Noise from arriving aircraft - summary

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1. Introduction

1.1 Purpose and status of report

1.1.1 This is the final report by the Secretariat on behalf of the ANMAC Technical Working Group (WG) on noise from arriving aircraft, whose membership is listed at Appendix A. Its purpose, in accordance with the agreed terms of reference, is objectively to describe the sources of operational noise for arriving aircraft, and to consider possible means of noise amelioration.

1.1.2 Our remit was not to advise on the desirability of noise limits, nor of any other particular measure. We have, however, had regard to ANMAC's remit to consider the feasibility of such limits, as well as of other measures intended to ameliorate noise nuisance.

1.1.3 It will now be for ANMAC to reflect upon the Group's report and, taking this in the wider context of community, airline, and airport concerns, deliberate on its considered recommendations to the Department.

1.1.4 The Department is grateful to all the members of the Working Group, especially those from the private sector, who have contributed their time and expertise both in meetings of the Group and outside.

1.2 Terms of reference

1.2.1 The WG's terms of reference were:

To identify and quantify, so far as reasonably possible, the principal causes of variability of noise levels on the ground between aircraft of similar types including but not restricted to ATC factors, pilot/autopilot actions, aircraft control mechanism characteristics, and weather conditions.

On the basis of findings from these investigations, to identify best practice by pilots and air traffic controllers, having regard to safety and capacity considerations and other constraints, in noise abatement at Heathrow, Gatwick and Stansted specifically, and possibly also internationally.

The WG will concentrate on issues common to arrivals at Heathrow, Gatwick and Stansted, and will normally remit airport-specific matters for consideration by the respective noise and track-keeping groups.

1.3 Concern about arrivals noise

1.3.1 Concern about noise from arriving aircraft is not new. The Noise Advisory Council (NAC) report Aircraft Noise: Flight Routeing Near Airports (1971), for instance, addressed most of the issues which interest us today, including two-segment approaches, joining the glideslope from above, minimum height joining points, and so on. Interception of the glideslope from above was discussed and trialled at around that time. At the time of publication of the NAC report, Heathrow already had a nominal glideslope of 3Â°; 2Â½Â° was still recommended by ICAO, yet increasing the angle further was seriously contemplated. The minimum joining heights for instrument approaches were already 2000 ft daytime and 2500 ft at night, or 'when traffic conditions permit'.

1.3.2 As jet aircraft have evolved over time, the 'noise footprints' of succeeding generations of aircraft of comparable mass and carrying capacity have shrunk. However, they have not done so uniformly: the area within the footprints under the departure-path has contracted, in general, substantially more than under the arrivals-path. The comparative footprints are illustrated at Figure 10.7 (see Annex 10).

1.3.3 This is for two main reasons. Firstly, engines have become much quieter - thanks primarily to the development of the high-bypass ratio turbofan. Secondly, the climb performance of aircraft has improved greatly over time, assisted by the replacement of 3- or 4-engined narrow-bodies by twins. As aircraft gain height more rapidly, the already-reduced aircraft noise is progressively more attenuated by the time it reaches the communities below.

1.3.4 Arriving aircraft have not benefited commensurately. Firstly, engine thrust, and thus noise in descent, is much lower than in the climb, to the extent that airframe noise can be a significant component of the noise event energy. And secondly, arriving aircraft have been constrained throughout to the standard 3Â° glideslope (steeper glideslopes conform to ICAO procedure design criteria only when set for obstacle clearance reasons, and are not acceptable for Category II/III approaches). Any improvement in noise attenuation has had to be sought mainly through attention to procedures in the initial/intermediate approach phase.

1.3.5 The net result has been that, while noise contours have contracted at Heathrow and Gatwick despite sustained growth in the number and average size of aircraft, noise from arriving aircraft has become an increasingly prominent component of the total noise environment, and communities have increasingly focused their attention on this point - including some beyond the 57dB(A) L_{eq} daytime contour (the commonly accepted noise measurement metric, which past social survey studies have suggested is related to the onset of significant annoyance or disturbance).

1.4 Dissemination of study

1.4.1 The focus of this study has, of course, been the aerodromes designated under s.80 of the Civil Aviation Act 1982 for the purposes of s.78: Heathrow, Gatwick and Stansted, on which airports alone ANMAC advises. However, in accordance with Ministers' policies of openness and of encouraging good practice, this report, including its technical annexes and associated tables, is published for wider consideration in the hope that airports, airlines, air-traffic controllers, local communities and regulators elsewhere may find in it information of wider relevance. Paragraph 10.2.2 below discusses the possibility of developing a code of practice. The Department will also take forward ideas from the study in the international context.

2. Regulatory framework

2.1 The level and incidence of arrivals noise are influenced by an array of regulations and procedures set for safety, traffic management and noise amelioration purposes, as set out below.

2.2 Noise at source

2.2.1 Subsonic aircraft are subject to noise certification requirements. Subsonic jet aircraft must conform to ICAO Annex 16 Chapter 2 or Chapter 3 (or equivalent standards), according to the date on which an application was accepted for a certificate of airworthiness for the prototype. Chapter 2 aircraft are due to be phased out by April 2002. The great majority of aircraft at the London airports are already certificated to the standards of Chapter 3.

2.2.2 In certification, noise in the arrival phase is measured (or estimated) directly below a 3Â° glideslope at a distance of 2 km from the runway threshold. The same point has been used for both Chapter 2 and Chapter 3 purposes.

2.3 Operational noise limitation

2.3.1 Noise from arriving aircraft is not normally subject, either at the London airports or in general at other airports around the world, to regulation on the basis of direct measurement, though some exceptions to this general rule are described below. ANMAC is to consider, partly on the basis of the WG's report, whether such regulation would be feasible or desirable.

2.4 Instrument and visual landings

2.4.1 The normal mode of final approach to the London airports is instrument landing, using the ILS. Microwave Landing System (MLS) is a precision instrument approach and landing system which may, in the long term, provide a capability for curved path or segmented final approach procedures. However, obstacle clearance approach procedure design criteria have not yet been developed by ICAO and suitable aircraft equipment is not yet commercially viable. In the short/medium term, therefore, MLS Instrument Approach Procedures will be 'ILS look-alike' - i.e. aligned with the extended runway centre-line.

2.4.2 SRA approaches are still, however, occasionally carried out at all three airports. The main reasons for SRA approaches is ILS not functioning on the runway in question.

2.4.3 It was not possible for the WG to compare noise from instrument and SRA approaches. We did not consider this a serious limitation, given the infrequency of the latter.

2.5 Standard arrival routings (STARs)

2.5.1 STARs are specified in the UK AIP. They specify standard routes from the upper airways down to the holding stacks. Aircraft are radar-vectored from the holding fix to the ILS intercept point.

2.6 Continuous descent approach (CDA)

2.6.1 CDA is most commonly taken to refer to the initial approach phase, between 6000 ft and interception of the glideslope. It has been pragmatically defined in research and monitoring studies as a phase of descent in which no segment of level flight longer than 2 nm occurs; but no formal definition is promulgated in the UK AIP or ICAO documents. The purpose of CDA is to reduce the noise experienced at ground level through two effects: by reducing the overall thrust required during the initial descent; and by keeping the aircraft higher for longer, thus realizing noise attenuation benefits.

2.6.2 CDA itself, and the operating procedures to comply with it, have been interpreted in various ways and the WG proposes to the Department through ANMAC below that consideration should be given to making the definition and instructions clearer and more consistent across the airports.

