"Will Say" Statements with respect to "Main Operational Airport Modelling/Contours" by Professor John-Paul Clarke, Georgia Institute of Technology, Atlanta, GA 30332, USA

The so-called Shultz Curve, relates values of the L_{dn} metric to the effects of the associated noise in terms of annoyance and disruptions. It is the most widely accepted relationship between energy-averaged noise levels such as the L_{dn} and the effects on humans of the associated noise.

There is no practical difference on the Shultz Curve between the effects at L_{dn} = 50 dB and L_{dn} = 55 dB. In fact, that is a large part of the reason that the Environmental Protection Agency (EPA) in the United States of America concluded that the threshold for acceptable noise with respect to residential life is L_{dn} = 55 dB.

In 1996, after a study of many different studies, Bradley concluded that "the threshold for negative effects to aviation noise" is approximately L_{dn} = 56 dB; and that noise levels greater than L_{dn} = 66 dB "are not suitable for residential development." Logically, this means that noise levels below L_{dn} = 56 dB are entirely suitable for residential development.

Further, there is a portion of the population that will be highly annoyed for any level of aircraft noise that is audible. Moving the standard from 55 to 50 will not reduce the number of highly annoyed. In fact, moving to 45 or 40 or 35 will not change the percent of population highly annoyed in any meaningful way as the people near the asymptote are highly annoyed at any level.

Therefore, my conclusion is that the use of an L_{dn} = 50 dB contour is excessive in that it places restrictions on those who own property within the contour band between L_{dn} = 50 dB and L_{dn} = 55 dB without any commensurate environmental benefits.

BEFORE THE CHRISTCHURCH REPLACEMENT DISTRICT PLAN INDEPENDENT HEARINGS PANEL

IN THE MATTER of the Resource Management Act 1991 and the Canterbury Earthquake (Christchurch Replacement District Plan) Order 2014

AND

IN THE MATTER of the General Rules and Procedures Proposal (Stage 3)

EVIDENCE OF JOHN-PAUL BARRINGTON CLARKE ON BEHALF OF SUBMITTERS:

BRUCE CAMPBELL (2489); DAVID LAWRY (2514); MIKE MARRA (2054); VANESSA PAYNE (2191); JOHN SEGRUE (2567); GERRIT VENEMA (2091).

ACOUSTICS

16 FEBRUARY 2016

Introduction

1. My full name is John-Paul Barrington Clarke.

2. I am a Professor at the Georgia Institute of Technology (Georgia Tech) in Atlanta, Georgia, USA; where I have appointments in the Daniel Guggenheim School of Aerospace Engineering and the H. Milton Stewart School of Industrial and Systems Engineering, and serve as Director of the Air Transportation Laboratory.

3. I have three degrees from the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, USA. I received the Bachelor of Science (S.B.) in Aeronautics and Astronautics in June 1991; the Master of Science (S.M.) in Aeronautics and Astronautics in September 1992; and the Doctor of Science Degree (Sc.D.) in Aeronautics and Astronautics in February 1997.

4. I am a globally recognized expert in aircraft trajectory prediction and optimization, especially as it pertains to the development of flight procedures that reduce the environmental impact of aviation. My research has been instrumental in changing both the theory and the practice of flight procedure design, and has spurred the global effort to reduce the environmental impact of aviation via changes in operational procedures.

5. I am also recognized globally for my work in noise propagation modelling. I was an integral member of the team that was the first to quantify how the noise directivity patterns of aircraft with wing-mounted engines differ from the noise directivity patterns of aircraft with fuselage-mounted engines, and then subsequently developed the state-of-the-art model that is used in the Integrated Noise Model (INM) to predict the "excess ground attenuation" that is observed for aircraft that are close to the ground, as they are near airports (Fleming et al., 2002). I have also developed multiple models for predicting the propagation of noise in non-standard atmospheric conditions. One such model is particularly useful for predicting noise propagation at night, when temperature inversions increase the distance over noise propagates (Clarke et al., 2004).

6. Further, I am an expert in the development and use of stochastic models and optimization algorithms to improve the efficiency and robustness of airline, airport, and air traffic operations. My research has changed long-established views regarding the need for and the best way to achieve robust schedules, particularly in the airline industry.

