Appendix F: Environment

We use the 3Di (3-Dimensional insight/inefficiency) metric to measure our environmental performance. 3Di is a proxy measure for aircraft fuel burn and emissions, developed by NATS in collaboration with airlines and the CAA. It provides a score for the efficiency of every commercial aviation flight, by comparing the actual path flown to an optimal profile. The combined score of all commercial flights indicates the overall efficiency of UK airspace usage.

In the horizontal flight plane, 3Di compares the actual distance flown by aircraft with the most direct 'great-circle' route possible. Inefficiency is defined by additional miles flown.

In the vertical plane level, portions of flight at low altitude use more fuel, so the 3Di tool measures vertical inefficiency using the amount of time spent in level flight and how far away it takes place compared to the airline's flight planned cruise level. Different weightings are applied for climb, cruise and descent phases in order to account for the varied rates of fuel burn and emissions performance across the different phases of flight.

Vertical and horizontal measures combine to give a single 3Di score for each flight. Any airspace region can also be measured through the cumulative scores of all flights through it. Scores run from zero (representing zero inefficiency) to over 100. The average UK score is 28-29 points.

Improvement targets to reduce the UK average 3Di score are set for each year of NERL's price control period. While a zero score is theoretically possible, it is extremely rare. This is due to factors outside NERL's control being reflected within the score, including the orientation of runways, airport noise preferential routes, shared use airspace and airline flight planning choices (eg minimum cost versus minimum fuel) which take aircraft away from their most efficient flight trajectories. As a result minimum scores are typically around 10-15 points. Beyond this, NERL can influence the airspace design and on the day performance of airspace, for a given level of traffic.

Proposed adjustments to 3Di

We have reviewed 3Di for NR23 to ensure the continued suitability and efficacy of the metric and its performance scheme. This included:

- Past 3Di and airspace performance data (including the period of low traffic levels during Covid-19)
- Predicted 3Di across NR23 using the STATFOR October 2021 traffic forecast
- Customer and CAA feedback in developing the proposals
- Recent external research (as described below)
- The potential improvement opportunity of our own plans and actions, for example through the anticipated benefits from the capital programme investments

› Changes to policy, and external developments/factors that may impact on 3Di performance.

We have not changed the 3Di structure and calculation methodology to ensure consistent analysis of our performance over time and to respond to customer/CAA requests for simplicity. As such, we remain incentivised to deliver the best overall flight efficiency for airlines by mitigating factors outside our control, continuous improvement of our daily service, and through our capital investment and improvement programmes.

We have proposed 3Di targets for NR23, and the associated incentive scheme, which reflect:

› enhanced evidence on the strength of the traffic-3Di relationship, and the need for an uncertainty mechanism regarding future traffic levels

› external research into air traffic control's potential contribution to decarbonisation (detailed within this appendix)

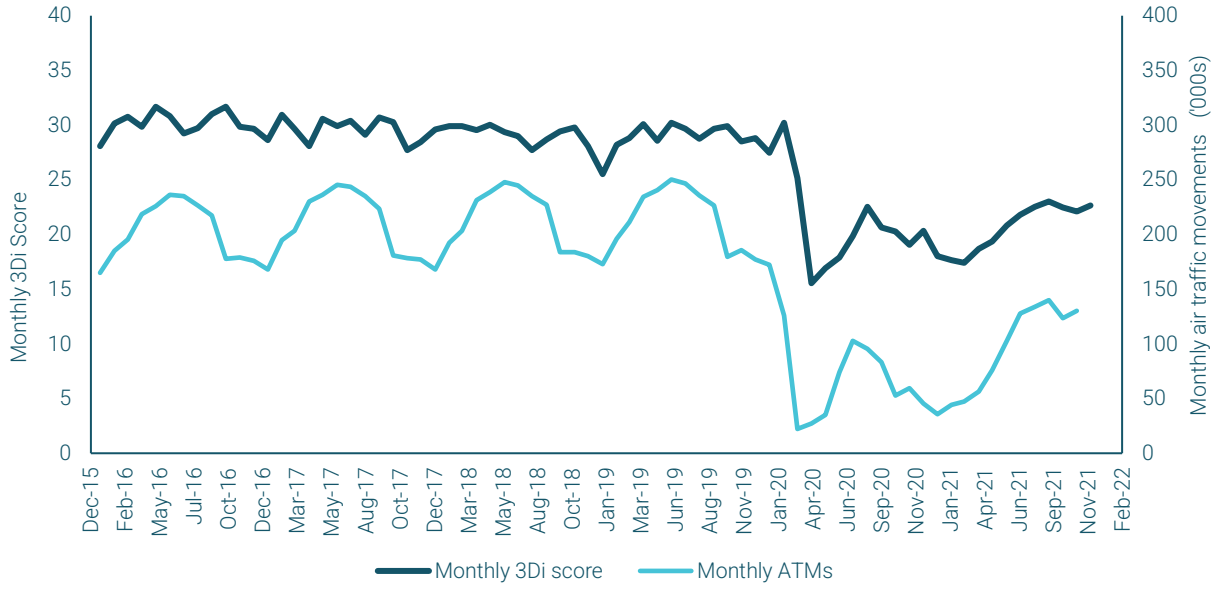
› ongoing potential for external (non-NERL) influences on 3Di