2.6.3 Relevant extracts from the s.78 Notices and AIP for Gatwick and Heathrow are at Appendix B.

2.6.4 In respect of Stansted, the 1985 Airports Policy White Paper indicated the Government's intention to introduce quiet landing procedures at Stansted as the airport develops. During the ANMAC study there were no formal requirements for CDA or for LP/LD at Stansted but CDA has subsequently been introduced for arrivals on runway 23 at Stansted from the new hold, ABBOT. NATS is also committed to evaluate whether CDA approaches will be possible from the LOREL hold to runway 23.

2.6.5 The expression "approach to landing" is defined in the ANO as "that portion of the flight of the aircraft, when approaching to land, in which it is descending below a height of 1000ft above the relevant specified decision height or minimum descent height".

2.7 Low power/low drag (LP/LD)

2.7.1 LP/LD refers to the configuration and thrust of the aircraft while descending. It is sometimes taken to relate only to the final approach phase, i.e. from the point at which the aircraft has become established on both the glideslope and localizer.

2.7.2 The definition accepted when LP/LD was first officially adopted (having been pioneered at Frankfurt), recommended by IATA and subsequently confirmed by ANMAC, covers the full initial, intermediate and final approach from stack to ground (cf. CAA 78002, CAA 78006, DR Comm 8708). In practice, without access to detailed time-specific aircraft configuration data (as available from flight data recorders), it is not possible routinely to measure LP/LD adherence over the whole descent.

2.7.3 Promulgation of LP/LD at Heathrow from 1976 was accompanied by an increase in the requested speeds issued by ATC. The speeds then introduced are essentially those still in use at all three airports today. It was apparently hoped at the time that compliance with these higher speed requests would, for typical airlines and aircraft types, in itself produce a high degree of LP/LD adherence and in particular would encourage the minimization of flap deployment along the descent before lowering the undercarriage.

2.7.4 Again, the WG suggests below that the definition and instructions appearing in the AIP could usefully be clarified. The Annexes discuss how LP/LD might be defined more tightly in the light of findings as to the relationship between noise and aircraft configuration on final approach, and in particular with regard to the need for some flexibility in the point at which a high flap setting is selected and the landing gear is deployed.

2.8 Safety requirements

2.8.1 Under civil aviation legislation, the commander of an aircraft is responsible for ensuring its safe operation. In controlled airspace it is also the commander’s duty to follow the instructions of an air traffic controller or to advise him/her if unable to do so.

2.8.2 Safe operation of aircraft includes the taking of proper precautions. Of relevance to arrivals noise, these include a requirement to prepare (’spool up’) engines for the possible need to initiate a go-around (missed approach procedure). The extent of spooling up, the position along the approach path at which it is required, and the noise consequences on the ground, vary according to aircraft type and airline. However, it is a general requirement and the margin for discretion, if it exists at all, is limited.

2.8.3 PANS-OPS (Vol 1 Pt V, 3.2.1) provides that "in noise abatement approach procedures ... the aeroplane shall not be required to be in any configuration other than the final landing configuration at any point after passing ... 5 nm" from threshold. This corresponds to a height of approximately 1500 ft.

2.8.4 The safety requirements for the operation of aircraft on final approach also require that they be fully configured and stabilized for landing before reaching 1000 ft above the aerodrome. This means that actions to prepare the aircraft for the landing configuration, such as lowering the undercarriage, have to be started substantially earlier.

3. Airport, airspace and capacity constraints

3.1 Airports/runways

3.1.1 Because arriving aircraft normally follow the extended centreline of the runway in use from at least 9 nm from touchdown at Heathrow (or 6 nm at Gatwick and Stansted where the minimum daytime intercept altitude for most aircraft is 2000 ft), the first consideration in determining where noise will be experienced is obviously the position of an airport and the orientation of its runways.

3.1.2 The orientations of the runways at the London airports have been taken as given, and indeed, in light of the extent to which other airport developments constrain options short of demolition, changing the position of any of these runways within the airport perimeters would not be feasible.

3.1.3 The question most obviously arises at Heathrow, where the historical legacy of the east-west orientation, and increasing urbanisation in and to the west of London, is acknowledged to be unfortunate from the arrivals noise standpoint. But it was not part of the WG remit to review the present orientation. Neither have we considered the question of directional preference. The question whether to continue westerly preference at night (Heathrow) was put in a consultation paper published on 23 November 1999. (The deadline for responses is 17 March 2000.)

3.2 Airspace design

3.2.1 The design of airspace contributes significantly to determining the broad areas which will experience aircraft noise, mostly at relatively low level, under the initial and intermediate approach.

3.2.2 Again the basic configuration of the airspace is largely historic, having evolved from the early post-war growth in air travel, and is to a great extent dictated by the runway alignments at the major airports as detailed above. Additionally a constraint is the locations of the terminal holding stacks, which in turn have been strongly influenced by the overall en-route airways structure linking the major traffic orientations. It was outside the remit of this WG to consider airspace reconfigurations. No major structural changes are currently planned, even to follow the introduction of the New En-Route Centre at Swanwick. Any changes that do take place are likely to be evolutionary rather than revolutionary and to be predicated on meeting safety and capacity requirements in the context of the overall growth of air traffic. The dominant consideration here is the position of the holding stacks; this will continue to become even more important in the short term as traffic increases. At Heathrow, approximately 45% of traffic is already stacked for at least one circuit through a typical 24 hour day (at Gatwick around 20%, Stansted 4% and rising). Even when holding is not required, aircraft approaching Heathrow and Gatwick are normally routed via the holding-points.

3.2.3 British Airways has raised with the Directorate of Airspace Policy (DAP) a suggestion that two new stacks should be created to the west of Heathrow. The primary specific noise objective would be to reduce the mean length of the intermediate leg on easterlies into Heathrow, perhaps even eliminating use of the BIGGIN and LAMBOURNE stacks $\overset{*}{-}$ during easterly operations. The initial DAP reaction was that they considered that, in the event of such a change within the existing airspace structure, it was probable that the perceived environmental benefits would be outweighed by safety and capacity disbenefits, although extensive simulation and evaluation of the proposal would be required. More fundamental airspace redesign could produce environmental benefits, but considerations of cost, capacity and transitional

disruption would need carefully to be weighed. The WG believes nevertheless that serious consideration should be given to commissioning a more detailed analysis of these proposals for airspace changes which might produce environmental benefit.

3.2.4 The longer term objective of Eurocontrol (the ECAC ATC co-ordinating body) is to minimize all forms of air traffic delays, including holding delays, by improving the co-ordination of scheduling, tactical slot allocation and airway allocation, etc. - the 'gate-to-gate' concept. It remains to be seen whether this programme will succeed in reversing the trend towards increased holding and, if so, whether there will in practice be a reversal of the trend towards the virtual disappearance of 'straight in' approaches at Heathrow and Gatwick in particular, or only a reduction in the average time spent by each aircraft in the holding pattern. Use of the holding points for standard routing of arriving aircraft, and some degree of holding, is likely to continue for the foreseeable future.

3.3 Capacity and traffic

3.3.1 The airspace and ATC resources, in conjunction with a complex range of factors including the wake vortex clearances required for safe separation of aircraft, help to determine the system's hourly capacity to accommodate arriving aircraft of various types.

3.3.2 As traffic presents itself close to capacity, so the controllers' task in sequencing that traffic such as to minimize delay becomes more challenging.

3.3.3 However, intensity of arriving traffic does tend to confirm the expected tendency for intermediate approach legs to lengthen during busy periods. This appears to be due to two factors: firstly, the need during such periods (at Heathrow) to make greater use of all the available stacks; and secondly, the greater need for 'fine tuning' by the use of track extensions ('S-manoeuvres' or 'trombone patterns') - extended upwind and downwind vectors in the shape described - to achieve the desired close sequence on finals resulting from need to make greater use of the available capacity.