7. I have received several awards for my work. Those most relevant to

the matters being addressed are the 1999 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award, the 2003 FAA Excellence in Aviation Award, the 2006 National Academy of Engineering Gilbreth Lectureship, the 2012 AIAA/SAE William Littlewood Lectureship, and the 2015 SAE Environmental Excellence in Transportation (E2T) Award.

8. In addition to my work in academia, I have served as a consultant for airports and community groups around the world on matters of noise prediction and regulations for over 20 years. Further, I have consulted for several airlines around the world on matters pertaining to their operations, including the schedule of flights and maintenance events.

9. In 2007, I was engaged by the Selwyn District Council to serve as their expert in the deliberations surrounding the appropriate extent of the noise contours around Christchurch International Airport. I ultimately ended up chairing the group, often referred to as the 'Panel of Experts,' that estimated the future operations at Christchurch International Airport and subsequently developed noise contours.

10. On this occasion I have been engaged as an expert by the following submitters (with associated submitted number): Bruce Campbell (2489); David Lawry (2514); Mike Marra (2054); Vanessa Payne (2191); John Segrue (2567); Gerrit Venema (2091).

11. Although this is not an Environment Court hearing (or a hearing being conducted under the Resource Management Act 1991), I have reviewed the code of conduct for expert witnesses contained in part 7 of the Environment Court Practice Note 2014, and have complied with it in preparing my evidence. I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of Evidence

12. My evidence, which is based on my aforementioned expertise, will be focused on the following topics:

    12.1. The need to contain ground run-up noise at the location where it is being generated, i.e. at source;

    12.2. The expected benefits of ground run-up enclosures, and the need for a noise monitoring system to ensure compliance.

    12.3. The complexities of DNL as a noise exposure metric and a predictor of annoyance.

    12.4. The suitability of DNL as a metric for ground run-up noise and the potential for excessive regulation when the DNL noise restriction threshold is lowered to the region of diminishing returns with respect to annoyance.

    12.5. The appropriateness of other metrics with respect to ground run-up noise.

More Needs to be Done to Contain the Noise at Source

13. Section 16 of the New Zealand Resource Management Act (RMA) states that "Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level."

14. As implied in section 16 of the RMA, the overriding requirement is that the noise be controlled 'at source'. In other words, even though section 17 of the RMA provides for an entity to "remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person," their first duty is to avoid unreasonable noise, which for all practical purposes means "containing as much of the sound as possible within their property."

15. While is clear from sections 10 and 20 of the RMA that an entity may be allowed to continue a pre-existing activity that contravenes a rule in a district plan or proposed district plan, the effects of the activity must be the same or similar in character, intensity, and scale to the effects that existed before the change.

16. It quickly became evident, from the noise impact contours that were present by Marshall Day at the noise expert conference held on 16

December 2015, that the initially proposed increase in ground run-up testing would drastically alter the character, intensity, and scale of the noise effects outside the airport boundary. In fact, it was during that conference that the idea of 'scaling back' the ground run-up operation to contain the resulting noise within the existing noise boundaries was proposed, leading to the revised contours that have now been presented.

17. It is clear to me that the airport has not given due consideration to the containment of the ground run-up noise within the airport boundary.

18. First, the location where ground run-up testing is conducted is poorly positioned relative to the population distribution around the airport. It is far from optimal in terms of containing the noise within the airport boundary or within the boundaries of the existing noise contours. An optimal location would most certainly not disproportionately increase the noise impact on a heavily populated side of the airport.

19. Second, prior to the meeting of noise experts in December 2015, the airport had not seriously investigated the use of noise barriers or insulation. In my experience, a serious proposal would have included at least one set of noise contour that factored in the benefits of a ground run-up enclosure.

A Ground Run-Up Enclosure is Required

20. My considered judgment is that a ground run-up enclosure is required to reduce the noise that will be produced during run-ups.

21. Ground run-up enclosures are an effective means of mitigating the noise that is produced during ground engine testing, i.e. mitigating the noise at source. Any statement to the contrary is either ill-informed or disingenuous.

