Aircraft Noise Assessment of Allowing CS100 Flights at Billy Bishop Toronto City Airport

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1.0 UNDERSTANDING OF THE WORK TO BE PERFORMED AND SUMMARY OF QUALIFICATIONS

1.1 Understanding of the Work to be Performed

Aircraft noise has always been an important issue in modern airport planning and development. While there has been a steady increase in the number of flights worldwide, the aircraft industry has been countering the corresponding increase in aircraft noise through the development of quieter engines and aircraft. These conflicting trends only highlight the importance of accurately assessing and managing the impact of aircraft noise on the local community.

This assessment will evaluate the proposed impact of adding the Bombardier CS100 aircraft to the fleet mix at the Billy Bishop Toronto City Airport (BBTCA). Because of this airport's proximity to downtown Toronto, it is important to accurately determine whether adding this airplane to the fleet will have an impact on the overall noise footprint of the airport. The Tetra Tech AMT Study Team will assess this issue through the following sections and discussions:

- **Summary of Noise Measurement with Respect to Aircraft Certification**
- **Description and Analysis of CS100 Noise Characteristics**
- **Review of Historical and Future BBTCA Operational Counts**
- **Review of BBTCA Historical Noise Regulations**
- **Conclusion**

1.2 Summary of Qualifications

Tetra Tech AMT is the aerospace management and the information technology arm of Tetra Tech, a $2.9 billion engineering services firm with over 14,000 employees in 330 locations worldwide supporting the federal government, international, and commercial sectors. Tetra Tech AMT provides mission critical and other information technology support services, including business transformation, identity management, information security, business process reengineering, enterprise architecture, and enterprise software development.

In the aviation sector, we are a world leader in Performance Based Navigation (PBN) and navigation systems support. Tetra Tech AMT's credentials are grounded in our 20 years of support to our nation's aerospace safety, environmental, scientific, homeland and national defense communities. From Green Aviation to developing software for homeland defense investigators to employing earned value management to identity management, Tetra Tech AMT's experience and innovation makes a difference. Tetra Tech AMT experts provide a proactive, systematic approach to the management of Satellite Navigation and PBN, aviation safety, environmental and safety management systems. In a complex world with competing demands for limited resources, Tetra Tech AMT offers clear and competitive solutions focused to meet customer needs.

Tetra Tech AMT has long been associated with managing large, complex navigation programs for both government and industry. Tetra Tech AMT provides engineering and technical support services for the planning, research, development, implementation, sustainment, and decommissioning of FAA's navigation, landing, and lighting systems across several FAA organizations. Our mission is to assist the

FAA transition to integrated ground- and space-based navigation systems architecture as well as provide fundamental support to NextGen.

Tetra Tech and its partner have an extensive acoustical engineering and consulting expertise specializing in the design, implementation and management of airport noise abatement programs, airport environmental issues and customized software solutions for the aviation industry. We have performed assessments of airport noise, residential and commercial developments, sound insulation and the development of airport noise monitoring system software for clients including local municipalities, multi-agency government contracts, airport operators and foreign governments. Tetra Tech AMT has developed NextGen procedures at several airports and examined noise and other environmental impacts, using FAA-approved screening software.

Our experience also includes conducting FAR Part 150, EA, EIS, and EIR studies at airports that face significant challenges due to terrain. Our team has conducted extensive noise studies in the western United States, including Arizona, California, Colorado, Oregon, and Utah, and Washington, Wyoming. Many of these airports are located in mountainous terrain that requires understanding of how aircraft fly at high altitudes, as well as during specific flying seasons such as winter and summer. This experience includes modeling existing flight procedures as well as interfacing with traditional radar, BI-6 radar, and multilateration systems to collect and analyze flight track data to present the most accurate representation of existing conditions, as well as modeling future procedures to determine the difference in noise (using annual average and single even) and emissions calculations.