3.3.4 At Gatwick and Stansted, there is greater use of speed control intervention, reflecting the different traffic management problems of mixed-mode operations.

* see paragraph 5.2.2

4. Aircraft operations

4.1 Initial/intermediate approach

4.1.1 From the holding beacon the aircraft is instructed by ATC to leave the stack on a certain heading at a certain speed. This speed is normally either 210 or 220 kts. For most types this equates to approximately the minimum clean speed (i.e. the lowest speed the aircraft can operate without flaps extended). B747 aircraft tend to be at Flap 5 due to higher V_{REF} speeds.

4.1.2 On most types flap extension speeds are directly related to the $V_{REF.}$ Minimum clean speed (Boeing) is typically V_{REF} (flap30) + 80 kts. Typical V_{REF} for a 747 is 140 kts, slightly less for the 777. There is some transient noise as flaps are extended. Some types exhibit a "flap hoot" caused by the

opening of a slot between the flap and the fixed wing section (similar to an organ pipe).

4.1.3 The aircraft normally leave the stack between FL70 and FL90 depending on the lowest available FL (flight levels are not fixed relative to ground level, so the actual height will vary depending on the ambient atmospheric pressure).

4.1.4 At some distance after leaving the hold the aircraft is given descent clearance, usually down to 4000 ft QNH (above mean sea level). The aircraft is turned onto a base leg, in essence this a heading at 90Â° to the extended runway centreline. A speed reduction to 170/180 kts is requested at this point, and further flap extension is normally required. The first information on "distance to go" should be given following descent from minimum stack level. Over the sample studied, this was done by the Intermediate Director (INT) $\pm^{*}$ on 69% of occasions; the Final Director (FIN) $\pm^{*}$ gave estimates on 61% of the sample flights.

4.1.5 The ATC control changes during this segment and often results in a different distance to touchdown being given. The flight crew need to know which is correct, but would tend to act on the pessimistic (shorter distance). Analysis of FDR data undertaken by DORA confirms that the distance information passed by ATC to pilots tends to be pessimistic. This causes the aircraft to be flown lower than an ideal CDA.

4.1.6 Descent to 4000 ft is normally achieved at idle thrust. However, accurate distance to threshold information is required for the crew to establish the fact they "are not rushed". An aircraft has a lot of momentum and to descend and slow down is a complex task.

4.2 Base leg

4.2.1 On base leg the aircraft may be given further descent depending on the distance to go to touchdown in order to achieve the requirement to intercept the glide path from below. This clearance may be to descend to 3000 ft or 2500 ft QNH. In exceptional cases the clearance can be to 2000 ft QNH.

4.2.2 When within 90Â° of the runway heading the ILS glidepath is displayed on the EFIS (Electronic Flight Instrument System) and crew can make more accurate adjustments to the required rate of descent.

4.2.3 In order to maintain a 3Â° descent an aircraft descends at approximately 300 ft per nautical mile. Pilot training and aircraft design makes 3Â° the normal descent gradient throughout the normal flight envelope, and certainly on the initial and final approach. Thus any change to distance to touchdown has an immediate effect of the optimum altitude and crew will make adjustments to correct. If the aircraft is too high, options include using speed brake, lowering landing gear earlier than planned, and requesting an extended routing.

4.2.4 If the aircraft is too low, the only option is to reduce the rate of descent by adding power.

4.3 Final approach

4.3.1 Once established on the extended runway centreline a speed reduction to 160 kts is requested and this is required to be maintained until approximately 4 nm from touchdown (1200 ft aal). In practice due to the requirement to be fully established by 1000 ft aal the final speed reduction is commenced at 1500 ft aal (5 nm).

4.3.2 Landing gear is lowered as the aircraft passes 2000 ft aal and speed is reduced through about 1500 ft to threshold speed V_{REF} (plus an amount depending on the surface wind and gusts). The normal requirement is for the aircraft to be fully established and stabilized in the landing configuration by 1000 ft aal. If the aircraft is not fully established by 500 ft aal a ’go-around’ will normally be mandated by the airline to preserve safety by avoiding ’rushed approaches’.

4.3.3 It must be remembered that the highest cause of aviation fatalities is due to ’controlled flight into terrain’ (CFIT), and one of the airline industrys main focuses on the avoidance of CFIT is to avoid a rushed approach. Therefore "gates" are set at various points on the approach. The final two "gates" are the 1000 and 500 ft points. A go-around is also required if the V_{REF} is exceeded by more than 15 kts at the threshold.

4.3.4 Power is reduced whilst flap/gear is extended then increased to a higher level once the aircraft is in the landing configuration. Due to spool up times this must be achieved by 500 ft or a missed approach executed.

4.3.5 A missed approach does not follow a normal departure Noise Preferential Route, with resulting annoyance in areas less frequently exposed to aircraft noise.

4.3.6 After landing braking is applied and reverse thrust may be selected. If conditions permit "Reverse Idle" may be selected, but this is not appropriate in certain circumstances.

4.3.7 On some aircraft types there are different flap settings permitted for landing. Less flap increases landing speeds, but reduces the amount of thrust used during the later stages of the approach. Less flap also reduces visibility from the flight deck and may not be permitted in poor visibility.

4.3.8 Reduced flap settings create less noise on the approach but increase landing speed and require more use of reverse thrust and/or may increase runway occupancy time.

4.3.9 Analysis of FDR data undertaken by DORA confirms that the aircraft in sample were operated in accordance with the instructions given by ATC. No evidence of other practice was observed during the research.

4.4 Effect of wind

4.4.1 To maintain a 3Âº glide path an aircraft requires a rate of descent of approximately half the ground speed (in kts) times 10. For example, G/S = 180 kts => RoD required = 900 ft per minute. In a strong headwind the ground speed is reduced by the headwind component of the wind affecting the aircraft. This will typically be significantly more than the surface wind.

4.4.2 Therefore with increasing headwind the ground speed is reduced, the rate of descent required is reduced and more thrust is required to maintain the glidepath at a constant indicated airspeed.

4.4.3 The opposite is true with a tailwind, and extra drag from lowering of the undercarriage or additional flap may be required to maintain the glidepath at the required speed.

4.5 Effect of icing conditions

4.5.1 ’Icing conditions’ are defined as visible moisture with an indicated outside temperature below +10ÂºC.

4.5.2 Aircraft engines are anti-iced using hot air from within the engine. To maintain an adequate flow of hot air a minimum engine speed is specified by the manufacturer and must be applied in icing conditions. This may cause unwanted additional thrust which must be dissipated by additional drag (more flap, lowering the undercarriage, etc.).

4.6 Manuals

4.6.1 Aircraft Flight Manual: this is a legal document produced by the aircraft manufacturer and approved by the relevant certificating authority. The contents must be complied with.

4.6.2 Manufacturer’s Operations Manual: an operations manual is produced by the manufacturer. This contains the basic procedures for operating the aircraft.

4.6.3 JAR-OPS requires an operator to provide its own Operations Manual. The contents detail how the crew should operate the aircraft. The manuals produced by manufacturers do not detail how to fly aircraft in line operations: the expertise for this rests with the operator.

4.7 Flight Management Systems (FMS)

4.7.1 Modern aircraft use FMS. The systems enable more accurate navigation under certain circumstances and have the potential of positioning an aircraft between the holding fix and a point on the extended centreline.

4.7.2 The mode of operations at the London airports currently strongly discourages the use of FMS positioning for intermediate approach, due to the manner in which FMS systems control the speed/altitude control, which is less predictable than ATC instructions as interpreted by the pilot.