22. To support this point, I draw your attention to the ground run-up enclosure that was designed by Blast Deflectors, Inc. (BDI) for Portland International Airport (PDX). Final results (i.e. noise measurements made at specific measurement points before and after installation of the ground enclosure) showed that the required goals for noise level reduction were either met or exceeded. Sound levels were reduced by as much as 20 dBA, which amounts to a noise level reduction of 75 percent during engine run-ups.

A Noise Monitoring System is Required

23. There is also no doubt in my mind that a permanent noise monitoring system should be installed to determine whether the entities conducting engine testing fully comply with the noise restrictions that are agreed to as part of this process.

24. Noise monitoring systems are particularly useful for monitoring and tracking maintenance ground run-ups. For example, it is common for a noise monitoring system to locate a microphone at the ground run-up area or enclosure to act as a trigger noise for any noise measured in nearby residential areas. This is done to ensure that ground maintenance noise is not confused with ground roll take-off noise or reverse thrust noise which may have similar acoustic characteristics.

25. I find it surprising that Christchurch does not have a permanent noise monitoring system. Permanent noise monitoring systems have become common worldwide and serve multiple useful purposes in addition to the verification of actual noise levels in the community.

26. To support this point, I draw your attention to Figure 1, in which is shown the worldwide installations of noise monitoring systems by one vendor (Bruel and Kjaer) with an installation base of nearly 200 airports. This map does not include the airport noise monitoring systems installed by other vendors such as Casper, O1dB, Harris (formerly Exelis), and Topsonic.

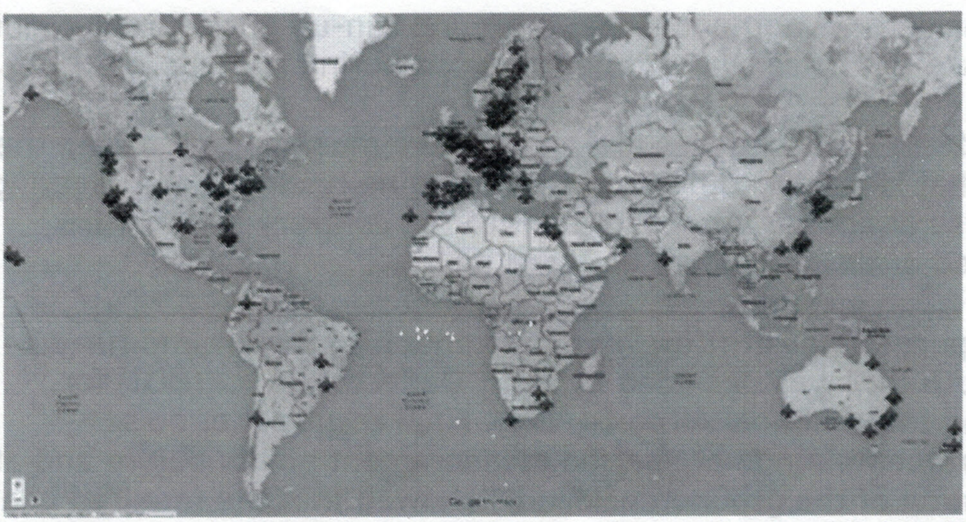

Figure 1: Locations of Bruel and Kjaer Airport Noise Monitoring Systems

There is a Complex Relationship Between DNL and Annoyance

27. The Day-Night Average Sound Level (DNL) is the metric most commonly used in aviation to predict annoyance.

28. It would therefore be logical to account for increased ground run-up noise by simply adding said noise to the DNL for the entire airport and determining whether the resulting sound levels are above the thresholds established at the noise contours used for land-use controls, i.e. the contours that CIAL refers to as noise control boundaries.

29. I would support such an approach, but I recognize that the contours that were agreed to in 2007 did not account for ground run-up noise. That being said, there was a recommendation in the report of the Panel of Experts that the assumptions underlying the modeling and resulting contours be reviewed after 10 years, and I believe the issue of ground run-up noise could be addressed within such a process.

30. Nevertheless, CIAL has proposed the use of a separate metric with separate thresholds for ground run-up noise, and has argued that they be allowed to increase ground-run up activities provided the associated contours stay within the existing noise control boundaries.