› increased societal and customer expectations on the environmental performance of aviation.

Our proposed changes will ensure that 3Di continues to incentivise NERL appropriately to deliver the fuel and associated emissions savings that airlines so highly value and society expects, while also ensuring an efficient service with capacity for reasonable levels of demand. The elements of the following proposed changes to the incentive scheme are closely inter-related and should be considered as a package: if one element were to be set aside, then others would need to be reassessed.

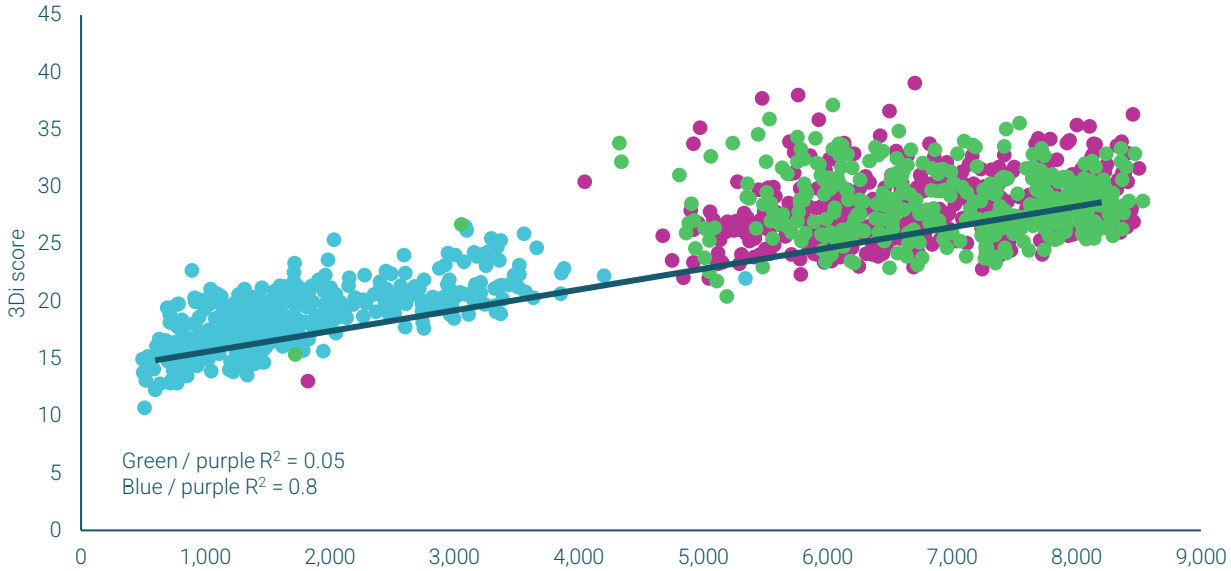
Traffic modulation mechanism

The low traffic levels during Covid-19 had a profound effect on the efficiency of UK airspace during 2020 and 2021; the lower demand removed constraints necessary to provide safe and efficient routes in complex airspace structures while also balancing airport runway capacity. As a result, the only constraint was the airspace structure itself, and controllers were able to provide optimised routeings. Arrival holding, which typically contributed around 10% of the 3Di score, was almost entirely removed, direct routeings increased, and vertical constraints were largely mitigated. These temporary improvements led to the best 3Di performance ever seen, as shown in the chart below.