* see paragraph 5.3

5. Air traffic control procedures

5.1 Aims and objectives

5.1.1 For arriving traffic the air traffic control system aims to achieve the maximum runway utilisation commensurate with safety, including the requisite separation standards. This requirement is within the context of the directions to the CAA under s.72(2) of the Civil Aviation Act, which require that air navigation services are "planned, provided and operated so as to take into account, inter alia, the need to mitigate as far as possible the environmental impact of civil aircraft operations and in particular the disturbance to the public arising from aircraft noise, vibration and pollution".

5.1.2 For Heathrow, where one runway is normally dedicated to arriving aircraft only, the maximum runway utilisation is achieved by consistently reducing to a minimum the spacing between successive arriving aircraft. However, in the case of Gatwick, Stansted and other UK airports, a larger than minimum gap often has to be applied to allow time for a departing aircraft to occupy the runway in between successive arrivals.

5.1.3 The minimum separation between successive aircraft on approach varies, depending on the combination of leading and following aircraft types. The normal minimum separation is 3 nm (2Â½ nm in certain circumstances). However, in many circumstances a greater minimum is required (in some cases as much as 8 nm) to ensure that smaller aircraft do not fly through the vortex wake of a preceding larger aircraft. For example the minimum separation required for a B747 following a B737 is 3 nm; whereas the minimum required for a B737 following a B747 is 5 nm; for a B747 following another B747 the minimum is 4 nm.

5.2 ATC system overview

5.2.1 Diagrams showing the Radar Manoeuvring Areas for Heathrow, Gatwick and Stansted are at Appendix C. The en-route ATC system comprises a network of airways from which inbound aircraft are fed via standard arrival routes (STARs) towards terminal holding patterns serving each airport. The terminal holding patterns form the interface buffer between the en-route sectors and the Approach Control sectors (both are located at the London Area and Terminal Control Centre (LATCC) located at West Drayton).

5.2.2 Four Terminal Holding Patterns serve the arriving traffic flows to Heathrow, to the north-west at Bovingdon (BNN), the north-east at Lambourne (LAM), the south-east at Biggin Hill (BIG) and the south-west at Ockham (OCK). For Gatwick there are two Terminal Holding Patterns (WILLO and TIMBA), both to the south and for Stansted there are also two Terminal Holding Patterns (at LOREL and ABBOT) both to the north. LOREL also serves Luton arrivals.

5.2.3 During busy periods, when the flow of arriving traffic exceeds the immediate system capacity, the Terminal Holding Patterns form a ’reservoir’ of queuing aircraft from which the approach radar controllers (known as Directors) arrange the optimum sequence.

5.3 Intermediate and Final Directors and the Tower Controller

5.3.1 Normally the Intermediate Directors (INT) are responsible for the initial streaming of aircraft from the Terminal Holding Patterns into a preliminary, fairly coarse, sequence. They then hand the aircraft over to the Final Director (FIN), who is responsible for the ’fine tuning’ of the initial streams onto the final approach (ILS). The appropriate minimum arrival spacing between the successive aircraft is primarily achieved by vectoring instructions, reinforced by the application of rigid speed control.

5.3.2 In the case of Heathrow there are (except at night) two Intermediate Directors, one merging traffic flows from the two northerly holding patterns into a single stream on a ’downwind leg’ to the north of the airport, the other Intermediate Director doing the same for the south. The Final Director then merges these two traffic streams onto the single final approach sequence. For Gatwick and Stansted there is normally a single Intermediate Director followed by the Final Director.

5.3.3 The Intermediate Directors initiate the approach sequence from the Terminal Holding Stacks by directing pilots to fly particular headings, determined by the controller, to convert a stack of aircraft one above another into a stream of aircraft one behind the other. The Intermediate Directors issue initial descent clearance to pilots taking into account the vertical and lateral boundaries of the airspace which is ceded to them. These boundaries (known as Radar Manoeuvring Areas (RMAs)) are determined by the need to permit departing aircraft to pass below the arriving aircraft and to allow aircraft to and from adjacent airports to be directed with the absolute minimum of inter-controller co-ordination. The RMAs are complex airspace divisions with stepped upper and lower limits within which the Intermediate Director must ensure his aircraft remain.

5.3.4 In addition to the vertical and lateral airspace constraints the Intermediate Director must take account of the environmental obligation to allow aircraft to achieve a Continuous Descent Approach (CDA) profile. Initial descent clearance should not be given too early, which might encourage the pilot to descend earlier than for the optimum CDA, but conversely must not be given too late which would require the pilot to make a steeper descent than necessary. The initial levels to which descent clearance is given will depend on the RMA constraints together with the necessary terrain/obstacle clearance requirements. (For example, for Heathrow arrivals to Runways 27, a constraining factor is the need to remain above flights to and from London City Airport; in turn the obstacle clearance requirements determine the minimum levels available to the London City flights. Conversely, the requirement for London City arriving flights to get below the levels necessary for the Heathrow flights is a constraining factor on the operation of these flights.)

5.3.5 Once the Intermediate Director has set up the initial stream of aircraft and issued initial descent clearance, the aircraft are transferred to the Final Director. His responsibility is to take aircraft from the initial stream(s) and accurately sequence them onto the final approach track at the optimum speed and spacing to achieve the maximum runway utilisation. In doing so he must also take account of terrain clearance requirements together with any additional environmental requirements imposed on the operation (such as minimum distance and/or minimum level at which the final approach track must be joined, or any special avoidance areas).

5.3.6 Once aircraft are established on the ILS and maintaining the appropriate separation minima, the Final Director transfers them to the Tower Controller. The Tower Controller is responsible for the runway and must ensure that the runway is clear and available for use by the landing aircraft at the appropriate time before landing. He/she is also responsible for integrating departing aircraft between successive arrivals (except most of the time at Heathrow) and also for the many other operations on the runway (inspections, bird dispersal, crossing aircraft etc.). He is also responsible for alerting the emergency services if necessary. If the runway is not clear in time for an arriving aircraft he will issue ’go around’ (missed approach) instructions and co-ordinate his actions with the other controllers. If a commander himself initiates a missed approach procedure, the controller will co-ordinate this.

5.3.7 One of the primary methods available to the controllers to enable them to establish and maintain the optimum spacing between aircraft is speed control. Naturally a stream of aircraft all flying at the same speed is a more stable entity and easier to manage than one where the aircraft all fly at different, and changing, speeds. Throughout the initial, intermediate and final approach the controllers will specify the speeds at which they require the aircraft to fly. Advance warning to pilots of the use of speed control techniques is given in the UK AIP, with an indication of the speed bands used and the distances from touchdown at which they will be required to be applied. However, the actual application of the speed

requirements from flight to flight is determined by the controller taking account of the overall traffic flow and integration of flows.

5.3.8 Use of speed control for arriving aircraft is a standard ATC practice world-wide. However, it frequently means that individual aircraft may not be able to fly in the most desirable configuration (whether that may be for economic or environmental considerations) at all stages of the approach. Speed control may be applied by ATC until the aircraft reaches a distance of 4 nm from touchdown, from which point the pilot must configure and stabilise the aircraft to achieve a safe landing.

5.3.9 Estimating distance to touchdown: clearly, it is necessary for pilots to be given as accurate as possible distance from touchdown information to enable them to judge the descent rate necessary to achieve a CDA. However, there are many variables acting on each aircraft as they progress through their descent towards final approach. The controllers continually have to make judgements about the progress of the aircraft and update those judgements in the light of what is observed to be going on. Ultimately the routeing of a particular aircraft in the approach sequence depends on the progress of the aircraft ahead of it in the sequence, which in turn depends on the progress of the aircraft ahead etc. The response of pilots and their aircraft to instructions issued by the controller is not uniform. Some of the variables, in no particular order of priority, are listed by way of examples:

1. The wind changes in direction and strength with altitude. As aircraft descend, the effect of the wind on the ground track (drift) varies. For aircraft which descend at different rates the overall effects will be different.

