in airspace between 9000 feet and 16,000 feet and was proximate to the LTMA[5]. We would like to see more detail on where the main interactions are, which airports are most affected, which of the letterboxes were relocated or removed from the model, and how this would impact on the core group of airports that must take forward airspace changes. We think including information on the busiest “tubes” and which airports they serve would also help in determining the minimum group of core airports that must take forward airspace changes.

6.3. The map in Figure 1 shows approximately how routes associated with the 15 airports interact up to 9000 feet assuming 5% minimum climb gradients from Heathrow and Gatwick and 8% from the others airports.

Figure 1: Map representing the extent of airport airspace interactions up to 9000 feet

6.4. In the addendum provided by NATS on 30 July, Farnborough are included in the core group of airports along with Heathrow, Gatwick, Northolt, Luton, Stansted and London City. Consideration should also be given to including Southend, noting that Ryanair will

[5] LTMA - London Terminal Manoeuvring Area

be opening a base there in April 2019 alongside easyjet's operations. Biggin Hill is situated below existing controlled airspace. Should Biggin Hill's future aspirations change, then suitable coordination with NATS will be required. In our view Southampton and Bournemouth are situated far enough away to deconflict their flight paths below 9000 feet from other airports, however we agree that they should be included for maximum network optimisation. It would be sensible for East Midlands and Birmingham airports to be included in the wider modernisation programme for optimal efficiency as part of Terminal Control Midlands airspace, but this would not be essential and therefore these airports would not be considered within the core.

6.5. Any modernisation of the network above 9000 feet for Cardiff and Bristol would be expected to fit with the wider network modernisation, however the South-East airspace modernisation is not considered to be dependent on changes below 9000 feet at these airports.

7. Coordination and sequencing of implementation

7.1. This section summarises our view on the feasibility of NATS' proposal for all airports involved in the programme and NATS to undertake their airspace changes concurrently, compared to an ordered sequential approach.

7.2. We agree with NATS' view that changes to optimise the overall airspace design will involve significant dependencies between sponsors. We think their assertion that 'as a result of these dependencies all airports and NATS should be required to conduct statutory airspace consultations concurrently and submit one single ACP', is too ambitious and that other solutions should be considered. The proposed requirement for absolute alignment, commitment and transparency across the industry is unlikely to be achievable. We think greater flexibility should be introduced into the next stage of programme planning to mitigate for the risks of misalignments, a lack of commitment, and potential constraints to absolute transparency caused by the conflicting commercial interests of the airports and Air Navigation Service Providers (ANSPs) involved.

7.3. Designing, consulting on and assessing a high number of airspace change proposals concurrently will create new risks that would not apply to individual or smaller groupings of proposals progressed in an ordered sequence, in particular:

- The risk that if one sponsor fails any individual gateway of the airspace change process, all changes will be held up. This includes the gateway to consultation, and would also apply if the consultation was not successful, either for process or technical reasons, and had to be revisited.
- The risk that sponsors do not have the collective capability, willingness or incentives to align to a single consultation window.
- The risk that running all consultations at concurrently will be unwieldy and confusing to stakeholders, especially where the affected areas overlap.
- The risk that the limited number of resources available to design airspace and prepare consultation materials will be stretched across all sponsors and the regulator at peak times during the process.

7.4. The greater the number of airspace changes that are co-dependent and happening in unison, the greater the risk is to delivery. A modular approach of smaller groups would reduce the risks. Our view is that the changes should be broken down into groups or modules, with those that are key enablers on which Heathrow's new runway is dependent being noted as critical.

8. Stack holding and the impact on noise

8.1. Low level stack holding is the preferred method of operation today to manage arrival delay when runway demand exceeds the capacity available at that time. The capacity of the runways with high demand for their slots have been managed by building in an average delay criteria to maintain a consistent demand pressure on the runway and allow air traffic controllers to manage the arrival stream to deliver an efficient flow onto the runway. In the current operation, this has proved to be a highly efficient method to maintain runway throughput but is not environmentally efficient, with both fuel burn, emissions and noise impacts.

8.2. The concept proposed in the report is expected to make use of new systems and tools, typically referred to as Arrival Management, AMAN or XMAN – where the capability crosses State boundaries. These new systems allow controllers to manage the flow of inbound traffic to a capacity constrained airport from much further away, to provide time for the arrival delay to be absorbed in the en-route phase of flight through management of the aircrafts' speed. Arrival Management is a more operationally and environmentally efficient way to absorb arrival delays that stack holding, providing that the required levels of runway throughput are maintained.

8.3. The systems and tools required by ANSPs to support this method of operation such as extended arrival management (XMAN), Demand and Capacity Balancing and a greater focus on "on time arrival" are all being developed. We agree with NATS that they could be useful solutions. At this stage in their development, greater confidence in their ability to deliver in the envisaged highly systemised environment is needed. The ability for these capabilities to provide resilience in the operation needs to be demonstrated, as well as how the concept would operate in periods of reduced capacity such as a runway closure or weather events.