Past 3Di performance data showing the impact of low traffic on airspace efficiency

As a result, we have been able to assess the relationship between 3Di and traffic more robustly than in the past, as shown in the chart below which plots 3Di scores versus daily flight movements for three periods: January-December 2018 (data in green), January 2019 up to the first national lockdown 15 March 2020 (data in purple), and 16 March 2020 to June 2021 (data in blue). The inclusion of data post pandemic provides strong evidence of the relationship comparing similar amounts of data (green-purple).



3Di score vs traffic

The strong positive correlation between 3Di and traffic volume is clear; the 0.8 R^2 value indicates that 80% of the variance in 3Di can be explained by the variance in traffic levels. This high level of correlation compares with a much lower R^2 of 0.05 when measured over the period 2018 to March 2020, when flights per day varied within a much smaller range than that covered in the period 2019 - June 2021.

Our proposed traffic modulation mechanism is based on this statistical relationship between 3Di and traffic: every 100,000 change in traffic movements pa leads to a change in 3Di of 0.5 points. The mechanism is vital, given the significant uncertainty surrounding the traffic forecasts, relative to previous price controls. It will ensure targets are set appropriately for the expected level of traffic, and will mean that NERL avoids windfall gains/losses when traffic deviates from the base forecast used to determine targets.

In practice, the mechanism would adjust the annual 'par' target based on the observed traffic levels in year N+1, looking back at the observed traffic in year N compared to the base traffic forecast. The trigger point for adjustment will be the point at which traffic increases/decreases by over 100,000 flights pa from base forecast. In these instances, 3Di should be adjusted up or down by the ratio of 0.5 points for every 100,000 movements per annum based on the actual difference in traffic (eg if movements were 150,000 pa below forecast 3Di would be adjusted down 0.75 points). Changes to dead-band values and the values at which max/min financial incentives are applied should be determined based on the existing 3Di incentive methdology.

We will continue to review the developing traffic situation, 3Di forecasts and modulation proposals as new STATFOR forecasts are produced prior to NR23 and adjust proposals accordingly.

Proposed reopener mechanism to deal with non-NERL influences on 3Di

3Di performance can be influenced, to advantage or disadvantage, to a great extent by factors outside our control. The likelihood and scale of impact is hard to predict, therefore we propose a mechanism

to reopen the calibration of the 3Di performance targets and metric methodology for factors including but not limited to:

- Airport-led airspace developments: the redesign of near airfield airspace expected during NR23 (+20 airfields) impacting 3Di to achieve noise mitigation or capacity imperatives
- Airline flight planning behaviour: particularly considering ANSP and fuel price differentials affecting the choice of airline business trajectories, and which may not reflect fuel minimal routes, particularly in a Free Route Airspace environment ie where airlines may choose to fly less efficient fuel routes to reduce air traffic control charges
- Space: Following the Space Industry Act and linked regulations, multiple space launch operators are expected to begin operations in NR23. This could lead to material volumes of airspace being restricted before, during and after launch, leading to large-scale re-routings of commercial flights that would affect traffic at the network level on the planned launch days. This is expected to lead to increased aviation CO_2 emissions and an increase in the 3Di score of the affected traffic
- Uncrewed aircraft systems: The potential impacts from the integration of Uncrewed Aircraft System Traffic Management (UTM) into the UK network, similarly, affecting civil air traffic routeings (increased holding and vectoring)
- Military: The impact of implementing new, special use airspace to meet future military airspace requirements
- Other changes to the designation of airspace: such as parachuting, gliding and general aviation, or reclassification of airspace under the Airspace Modernisation Strategy impacting civil air traffic routeings
- Data capture: changes to the scope or accuracy of data capture can modify 3Di values, for example by including more or less radar data within the capture of the 3Di model
- Combination: of factors which together meet an agreed impact threshold

This would enable NERL to present evidence of the impacts of non-NERL events on our ability to deliver the 3Di target and to consult with customers about solutions/adjustments. While we would aim to minimise the impact on 3Di, we would seek either an adjustment to the individual flight scores/data affected, an adjustment to the aggregated 3Di score, or an adjustment to 3Di target.

The trigger for the call-in process should be linked to the performance regime, for example a demonstrable change (six months' data prior to and after change) impacting the score by half the width of the deadband between par and upper/lower thresholds (eg an external impact causing 3Di score to change by at least 2%, if the deadband is 4%, would be called in).