2. Pilots do not respond uniformly to ATC instructions. Cockpit workload is extremely high during this phase of flight. Sometimes there is a delay before the pilot reacts to the instruction. Some aircraft systems apply bank angles to initiate turns more quickly than others.

3. Aircraft may turn at different rates, resulting in different turn radii. The radius of the turn depends on the bank-angle, the speed of the aircraft, its altitude, its weight (or inertia), the effect of the wind, and the pilot/autopilot/control-system reaction time.

4. When wind shear exists the aircraft may experience a sudden change to its ground track or speed as it descends through the wind shear level.

5.3.10 All of these variables will affect the initial tactical plan that the controller sets up. Particularly when integrating multiple traffic flows into a single stream (e.g. from two holding patterns into a single downwind leg stream) the initial estimate has to be adjusted following continuous observation. The initial heading given may have to be widened out or tightened up as a result of the actual response of each individual aircraft to the instructions given. Sometimes even the initially planned order of flights has to be changed.

5.3.11 When the controller setting up the initial sequence hands his traffic stream over to the Final Director, further fine-tuning may be needed to achieve the minimum spacing on final approach, lengthening or reducing the path of the aircraft or adjusting its speed.

5.3.12 In the case of Heathrow arrivals during the day, two Intermediate Directors are setting up the two initial traffic streams independently of each other, although each will be aiming to achieve a flow which will be easily integrated into the opposing flow by the Final Director. So in the early stages of the

approach, when the initial descent instructions are given, there can be no certainty of the eventual ground track along which the aircraft will be directed. The controllers task involves planning, instructing, observing and adjusting. Only as the aircraft progresses through the approach do things become more refined and certain and distance estimation will improve.

5.3.13 The controller must plan his workload. In view of the high R/T workload, especially at busy periods, the controller must take the opportunity to issue his instructions when he can, and cannot always choose precisely the optimum time. He might be passing an instruction to another aircraft at that optimum moment, or be responding to another transmission, or a pilot may be speaking on the R/T. The controller has other things to do as well, such as co-ordinating with other controllers directly or by telephone (perhaps waiting for the other controller to answer the telephone), assimilating new data for pending aircraft, and checking weather information etc.

5.3.14 Detailed instructions for procedures used by Air Traffic Controllers are published in the Manual of Air Traffic Services (MATS). MATS Part 1 contains nationally applied procedures, including separation standards (such as the vortex wake separation requirements) and is published by the Safety Regulation Group (SRG) of the CAA. MATS Part 2 contains Local Operating Procedures for individual ATC Units and is published by the ATC Unit (and approved by SRG). Promulgation of information is discussed further at Appendix D.

6. Empirical evidence

6.1.1 The Annexes to this report principally describe the evidence from the Gatwick monitor string study and from the Heathrow study conducted under the aegis of the WG.

6.1.2 The Annexes constitute a self-contained document. Conclusions deriving from this study, from previous evidence and from the WG's deliberations, are described in Â§ 10 below.

6.1.3 The primary methods of control available to ATC are tactical and involve variations of the aircraft path through vectoring and through speed control. The principal noise mitigation measures over which ATC actions have influence were CDA and LP/LD. For an individual flight benefits for CDA of up to 5 dBA in the region 25 to 10 nm from touchdown and for LP/LD of 1 to 3 dBA in the region 20 to 12 nm could be achieved.

6.1.4 The actual benefit from CDA depends on the proportion of approaches achieving CDA; although CDA achievement rates at night/early morning have already been increased over recent years, with some consequent noise benefit, substantially greater noise benefits could be obtained from further increases in rates of CDA achievement: during the daytime where practicable as well as at night. Improved spacing tools should help to deliver these improvements. Similarly, greater use of LP/LD would result in a further noise benefit. It should be noted that these noise benefits are obtained in the area outside the 57dB(A) Leq 16-hour daytime noise exposure contour.

6.1.5 The analysis of current practice revealed that some non-CDAs occurred even though conditions were apparently suitable for the achievement of a CDA. Several factors may influence this, including interpretation of the AIP, ATC action or pilot action or both. It was recognized that some ATC instructions, though valid and meeting safety requirements, could be interpreted in different ways, e.g. clearance to descend to a particular height and position could result in a continuous descent, or descent

followed by level flight.

6.1.6 It is also apparent that the relationship between the ’500 ft/min minimum descent rate’ and the CDA requirements in the AIP as currently worded has not been made sufficiently clear. This may result in some approaches not achieving CDA. These problems suggest that work is needed on the specification of procedures in the AIP and elsewhere, as well as on methods for encouraging better adherence to them.

6.1.7 BAA Heathrow carried out a series of studies at Heathrow Airport over the period September 1994 to September 1999 to investigate the main causes of variability in arrivals noise levels during approach along the 3Â° glideslope. The main variables investigated were: aircraft type and engine fit, instantaneous thrust setting, height and track, meteorological variation, and operating procedures. For a controlled sample of B757 arrivals, the results showed that instantaneous thrust settings could have small but inconsistent effects on noise levels on the ground. For a much larger sample of different aircraft types, when the undercarriage was lowered at an earlier stage during the approach this was found to increase noise levels by between 1 to 2 dB, but lowering the flaps could produce either small increases or small decreases in noise level, depending on the aircraft type. A number of meteorological variables were found to have some explanatory effect, but the overall improvement in statistical correlation when all these variables were taken into account was quite small.

6.1.8 In summary, the evidence of these Heathrow studies has, we were told, suggested that individual arrivals noise levels can be significantly affected by weather variations and other effectively random factors. Most of the residual variability in average arrivals noise levels achieved by different operators of the same aircraft type can be explained by the underlying noise capabilities of their aircraft fleets as indicated by the approach certificated noise levels for each engine/aircraft type combination. It seemed likely that possible differences in average landing weights for different operators could explain much of the remaining variability in average noise levels.

7. Approach noise monitoring/regulation at some other airports

7.1.1 Information is available in the AIP for UK aerodromes, and from the Internet and other sources for a selection of those overseas, together with the collective experience of the WG.

7.1.2 This survey does not purport to be comprehensive. There is no comprehensive official world-wide database for detailed aerodrome procedures. It is possible, therefore, that arrivals noise limits or amelioration measures may exist at airports for which we have not been able to obtain information in the time available.

7.1.3 The majority of aerodromes which we have looked at, however, neither set noise limits for nor systematically monitor the noise of arriving aircraft. The principal exceptions are described below.

7.1.4 The sole exception we have identified in the UK is Birmingham International Airport where, pursuant to a s.106 planning agreement, an arrivals noise limit regime operates in the night period only. At Birmingham there are three noise monitoring microphones located along the extended centreline of runway 15/33 in each direction. The centre monitor for each group of three is at a distance of approximately 4.5 km (2.4 nm) from threshold.

7.1.5 A night violation occurs when a noise level of 87 dB(A) or above is registered by an aircraft at that noise monitor during the 'Night Period' (23:30 to 06:00 hours). In this event, a surcharge equivalent to a full runway charge for the aircraft will be levied against the operator. Income from such surcharges goes into Birmingham International Airport's Community Trust Fund for use on local community projects. The revised night flying policy was introduced in October 1997.

7.1.6 Leeds-Bradford Airport operates a scheme of 'target noise levels'. Departure monitor 'gates' are used to monitor adherence to advisory L_{max} limits of 85dB(A) (day) and 79dB(A) (night) for approaches to runway 32 only.