In a world dominated by increasing demands for efficiency, Tetra Tech AMT's specialists ensure sustainable operations are incorporated inside the aviation safety portfolio. The fusion of operational efficiencies, technology and aviation policy comes together in the cockpit and air traffic control facility. Our safety and environmental experts use the latest modeling tools, such as the Aviation Environmental Design Tool (AEDT) to implement safe and harmonized procedures, allowing pilots and controllers to achieve efficiency gains while maintaining the safety of the airspace.

2.0 SUMMARY OF NOISE MEASUREMENT WITH RESPECT TO AIRCRAFT CERTIFICATION

2.1 Noise Background and Metrics

Noise is simply defined as unwanted sound. Sound is technically described in terms of the loudness and frequency. These two terms correspond to intensity or volume of sound and to pitch respectively. The standard unit of measurement of the frequency of sound is Hertz (Hz) and the unit of measurement of the loudness of sound is the Decibel (dB). Decibels are measured on a logarithmic scale, which compresses the wide range in sound levels to a more usable range of numbers in a manner similar to the Richter scale used to measure earthquakes. Multiple noise values cannot be simply added or subtracted like normal numbers. Decibels are added and subtracted logarithmically; for example, if two sounds of the same level are added, the sound level increased by approximately 3 dB.

As sound moves farther away from the source of the noise, the loudness of the sound decreases. The reduction of the sound over a set distance can vary depending on 3 main factors: wave divergence, atmospheric absorption, and ground attenuation. As the sound wave form travels away from the source, the sound energy is dispersed over a greater area, thereby decreasing as the wave diverges.

Atmospheric absorption can have a wide influence on the loudness of a sound over distance. The degree of absorption depends on the frequency of the sound as well as the humidity and temperature of the air. Variations in humidity and temperature, therefore, can play a significant role in affecting the loudness of a particular sound. Ground attenuation means that the type of ground surface can also have an impact on how the sound propagates over a set distance. Any intervening topography can have a substantial effect on the effective perceived noise levels. It should be noted that the above factors are not accounted for during the engine noise certification process since engine noise is certified independent of location.

In terms of human response to noise, a sound 10 dB higher than another is judged to be twice as loud; and 20 dB higher four times as loud; and so forth. Everyday sounds normally range from 30 dB (very quiet) to 100 dB (very loud) while the healthy ear can typically detect a change in noise at 3 dB. The human hearing system responds to a wide range of frequencies (typically 20 to 20,000 Hz) and tolerates tremendous range of fluctuating sound pressure levels. For the purposes of aircraft noise certification, a range of frequencies from 50 to 10,000 Hz are typically considered.

Since the human ear is not equally sensitive to sound at all frequencies, a special frequency-dependent rating scale has been devised to relate noise to human sensitivity. This tone-corrected perceived decibel measured by Effective Perceived Noise level in decibels (EPNdB) is a measure of human annoyance to aircraft noise which has special spectral characteristics and persistence of sounds. It accounts for human response to spectral shape, intensity, tonal contact and duration of noise from an aircraft. It is complex and has to be calculated after making measurements using a sound level meter. It is calculated by applying an adjustment to the noise level that is related to the degree of irregularity that may occur among sound pressure levels of aircraft noise. The following discusses the two tone-corrected perceived noise metrics in increased detail.

> Effective Perceived Noise Level (EPNL) describes noise for single noise events. It is calculated when the sound rises above the ambient level until it drops below background levels; accounting for the duration of an event. It incorporates a penalty for the presence of pure tones to account for people's increased annoyance with single frequencies, such as the tone emanating from the compressor of turbofan engines.
>
> Noise Exposure Forecast (NEF) is a single number rating of overall aircraft noise. It takes into account the duration of the flyover, the peak noise level, the tonal characteristics and the number of aircraft movements in both the day and night time period. A National Research Council (NRC) study completed in 1996 reviewed the NEF system to determine its validity as a predication system for evaluating airport noise and land use compatibility, establishing that it compared favorably with other prediction noise metrics used in other countries throughout the world. For comparison purposes, it was determined in the study that the NEF system could be equated to the DNL system that is used by the United States FAA. Transport Canada's methodology for producing NEF values in Canada requires that nighttime events are penalized 12.2 dB between the hours of 22:00-7:00. One nighttime event equals 16.7 daytime operations. The 12.2 dB penalty (the highest in common use) is higher than the more common 10 dB penalty used in the United States FAA's DNL metric. For BBTCA, the NEF noise levels are determined based upon a noise model that takes into account the number of operations by type of aircraft, the time of day, runway use, and flight paths/procedures to generate noise contours that must not extend into areas defined as noise sensitive.