31. Before I address the appropriateness of the proposed metric, I think it is important to discuss the complexities of the relationship between DNL and annoyance.

32. The testimony of Christopher Day does not include recent research findings that provide a much clearer and explanatory relationship between DNL and the percentage of the population that is highly annoyed. In a peer-reviewed journal article published in 2011, Fidell et al. presented a method to understand human response to noise in terms of acoustic and non-acoustic responses (Fidell, 2011). Their results match very closely with the results of the research by Miedema that is referenced by Day, but provides far more detail and understanding of annoyance response.

33. The latest research shows that annoyance response follows a sigmoid curve (an S-shaped curve) as would be expected for a dose-response relationship. In this case the shape of the curve is based on time-weighted loudness expressed as DNL. For purposes of describing the difference in response from one airport to another a measure called Community Tolerance Level, CTL, was defined as that DNL at which 50% of the population is highly annoyed. This measure is not meant as a regulatory measure, but only as a means to compare airports/communities. The 'cloud' of human response data shown in

Figure 2 has been collected worldwide since the 1950s (44 social survey studies, over 100,000 interviews). This cloud expands the work of Schultz (Schultz, 1978) to include social survey data collected through the year 2010. Also shown in Figure 2 is the Grand Mean CTL Curve for all the airports at which data was obtained. The Grand Mean CTL is approximately 73 DNL, meaning that in terms of a worldwide average, half of the population is highly annoyed at a DNL of 73.

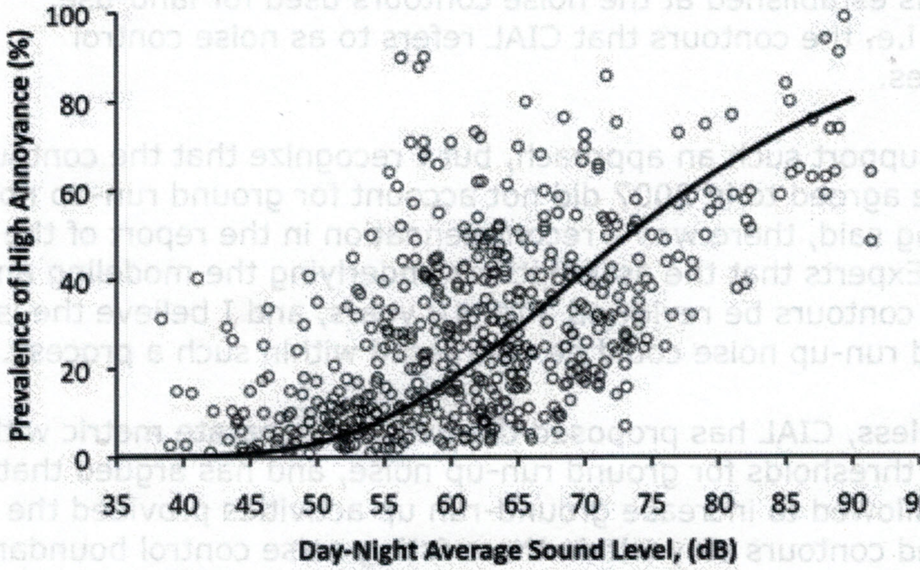

Figure 2: Cloud of Worldwide Social Survey Data and the Grand Mean Community Tolerance Level.

34. In Figure 3, the Grand Mean CTL curve is compared to the curve published by Meidema (Meidema, 1998), i.e. the work that is referenced in the testimony of Day. As may be seen, there is no significant difference between the curves.

