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Detailed flight operation data for accurate aircraft noise assessment

Usually the aircraft fleet and air traffic with appropriate distribution of flights between the routes are necessary input data for aircraft noise calculations. Aircraft performance and noise data base together with operational weights (depending on flight distances) and operational procedures (including low noise procedures) influence huge on results of contour assessment in real atmosphere conditions. Current recommendations allow to define the flight profiles via solutions of balanced motion equations. But the difference still exists between the measurement noise level data and calculated ones. Some of them are well explained by differences between balanced flight parameters (thrust and velocity first of all) and monitored by the traffic control system. Statistical data was gathered to make more general view on these differences and some proposal to use them in calculations has being proved.

Introduction

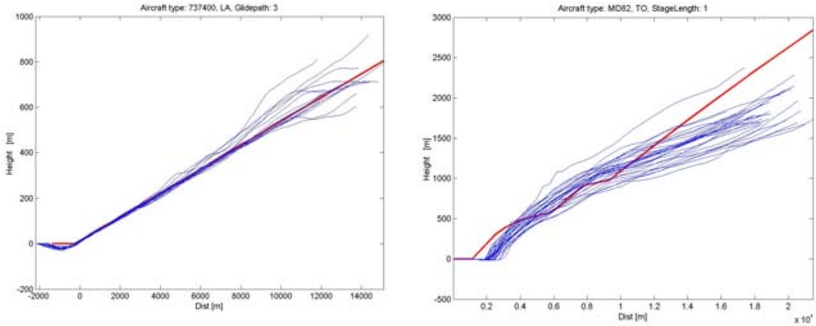
Current recommendations for aircraft noise calculations are defined by ICAO [1] and ECAC [2] documents. The methodology applies to long-term average noise exposure only, "… it cannot be relied upon to predict with any accuracy the absolute level of noise from a single aeroplane movement and should not be used for that purpose" [1]. Current versions of appropriate software (INM, SONDEO, ANCON, IsoBella, etc) are fully correspondent with these recommendations. But a number of national noise regulation rules require for single noise event control or via L_{Amax}, or via *SEL*, or via any other noise descriptor, which is correspondent with noise event, particularly with aircraft noise event.

Flight Profiles

Flight profiles in real operation differ greatly from the results of prediction for balanced motion usually, as for take-off/climbing, so as for descending/landing profiles(Figure 1 [4]). The differences are observed not only for the height-distance dependences, but for the flight speeds and thrust settings, which contribute much to the predicted levels of noise also.

Arrival flight profile parameter analysis

In Figure 2 (combine from four figures, which are taken from [4]) the data for arrivals for two types of the aircraft are shown. If to look on the flight speed it should be found that operational speeds (blue) vary along glide path and sometimes their values may be below the safety requirements (value of balanced flight solution is shown in red). In these cases a pilot must operate with thrust, making engine thrust settings higher, to return the speeds to the safe values - overbalanced thrusts (control from pilot to return the velocity into safe diapason). It was found that the thrusts may be twice and more higher than the balanced predictions for them. For some types of the aircraft the balanced predictions were found much less than observed thrust in operation (Figure 3, is taken from [4] also), which may be accessed as a mistake in input values for coefficients (aerodynamic or thrust) in used data bases.



(a) (b)

Figure 1. Flight profiles (height via distance) observed in operation (blue-coloured) in comparison with balanced prediction (red-coloured): a – arrival; b – departure [4]