2.2 ICAO Aircraft Certification and Noise Measurement Points

In 2001, the International Civil Aviation Organization (ICAO) endorsed the concept of a "balanced approach" to aircraft noise management. This consists of identifying the noise problem at an airport and then analyzing the various measures available to reduce noise through the exploration of four principal elements, namely reduction at source (quieter aircraft), land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner. ICAO developed policies on each of these elements and the recommended practices for each are contained in ICAO Doc 9829, "*Guidance on the Balanced Approach to Aircraft Noise Management*."

Much of ICAO's effort to address aircraft noise over the past 40 years has been aimed at reducing noise at the source. Aircraft built today are required to meet the noise certification standards adopted by ICAO. The noise certification standards are contained in Annex 16 – Volume 1 (Environmental Protection – Aircraft Noise), while practical guidance to certificating authorities on implementation of the technical procedures of Annex 16 is contained in Doc 9501, "*Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft*."

According to the Committee on Aviation Environmental Protection (CAEP), "The prime purpose of the noise certification is to ensure that the latest available noise reduction technology is incorporated into aircraft design demonstrated by procedures which are relevant to day to day operations, to ensure that noise reduction offered by technology is reflected in reductions around airports."

For noise certification based upon ICAO Annex 16, Chapter 5 and Appendix 2, aircraft noise levels are measured at the following three measurement points:

> Point 1 – Take-off/flyover: 6.5 kilometers from the start of the roll, directly under the take-off flight path;
>
> Point 2 – Sideline/lateral: the highest noise measurement recorded at any point 450 meters from the runway axis during take-off;
>
> Point 3 – Approach: 2 kilometers from the runway threshold, directly under the approach flight path. On level ground this corresponds to a position of 120 meters vertically below the 3 degree path originating from a point 300 meters beyond the threshold.

Refer to Figure 1 for the noise measurement points for the departures/arrivals on Runway 26 of BBTCA. Departures/arrivals on Runway 26 account for 65% of all operations. Refer to Figure 2 for the noise measurement points for the departure/arrivals on Runway 08. Departures/arrivals on Runway 08 account for 35% of all operations.

It is also common to evaluate the certificated aircraft noise levels measured at the three points as either the cumulated or averaged level in that it allows the certificated noise to be defined as a single number rating for all phases of flight (departure, arrival and departure sideline). Cumulative levels are defined as the arithmetic sum of the certification levels at each of the three points. Average levels are defined as the arithmetic average of the certification levels at each of the three points. Having this information as a single number is very useful to compare the overall noise from different aircraft. This provides a useful measure of the overall noise characteristics of an aircraft that is much simpler for the public to understand. Given that the engine noise is the dominate source of noise in an aircraft, for modern aircraft the relative noise level in each phase of flight ranges up and down consistent with the noise characteristics of the aircraft engine. As an example, Stockholm Bromma Airport successfully uses the averaged value of the three certificated noise levels as a means of restricting the types of aircraft that can operate at the airport.

Figure 1 - Runway 26 Departures/Arrivals – Noise Measurement Points

(Data provided by Porter Airlines and verified by Tetra Tech AMT)

Figure 2 - Runway 08 Departures/Arrivals – Noise Measurement Points

(Data provided by Porter Airlines and verified by Tetra Tech AMT)

3.0 DESCRIPTION AND ANALYSIS OF CS100 NOISE CHARACTERISTICS

3.1 Tripartite Agreement and the CS100 Aircraft

The 1983 Tripartite Agreement (hereinafter referred to as the "agreement") executed by City of Toronto, Transport Canada, and the Toronto Port Authority (TPA) sets limits on which aircraft can operate at BBTCA. The July 19, 1985 amendment to the agreement added the Bombardier Dash-8 series to the definition of general aviation permitted to operate. General aviation under the agreement includes all civil aviation activities undertaken by individuals, organizations, or corporate entities engaged in the operation of commercially registered aircraft. The Bombardier Q400 is aeronautically classified as the Dash-8 400, which is included in the agreement definition of general aviation and therefore compliant to it.