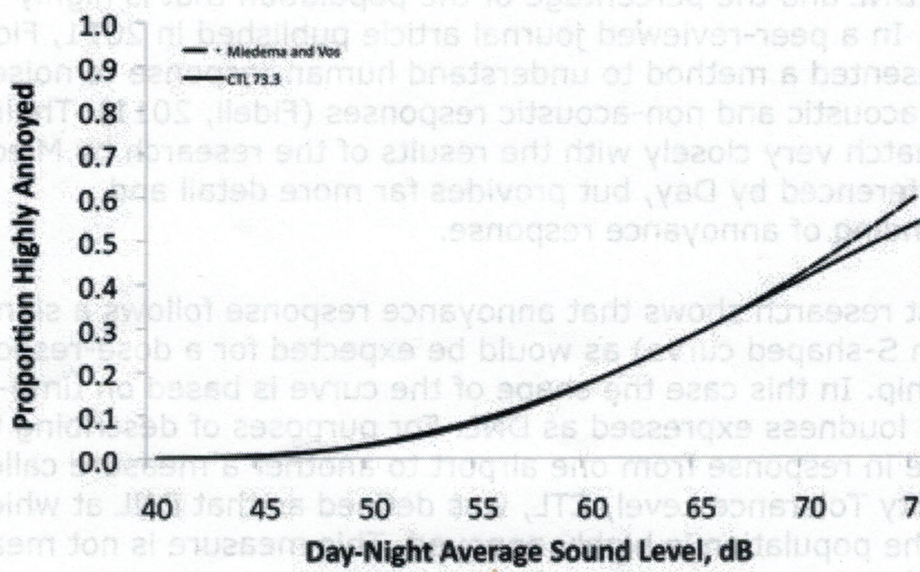

Figure 3: Comparison of Worldwide CTL with Miedema and Vos

35. The CTL method allows us to identify how one airport community rates noise compared to another, i.e., it allows us to determine whether one community is more sensitive to noise than another. The fact that communities form a unique attitude about noise is evidenced in Figure 4, where the CTL curves for 6 example airports are presented. As may be seen, the S-shaped curve for each airport fits the data for that airport very well. However, the parameters of the fit varies by community. For example, communities surrounding Oslo airport are far more tolerant of aircraft noise than communities surrounding Orly airport in Paris.

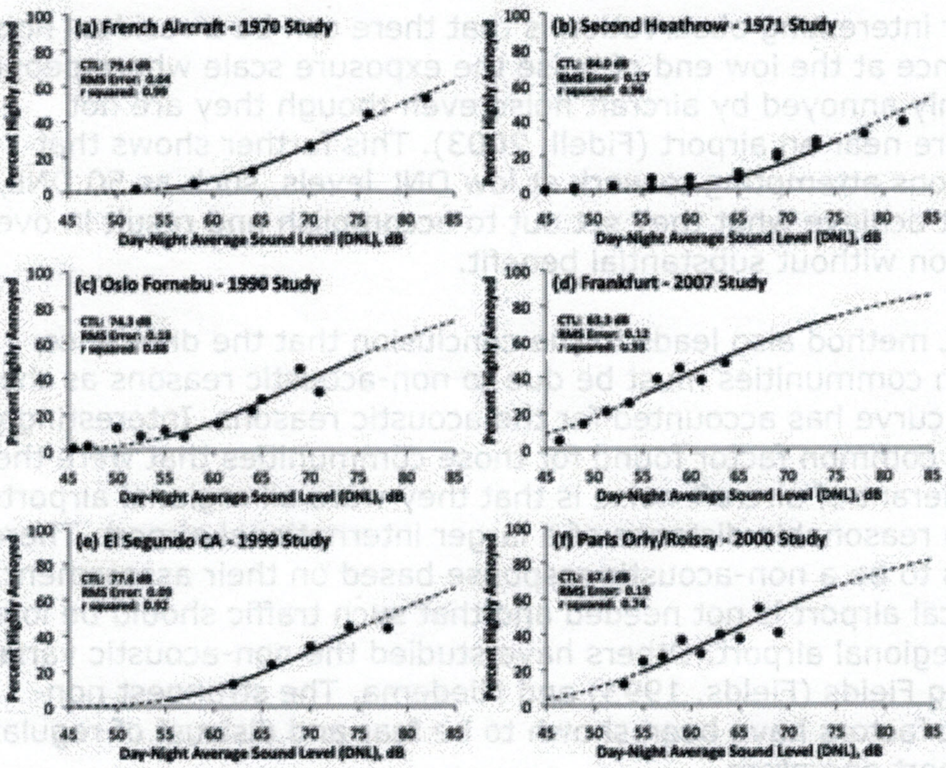

Figure 4: CTL Curves for 6 Example Airports

36. The CTL method has been adopted by the International Standards Organization (ISO), 1996-1 standard, "Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures" (ISO, 2015). The ISO standard uses CTL to adjust aircraft, road and rail DNL to account for varied response to these sources.

