West Airspace Deployment L6203

London Airspace Management Programme 2, Deployment 1.1

ACP-2017-70

Gateway documentation:
Stage 3 Consult

3A Options Appraisal (Phase II – Full)

Roles

Action	Role	Date
Produced	Manager Airspace Change Compliance & Delivery NATS Directorate of Airspace & Future Operations	29/07/2021
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Issue	Month/Year	Changes this issue
1.0	July 2021	Initial version submitted to CAA for Stage 3 (August 2021) gateway.
1.1	August 2021	Updated cost benefit table page 13
1.2	August 2021	Updates to WebTAG data outputs

Contents

1. Introduction

This Airspace Change Proposal (ACP) is sponsored by NATS. Today's air traffic services (ATS) route network has evolved over time and does not exploit modern navigation technology. The objective of this project is to update the route network in accordance with the CAA's Airspace Modernisation Strategy (AMS) using Performance Based Navigation (PBN). This will provide benefits in capacity while minimising environmental impacts.

This document forms part of the document set required for the CAP1616 airspace change process:
Stage 3 Consult, Step 3A Consultation Preparation: Options Appraisal (Phase II - Full) including a safety assessment and a full analysis of shortlist options.
Its purpose is to provide a more detailed quantitative assessment on the defined shortlist of design options which have progressed through the Step 2B Initial Options Appraisal, which was based around a qualitative assessment. This document will include a quantitative assessment of all reasonable costs and benefits of the design options, other costs and benefits described qualitatively and reasons why they could not be quantified. A preferred design option will also be provided, including reasons for the preference.

There are two design options in this document which are compared to the baseline do-nothing scenario. The options to have progressed to this stage are:

- Option 4 – Systemised routes Free Route Airspace (FRA) above FL305
- Option 6 – Systemised routes with FRA above FL245 (NATS' preferred option)

The other two design options assessed in the Step 2B Initial Options Appraisal have not progressed to this stage after concluding that they were sub-optimal when compared to the above options, particularly when considering their environmental performance.

Where are we in the airspace change process?

We have completed Stage 2 Develop and Assess, where we developed a long list of design options that addressed the Statement of Need and aligned with the Design Principles. The Step 2A Design Principle evaluation reduced the long list of design options by rejecting any which categorically did not meet a Design Principle. Finally, the Step 2B Initial Options Appraisal provided a qualitative assessment on the four design options and baseline.

We are now in Stage 3 Consult.

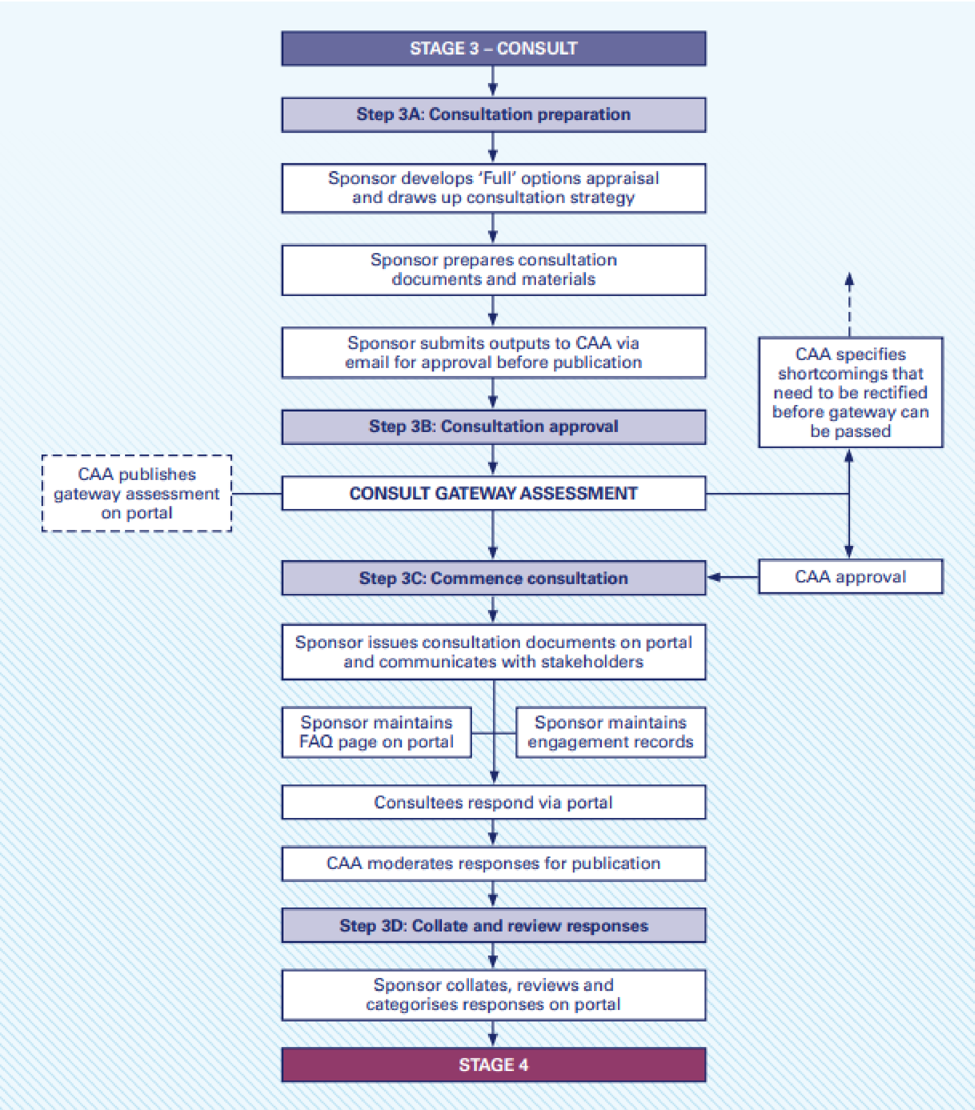

Figure 1: CAP1616 Airspace Change Process Stage 3

2. How to read this document – illustrations of current and potential impacts

The following tables are based on CAP1616 4th edition, Table E2, pages 201-203.