7.1.7 Frankfurt emphasizes the importance of LP/LD procedures, and requires interception of the glidepath no lower than 3000 ft. Noise caused by approaches to Runway 25 is measured (in L_{AZ} - akin to SEL) at approximately 6.5 nm from threshold; for Runway 07, at 4 nm. 'Fleet Noise Levels', for arrivals as well as departures, are calculated by energy-averaging (rolling year, by month), disregarding the upper and lower 5-percentiles, for categories of aircraft defined by MTOW, Chapter 2/3 status, and number of engines. Emergencies and flights under special ATC directions are disregarded, and a weather-window (>=30% relative humidity, =<20kt wind component and =<25Â°C, all taken at airport level) is applied. Individual exceedances over the type average of >=4dB(A) are reported back to the airline. 'League tables' are produced, ranking the operators within each category. This is primarily an advisory system: there is no direct noise surcharge on event exceedances or league position. However, the monitoring results can determine whether or not an airline-fleet qualifies for the airport's 'bonus-list', thus qualifying for lower landing charges. Specifically a fleet average below 73dB(A) L_{AZ} so qualifies.

7.1.8 Numerous airports either levy charges (e.g. Sydney (Kingsford Smith)), or operate curfews or noise quota type systems with financial penalties attaching (e.g. Washington National) based on noise certification values for landing. We have not sought to list or analyse all these.

7.1.9 Osaka City, which has been superseded by Osaka International for long-haul and most larger short-haul operations, operates a system of noise limits for aircraft approaching runway 14R. The relevant monitor is at approximately 2.4 km from threshold. The daytime limit (0701-2230) is 107dB(A) with lower limits (75 and 100 dB(A)) applying at night (2231-0630) and early morning (0631-0700) respectively. In effect, the limit serves to make runway 14L the preferred arrival runway on south-easterlies.

7.1.10 Copenhagen (Kastrup) has recently introduced a system of noise limits for arriving, as well as departing, aircraft at night (2300-0600 as scheduled). A flat rate limit of 85dB(A) L_{max} applies for arrivals and departures alike. Six (out of nine fixed) monitoring stations are used, close to the airport on either side of the runway and extended centreline. The limit is due to fall to 80dB(A) in 2005.

7.1.11 Zurich operates a system of categorization for the purpose of calculating landing charges, based upon energy-average noise levels for each aircraft type from arrivals and departures combined. The deployment of noise monitors from which the readings are taken is 'community-based'. Noise limits are for departures only.

7.1.12 Prague too operates a system of categories, in this case based on the minimum of comparisons, for flyover, sideline and approach, of adjusted actual against certification levels. Noise surcharges are applied according to category.

7.1.13 For the cases described above the WG has not been able to identify evidence to show that the noise monitoring arrangements in place there deliver information which can feed back to influence airline or ATC procedures. The monitors do not in general appear to be located far enough away from the runway thresholds to be within the range of significant operator discretion (see 8.2 below); one exception is the monitor at about 6.5 nm from threshold of runway 25 at Frankfurt.

8. Feasibility of noise limits for arriving aircraft

8.1 The WG remit

8.1.1 As explained earlier, the WG was not asked to draw conclusions as to the feasibility or otherwise of noise limits for arriving aircraft. In the event, ANMAC advised, in the light of the WG's findings, that operational noise limits would not be appropriate.

8.1.2 What we tried to do was to establish a framework within which 'feasibility' can meaningfully be interpreted, and to provide some of the evidence necessary to assess it.

8.1.3 We touched on the question of limits bearing in mind the Ministerial remit to ANMAC, though it was not part of our terms of reference to answer it.

8.1.4 The Annexes examine matters relevant to the feasibility or otherwise of noise limits in the categories discussed below.

8.2 Efficiency of monitors vs. distance from threshold

8.2.1 Annex 5 describes (paragraph 5.16; Fig 5.18) the proportions of arriving aircraft found to be established on the localizer at various distances from threshold at each airport. It describes why it is not feasible routinely to monitor noise beyond the point where a large proportion of approaches are established on the localizer.

8.3 Aircraft operators' discretion

8.3.1 The aircraft operator is required to produce an operations manual consistent with the stipulation that aircraft must be established in landing configuration no later than 5 nm from threshold. (This range, of course, encompasses the location of the existing fixed monitors used to check compliance with the departure noise limits.)

8.3.2 During the preceding stages of the approach, operators are quite constrained, for example by the needs to follow the ILS, and by the need to follow ATC speed instructions. As a result, there is frequently little scope for pilot discretion, so a limit-based monitoring system is unlikely to be workable.

8.4 Other relevant considerations for ANMAC

8.4.1 The WG was not remitted to consider the broader policy context within which the feasibility of limits would need to be assessed. It may be necessary to consider, in particular, such issues as required standards of proof, and whether there was any risk to safety in the unlikely event that limits could, in some

circumstances, introduce theoretical incentives to adopt non-standard operating procedures in order to avoid breaching the limits set.

8.4.2 Another consideration might be the possibility that unfamiliarity with new or non-standard procedures, were such to be introduced, may lead to transitional or more persistent non-adherence such that the full putative benefits might not be realized.

8.4.3 ANMAC and the Department would also need to weigh the extent to which any proposed limits were liable to be breached (by any aircraft types) because of weather-related factors or non-standard instructions from ATC.

8.4.4 Some of the difficulties inherent in a limit-based monitoring system might be better handled in an advisory system based on average noise levels. Such a system would be more applicable to comparisons between operators, but the WG was not remitted to examine this issue in depth. A system based on this concept is operational at Frankfurt Airport as described above (paragraph 7.1.7).

9. Other possible operational measures

9.1 Height and lateral track monitoring

9.1.1 ANMAC was asked to consider whether systematic height and lateral track monitoring might be operated on arrivals, particularly as a means to assess CDA achievement. Monitoring is now done routinely at Heathrow and Gatwick, for night arrivals.

9.1.2 The GEMS Â® NTK system, now installed at the London airports, may be capable of automated monitoring of CDA achievement. This is currently being explored with the suppliers Lochard but we have not yet been able fully to explore the feasible options.

9.1.3 It does not appear to the WG that it would be possible to determine the causes of non-achievement of CDA solely from inspection of height and lateral tracks. Detailed investigation of particular instances would always be required if a robust and definitive conclusion were to be required in every case.

9.1.4 Monitoring results could certainly, however, provide useful feedback for purposes of promoting good practice, as they do already in the case of CDA at night at Heathrow and Gatwick. They could also be used systematically to confirm that avoidance areas specified in the AIP are adhered to.

10. Conclusions

10.1.1 In accordance with our terms of reference, our conclusions focus on causes of variability and on good practice.

10.1.2 The principal causes of variability of noise in initial approach are:

1. whether extended level segments are flown and if so, at what height above ground level. This was found to be the single most important factor;

2. noisiness of aircraft flying level segments depends in particular on whether the aircraft is systematically decelerating (using very low thrust) or flying at roughly constant speed (greater thrust required to overcome drag).

10.1.3 In the final approach phase, it is important to distinguish between variability in the sense of one flight being consistently noisier than another along the ground track, and variability in the sense of fluctuations of noise along such a track. The main sources of variability are:

1. the aircraft configurations selected along the glideslope. There is evidence from HAL of greater variability across the full range of operators than was present within the samples for which FDR data was available. Nevertheless, FDR evidence and modelling showed significant correlation between configuration and noise (engine and airframe combined). While it was not always possible to be sure from the data precisely why particular settings were selected, the evidence overall supports LP/LD as a noise mitigation technique;

2. the timing of deployment of the undercarriage, and associated flap and thrust changes;

3. we surmised that any substantial changes to the speed controls given by ATC would be likely to affect noise variability. However, speed controls at the London airports are standardized and it was not possible to make inferences on this point from the evidence.