Proposal for narrower deadband based on increased societal expectations

The introduction of traffic modulation and reopener mechanisms would reduce, but not remove, uncertainties of external influence on the 3Di score. As a result we propose that it is fair, in turn, to reduce the size of the deadband in the NR23 period, to reflect the greater focus of the measure now on factors within NERL's control. We propose to narrow the deadband to 4% either side of the par targets, compared to the 5% deadband which applied in RP3. This change would sharpen the incentive on NERL to meet or exceed 3Di targets, making us more accountable to deliver service outcomes within our control.

Proposed treatment of non-revenue flights for NR23

During the RP3 determination the CAA agreed with our proposals to remove non-revenue flights from the 3Di metric (and thus the financial incentive payments based on this metric), on the basis that these

flights have a disproportionately large impact on the score and do not typically seek to maximise flight efficiency. For the purposes of target setting, the CAA applied a downward adjustment of 0.6 points based on NERL data showing the impact of non-revenue flights on the national scores in 2019. It is clear from the CAA's recent Licence modifications, CAP2279, that the CAA has an expectation that, for the RP3 period, this proxy also be used in the treatment of reported scores and the annual 3Di review mechanism (rather than the removal of non-revenue flights from data).

For the NR23 period, we propose that non-revenue flights should continue to be removed from the score, as a matter of principle, with this adjustment implemented by removing the relevant data at source from the calculations rather than via a proxy adjustment based upon historical average impact of non-revenue flights. This would apply to targets, treatment of reported data and the annual review verification process ie the non-revenue flights will not have a 3Di score calculated within our reported data, targets and verification. Our proposals herein remove all non-revenue flights from our datasets, future projections of 3Di and proposals.

Customer feedback

During consultation, airlines supported environmental targets but highlighted the conflicts between the optimal 3Di routeing and alternative options suggested by aircraft onboard telemetry based on temperature and wind conditions.

We consider 3Di remains appropriate for NR23 given previous levels of support for the metric (for example, as part of the RP3 price control consultations). The CAA has previously recognised the advantages of 3Di, specifically the benefit it brings compared to the metric used across Europe (Track Extension of the Actual trajectory, KEA) which measures only the horizontal component of flight inefficiency, not the vertical component. However, we recognise the need to continue to evolve 3Di, and will work with airlines to further develop the metric ahead of NR28.

NR23 targets

Link with external research in ATM's contribution to aviation decarbonisation

Since early 2020, three reports have been published about pathways to decarbonise aviation. These provide largely consistent views about the contribution air traffic control can make. These are summarised below and have been used to guide our target proposals for NR23.

Publication	Date	Scope	Air traffic control contribution	Equivalent average annual 3Di improvement rate
Destination 2050, Royal Netherlands Aerospace Centre, SEO Amsterdam Economics	February 2021	EU aviation (including UK, EFTA)	Intra-EU 5.1% reduction in aviation emissions between 2020 – 2035 (4.4% excluding ground-based improvements)	0.29%
Waypoint 2050, Air Transport Action Group (ATAG/IATA)	September 2020	Global aviation	Three scenarios 0, 3 and 6% reduction in aviation emissions by 2050 including airline and operations improvements	0, 0.1% and 0.2% respectively
Decarbonisation road-map: a path to net zero, UK Sustainable Aviation	February 2020	UK aviation Bunker to fume	4.7% reduction in aviation emissions from 2010 to 2050	0.12% (0.18% with airport and airline operations improvements)

Summary of external research in ATM's contribution to aviation decarbonisation

Each of the roadmaps above describes air traffic management's contribution to aviation decarbonisation as being between 0–6% of overall emissions (ie 0–6 percentage points towards the 100% of emissions aviation needs to reduce or offset to achieve net zero. We have taken account of this new evidence and propose that this forms the basis of our targeted annual improvement rate. This

is because of the correlation between 3Di performance and aviation emissions - reductions in 3Di correspond to reductions in aviation emissions. We have taken the independent research by the Royal Netherlands Aerospace Centre as our reference point, and target a 4.4% reduction in overall 3Di, over a 15-year period. This represents a 0.29% per annum improvement rate from the start of NR23 for 15 years consecutively. The Royal Netherlands Aerospace Centre assessment looks at the potential ATM contribution in EU (and UK) domestic airspace and gives us the highest annual improvement rate of the three roadmaps.