From Step 2B two design options, alongside the baseline, have been short-listed: these are Options 4 and 6. A separate analysis is presented for each option. For each option the table lists stakeholder groups alongside types of impact the option would have.

The changes described within this ACP will only affect the en-route network in airspace at & above 7,000ft. The ACP Level has been agreed by the CAA as Level 2.

In this document we provide tables for the two candidate design options. Note that these are compared against the baseline, do-nothing scenario. We describe broadly what we expect the scale of impact might be, for each option.

This document will provide a quantitative assessment of each design option including impacts such as environmental and economic. This will include potential savings which might be achieved if the design option was implemented. As described below, owing to the proposed design options being above 7,000ft, there are some impacts – such as air quality – which will not be affected. This assessment is based on the current design concepts and will be subject to refinement following the upcoming consultation, so the numbers may change as the design is refined. This is proportionate and in line with the expectations of CAP1616 Stage 3.

There is a fixed correlation between fuel burnt and greenhouse gases emitted. For every 1kg of fuel that is burnt 3.18kg of CO_2 equivalent (CO_2e) is emitted.

3. Design Options

3.1. Option 0 Do Nothing (Baseline)

Group	Impact	Level of Analysis	Evidence
Communities	Noise impact on health and quality of life	Qualitative	No change – no impact.
Communities	Air quality	Qualitative	No change – no impact.
Wider society	Greenhouse gas impact	Qualitative	No change – no impact. In the long term, lack of systemisation would have a negative impact on greenhouse gas emissions.
Wider society	Capacity/ resilience	Qualitative	No change to extant. In the long term the impact of constrained effective capacity would have a negative impact on resilience & capacity.
General Aviation (GA)	Access	Qualitative	No change – no impact.
General Aviation / commercial airlines	Economic impact from increased effective capacity	Qualitative	No change to extant. In the long term the economic impact of constrained effective capacity would have a negative economic impact.
General Aviation / commercial airlines	Fuel burn	Qualitative	No change – no impact. In the long term, lack of systemisation would have a negative impact on fuel burn.
Commercial airlines	Training cost	Qualitative	No change – no impact.
Commercial airlines	Other costs	Qualitative	No change – no impact.
Airport/ Air navigation service provider	Infrastructure costs	Qualitative	No change – no impact.
Airport/ Air navigation service provider	Operational costs	Qualitative	No change – no impact.
Airport/ Air navigation service provider	Deployment costs	Qualitative	No change – no impact.

Table 1: Options Appraisal (CAP1616), Systemisation – Baseline (Do Nothing)

Conclusion

The baseline "Do Nothing" Option 0 does not meet the following Design Principles:

- DP2 Economic Fuel Burn
- DP3 Environmental CO_2e emissions
- DP9 Technical (PBN)
- DP10 Technical (AMS)

For further information please see the DP evaluation matrix in the Stage 2a Design Options and Evaluation document.

As such this option was rejected. It is included here for comparison purposes.

3.2. Option 4. Systemised routes with FRA above FL305 (FL245 for S9)

Group	Impact	Level of Analysis	Evidence
Communities	Noise impact on health and quality of life	Qualitative	This airspace change only affects airspace above 7,000 ft and will therefore have no significant impact on the noise metrics (contours etc) associated with airspace change. This proposal covers a large portion of the South West of England and Wales. This area encompasses the following Areas of Outstanding Natural Beauty (AONBs) and National Parks; Llŷn, Shropshire Hills, Cannock Chase, Gower, Wye Valley, Cotswolds, North Wessex Downs, Chilterns, Mendip Hills, Quantock Hills, Cranborne Chase and West Wiltshire Downs, Dorset, East Devon, Blackdown Hills, North Devon, South Devon, Cornwall, Tamar Valley, Isles of Scilly, Snowdonia, Pembrokeshire Coast, Brecon Beacons, Exmoor, Dartmoor, New Forest. This area also encompasses the following designated quiet areas: Swansea and Neath Port Talbot; Cardiff and Penarth; Newport. No flight trajectories below 7,000 ft will be altered over these AONBs, quiet areas & National Parks.
Communities	Air quality	Qualitative	Government guidance states that aircraft flying higher than 1,000 ft are unlikely to have significant impact on local air quality.[1] This Airspace change only affects airspace above 7,000 ft and will therefore have no significant impact on air quality
Wider society	Greenhouse gas impact	Quantitative	The impact assessment indicates that 422,069 flights per year would be impacted by the change in 2023, rising to 587,073 in 2033. Computer modelling indicates an overall CO_2e saving of 1,500 tonnes in 2023. (see table (i) below) This comprises: The LD1.1 base model (assumes the options at Southern (Channel Islands/ Brest) and Western (Ireland) interfaces remain as per the baseline model) which predicts enabled benefit (reduction) of 1,476 tonnes of CO_2e. The interface options have been modelled separately for each of the two interfaces. The Southern (Channel Is/Brest) interface shows a disbenefit of 132 tonnes of CO_2e tonnes for Option 4 The Western (Ireland/D201) interface shows a benefit of 49 tonnes for Option 4 The overall forecast reduction of CO_2e emissions in the opening year (2023) and 10 years post-implementation are shown below for Option 4:

	CO_2e change 2023 (T)	CO_2e change 2033 (T)
LD1.1 base	-1476	-2054
Op4 Southern interface	132	183
Op4 Western interface	-156	-218
Total	**-1500**	**-2089**

Table (i) LD1.1, Option 4, CO_2e changes

Note negative values are

WebTAG was used to assess the greenhouse gas impact over 10 years after the proposed changes. 49.3% of flights have origin and destination within the EU (traded), and 50.7% originate or are destined for airports outside of the EU (non-traded[2]).

[1] See Air Navigation Guidance 2017

[2] In accordance with CAA guidance, CO_2e emissions for flights within the EU+UK are accounted for in WebTAG as traded, and flights whose origin or destination are outside of the EU+UK are non-traded. Proportions of flights are derived from analysis of traffic by NATS.

