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Christopher Day
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Dear Mr. Day,

Per your request, I have reviewed the materials that you and your associates provided to me regarding the INM model of the Queenstown airport that you have developed and used in the noise contour study described in the draft report dated 9 April 2008. I note that the draft report did not include the annexes or the figures that are referenced in the draft report, and that the draft report was accompanied by the following files:

- INM files [‘Queenstown 2008’],
- Forecast spreadsheet [‘For MDA_a.xls’]
- Operations data spreadsheet [‘071121 INM movement data R02.xls’]
- Spreadsheet comparing measured versus predicted noise levels [‘080207 Summary Measured vs. Predicted.xls’]

I reviewed the topographic data for the Queenstown airport and the operations data, flight tracks, modifications to Noise Power Distance (NPD) data, and custom aircraft flight profiles for fixed wing aircraft. Helicopter noise data were not reviewed.

1. Flight Tracks

The flight tracks were reviewed only in a cursory way as they were derived from radar data. Nothing unusual was observed and it was noted that the flight tracks did include flight track dispersion, as is appropriate for this type of study.

2. Operations Data

I did not review the model used to forecast the number of operations and have no comments as to whether the number of operations in the future forecast year is reasonable. However, I did note that the future forecast year of 2037, which is 29 years from now, is significantly greater than the minimum of 10 years specified in the New Zealand Standard NZS 6805, Section 1.4.3.1. It is also greater than the 20-year planning period used in the U.S. and thus longer than airport planning horizons with which I am familiar. My only concern in this regard is that the longer planning horizon is by definition accompanied by greater uncertainty.

Several issues were identified with the operations data. These are summarized as follows:

2.1 Year 2003 Fleet Mix

The report references compliance contours that were done for the years 2006 and 2007. The INM files for these years were not included in the INM files provided with the report. There was a file for the year 2003 (the files was labeled 2003, and I have assumed that this was the year represented and not the date the file was created). In the INM file labeled 2003, the only air carrier jet aircraft included in the fleet were the A320 and B737700 (3,192 and 508 annual operations respectively). The spreadsheet 'For MDA_a.xls' has two columns of operations data labeled 'actual 2005' and 'actual 2006.' The 2005 and 2006 data show a fleet dominated by the B737300 with only 2 to 4 annual operations of the B737700 and only 236 to 230 annual operations of the A320. This leads to the question of the validity of the operations data contained in the year 2003 INM file.

2.2 Year 2037 INM files

There were 2 versions of the ops_flt.dbf for the planning year included with the INM files, one labeled R11a and one labeled R11b. There were also scenarios for each of these. The ops_flt.dbf files appeared identical. The report should make a clear reference to which INM files were used for the published contours.

2.3 Year 2037 Fleet Mix

The year 2037 fleet mix includes B737-200, B737-300, and B737-400 aircraft that will not likely be in the fleet 29 years from now. These aircraft should be replaced with either the B737-700 and/or the B737-800. The -700 and -800 represent the smaller and larger versions, respectively, of the next generation of the B737 family. They also have as standard equipment the advanced Flight Management System (FMS) with Required Navigation Precision (RNP) that is necessary for the recently developed arrival procedures at Queenstown. Of particular concern is the fact that the numbers of operations performed by these aircraft types grow with time. While the total number of B737-200 aircraft is small, it is not credible to forecast that this aircraft type will be in the fleet 29 years from now given that the last aircraft of this type was produced in 1988, and the youngest such aircraft would be 49 years old in 2037. Further, B737-200 aircraft are particularly loud relative to the newer B737 aircraft, thus their inclusion will result in larger contours than is to be realistically expected. Similar situations exist with the B737-300 and B737-400, which were last produced in 1999 and 2000, respectively, meaning that the youngest such aircraft would be 38 and 37 years old, respectively, in 2037.

Given the very high number of B737 operations and the differences in noise characteristics, it is important that the most appropriate model of the B737 is used.

2.4 A320 Operations

The year 2037 operations data shows 954 annual arrivals of the A320, but only 434 departures. The total operations for the year differ by this amount as well. This is probably just a coding error that needs to be corrected.

3. Topographic Data

The topographic data provided were loaded and reviewed in INM and compared to topographic data shown in Google Earth for the Queenstown area. The terrain data appeared to be both offset or not properly scaled. A plot of the Year 2037 contours with topography and CAD files turned on and overlaid on a Google Earth aerial is shown in Figure 1. The INM file has been made partially transparent to show the underlying aerial. The yellow ellipses show where there are topographical lines over water areas, or where the river in the aerial does not follow the contour lines from the topography file. While it may be a bit difficult to read through the INM plot onto the aerial, the differences are noticeable. The differences are not large, but could be important. Aligning terrain files in INM can be difficult, so care must be taken.