10.1.4 These sources of variability in turn depend on a sometimes complex range of circumstances and events. However, we have found it possible to conclude that some of the factors may be partly within airline, pilot or ATC discretion:

1. the probability of achievement of continuous descent (where this procedure is requested) depends on two main factors:

the point at which descent clearance from minimum stack level is given and to a lesser extent the accuracy of distance-to-run estimates, in particular that provided by the Intermediate Director; and

the action (rate of descent selected) taken by the aircraft commander when descent clearance is given, which in turn may possibly depend on the form of that clearance. Since CDA is not required nor requested on approach to most airports around the world, pilots - particularly those of foreign airlines, infrequent visitors and/or those with limited experience of the London system - will not necessarily remember or assume that it is expected unless a reminder in some form is available. (It used to be normal practice, in the case of Heathrow arrivals, for a reminder to be broadcast on ATIS.)

1. the point at which the undercarriage is deployed is constrained by the safety requirement that the aircraft should be stabilized, in the landing configuration and on the glideslope, before 1000 ft. In practice this translates for many aircraft types into initiating lowering of the undercarriage at 2000 ft or earlier. But there is some variability in the precise position at which this is done. The variability appears to be partly determined by traffic and weather conditions (particularly wind), landing weight, speed corrections and other, exogenous factors; and (to a limited extent) partly discretionary.

10.1.5 Most of the meteorological factors examined appear to play a relatively small part in determining noise levels, although wind is a significant factor (see Annex 9). We were unable to examine empirically the effect of extreme weather conditions. However, analysis within the available weather window is

described in the Annexes to this report. The conclusions were:

1. no statistically significant relationship between temperature and L_{max} (though see section 4.5 above and paragraph 5.33 of Annex 5 on icing conditions and Annex 9, paragraph 9.16, on temperature inversions);

2. the study could not reach detailed conclusions about wind effects because the available data were not sufficiently resolved over time. However, wind (both headwind and crosswind components) has been found (effects in the order of Â±1dB(A)) to affect arrivals noise, other things being equal;

3. indications from other sources, embodied in standard SAE attenuation assumptions, suggest a correlation with relative humidity, though it was poorly correlated with noise in this study;

4. no trend of noise level with cloud cover was observed;

5. air pressure had been found in Heathrow studies to be inversely, though weakly, correlated with noise: the present study covered too limited a range of pressure data to enlarge on this finding;

6. effects of any turbulence on the noise source or in the propagation path could not be studied in the time available.

10.2 Good practice recommendations

10.2.1 The WG went on to consider to what extent it was possible to form conclusions as to good (we hesitate to pronounce definitively on 'best') practice for aircraft operators and for air traffic controllers. The conclusions were as follows.

10.2.2 The WG recommends that consideration be given to developing a code of good practice, in respect of arrivals noise, for air traffic controllers, airlines, airport managers, and others. A draft outline, which ANMAC may wish to consider, is attached at Appendix E.

10.2.3 CDA, where it is feasible, is strongly confirmed to be the current practice generally most conducive to noise abatement. Although CDA achievement rates at night have increased recently, with some consequent noise benefit, substantially greater noise benefits could be obtained from further similar increases in rates of CDA achievement. The following measures were found to represent good practice in the interests of promoting successful CDA:

1. descent clearance through/from 6000 ft should normally be delayed until 20 nm distance to run;

2. improving the accuracy of distance to run estimates given by ATC. Currently distances tend to be underestimated. It is expected that the FAST sequencing tool (see Appendix F), currently under development, will lead to an improvement in accuracy;

3. the Intermediate Director could (avoiding unnecessary increases in R/T time) give descent clearance in such form as to remind the pilot (where appropriate) that CDA is requested. Alternatively, and perhaps preferably, opportunities to reinstate the former practice of issuing CDA reminders on ATIS should be explored;

4. developing an appreciation of the environmental importance of CDA, and of strategies for its achievement, should be part of controllers' and flight crews' standard training.

10.2.4 LP/LD appears to be confirmed as good environmental practice on final approach. Clarification of the definition of LP/LD in the AIP seems highly desirable. This issue is discussed further in Annex 6.

10.2.5 Instructions and requests in the AIP should be clear and unambiguous. The broad concepts of CDA and LP/LD are generally understood in the aviation world, but more precise definition of their application would assist pilots and their airlines, and remove possible current ambiguity.

10.2.6 The present direction to pilots, to inform ATC in the event that a descent at a rate lower than 500 ft/min is expected, warrants review. Unless the instruction is properly understood, its value in assisting controllers to maintain clearance must be doubtful. In the event of unusual wind conditions, or unusual requirements for many aircraft to undertake very long intermediate legs, this instruction could lead to unnecessary R/T congestion.

DETR/AED4
for the Technical Working Group
December1999

List of abbreviations

aal	Above Aerodrome Level
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
ANMAC	Aircraft Noise Monitoring Advisory Committee
Annex	unless otherwise stated, means any technical Annex to this report
ANO	The Air Navigation (No. 2) Order 1995
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
CAA	Civil Aviation Authority
CDA	Continuous Descent Approach
CFIT	Controlled Flight Into Terrain
DAP	Directorate of Airspace Policy (CAA/MoD)
dB(A) or dBA	Decibels ('A' frequency weighting)
DORA	Department of Operational Research and Analysis, NATS
ECAC	European Civil Aviation Conference

EFIS	Electronic Flight Instrument System
FAST	Final Approach Sequencing Tool
FDR	Flight Data Recorder [Quick Access Recorder]
FIN	Final Director
FL	Flight Level (given in multiples of 100 ft referenced to 1013.2mb/hPa)
FMS	Flight Management System
ft	Feet
G/S	Ground Speed
GEMS Â®	Global Environmental Management System (Lochard NTK software suite)
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
INT	Intermediate Director
JAR-OPS	Joint Aviation Regulations Operations
kt or kts	Knots [nautical miles per hour]
LATCC	London Area and Terminal Control Centre
L_{AZ}	A SEL-like noise index used at Frankfurt
L_{eq}	Equivalent Continuous Noise/Sound Level
L_{max}	Maximum Noise/Sound Level
LP/LD	Low Power, Low Drag
MATS	Manual of Air Traffic Services
MLS	Microwave Landing System
MLW	Maximum Landing Weight (Mass)
MTOW	Maximum Take-Off Weight (Mass)
NAC	Noise Advisory Council (1971)
NATS	National Air Traffic Services Ltd
nm	nautical miles
NTK	Noise and Track-Keeping

PANS-OPS	Procedures for Air Navigation Services: Operations [ICAO]
QFE	pressure setting from aerodrome elevation, hence height of aircraft
QNH	altimeter subscale setting to give ground elevation, hence altitude
R/T	Radio-Telephony
RMA	Radar Manoeuvring Area
RoD	Rate of Descent
s.	Section
SAE	Society of Automotive Engineers
SEL	Sound Exposure Level
SRA	Surveillance Radar Approach
STARs	Standard Arrival Routeing
V_{REF}	a reference aircraft velocity
WG	this ANMAC Technical Working Group

Note: longer explanations of most of these abbreviations are provided in the Glossary at the start of the Annexes.