<table>
<tr><td></td><td></td><td></td><td>The monetised NPV benefit calculated by WebTAG due to the reduction in per flight GHG emissions is £401,907.

Note that this analysis only includes flight planned routes and does not include any holding, vectoring, or streaming. Therefore, improvements in predictability leading to improved flight planning and reduced delay and holding could further increase this benefit.

The WebTAG GHG worksheet outputs are shown in Appendix A. The NATS May 21 STATFOR extended forecast was used and traffic figures grown year-on-year for the WebTAG input.</td></tr>
<tr><td>Wider society</td><td>Capacity/ resilience</td><td>Qualitative</td><td>The changes contained within this design option introduce numerous new systemised routes. These routes will provide an efficient deconflicted network with added connectivity to UK Flight Information Region (FIR) exit areas yielding capacity benefits and a reduction in air traffic control (ATC) complexity. This would increase the resilience of the ATC network.</td></tr>
<tr><td>General Aviation (GA)</td><td>Access</td><td>Qualitative</td><td>There will be no change to GA access to the extant Controlled Airspace (CAS). This ACP may require an increase in CAS in some areas and a reduction in others. The proposed airspace classification is not yet set but will usually reflect the adjoining airspace. (See Consultation Doc section 16.)
The LD1.1 project will undertake a comprehensive review of airspace bases with a view to releasing airspace that is no longer required. This will help to offset the additional new airspace required.</td></tr>
<tr><td>General Aviation / commercial airlines</td><td>Economic impact from increased effective capacity</td><td>Qualitative</td><td>The proposed changes will increase the effective capacity of the airspace. The economic impact of this would be positive, however it has not been quantified.</td></tr>
<tr><td>General Aviation / commercial airlines</td><td>Fuel burn</td><td>Quantitative</td><td><table>
<tr><th></th><th>Fuel burn total 2023 (T)</th><th>Fuel burn total 2033 (T)</th></tr>
<tr><td>LD1.1 base</td><td>-464</td><td>-646</td></tr>
<tr><td>Op4 Southern interface</td><td>41</td><td>58</td></tr>
<tr><td>Op 4 Western interface</td><td>-49</td><td>-69</td></tr>
<tr><td>Total</td><td>-472</td><td>-657</td></tr>
</table>
Table (ii) Option 4 Fuel burn (negative values in this table are a reduction in fuel burn (i.e. benefit)
The average calculated network fuel burn saving per flight for Option 4 is 1.12kg compared to the baseline (based on 422,069 impacted flights in 2023).
This small benefit per flight would lead to noticeable per annum savings due to the annual traffic in this part of UK airspace. Current fuel costs predict an annual fuel saving of £215,974 in 2023, rising to £300,803 in 2033.
These figures are based on the IATA jet fuel price of 9 July 2021, at $634US per tonne and converted to GBP at 0.72£/$1 and presumes a constant fuel price and exchange rate. The forecast used was NATS May 21 STATFOR extended forecast.
Note that improvements in predictability leading to improved flight planning and reduced delay and holding could further improve upon this saving.</td></tr>
<tr><td>Commercial airlines</td><td>Training cost</td><td>Qualitative</td><td>Flight procedures worldwide are updated with each aeronautical information regulation and control (AIRAC) cycle and airlines update their procedures accordingly, training as required. This proposal is not anticipated to require additional training costs for airlines.</td></tr>
<tr><td>Commercial airlines</td><td>Other costs</td><td>Qualitative</td><td>No other airline costs are foreseen.</td></tr>
</table>

Airport/ Air navigation service provider	Infrastructure costs	Qualitative	This proposal is not expected to change Airport or air navigation service provider (ANSP) infrastructure, beyond the initial deployment phase which will require some systems engineering amendments.
Airport/ Air navigation service provider	Operational costs	Qualitative	This proposal is not expected to change Airport or ANSP operational costs.
Airport/ Air navigation service provider	Deployment costs	Qualitative	This proposal is expected to require air traffic controller familiarisation training, in the order of 120-150 controllers and c.50 assistants at NATS Swanwick, including extensive use of the NATS simulator facility. Support staff are required to run the simulator – planning, training staff, data preparation and testing, pseudo pilots, safety analysts, outputs to be recorded and reported etc. Some staff may only require briefings. There may be occasions where the reduced availability of operational controllers during their conversion training could mean operational rostering becomes a factor when considering continuous service delivery. The Military ANSP may also require briefing prior to deployment. This requirement will be clarified as designs mature through on-going engagement.

Table 2: Options Appraisal (CAP1616 E2) – Option 4 Systemised routes, FRA above FL305

Option 4 Conclusion

Compared to the baseline, the performance of Option 4 represents a benefit in terms of CO_2e emissions, fuel burn, capacity & resilience.

The Systemised PBN routes offer a highly efficient network design which would keep aircraft safe with minimal ATC intervention. The use of a 5nm separation radar environment requires no upgrade to existing radar or associated systems. The introduction of direct routings enables environmental benefits.

In isolation the CO_2e emissions and fuel burn performance of Option 4 appears better than for Option 6. However, this is a result of the additional airspace volume in this option (between FL245-305). To make an accurate comparison to ascertain the performance across the whole system, the performance across identical volumes of the combined LD1.1 + FRA D2 airspace should be considered. The combined results are presented in Appendix B. These show that for the combined system Option 4 has less benefit with a smaller reduction in CO2E and fuel burn.

The capacity & resilience benefits for Option 4 are also judged to be less than for Option 6.

Option 4 is a viable option and as such is presented for consultation under CAP1616 Stage 3. However, Option 4 is not NATS' preferred option.