It is difficult to estimate how much a terrain shift will affect the contours. A good test is to run the contours without using the terrain option and compare to the contours using terrain. If the differences are small then the terrain is not important. However, if there are locations where terrain interrupts line of sight to the aircraft, INM will calculate a noise barrier effect and this effect will be significant.

It is also possible that the alignment error shown by the topographic lines over water is due to a misalignment in the CAD file. Of course this would be very serious as the CAD file is used to relate the contours to local land use. But this is unlikely, as the CAD file matches the Google Earth aerial very well.

Lastly, having topographic contours overlap bodies of water could be a magnet for criticism.

4. Meteorological Data

The INM files are based on a temperature of 9.7°C, pressure of 726.95 mm-Hg and 75% Relative Humidity. This is not discussed in the report. It is recommended that you describe this in the written report and provide a source reference for the data. Further, it should be stated whether the average temperature and humidity are 24-hour averages or daytime averages.

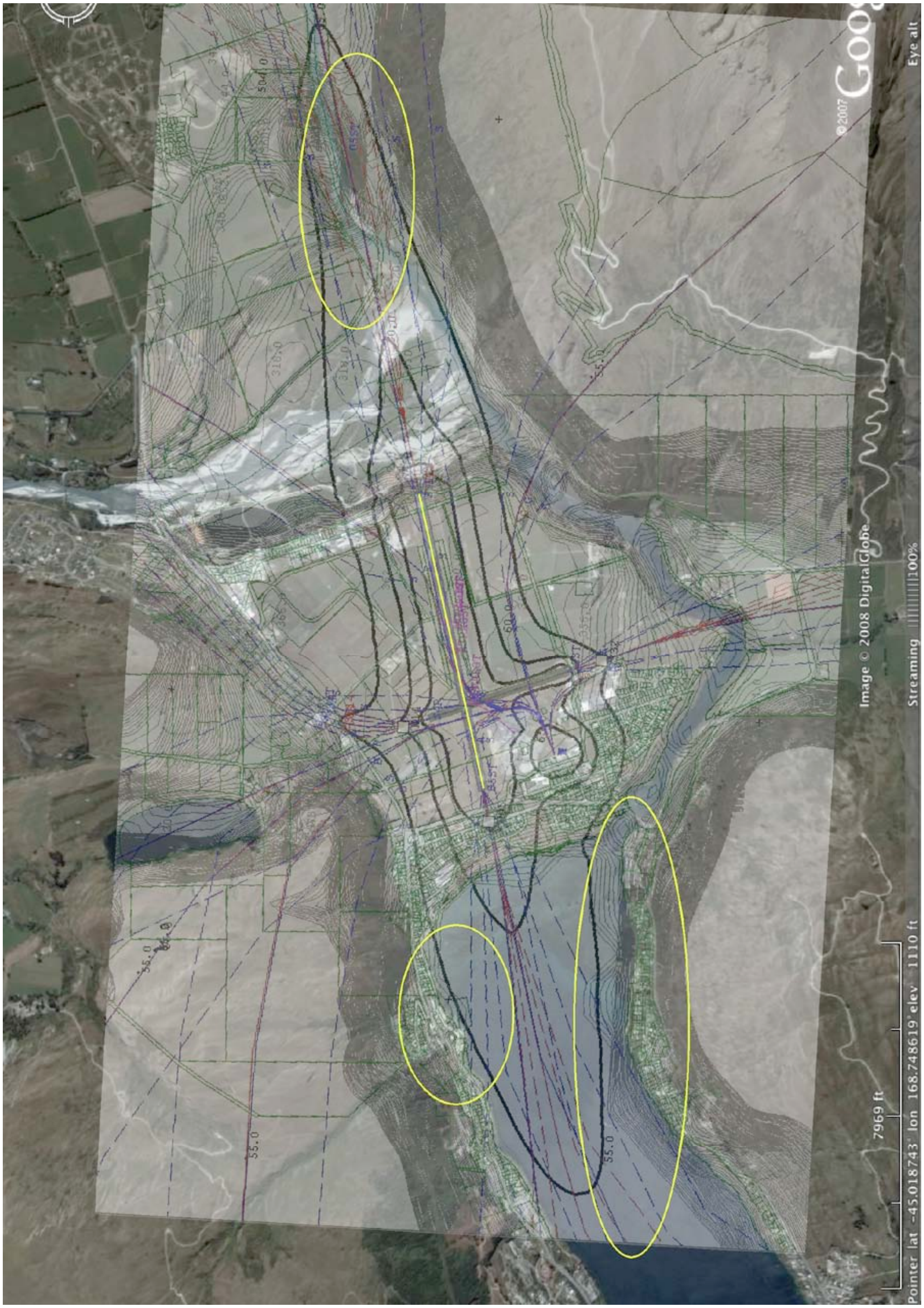

Figure 1: Noise contour, topographical contours, and CAD contours overlaid on Google Earth map showing discrepancies between the topographical and CAD contours.