The agreement states within Section 14 (Special Conditions) that aircraft generating excessive noise shall be determined by reference to the most recent ICAO listing of aircraft noise data and shall include:

2a. *All those propeller-driven aeroplanes not exceeding 5700 kilograms maximum takeoff weight which generate a noise level in excess of 83.0 dB(A) on overflight, calculated in accordance with the procedures set out in ICAO Annex 16, Chapter 6 and Appendix 3;*

2b. *All those propeller-driven aeroplanes exceeding 5700 kilograms maximum takeoff weight other than those aeroplanes classified as STOL aircraft in accordance with the definition of Chapter 7 and Attachment C thereto of ICAO Annex 16, which generates a noise level in excess of 84.0 EPNdB on takeoff (flyover), or in excess of 83.5 EPNdB on sideline at takeoff (lateral to the flight path) or in excess of 92.0 EPNdB on approach, all calculated in accordance with the procedures set out in ICAO Annex 16, Chapter 5 and Appendix 2;*

2c. *All those propeller-driven aeroplanes exceeding 5700 kilograms maximum takeoff weight and classified as STOL aeroplanes in accordance with the definition given in Chapter 7 and Attachment C thereto of ICAO Annex 16, which generates a noise level in excess of 93 EPNdB on takeoff (flyover) or in excess of 88 EPNdB on sideline at takeoff (lateral to the flight path) or in excess of 91.5 EPNdB on approach, all calculated in accordance with the procedures set out in ICAO Annex 16, Chapter 7, including Attachment C thereto.*

The Bombardier Dash-8 series (100, 200, 300, and Q400) size and performance would place them under the requirements of item 2b and the noise limits described in this section. However the agreement exempts these aircraft from meeting these noise level requirements. All four of these regional turboprop aircraft exceed one or more of the noise certificated limits. The Q400 would qualify with the use of the trade-offs described further in this chapter.

The measurement procedures within ICAO Annex 16, Chapter 5 and Appendix 2 as referenced in the Tripartite Agreement apply "trade-offs" whereby minor excesses to one or two measurement points are deemed acceptable for determining if an aircraft qualifies for the different noise "Chapter" rating (i.e., to classify an aircraft as Chapter 3, etc.). The Annex allows of the tradeoffs provided the following criteria are maintained:

a. *The sum of the excesses shall not be greater than 3 EPNdB.*
b. *Any excess at any single point shall not be greater than 2 EPNdB.*
c. *Any excesses shall be offset by corresponding reductions at the other point or points.*

Table 1 below lists the certified noise levels (EPNdB) of various aircraft, including the guaranteed levels for the CS100 aircraft. The certified noise levels for all of the aircraft besides the CS100 were obtained from the European Aviation Safety Agency (EASA) and ICAO.

Table 1 – Certified Noise Levels (EPNdB) – Aircraft Comparison to the Tripartite Agreement