3.3. Option 6. Systemised routes with FRA above FL245

Group	Impact	Level of Analysis	Evidence
Communities	Noise impact on health and quality of life	Qualitative	This Airspace change only affects airspace above 7,000 ft and will therefore have no significant impact on noise. This proposal covers a large portion of the South West of England and Wales. This area encompasses the following AONBs and National Parks; Llŷn, Shropshire Hills, Cannock Chase, Gower, Wye Valley, Cotswolds, North Wessex Downs, Chilterns, Mendip Hills, Quantock Hills, Cranborne Chase and West Wiltshire Downs, Dorset, East Devon, Blackdown Hills, North Devon, South Devon, Cornwall, Tamar Valley, Isles of Scilly, Snowdonia, Pembrokeshire Coast, Brecon Beacons, Exmoor, Dartmoor, New Forest. This area also encompasses the following designated quiet areas: Swansea and Neath Port Talbot; Cardiff and Penarth; Newport. No flight trajectories below 7,000 ft will be altered over these AONBs, quiet areas & National Parks.
Communities	Air quality	Qualitative	Government guidance states that aircraft flying higher than 1,000 ft are unlikely to have significant impact on local air quality[1]. This Airspace change only affects airspace above 7,000 ft and will therefore have no significant impact on air quality.
Wider society	Greenhouse gas impact	Quantitative	The impact assessment indicates that c.422,069 flights per year would be impacted by the change in 2023, rising to 587,073 in 2033. Computer modelling indicates overall CO_2e savings of 1,198 tonnes in 2023 for the proposed design for Option 6. This comprises: The LD1.1 base model (assumes the options at Southern (Channel Is/Brest) and Western (Ireland/D201) interfaces remain as per the baseline model) which predicts enabled benefit of 1,154 tonnes of CO_2e. The interface options have been modelled separately for each of the two interfaces. The Southern (Channel Is/Brest) interface shows a GHG disbenefit of 121 tonnes of CO_2e in the implementation year of 2023 for Option 6. The Western (Ireland/D201) interface shows a GHG benefit of 165 tonnes CO_2e in the implementation year of 2023, for Option 6 The overall forecast reduction of CO_2e emissions in the opening year (2023) and 10 years post-implementation are shown below for Option 6:

	CO_2e change 2023 (T)	CO_2e change 2033 (T)
LD1.1 base Op 6	-1154	-1606
Op 6 Southern interface	121	168
Op 6 Western interface	-165	-231
Total	-1198	-1669

Table (iii) LD1.1, Option 6, CO_2e changes (Negative values are a reduction in CO_2e emissions (benefit))

WebTAG was used to assess the greenhouse gas impact over 10 years after the proposed changes. 49.3% of flights have origin and destination within the EU (traded), and 50.7% originate or destined for airports outside of the EU (non-traded[3]).

The monetised NPV benefit calculated by WebTAG due to the reduction in per flight GHG emissions is £320,999.

Note that this analysis only includes flight planned routes and does not include any holding, vectoring, or streaming. Therefore, improvements in

[3] In accordance with CAA guidance, CO_2e emissions for flights within the EU+UK are accounted for in WebTAG as traded, and flights whose origin or destination are outside of the EU+UK are non-traded. Proportions of flights are derived from analysis of traffic by NATS.

<table>
<tr><td></td><td></td><td></td><td>predictability leading to improved flight planning and reduced delay and holding could further increase this benefit.
The WebTAG GHG worksheet outputs are shown in Appendix A. The NATS May 21 STATFOR extended forecast was used and traffic figures grown year-on-year for the WebTAG input.</td></tr>
<tr><td>Wider society</td><td>Capacity/ resilience</td><td>Qualitative</td><td>The changes contained within this design option introduce new systemised routes. These routes will provide an efficient deconflicted network with added connectivity to UK FIR exit areas yielding capacity benefits and a reduction in ATC complexity. This increases the resilience of the ATC network.
The connectivity to FRA at higher levels enables increased flight planning flexibility which would allow aircraft operators to flight plan more efficiently and give them the option of avoiding capacity constrained areas. This ability to avoid restrictions by utilising alternative flight plan trajectories would reduce the likelihood of delay and improve the resilience of the wider network.</td></tr>
<tr><td>General Aviation</td><td>Access</td><td>Qualitative</td><td>There will be no change to GA access to the extant Controlled Airspace (CAS). This ACP may require an increase in CAS in some areas and a reduction in others. The proposed airspace classification is not yet set but will usually reflect the adjoining airspace. (See Consultation Doc section 16.)
The LD1.1 project will undertake a comprehensive review of airspace bases with a view to releasing airspace that is no longer required. This will help to offset the additional new airspace required.</td></tr>
<tr><td>General Aviation / commercial airlines</td><td>Economic impact from increased effective capacity</td><td>Qualitative</td><td>The proposed changes will increase the effective capacity of the airspace. The economic impact of this would be positive, however it has not been quantified.</td></tr>
<tr><td>General Aviation / commercial airlines</td><td>Fuel burn</td><td>Quantitative</td><td><table>
<tr><th></th><th>Fuel burn total 2023 (T)</th><th>Fuel burn total 2033 (T)</th></tr>
<tr><td>LD1.1 base</td><td>-363</td><td>-505</td></tr>
<tr><td>Op 6 Southern interface</td><td>38</td><td>53</td></tr>
<tr><td>Op 6 Western interface</td><td>-52</td><td>-73</td></tr>
<tr><td>Total</td><td>-377</td><td>-525</td></tr>
</table>
Table (iv) Option 6, Fuel burn (negative values in this table are a reduction in fuel burn (i.e. benefit)
The average calculated network fuel burn saving per flight for Option 6 is 0.89kg compared to the baseline (based on 422,069 impacted flights in 2023).
This small benefit per flight would lead to noticeable per annum savings due to the annual traffic in this part of UK airspace. Current fuel costs predict an annual fuel saving of £172,504 in 2023, rising to £240,260 in 2033. based on 587,073 impacted flights in 2033.
These figures are based on the IATA jet fuel price of 9 July 2021, at $634US per tonne and converted to GBP at 0.72£/$1 and presumes a constant fuel price and exchange rate. The forecast used was NATS May 21 STATFOR extended forecast.
Note that improvements in predictability leading to improved flight planning and reduced delay and holding could further improve upon this saving.</td></tr>
<tr><td>Commercial airlines</td><td>Training cost</td><td>Qualitative</td><td>Flight procedures worldwide are updated with each AIRAC cycle and airlines would update their procedures accordingly, training as required. This proposal is not anticipated to require additional training costs for airlines.</td></tr>
<tr><td>Commercial airlines</td><td>Other costs</td><td>Qualitative</td><td>No other airline costs are foreseen</td></tr>
</table>