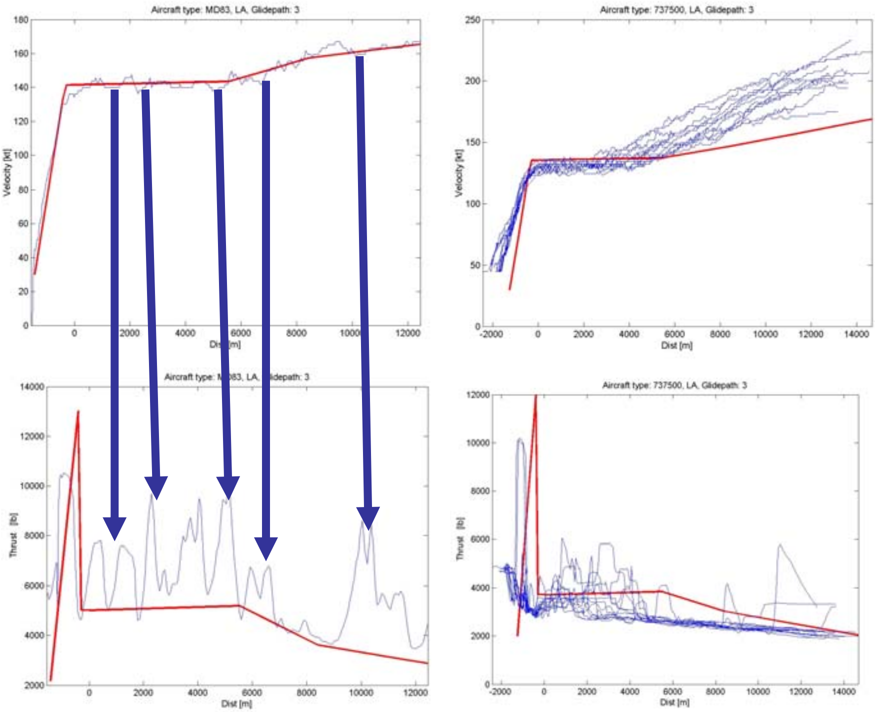


Figure 2. Comparison between observed in operation (blue) velocities and thrusts and predicted balanced values (red)

Departure flight profile parameter analysis

In Figure 4 (combine from the figures, which are taken from [3]) the data for departure are shown. If to look on the flight speed (bottom figure) it should be found that operational speeds (blue) vary along take-off/climbing stage of the flight path and usually are less than balanced values (red). Appropriate operational thrusts are much less also (right figure), but both of them – speed and thrust – located in safe diapason, these data are the results of pilot operational qualification and may be defined for every airport/airline/aircraft via statistical analysis.

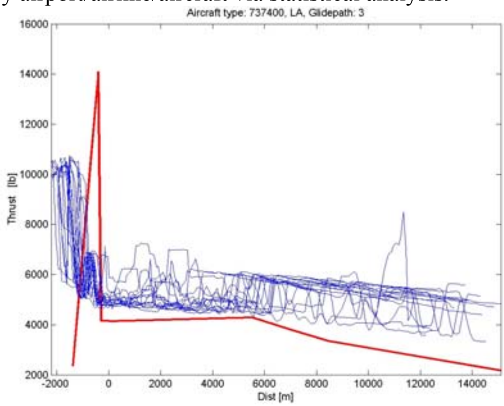


Figure 3. Balanced predictions much less than observed thrust in operation [3]

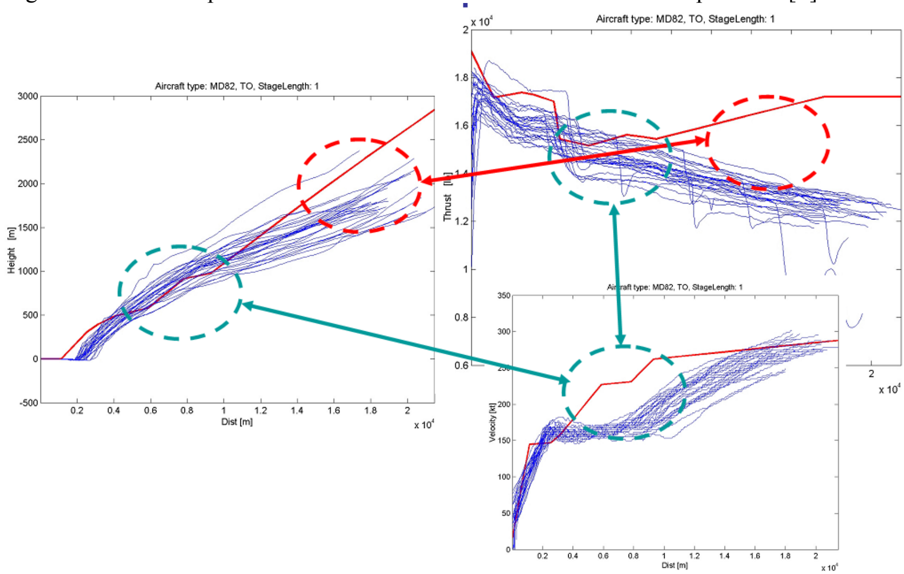


Figure 4. Balanced predictions for departure thrusts are much less than observed in operation thrusts

Noise measurement results

The measurements were done in vicinity of city airport which operates the aircraft on short and middle distance routes: A-320, A-319, B-737, B-738, B-735, EMB-195, MD-83, DH-8, ATR-72, ATR-42, F-70, SAAB-2000, RJ-85, etc. 5 points of noise control were chosen on distances up to 2 km from runway, two of them very closely to the arrival/departure nominal route, three – up to 1 km aside of it. Analyzed data for measured maximum levels are shown in Table 1. The diapason of changes at every point is quite huge, even for the same type of the aircraft and same flight mode, but their difference from the predictions is much greater.

