ANNEX

Appendix B

Flight performance calculations

B1 INTRODUCTION

Flight path synthesis

In the main, this appendix recommends procedures for calculating an aeroplane flight profile, based on specified aerodynamic and powerplant parameters, aircraft weight, atmospheric conditions, ground track and operating procedure (flight configuration, power setting, forward speed, vertical speed, etc.). The operating procedure is described by a set of *procedural steps* that prescribe how to fly the profile.

The flight profile, for takeoff or approach, is represented by a series of straight-line segments, the ends of which are termed *profile points*. It is calculated using aerodynamic and thrust equations containing numerous coefficients and constants which must be available for the specific combination of airframe and engine. This calculation process is described in the text as the process of flight path *synthesis*.

Apart from the aircraft performance parameters, which can be obtained from the ANP database, these equations require specification of (1) aeroplane gross weight, (2) the number of engines, (3) air temperature, (4) runway elevation, and (5) the procedural steps (expressed in terms of power settings, flap deflections, airspeed and, during acceleration, average rate-of-climb/descent) for each segment during takeoff and approach. Each segment is then classified as a ground roll, take-off or landing, constant speed climb, power cutback, accelerating climb with or without flap retraction, descent with or without deceleration and/or flap deployment, or final landing approach. The flight profile is built up step by step, the starting parameters for each segment being equal to those at the end of the preceding segment.

The aerodynamic-performance parameters in the ANP database are intended to yield a reasonably accurate representation of an aeroplane's actual flight path for the specified reference conditions (see **Section 2.7.6 of the main text**). But the aerodynamic parameters and engine coefficients have been shown to be adequate for air temperatures up to 43 °C, aerodrome altitudes up to 4 000 ft and across the range of weights specified in the ANP database. The equations thus permit the calculation of flight paths for other conditions; i.e. non-reference aeroplane weight, wind speed, air temperature, and runway elevation (air pressure), normally with sufficient accuracy for computing contours of average sound levels around an airport.

Section B-4 explains how the effects of turning flight are taken into account for departures. This allows bank angle to be accounted for when calculating the effects of lateral directivity (installation effects). Also, during turning flight, climb gradients will generally be reduced depending in the radius of the turn and the speed of the aeroplane. (The effects of turns during the landing approach are more complex and are not covered at present. However these will rarely influence noise contours significantly.)

Sections B-5 to **B-9** describe the recommended methodology for generating departure flight profiles, based on ANP database coefficients and procedural steps.

Sections B-10 and **B-11** describe the methodology used to generate approach flight profiles, based on ANP database coefficients and flight procedures.

Section B-12 provides worked examples of the calculations.

Separate sets of equations are provided to determine the net thrust produced by jet engines and propellers respectively. Unless noted otherwise, the equations for aerodynamic performance of an aeroplane apply equally to jet and propeller-powered aeroplanes.

Mathematical symbols used are defined at the beginning of this appendix and/or where they are first introduced. In all equations the units of coefficients and constants must of course be consistent with the units of the corresponding parameters and variables. For consistency with the ANP database, the conventions of aircraft performance engineering are followed in this appendix; distances and heights in feet (ft), speed in knots (kt), mass in pounds (lb), force in pounds-force (high-temperature corrected net thrust), and so on — even though some dimensions (e.g. atmospheric ones) are expressed in SI units. Modellers using other unit systems should be very careful to apply appropriate conversion factors when adopting the equations to their needs.

Flight path analysis

In some modelling applications the flight path information is provided not as procedural steps but as coordinates in position and time, usually determined by analysis of radar data. This is discussed in **Section 2.7.7** of the main text. In this case the equations presented in this Appendix are used ‘in reverse’; the engine thrust parameters are derived from the aircraft motion rather than vice-versa. In general, once the flight path data has been averaged and reduced to segment form, each segment being classified by climb or descent, acceleration or deceleration, and thrust and flap changes, this is relatively straightforward by comparison with synthesis which often involves iterative processes.