Airport/ Air navigation service provider	Infrastructure costs	Qualitative	This proposal is not expected to change Airport or ANSP infrastructure, beyond the initial deployment phase which willrequire some systems engineering amendments.
Airport/ Air navigation service provider	Operational costs	Qualitative	This proposal is not expected to change Airport or ANSP operational costs.
Airport/ Air navigation service provider	Deployment costs	Qualitative	This proposal is expected to require air traffic controller familiarisation training, in the order of 120-150 controllers and c.50 assistants at NATS Swanwick, including extensive use of the NATS simulator facility. Support staff are required to run the simulator – planning, training staff, data preparation and testing, pseudo pilots, safety analysts, outputs to be recorded and reported etc. Some staff may only require briefings. There may be occasions where the reduced availability of operational controllers during their conversion training could mean operational rostering becomes a factor when considering continuous service delivery. The Military ANSP may also require briefing prior to deployment. This requirement will be clarified as designs mature through on-going engagement.

Table 3: Options Appraisal (CAP1616 E2) – Option 6 Systemised routes with FRA above FL245

Option 6 Conclusion

Compared to the baseline, the performance of Option 6 represents a benefit in terms of CO_2e emissions, fuel burn, capacity & resilience.

The Systemised PBN routes offer a highly efficient network design which would keep aircraft safe with minimal ATC intervention. The use of a 5nm separation radar environment requires no upgrade to existing radar or associated systems. The lower FRA base allows operators to begin the user preferred trajectories earlier in the flight and this can enable environmental benefits.

In isolation the CO_2e emissions and fuel burn performance of Option 6 appear worse than for Option 4. However, this is a result of the additional airspace volume in Option 4 (between FL245-305). To make an accurate comparison to ascertain the performance across the whole system, the performance across identical volumes of the combined LD1.1 + FRA D2 airspace should be considered. The combined results are presented in section 4 below and in Appendix B. These show that for the combined system Option 6 has greater benefit, with a greater reduction in CO_2e and fuel burn.

The capacity & resilience benefits for Option 6 are also judged to be greater than for Option 4. When viewed across the whole airspace, the performance of Option 6 represents the greatest benefit in terms of CO_2e emissions, fuel burn, capacity & resilience.

As such, Option 6 is NATS preferred option and is presented for consultation under CAP1616 Stage 3.

4. Cost Benefit Comparison

The monetised benefits of both options have been totalled in analysis below (Note, with 2 years before implementation, project and deployment costs have not been quantified at this stage. There are no significant differences in the cost of implementation of the options). This analysis shows both the individual benefits for LD1.1 and FRA D2 and the combined results for both Option 4 and 6. The discount rate of 3.5% has been applied as per the standard rate given in the Treasury Green Book Annex A6).

The results in Table 4 show that the monetised benefit over ten years for Option 6 (£5,860,352) is marginally greater than that for Option 4 (£5,817,946).

CAP1616 cost-benefit example - FRA Option 1 implemented at FL305 (LD1 Op4)							2					
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	
Year	0	1	2	3	4	5	6	7	8	9	10	NPV
Discount factor	1	0.965	0.931	0.899	0.867	0.837	0.808	0.779	0.752	0.726	0.700	
Option 1 - Full FRA (100% benefit)												
Net community benefit (CO2)	£36,062	£42,442	£46,250	£49,112	£51,002	£53,065	£54,605	£56,460	£60,564	£64,774	£68,121	
Net airspace users benefit (Fuel)	£173,877	£197,213	£210,025	£216,431	£219,634	£223,295	£225,583	£229,701	£234,734	£238,395	£241,598	
Net sponsor benefit	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	
Present value	£209,939	£232,753	£241,830	£243,604	£241,464	£239,925	£236,772	£235,460	£237,084	£237,773	£237,307	£2,593,912
LD1.1 Option 4												
Net community benefit (CO2)	£44,821	£52,680	£57,448	£61,022	£63,342	£65,847	£67,831	£70,142	£75,260	£80,538	£84,705	
Net airspace users benefit (Fuel)	£215,974	£244,914	£260,833	£269,180	£272,679	£277,588	£280,641	£285,693	£291,978	£296,358	£300,803	
Net sponsor benefit		£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	
Present value	£260,794	£289,022	£300,343	£302,916	£299,804	£298,141	£294,460	£292,776	£294,828	£295,599	£295,352	£3,224,035
Combined: FRA Op1/LD1.1 Op4)												
Net community benefit (CO2)	£80,883	£95,123	£103,698	£110,135	£114,344	£118,913	£122,436	£126,602	£135,824	£145,312	£152,825	
Net airspace users benefit (Fuel)	£389,851	£426,653	£438,475	£436,386	£426,924	£419,153	£408,796	£401,634	£396,088	£388,060	£379,833	
Net sponsor benefit	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	
Present value	£470,733	£521,775	£542,173	£546,520	£541,269	£538,065	£531,232	£528,236	£531,912	£533,372	£532,659	£5,817,946