3Di scores under do-nothing scenario

We project 3Di performance with a machine learning model which uses the future traffic forecast to grow sector and route scores. As inputs, the model takes past 3Di data by time of day, where 3Di varies with traffic loadings by sector and route. Peak traffic hours have higher observed 3Di scores as a result of the need to resolve traffic interactions with controller intervention (vectoring of traffic and level capping). To facilitate future movement rates, peak traffic hours are modelled to occur for longer periods of the day. The model includes a 3Di holding algorithm to predict levels of holding, and 3Di when airports are forecast to reach capacity (eg when the demand for a runway exceeds the maximum landing rate, aircraft start to hold or are vectored). Taking these elements into account, our forecast model suggests that without any action, 3Di scores will start NR23 at 28.1 and grow to 29.3 by 2027 (based upon the October 2021 STATFOR base case forecast).

Proposed targets

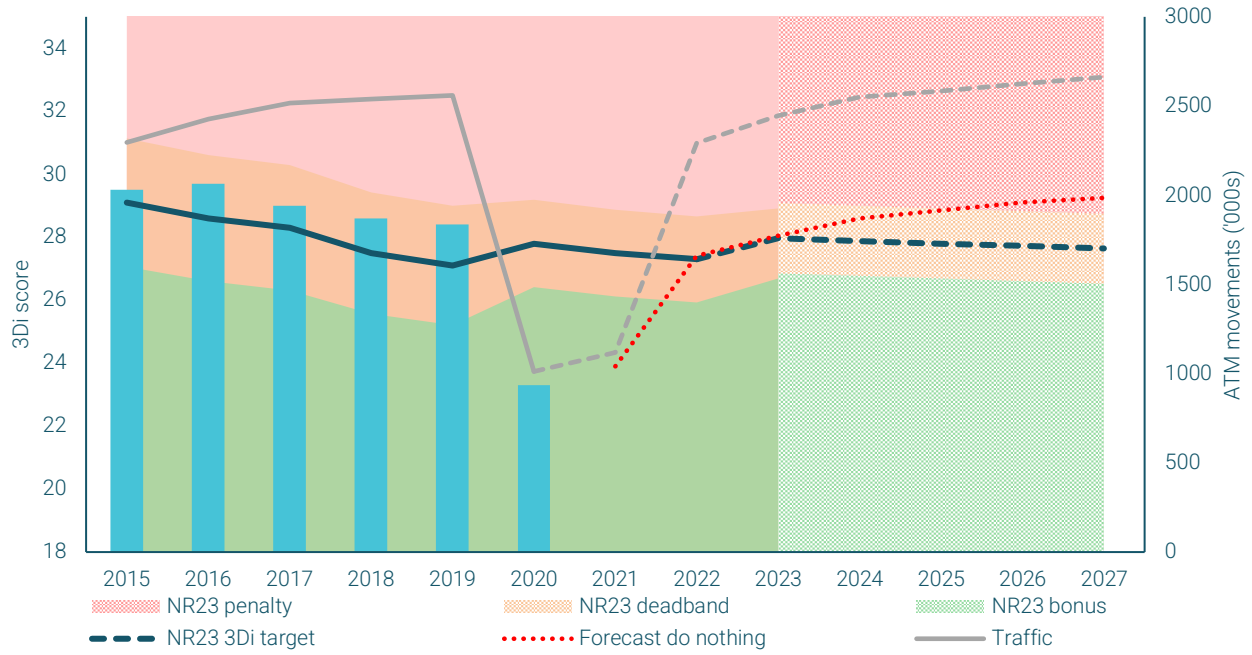
We are targeting a sustainable reduction in 3Di scores, against the base traffic forecast, in line with research quantifying the contribution ATM can and should make to support aviation decarbonisation.

We believe the forward-looking data-driven approach used in the decarbonisation roadmaps now provides a stronger basis on which to set targeted performance. Our 4.4% reduction target represents a challenging target profile of continued improvement against increasing traffic across NR23 and adopts the highest annual improvement rate suggested within external research. The growth in traffic across NR23 is forecast to increase 3Di by 1.2 points under a do-nothing scenario, and will be mitigated by our improvement actions.

Material changes to the traffic observed in any given year compared to the base traffic forecast will be dealt with by modulation of targets and the associated deadband. Managing increases to 3Di in relation to the forecast traffic growth across NR23 represents a stretch over and above the delivery of our proposed rate of annual improvement. In addition, our do-nothing forecast assumes ongoing continuous improvements to the score which are yet to be identified, and become harder to achieve as we approach the frontier of efficiency. Therefore, taking these factors together, our targets contain an appropriate level of ‘stretch’.