Table 1 - Statistical data for measured maximum levels at 5 points of noise control

Level data observed in survey	Maximum Level L_{AMax}, dB (A)				
	Point 1	Point 2	Point 3	Point 4	Point 5
Maximum	99.6	84.2	77.8	85.2	78.4
Minimum	86.5	78.2	69.0	81.2	73.0
Average	91.2	80.1	73.3	82.8	75.1
σ	3.9	1.7	2.2	1.2	1.4
±Δ	1.7	0.8	1.0	0.5	0.6

Operational via balanced data

Difference between the observed in operation and balanced data for flight parameters (Figure 2,3) provides at arrival stage on 2-3 dBA higher maximum levels than it is calculated by INM – Figure 5. Same results may be found for contours (IsoBella results in Figure 6) – for results with input data for flight parameters observed in operation approach/landing contours are longer closely to runway end and appropriate to them difference for L_{Amax} ~2 dBA at distance 1000 m from the runway end. For the take-off/climbing flight stage noise contour for L_{Amax} = 75 dBA, which is defined by input data for flight parameters observed in operation is longer on 1.5 km.

Conclusions

By correction of the thrust at final glide slope descend for B-734 the L_{Amax} is higher on 2 dBA than for INM balanced flight input data. By correction of the thrust with correspondent height and speed at climb out the contour for the L_{Amax} =75 dBA is predicted longer on 1,5 km comparing with INM balanced flight input data for standard atmosphere conditions. Thus appropriate changes were done in Isobella software to make closer the calculated levels L_{Amax} to measured ones. Same recommendations were made in the algorithm of the ICAO/ECAC methods [1,2].

For arrivals, during the flight along the glideslope just before landing, overbalanced thrust (due to control by pilot to return the velocity value into safe diapason) is 50-100% higher than used in INM and similar calculation tools. At take-off/climbing the thrust at valuable for noise contours distances is less than solution for balanced motion of the aircraft.

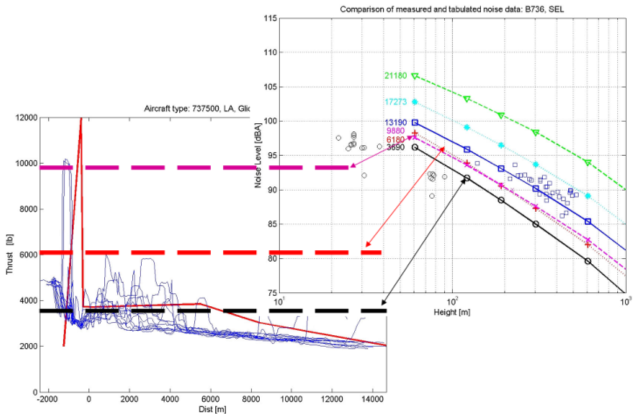


Figure 5. Comparison of observed in operation (magenta) and balanced (black) NPD curves for B-737-400/500/600 at glideslope

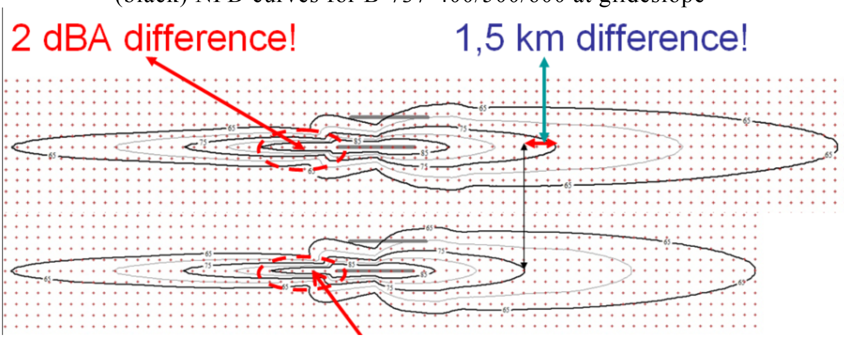


Figure 6. IsoBella results for B-737-400 noise contours (approach/landing and take-off/climbing): over – with input data for flight parameters observed in operation and below – for balanced input data for flight parameters

References

1. Recommended Method for Computing Noise Contours Around Airports. ICAO Doc 9911, 2008.

2. Report on Standard Method of Computing Noise Contours around Civil Airports. ECAC.CEAC Doc 29. 3rd Edition. 2005.

3. Idar L N Granøien, et al. Comparison of INM profiles and measured flight profiles at Gardermoen, SINTEF Report STF40 A02032, 2002.