CAP1616 cost-benefit example - FRA Option 1 implemented at FL245 (LD1 Op6)												
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	
Year	0	1	2	3	4	5	6	7	8	9	10	NPV
Discount factor	1	0.965	0.931	0.899	0.867	0.837	0.808	0.779	0.752	0.726	0.700	
Option 1 - Full FRA (100% benefit)												
Net community benefit (CO2)	£45,693	£53,769	£58,587	£62,233	£64,619	£67,213	£69,189	£71,521	£76,707	£82,024	£86,286	
Net airspace users benefit (Fuel)	£220,092	£249,376	£265,849	£274,543	£278,203	£282,779	£285,982	£291,015	£297,421	£301,539	£306,115	
Net sponsor benefit	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	
Present value	£265,785	£294,417	£306,152	£308,945	£305,871	£303,850	£300,131	£298,302	£300,368	£300,846	£300,653	£3,285,320
LD1.1 Option 6												
Net community benefit (CO2)	£35,765	£42,094	£45,909	£48,721	£50,601	£52,624	£54,154	£56,001	£60,082	£64,266	£67,675	
Net airspace users benefit (Fuel)	£172,504	£195,620	£208,335	£215,002	£217,797	£221,717	£224,156	£228,191	£233,211	£236,709	£240,260	
Net sponsor benefit	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	
Present value	£208,269	£230,867	£239,916	£241,929	£239,470	£238,164	£235,169	£233,824	£235,457	£236,041	£235,924	£2,575,031
Combined: FRA Op1/LD1.1 Op6)												
Net community benefit (CO2)	£81,458	£95,863	£104,496	£110,954	£115,220	£119,837	£123,344	£127,522	£136,789	£146,290	£153,961	
Net airspace users benefit (Fuel)	£392,596	£429,421	£441,572	£439,920	£430,121	£422,177	£411,957	£404,605	£399,036	£390,597	£382,617	
Net sponsor benefit	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	
Present value	£474,054	£525,284	£546,068	£550,874	£545,341	£542,014	£535,300	£532,127	£535,825	£536,887	£536,577	£5,860,352

Table 4: LD1.1 and FRA D2 Combined cost benefit (Option 4 and 6)

5. Full Options Appraisal Overview

Two options: 4 & 6 were carried forward from Stage 2.
As a result of the Full Options Appraisal, quantitative and qualitative analyses Option 4 and Option 6 demonstrated benefit and are being presented in the consultation under CAP1616 Stage 3.

6. Safety Assessment

This section provides a brief, qualitative overview of the impact of each option on aviation safety.
It should be noted that only Options 4 and 6 are proposed to be progressed, nonetheless their progression was not on the basis that these two options were the only ones on the grounds of safety. The other options, rejected at Stage 2, also met the design principles on safety but were considered sub-optimal with regards to the other success criteria.

6.1 Options Appraisal Safety Assessment - Baseline

The current operation uses a published route structure and airline operators flight-plan to follow available ATS routes or flight plannable Directs (DCT) as published in the Route Availability Document (RAD). The published routes are supportive of strategic de-confliction between flights against active Special Use Airspace volumes (such as Danger Areas) and airspace with constrained radiotelephony or surveillance coverage. The routes also provide an operational framework that is conducive to Air Traffic Controllers' familiarity with traffic patterns, potential conflict points and practices for conflict avoidance/resolution. Flights into and out of the airspace volume (i.e. across boundaries with other Sectors and Air Traffic Control Units) are managed via published waypoints and agreed co-ordination points (COPs).

In addition to flights following routes, some may be instructed to take a more direct path through the airspace. This is done in a tactical manner by Air Traffic Controllers based on their judgement that a different path can be followed safely.

Air Traffic Controllers are supported in their task by equipment functionality (tools) that includes prediction of the trajectories that aircraft will follow. Predicted trajectories can be viewed by Controllers, and the tools use the former to identify potential areas of conflict between aircraft for Controllers' attention. The tools also monitor the conformance of aircraft to their expected trajectories and highlight deviations. The tools support the Controllers in ensuring that the aircraft pass through the airspace safely separated from other aircraft, and other airspace such as Danger Areas.

6.2 Safety Assessment – Option 4 Systemised routes, FRA above FL305.

Project activities so far have included multiple iterations of fast-time simulation computer modelling, Real Time Development Simulation. Safety and Human Performance (HP) experts have attended a significant part of these workshops.
The feedback from the simulations and from the early design activities has been assessed during a Preliminary Safety Issues Identification workshop that will form the basis for the planning and the execution of the safety and HP activities throughout the project lifecycle.
The initial findings from workshops at the time of this Safety Statement are as follows:

- Airspace Safety Review –the Airspace Safety Review concluded that the proposed designs could be implemented safely, and initial work has indicated that overall, the proposed changes would result in a small improvement in safety.
- Tempest Assessment – The LD1.1 design is predicted to result in a small safety benefit (<1%) in terms of NATS En Route RAT ATM Ground points at the NATS En Route Level.

The concept of operations for the systemised airspace is "File it, fly it", so aircraft will fly the filed flight plan. As such, the level of tactical intervention required will be reduced from that of today. Initial work that has been done has indicated that the Air Traffic Controllers regard the systemised airspace mode of operation as being similar to the flows of traffic experienced today, achieved with substantial tactical traffic intervention but with more emphasis on monitoring traffic flows and less active intervention being required. Key factors underlying

this are that routings that are provided (tactically) today are expected to be reflected in flight plans and that the tools will continue to support Controllers in foreseeing and resolving potential conflicts.
The proposed ATS route structure will consist of formally defined PBN routes, meaning that route spacing rules and route containment will be considered in accordance with current CAA policies. During the simulations the participants did not identify any significant safety related issues. Following the Airspace Safety Activities (including the Airspace Safety Review) and the liaison meetings with the different stakeholders the design team will identify, if necessary, any updates required to the proposed design and this will be assessed during the further development simulations.
The changes introduced are aimed at reducing ATC workload - the concept underlying the proposed design is the introduction of a systemised ATS route network and this proposed solution is seen as beneficial from an ATC perspective.
Appropriate safety cases will be written, as will an analysis of CAP1385 route separation criteria of each route segment against adjacent proposed routes.

6.3 Safety Assessment – Option 6 Systemised airspace with FRA above FL245.

The concept of operations for Option 6 is the same as for Option 4, but with different division flight level (DFL) between the systemised airspace and the overlying FRA. For Option 4 the DFL is FL305 and for Option 6 it is lower at FL245.

The same project activities have been undertaken as for Option 4.
A qualitative high-level safety appraisal for the two proposed options for the LD1.1 systemised airspace network indicates that the existing level of safety performance undertaken within the current operation would be at least maintained. We are confident that either of these two options could be implemented safely.

7. Conclusions and next steps

The Statement of Need for this proposal can be summarised:

Current Situation – Today's network does not exploit modern navigation technology or provide capacity for long-term growth in aviation.