37. The CTL method also allows us to address an issue raised in the testimony of Day, i.e. whether the social survey data for Christchurch shows a more or less tolerant attitude about aircraft noise than has been reported elsewhere in the world. While the CIAL survey data quoted by Day was not included in the worldwide survey data, because it has never published in a peer reviewed journal, it can be used to assess the Christchurch noise 'temperature' if you will. While

the CIAL social response data do not extend to the point where 50% of the population is highly annoyed, the data do show that at 65 DNL about 30% of the population is highly annoyed. This matches very well with the Grand mean CTL curve (and the Miedema curve). This strongly suggests that the communities around Christchurch are no more or no less sensitive to aircraft noise than the average person around the world and any argument that they are more sensitive than the average is not supported by the data.

No Appreciable Benefit to Regulating at 50 DNL

38. Another interesting observation is that there can be a residual noise annoyance at the low end of noise the exposure scale where people are highly annoyed by aircraft noise even though they are not anywhere near an airport (Fidell, 2003). This further shows that regulations attempting to work at low DNL levels, such as 50 DNL, may not achieve what they set out to accomplish and result in over regulation without substantial benefit.

39. The CTL method also leads to the conclusion that the difference between communities must be due to non-acoustic reasons as the S-shaped curve has accounted for the acoustic reasons. Interestingly, the one common factor found for those communities that were the least tolerant of aircraft noise is that they were all regional airports within a reasonable distance of a larger international airport. There appears to be a non-acoustic response based on their assessment that their local airport is not needed and that such traffic should be located at the regional airport. Others have studied the non-acoustic variables including Fields (Fields, 1993) and Miedema. The strongest non-acoustic factors have been shown to be fear and distrust of regulators and airport operators.

Proposed Metric is Not the Most Appropriate Metric

40. The issue remains as to whether the proposed metric is the most appropriate metric for ground run-up noise. Ground maintenance run-ups are unlike regular aircraft operations, i.e. they are different both in terms of numbers of operations and in terms of time history. Thus, while the DNL may increase close to the run-up area as you add ground maintenance operations to regular airport flight operations, the change in DNL may not reflect the impact of the additional noise events.

41. Further, since CIAL uses the 50 DNL land use limit, which incidentally is the most restrictive land use limit in the world, the change in the population highly annoyed in response to a change in the noise level will be quite small because this range of DNL lies on the asymptote of

the curve. In other words, 50 DNL is at the very flat part of the curve shown in Figure 2, thus a change in exposure from 50 to 55 DNL would result in a change in annoyance of approximately 5%. This is in contrast to the change in the population highly annoyed from 18% to 30% that would result if noise exposure were to change from 60 to 65 DNL.

42. Finally, we know from experience that ground run-up operations have a significant impact on annoyance. Thus, I have no objections to using a different metric for ground run-up noise.

43. CIAL has proposed the use of a 7-day rolling average DNL that shall not exceed 65dB at five engine testing compliance monitoring positions (ETMCPs).

44. There is no basis for this metric in the acoustics literature, and thus no way for anyone to judge a priori whether ground run-up noise that satisfies the proposed limit will be acceptable. In fact, it would be unwise for any entity, especially a public entity, to utilize a metric for which there is no basis in the scientific literature.

Short-Duration Equivalent Noise Level is More Appropriate Metric

45. Ground run-up noise would be better managed through a local noise ordinance as would be applied to any industrial noise. Such local noise ordinances generally use a short term measure of noise exposure such as Equivalent Noise Level, Leq, or percent of time above a noise level such as noise level exceeded for 50% of the time. The time period used for noise ordinance compliance is usually in the range of 15 minutes to 1 hour, capturing just the run-up noise and not averaging the run-up noise over 24 hours or greater with a night penalty.

John-Paul Clarke

John-Paul Barrington Clarke
16 February 2016

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