We originally proposed to start NR23 with the CAA’s 2020 par target, rolled forward to 2023. However, the volatility between recent traffic forecasts (STATFOR May vs October 2021) combined with improved evidence on the strength of the 3Di-traffic relationship leads us to propose that the start point should relate to the 3Di score expected for the traffic that materialises, with improvement targets being overlaid. We use our 3Di projection as the basis of this do-nothing. We have excluded all non-revenue flights from our forecasts and target projections, so that no further adjustments are needed to deal with these flights.

The chart below shows 3Di target proposals for NR23 (solid light grey line) against forecast traffic (dotted grey line) and 3Di do-nothing projections (dotted red line), compared to past performance (blue bars) and past CAA targets (solid brown line). The shaded areas in green, amber and pink represent annual 3Di scores where financial bonus, nil impact and penalty apply.



NERL 3Di proposals compared with traffic and no action scenario forecasts

Metric	Traffic	3Di forecast 'do nothing'	Lower threshold	Target	Upper threshold
2023	2,444,377	28.1	26.8	28.0	29.1
2024	2,548,822	28.6	26.8	27.9	29.0
2025	2,584,113	28.9	26.7	27.8	28.9
2026	2,623,960	29.1	26.6	27.7	28.8
2027	2,662,145	29.3	26.5	27.6	28.7

Summary of NERL's 3Di target proposals with deadband thresholds at 4% either side of targets

Link with capital investment

We will achieve the 3Di target profile through the implementation of a range of airspace and air traffic developments, including:

- Free Route Airspace
- Interface Improvements around our boundaries
- FASI Network Changes
- Extended Arrivals Management (AMAN/XMAN)
- Time-Based Separation (TBS)

The combined impact from the proposed portfolio is expected to improve 3Di performance by up to a maximum of 2-3 points, noting that projects are at different stages of maturity in terms of their lifecycle (design and scope) and benefit expectations. See Appendix H for more detail on our capital proposals.

Discounted options

In developing our proposals we considered how future developments could unduly impact the score.

We assessed that the interdependency between noise and emissions has an increasing potential to impact 3Di in NR23 and reconsidered options to exclude the lowest levels of airspace from 3Di. This was due to:

- Changes to Government policy[1] strengthening noise priorities up to 7,000ft
- The introduction of new Government policy in 2020 to regulate changes to air traffic procedures which could lead to the Planned and Permanent Redistribution of air traffic (PPR)[2] below 7,000ft
- Airports' ownership of the design of departure and arrivals flows of traffic near to their airfields[3]. This is relevant since airport-led redesign of airspace below 7,000ft (+20 airfields) is expected during the NR23 timeframe under the UK airspace modernisation programme
- Given the clear priorities on noise and airport accountability for airspace change in these areas, NERL has no effective means of influencing horizontal flight efficiency below 7,000ft. While NERL currently facilitates improvements to vertical flight trajectories within the London Approach area, these may similarly be affected by non-NERL airspace redesign

We concluded that the potential impacts still remain emergent and, for now, unclear in terms of materiality. As with other emergent developments that could affect 3Di, such as the integration of space ports and UTM into the UK airspace network, we have considered that these could be better managed with the proposed reopener mechanism, should they be proven to materialise, are significant and can be demonstrated using data on 3Di score impact.

Further areas discounted were:

- Exclusions based on specific elements of the score: for example, recent analysis has shown that the impact of runway orientation is significant. We discounted this proposal on the basis that they were stable elements of the score, and again for simplicity
- Exclusions based on one-off events: such as drone incursions, large-scale military activities and significant weather events which can lead to high scoring 3Di days. While these have continued to impact operational buy-in to the 3Di, we discounted the proposal again on the basis of simplicity, particularly in the annual management of the performance scheme
- Alternative out-turn performance metrics based on CO_2 emissions: we concluded that these remain more overtly affected by economic factors outside our control than 3Di (airline fleet decisions, economic factors determining destination and distance flown)

[1] Air navigation guidance 2017 (publishing.service.gov.uk), section 3.3
[2] Civil Aviation Authority (Air Navigation) (Amendment) Directions 2018
[3] Various sources; the ANG (pg10), CAP1711 Airspace Modernisation Strategy (2.13, 2.14), and airport design principles (Gatwick and Heathrow)