5. Noise Power Distance Curve and Flight Profile Modifications

5.1 Comparing Measured and Modeled Noise Levels

Comparing measured and modeled noise levels is a complex topic. When making such comparisons it is critical to understand the uncertainty associated with both the modeled and measured data. When the levels are compared using the uncertainty associated with each, one must be very careful when drawing conclusions about the correctness of the modeling results. If the uncertainties overlap, i.e., modeled of 65.1 plus or minus one dB and measured of 66 plus or minus one dB, you cannot conclude that there is a significant difference. In this case the modeled results fall within the uncertainty of the measurement data. INM uncertainty is not well defined and is the subject of at least one current research effort, but suffice to say the INM uncertainty is on the order of dB's and not fractions of a dB. The INM uncertainty is difficult to quantify because it will be quite different under the flight track versus to the sideline, and varies by distance from the aircraft. That being said, the INM uncertainty near the 65 DNL will certainly be less than the uncertainty near the 55 DNL.

The guidance on measurement uncertainty can be found in at least two relevant documents. These are "ISO/DIS 20906.2, Acoustics -- Unattended monitoring of aircraft sound in the vicinity of airports," and "SAE ARP 4721, Part 1, Monitoring Aircraft Noise and Operations in the Vicinity of Airports: System Description, Acquisition, and Operation." The ISO document is in the final stages of adoption and has been approved by the technical committee. It contains an annex on measurement uncertainty. The SAE document includes an entire chapter on temporal monitoring and estimating the uncertainty of portable noise monitoring. In each case the discussion of sample sizes and estimating uncertainty are treated quite rigorously. The uncertainty of measurement is greater than the calibration uncertainty. The ISO document shows that uncertainty associated with directional characteristics and frequency response of a microphone dominate the measurement uncertainty. Measurement uncertainty, again, is on the order of dB's and not fractions of a dB. Sample size and the frequency characteristics of the source also contribute to the measurement uncertainty. A simple experiment of placing two identical calibrated Class 1 Sound Level Meters, such as the B&K 2250's referenced in the report, next to each other and measuring a sample of aircraft flyovers. The results will show that both the Lmax and Sound Exposure Levels for individual events will differ between the monitors by an amount much greater than the calibration uncertainty. Averaging over a large number of samples will reduce the differences (uncertainty), but it does demonstrate that measurement data have an inherent uncertainty that must be accounted for when comparing measurement data to modeling data.

There are two examples of modeling efforts where measurement data are used to affect model results. The first is the ANCON model developed by the CAA for the London airports (Heathrow, Gatwick, Stanstead). This is an airport specific model that includes custom profiles such that noise-modeling results match measurement results to a fraction of a dB. The ANCON model includes the methodology described in Doc 29 ("Report on Standard Method of Computing Noise Contours Around Civil Airports," European Civil Aviation Conference,Doc 29, July 2005). INM Version 7 and Doc 29 have been harmonized so that they use a common methodology. ANCON also uses the same aircraft noise database as INM ("The Aircraft noise and Performance Database (ANP), An International Data Resource for Aircraft Noise Modellers", Eurocontrol, www.aircraftnoisemodel.org). ANP contains exactly the same noise curves and aircraft profiles as the INM. ANCON uses custom profiles (speed, altitude, thrust setting) to match the airline procedures at the London airports.

The other example of using noise measurement data to adjust modeling results is in the State of California in the U.S. California requires that airports with noise problems monitor along or near the 65 DNL contour (actually California uses CNEL which is DNL with an evening time weighting). Quarterly noise contours are then adjusted to match the measurement results to within the specified measurement system accuracy of plus or minus 1.5 dB. This ‘adjustment’ is usually empirically based and may be done through profile adjustment or manual manipulation of the contour plot (varies by airport).

It is not clear that any adjustments to the B737-300 or B737-800 are justified on the basis of the measurement data provided. For such a modification to be justified, it must be shown that the modeling results fall outside the range of uncertainty of measurement.