Appendix A

MEMBERS OF THE TECHNICAL WORKING GROUP

Mr P Grindrod*	DETR/AED - Chairman
Mr A Kemp	NATS/LATCC
Mr N Smith*	DAP/AP1
Mr R Neil*	BAA plc
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Mr R Cadoux*	NATS/DORA
Dr D Rhodes	NATS/DORA
Mr A Kershaw	NATS/DORA
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Mr G McInerney*	DETR/AED - Secretariat

* current ANMAC member

Appendix D

Promulgation of information

D1. Details of airspace structures and procedures, as well as aerodrome information are published in the United Kingdom Aeronautical Information Publication (UK AIP) (which is known as the Air Pilot). The AIP is a ’State Document’ issued in accordance with ICAO Standards and is also a ’Notified Document’ carrying a legal status under UK legislation. Although the AIP is the authoritative document it is not designed for use on the flight deck. Commercial flight deck documentation providers (such as RACAL AERAD and Jeppesen), or individual airlines themselves, extract the AIP data into a format suitable for flight deck use.

D2. For each aerodrome, the AIP entry contains details of the physical layout of the aerodrome, operating conditions (such as noise abatement requirements) required by the Aerodrome Operator (in the case of the three designated airports the noise abatement procedures are notified by the Secretary of State), ATC procedures such as departure and arrival procedures, loss of communication procedures and instrument approach procedures.

D3. For Heathrow, Gatwick and Stansted, the operating procedures section includes a description of the initial approach requirements under radar control, including details of the speed control measures that will be applied by ATC to achieve the approach spacing and information on the application of Continuous Descent Approach procedures. An extract is given at Appendix B for information.Temporary, but fairly long term, changes to procedures can be published by supplements to the AIP (the six-monthly noise quota arrangements are published by this means). Short term information, such as failure of a navigation aid or change to an obstacle clearance height, would normally be notified by NOTAM.

D5. Aeronautical Information Circulars (AICs) are published giving more general information on certain topics, although they do not notify procedures.

Appendix E

Initial proposal for the possible elements of a minimum noise arrivals code

1. Airline procedures:
Guidelines on speed, use of flap, undercarriage deployment, and use of reverse thrust;Calculations for helping to achieve continuous descent approaches;Consideration of special arrangements at night when traffic flows are reduced.

2. ATC procedures:
Timing and accuracy of information given to flight crew on distance to touchdown;Use of spacing methods that avoid the need for level segments;
Consideration of special procedures at night to help ensure continuous descent approaches;
Continuous descent approach policy unambiguously published (AIP/AIC etc.).

3. Airport procedures and implementation of the code:
Runway maintenance;
Provision of (real time?) feedback to flight crews and air traffic controllers (possibly from the NTK system);
Auditing compliance with the code;
Analysis and open communication of results;
Contractual arrangements with NATS to include environmental objectives.

4. Longer term airspace objectives:
Possible amendment of westerly preference arrangements, for example to reduce operations in tailwinds;
Creation of two new westerly holding points;
Consideration of approach routes and scope for future change.

Appendix F

Final Approach Spacing Tool (FAST)

To enable Heathrow airport to achieve its maximum arrival runway capacity, it is vital that the achieved spacing between aircraft when crossing the outer marker, some 4 nm prior to touchdown matches the required minimum. In current operations, controllers do this solely on the basis of their expertise. Late in 1995, a business case was raised by London Terminal Control to develop a computer based tool to assist controllers achieve arrival landing rates with increased accuracy and consistency. As a result, the NATS Department of ATM Systems Research (DASR) commenced development of the Final Approach Spacing Tool (FAST) for Heathrow in Autumn 1996, leading to real time trials of the FAST prototype in January and June 1998. The trials featured runs both with and without FAST in operation, thus allowing both objective and subjective measurements concerning the performance of FAST. Results suggest that FAST could usefully affect the consistency and accuracy of achieved spacing on the ILS and may decrease the Final Directors workload. As a result of these trials, it is now planned to progress to large scale simulations at the Air Traffic Management Development Centre (ATMDC) in Autumn 1999, followed, if successful, by operational trials of FAST During Winter 1999/2000.

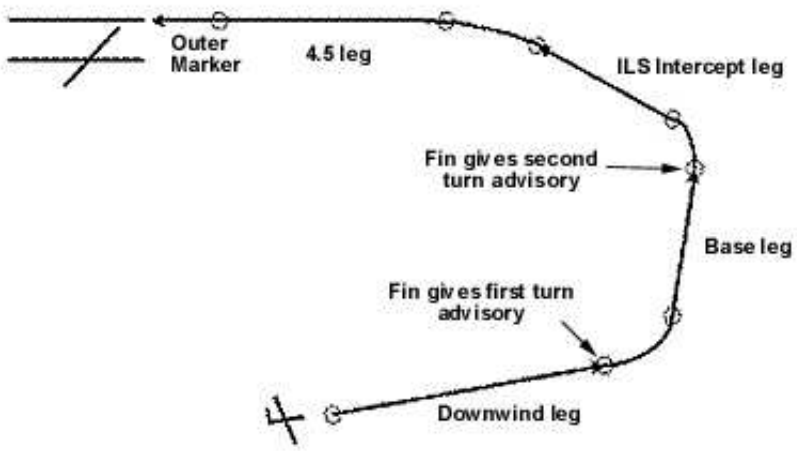

Figure F1

The FAST concept

FAST has been designed to provide guidance to controllers in order that the minimum required spacing on the ILS is achieved with greater accuracy and consistency. The Final Director (FIN) is the controller responsible for feeding aircraft onto the ILS. At present, the FINs primary method of guiding aircraft onto the ILS at the required minimum spacing is through varying the aircrafts track length before it joins the ILS. This is achieved by varying the timing of the turn from the downwind to the base leg and from the base leg to the ILS intercept leg (see Fig F1). Since these turns have the greatest effect on the achieved spacing FAST has been designed to provide guidance on the timing of these turns, with the following assumptions:

The controller retains responsibility for aircraft achieving the required spacing and maintaining radar separation - i.e. FAST is providing guidance only.

FAST has to fit in with the current operational environment and working procedures (since FAST is required for rapid implementation it has been designed to operate within current ATC hardware and controller practices).

FAST has to operate without increasing the controllers overall workload - at busy times the FINs workload is very high. It is therefore vital that FAST can provide guidance to the FIN without increasing his/her workload.

Controllers remain responsible for the arrivals sequence - FAST does not attempt to optimise the arrival sequence, e.g. for wake vortex considerations.

Controllers remain responsible for height clearances used to achieve the required descent profiles and for refining spacing through the tactical use of speed advisories.

FAST Display and Interface

Information concerning FAST is displayed both on the radar screen and through a dedicated touch panel located on the console beneath the radar display.

The FAST advice for the turn to base leg is shown as a countdown in the track data block on the radar display from 15 seconds before the aircraft should start turning until the time that the aircraft is due to begin its turn. The FAST advice for the turn to ILS Intercept Leg is shown as an arrow displayed in the track data block on the radar display from 15 sec before the aircraft should start turning until the time the aircraft is due to begin its turn. The arrow will start flashing halfway through this period and indicates the expected direction of turn - < for Westerly approaches and > for Easterly approaches.

The FAST landing sequence is displayed at the bottom of the radar screen. The aircraft are ordered from left to right for Westerly approaches and right to left for Easterlies. The radar sequence display is not interactive; changes to the landing sequence are made from the FAST touch panel and are reflected in the radar display.

Whilst FAST operates without tactical controller intervention, certain strategic data needs to be maintained such as the spacing policy in use (e.g. low visibility procedures) and the runway in use. There are also occasions when the controller will have to amend data to reflect tactical decisions made late in the aircrafts approach, such as changes to the planned sequence. In order to facilitate these changes FAST provides a touch panel located beside each controllers flight strip bay. All changes to the FAST system are made by controllers other than the FIN, thereby ensuring that the workload of the FIN is not affected by data entry. In this way the controller can inspect the information which FAST is using to provide the advisories and amend information as necessary with minimum effort.

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