Many UK airports plan to change their low-level airspace to better suit their needs. Modern aircraft have navigation performance far exceeding that of the types which the network was originally designed.

There is the opportunity to enable significant environmental and capacity benefits by changing the network to suit the navigation performance of modern aircraft.

Desired outcome – The Optimal alignment and connectivity of the ATS route network with each airport's airspace structures, such that network capacity should not be a significant constraint on airport capacity and environmental impacts are minimised.

Two Design options were developed to deliver the desired outcome. Stakeholder feedback as well as input from subject matter experts has been incorporated into the design options.

We thank all stakeholders who have participated in engagement thus far and look forward to their feedback during consultation and continued involvement with the development of this proposal.

From this full options appraisal, the following options are presented for consultation:

- Option 4 – Systemised routes, FRA above FL305 (FL245 in S9)
- Option 6 – Systemised routes, FRA above FL245.

Consultation will include detail of the benefits and impacts, monetised such that the overall benefit and impacts can be assessed.

Appendix A: WebTAG Calculations for LD1.1 Option 4

The data used for the inputs to WebTAG are given below:

Traffic forecasts:

Year	Base Growth Flights (000's)	Base Growth Rate
2023	2,132	
2024	2,418	13.40%
2025	2,574	6.50%
2026	2,657	3.20%
2027	2,691	1.30%
2028	2,740	1.80%
2029	2,769	1.10%
2030	2,818	1.80%
2031	2,879	2.20%
2032	2,922	1.50%
2033	2,965	1.50%

Table A1: Base Case forecast traffic growth 2023-2031 (NATS May 21 STATFOR extended forecast)

Computer Modelling Results:

Year	Flights per year in LD1.1 Area	Simulated Fuel Saving (T)	Simulated CO2e saving (T)	Traded CO2e saving (49.3%)	Non-traded CO2e saving (50.7%)	Fuel Cost saving (USD)	Fuel Cost saving (GBP)
2023	422,069	472	1,500	740	761	299,248	215,974
2024	478,695	535	1,701	839	862	339,347	244,914
2025	509,584	570	1,812	893	918	361,405	260,833
2026	525,997	588	1,870	922	948	372,970	269,180
2027	532,905	596	1,894	934	960	377,818	272,679
2028	542,534	607	1,928	950	977	384,619	277,588
2029	548,232	613	1,949	961	988	388,850	280,641
2030	557,967	624	1,984	978	1,006	395,849	285,693
2031	570,108	638	2,028	1000	1,028	404,558	291,978
2032	578,528	648	2,058	1015	1,044	410,626	296,358
2033	587,073	657	2,089	1030	1,059	416,786	300,803

Table A2, computer simulation results for LD1.1 Option 4

The results calculated by NATS Analytics for the fuel saving and CO_2e savings are given in Table A2 Columns 3 and 4.

Year	Flights per year in FRA D2 Area	Simulated Fuel Saving (T)	Simulated CO2 saving (T)	CO2 Traded (49.3%)	CO2 non-traded (50.7%)	Fuel Cost (USD)	Fuel Cost (GBP)
2023	422,069	481	1,530	754	776	304,954	220,092
2024	478,695	545	1,736	856	880	345,530	249,376
2025	509,584	581	1,847	911	936	368,354	265,849
2026	525,997	600	1,907	940	967	380,400	274,543
2027	532,905	608	1,932	952	980	385,472	278,203
2028	542,534	618	1,967	970	997	391,812	282,779
2029	548,232	625	1,988	980	1,008	396,250	285,982
2030	557,967	636	2,023	997	1,026	403,224	291,015
2031	570,108	650	2,067	1,019	1,048	412,100	297,421
2032	578,528	659	2,097	1,034	1,063	417,806	301,539
2033	587,073	669	2,128	1,049	1,079	424,146	306,115

Table A3, computer simulation results for FRA, with a division flight level of FL245 (i.e. base of FRA is FL245).

The results calculated by NATS Analytics for the fuel saving and CO_2e savings are given in Columns 3 and 4.

1. WebTAG GHG Workbook Output: LD1.1 Option 4

Greenhouse Gases Workbook - Worksheet 1

Scheme Name: NATS LD1.1 Opt 4

Present Value Base Year 2010

Current Year 2021

Proposal Opening year: 2023

Project (Road/Rail or Road and Rail): road

Overall Assessment Score:

Net Present Value of carbon dioxide equivalent emissions of proposal (£): £401,907

*positive value reflects a **net benefit** (i.e. CO2E emissions reduction)

Quantitative Assessment:

Change in carbon dioxide equivalent emissions over 60 year appraisal period (tonnes): -20,813
(between 'with scheme' and 'without scheme' scenarios)

Of which Traded -10262

Change in carbon dioxide equivalent emissions in opening year (tonnes): -1,501
(between 'with scheme' and 'without scheme' scenarios)

Net Present Value of traded sector carbon dioxide equivalent emissions of proposal (£): £321,731
(N.B. this is not additional to the appraisal value in cell I17, as the cost of traded sector emissions is assumed to be internalised into market prices. See TAG Unit A3 for further details)

*positive value reflects a **net benefit** (i.e. CO2E emissions reduction)

Change in carbon dioxide equivalent emissions by carbon budget period:

	Carbon Budget 1	Carbon Budget 2	Carbon Budget 3	Carbon Budget 4
Traded sector	0	0	0	-4328
Non-traded sector	0	0	0	-4449

Qualitative Comments:

Sensitivity Analysis:

Upper Estimate Net Present Value of Carbon dioxide Emissions of Proposal (£): £602,879

Lower Estimate Net Present Value of Carbon dioxide Emissions of Proposal (£): £200,973

Data Sources:

2. WebTAG GHG Workbook Output: LD1.1 Option 6

Greenhouse Gases Workbook - Worksheet 1

Scheme Name: NATS LD1.1 Opt 6

Present Value Base Year 2010

Current Year 2021

Proposal Opening year: 2023

Project (Road/Rail or Road and Rail): road

Overall Assessment Score:

Net Present Value of carbon dioxide equivalent emissions of proposal (£): £320,999

*positive value reflects a **net benefit** (i.e. CO2E emissions reduction)

Quantitative Assessment:

Change in carbon dioxide equivalent emissions over 60 year appraisal period (tonnes): -16,621
(between 'with scheme' and 'without scheme' scenarios)

Of which Traded -8194

Change in carbon dioxide equivalent emissions in opening year (tonnes): -1,198
(between 'with scheme' and 'without scheme' scenarios)

Net Present Value of traded sector carbon dioxide equivalent emissions of proposal (£): £256,892
(N.B. this is not additional to the appraisal value in cell I17, as the cost of traded sector emissions is assumed to be internalised into market prices. See TAG Unit A3 for further details)

*positive value reflects a **net benefit** (i.e. CO2E emissions reduction)

Change in carbon dioxide equivalent emissions by carbon budget period:

	Carbon Budget 1	Carbon Budget 2	Carbon Budget 3	Carbon Budget 4
Traded sector	0	0	0	-3456
Non-traded sector	0	0	0	-3554

Qualitative Comments:

Sensitivity Analysis:

Upper Estimate Net Present Value of Carbon dioxide Emissions of Proposal (£): £481,515

Lower Estimate Net Present Value of Carbon dioxide Emissions of Proposal (£): £160,516

Data Sources:

Appendix B: Combined benefits for LD1.1 and FRA D2

It is important to note the interdependency of LD1.1 with the FRA D2 ACP, and to recognise the cumulative impact of both ACPs when considering the potential benefits. Due to the interdependency with this ACP and the FRA D2 ACP, the actual implementation level of FRA in this airspace will be determined post-consultation during Stage 4. The flight level at which FRA is implemented impacts the enabled benefits for FRA.

In order to give the complete (combined) picture, the benefits for FRA D2 Option 1 with LD1.1 Option 6 (FRA DFL of FL305 (FL245 in Swanwick AC Sector 9)) and FRA D2 Option 1 with LD1.1 Option 6 (FRA DFL of FL245 throughout the region) are presented, with the summed overall impacts for each option summarised below:

		2023 CO_2e (T) reduction	2033 CO_2e (T) reduction	CO_2e (£ saved) (traded)	CO_2e (£ saved) (non-traded)
LD1.1 impacts	LD1.1 Option 4	1,500	2,089	321,731	401,907
	LD1.1 Option 6	1,198	1,669	256,892	320,999
FRA D2 impacts	LD1.1 Option 4	1,208	1,680	258,945	323,512
	LD1.1 Option 6	1,530	2,128	327,978	409,863
LD1.1 + FRA combined impacts	LD1.1 Option 4	2,708	3,769	580,675	725,419
	LD1.1 Option 6	**2,728**	**3,797**	**584,870**	**730,862**

Table B1 Combined CO_2e benefits for LD1.1 and FRA D2

		2023 Fuel (T) reduction	2033 Fuel (T) reduction	2023 Fuel Fuel saving (T)	2033 Fuel Fuel saving (T)
LD1.1 impacts	LD1.1 Option 4	472	657	215,974	300,803
	LD1.1 Option 6	377	525	172,504	240,260
FRA D2 impacts	LD1.1 Option 4	380	528	173,877	241,598
	LD1.1 Option 6	481	669	220,092	306,115
LD1.1 + FRA combined impacts	LD1.1 Option 4	852	1,185	389,851	542,401
	LD1.1 Option 6	**858**	**1,194**	**392,596**	**546,375**

Table B2 Combined fuel impact for LD1.1 and FRA D2

The tables above show that in isolation LD1.1 Option 4 appears to provide the greater CO_2e benefit than Option 6 (Table B1 first row). However, when combined with the implementation of FRA in the airspace above, Option 6 provides the greatest overall benefit (Table B1, last row). Therefore, to optimise the largest environmental benefit from both ACPs, NATS advocates Option 6 as the preferred option, given the holistic overview.

Modelling assumptions

The AirTOp ATC computer simulation software was utilised plus RALPH pre-processor v1.3.17, and NEMo post processorv2.6

Traffic levels were grown as per the May 21 STATFOR extended forecast.

The same traffic sample has been used in all baseline and scenario models to ensure a valid comparison. One sample day (14th June 2018) was modelled in a westerly configuration. To account for the 2 easterly SID Truncations for EGGD/EGFF as part of the West project, the easterly configuration of these flows has been modelled and accounted for in the overall figures using a 30/70 split for Easterly/Westerly.

Trajectory profiles are calculated using NATS business intelligence (BI) data statistics on observed climb/descend rates, speeds and turn rates for BADA aircraft groups.

No "go-arounds" were simulated.

The current airspace was been connected to the proposed designs inside West Airspace where possible.

Validation of the model was conducted by the LD1.1 ATC design team and Analytics, this task was completed to a level acceptable with the design team.

The baseline model includes SAIP AD4/5 and Farnborough ACP.

Unconstrained demand was modelled, thereby excluding the naturally occurring influence of flow restrictions (i.e. no regulations were applied to the traffic sample).
A "blue sky" weather scenario, where no wind effects are present, was assumed.
No conflict resolution was applied en-route.
No network effects are simulated (i.e. no holding, vectoring, AMAN, runway arrival and departure separations).
No randomisation of flight plan departure times was utilised.
Fuel burn was calculated using NATS NEMO tool which uses BADA 4.2 data. Aircraft types not in BADA 4.2 use BADA 3.13 data.
Controller tasks were completed instantaneously with each controller able to control multiple aircraft simultaneously (i.e. no workload or response time constraints).
Sectorisation has been based on the Eurocontrol sector definitions.
The following updates were made to the traffic sample as requested by the project team:

- B744 and A380 aircraft types for BAW were replaced with 60% B772 and 40% B788
- A318 aircraft types for BAW were removed from our sample
- A340 aircraft types for VIR were replaced with B789

As the level restrictions on the scenario ATS Routes were still being developed, these have not been included in the fast-time simulations to avoid unrealistic flight profiles.