8.4. Some low-level contingency holding capacity would likely need to remain in place close to airports. The positioning of these holds will be challenging in a systemised operation if it is intended to maintain that systemised approach during periods of constrained capacity. There may be other methods of low level contingency holding that are being explored through PBN research projects, but these are lacking maturity at this stage.

8.5. We would recommend that NATS develops a demonstration of arrival management in various testing scenarios, to explain to airport and airline operators the intended concept of operations and how this might work in periods of constrained capacity. The Network Management Function in Eurocontrol must also be part of this demonstration.

8.6. The Arrival Management concepts that are relied upon in the concept to remove stack holding require the cooperation of neighbouring States' ANSPs to help manage inbound traffic flows. We would like to understand more about how mature the engagement with neighbouring States' ANSPs is and what formal agreements need to be in place. The expected reduction in the operational need for stack holding is likely to have beneficial noise impacts. The main noise benefits (and dis-benefits) associated with the concept come from the repositioning of flight paths at lower altitudes. The extent of environmental benefits generated by the removal of stack holding has not yet been quantified.

9. Other observations

9.1. This section offers some concluding comments and other observations on the report that we would like to raise following our review, which may be of use to NATS in the next phase of work.

9.2. The CAA and DfT are co-sponsors of the UK's airspace modernisation programme. The CAA is obliged (through the Air Navigation Directions 2017) to deliver an Airspace Modernisation Strategy and to report annually on the progress of the airspace modernisation programme. The final governance arrangements to support this will be agreed later this year, once the CAA has reviewed public engagement responses to the draft strategy. The final arrangements will ensure the co-sponsorship role is separate from airspace design work, in which the CAA and DfT cannot participate as they have decision-making roles on the airspace design proposal. The report was completed whilst work was still ongoing on the CAA's AMS and the CAA/DfT/NATS work on airspace governance (as noted in the report). At this stage it is broadly aligned with the strategy and governance, but some refinements to NATS' programme proposals may be needed once they are finalised.

9.3. In the draft strategy, the CAA notes that they are "considering whether to task an industry group or other organisation with developing a nationwide strategic roadmap that would set out where airspace design changes are needed having considered … the factors in Section 70" (see paragraph 6.7 of the draft AMS, CAP 1690). We also note that any potential strategic roadmap that is developed would have to take current coordination work into account. For example, it might build on any roadmap that is developed for the FAS Implementation (FASI) North and South developments whilst cognisant that the CAA's strategy deals with a broader range of factors and a longer timeframe.

9.4. One of the most important policy deliverables for airspace modernisation in the South East is Heathrow's third runway. We understand that Heathrow plans to submit its Development Consent Order (DCO) submission to the Planning Inspectorate in the first quarter of 2020. This will trigger a time-limited examination process and subsequent decision by a Government Minister on whether to grant consent, currently estimated to be towards the end of 2021. When Heathrow makes its submission, it is important that there is a credible plan for delivering the necessary airspace reform and that this plan is on schedule for delivery by the time the runway will be in use. The report suggests that all airports and NATS should consult on their constituent airspace change proposals in August 2020. We are not sure that this timeline aligns with Heathrow's own timeline for their airspace change process, nor (as noted earlier in the report) that it accounts for specific airspace changes necessary to enable Heathrow's change, and the risks of delay to any of those. A clear roadmap of airspace changes that are necessary to enable Heathrow's third runway therefore remains essential. We would encourage NATS to be clear what is required as a minimum to deliver R3 and an assessment of whether this is compatible with the wider plan for modernisation in the SE or poses certain trade-offs and conflicts.

10. Conclusion

10.1. In conclusion, the CAA is supportive of the ambition to modernise the airspace and deliver capacity to support airports growth aspirations in the South-East. NATS' engagement of airports and foresight in thinking conceptually about a future airspace network is impressive. The extent of this task should not be underestimated. The feasibility report from NATS was created before the conceptual work has been completed. It is understandable that further work is required and is already underway to demonstrate the feasibility of deploying this concept. This assurance report has offered specific recommendations as to what the next stage of work should usefully address, to better investigate and evidence the proposed concept.

10.2. Although this next stage of work is already under way, our concern remains that the timeline of deployment looks to be too ambitious. We would like to see a more realistic proposal that takes account of the number of co-dependent sponsors, the Heathrow R3 DCO process, aircraft capability upgrade timeframes and the deployment of enabling systems and tools for air traffic controllers.

10.3. The CAA would like to remain engaged as the concept matures, to help ensure continued alignment with the Airspace Modernisation Strategy and programme.