5.2 NPD or Profile Issues

The NPD data in the INM and ANP are based on aircraft certification data. Aircraft certification measurements are done under very controlled conditions within a specified range of meteorological conditions. Certification noise data are collected along with detailed data on aircraft position, speed, flap setting and configuration. The NPD data in the INM and ANP for Boeing and Airbus aircraft are supplied directly by Boeing and Airbus (NPD data for older Boeing aircraft such as the B737-200 were developed by consultants, but all aircraft from the B737-300 on have been provided by Boeing). When the Queenstown reports a difference between modeled and measurement results, the assumption appears to be made that the difference is due to the NPD data in the INM. That conclusion may not be correct. In fact that conclusion can only be reached if you have knowledge of the aircraft position, speed, thrust setting and configuration. If you know that you are comparing measurement data at a known distance, elevation angle, speed, thrust and configuration with modeled data at that same distance, elevation angle, speed, thrust and configuration, then you can assess the quality of the NPD.

The Queenstown measurement data assumes that the aircraft are at the same distance, elevation angle, speed, thrust and configuration as is being modeled in the INM. There is no basis for that assumption. In fact, it is highly probable that the profiles in the noise model do not match the profiles used by the airlines. The INM includes profiles known as Standard, ICAO A, and ICAO B. The Standard profiles are often used as defaults. These profiles are provided by Boeing and Airbus, but may not be typical. In general, the Standard profiles are representative of US domestic carriers and are probably not very good estimates for international carriers. The ICAO A and B procedures represent generic close-in and distant noise abatement procedures. These are generic because the definitions of ICAO A and B procedures (new ICAO terminology is NADP 1 and 2) are not specific. For example ICAO A includes a minimum cutback altitude and minimum cutback thrust level. Airlines are free to develop a different ‘ICAO A’ procedure using different cutback altitudes and thrusts.

In order to compare INM results with measurements it is necessary to know the airline procedures, and then model the airline procedures as flown. Only then can you draw a meaningful conclusion about the quality of the NPD data. For example, Air New Zealand probably uses a different procedure than the INM ‘Standard’ procedure. It is recommended that Air New Zealand, Qantas, and the other operators at Queenstown be contacted and queried as to their departure and arrival procedures at a particular airport. Then INM aircraft profiles can be developed for each aircraft type and used in INM to reflect what is actually occurring. This will improve the INM modeling results considerably. This is particularly important for the arrival profiles where INM uses a very simplistic 3° approach without any level segments. At Queenstown, the elevation and steep terrain may mean a very unique approach that is very different from the generic approach used in INM.

Getting procedure information from the airlines is the best way to proceed. Modify the profiles to match the procedures described by the airlines and then compare with measurement results. If you cannot get airline profile data, an empirical approach that modifies profiles in order to match measurement data can be done as a less desirable substitute. This has the advantage of changing the INM data only in the area where you have measurement data and is greatly improved method over changing the NPD that affects the noise at all points along the flight track. Modifying the NPD's is not recommended, and would not be considered best practice for INM studies.

5.3 Flight Profile/Thrust Reverser Modifications

The report indicates that the thrust reverser data in the profiles was modified. The report is confusing as to how and why the reverse thrust was modified. First, the report is unclear which set of monitors was used to determine that a thrust reverser discrepancy existed. For example, where was the measurement site compared to where the INM profile shows thrust reverser coming on or off? The issue is whether the discrepancy is due to the thrust level or the fact that at Queenstown the steep terrain and elevation may contribute to an early and longer duration thrust reverse operation. The second is the ambiguity of the report concerning the thrust level that was used. The report states "increase in Reverse Thrust component (as percentage of static thrust of 60%) on touchdown." The meaning of this statement is less than clear. The INM input files shows that the reverse thrust was set to about 20,000 pounds for the B737-300 and 21,000 pounds for the B737-800. This is close to 100% of takeoff power. To what does the 60% in the report refer? Reverse thrust is dependent on landing speed, runway length, tailwind, and runway conditions (e.g. wet or icy runways). Given the relationship between thrust and noise, it is critical that the amount of reverse thrust used at Queenstown, and the location where reverse thrust is applied, be confirmed with the airlines

6. Summary

The INM model that you have developed is in general reflective of the operations at Queenstown. However, the issues identified above must be addressed before it truly is representative of the operations at that airport. I have every confidence that you and your colleagues will make the necessary changes and where you disagree with my recommendations, you will make the appropriate notations.

Sincerely Yours,

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