Aircraft	Model	Entry Into Service (EIS)	Sideline/ Lateral	Take-Off/Flyover	Approach	Cumulative	Average
B747	B747-400	2/9/1969	100.3	95.7	102.2	298.2	**99.4**
B767	B767-300	9/26/1981	95.8	90.7	97.7	284.2	**94.7**
A320 (family)	A320-212	2/22/1987	94.0	86.7	96.0	276.7	**92.2**
B737 (family)	B737-700	4/9/1967	94.8	84.8	96.2	275.8	**91.9**
Dash 8-300	DHC8-301	2/1989	87.4	84.3	98.9	270.6	**90.2**
A319	A319-132	6/10/1993	91.6	84.3	94.4	270.3	**90.1**
B737-600	B737-600	9/18/1998	89.2	85.2	95.6	270.0	**90.0**
E190*	E190	3/12/2004	91.5	83.7	92.4	267.6	**89.2**
CRJ700	CRJ700	5/27/1999	89.4	82.7	92.6	264.7	**88.2**
Dash 8-200	DHC8-201	4/1985	85.6	80.5	97.2	263.3	**87.8**
Dash 8-100	DHC8-102	10/23/1984	86.3	80.8	94.8	261.9	**87.3**
Tripartite/Agreement			**83.5**	**84.0**	**92.0**	**259.5**	**86.5**
CS100	CS100	TBD	TBD	TBD	TBD	< 259.5	**< 86.5**
Dash 7-100	DHC7-100	2/3/1978	83.3	80.1	91.6	255.0	**85.0**
Q400	Q400 IGW	1/2000	84.0	78.0	93.1	255.1	**85.0**

**The E190 is an aircraft of similar size and takeoff weight to the CS100*
(Data provided by Porter Airlines and verified by Tetra Tech AMT)

For the CS100 aircraft, Bombardier has provided a written guarantee to Porter Airlines that the CS100, with PW1524G engines, will have cumulative and average noise levels lower than 259.5 and 86.5 EPNdB respectively. Based upon thousands of hours of engine testing under heavily regulated criteria and aircraft design performance, the manufacturer is able to provide a guarantee in terms of overall noise that the aircraft will be significantly quieter than current generation jet aircraft. At this point in their design development they are not able to provide guarantee values at the individual three measurement points, but are able to commit to a cumulative noise level of under 259.5 EPNdB and average of under 86.5 EPNdB, which is the arithmetic sum and average of the three noise measurement point standards contained within the agreement.

This is primarily determined from the engine flight and static testing that have been conducted on the CS100 aircraft and model predictions based upon the expected aircraft performance. Once actual flight testing on the CS100 aircraft itself is conducted, then the manufacturer is able to provide more guaranteed commitments such as the individual measurement points. A more detailed description of the aircraft certification process is contained in the following section.

It is important to note that the cumulative and average noise levels for the CS100 aircraft will have noise values that are equal to the average EPNdB levels contained within the Tripartite Agreement and lower than the Dash-8 series (100, 200, and 300), which are aircraft currently allowed to operate at BBTCA. The Dash-8 series (100, 200, and 300) aircraft have been permitted under the agreement and have operated for over 20 years with this higher certified noise level. On a noise energy basis, the CS100 aircraft is 17%, 26%, and 57% quieter than these Dash 8 series aircraft (100,200, and 300 respectively). The CS100 aircraft is predicted to be similar to the noise footprint of the Q400 aircraft, which is the primary aircraft that Porter Airlines is operating today. The CS100 aircraft is also predicted to be quieter than an aircraft (the E190) with similar length, size, and passenger capacity.

The guaranteed average certification level for the CS100 aircraft is 1.5 dB higher than the actual average certification level for the Q400. However, guaranteed levels have some level of safety margin, in that buyers can be released from their contract to buy an aircraft or can ask for compensation when guarantees are not achieved. Based upon past experience of guaranteed vs. actual certification levels, the actual levels for the CS100 aircraft would be expected to be similar to the Q400 aircraft.

3.2 CS100 Aircraft Noise Level Comparison to Other Aircraft and Measurements

As shown in Table 1, the CS100 aircraft will have a comparable noise footprint to the Q400. According to the report (hereinafter referred to as “Jacobs Report”), “Billy Bishop Toronto City Airport – Noise Management Study – Interim Report” prepared by Jacobs Consultancy Canada Inc. for Toronto Port Authority (TPA) in 2010, other ambient noise readings in the southern part of the City of Toronto at certain specific residential locations were equal to or greater than Q400 aircraft in either take-off or approach mode. This is directly due to new technology; the new generation of engines that have enabled the production of quieter aircraft. The CS100 would also be below other ambient noise sources as measured in the report.

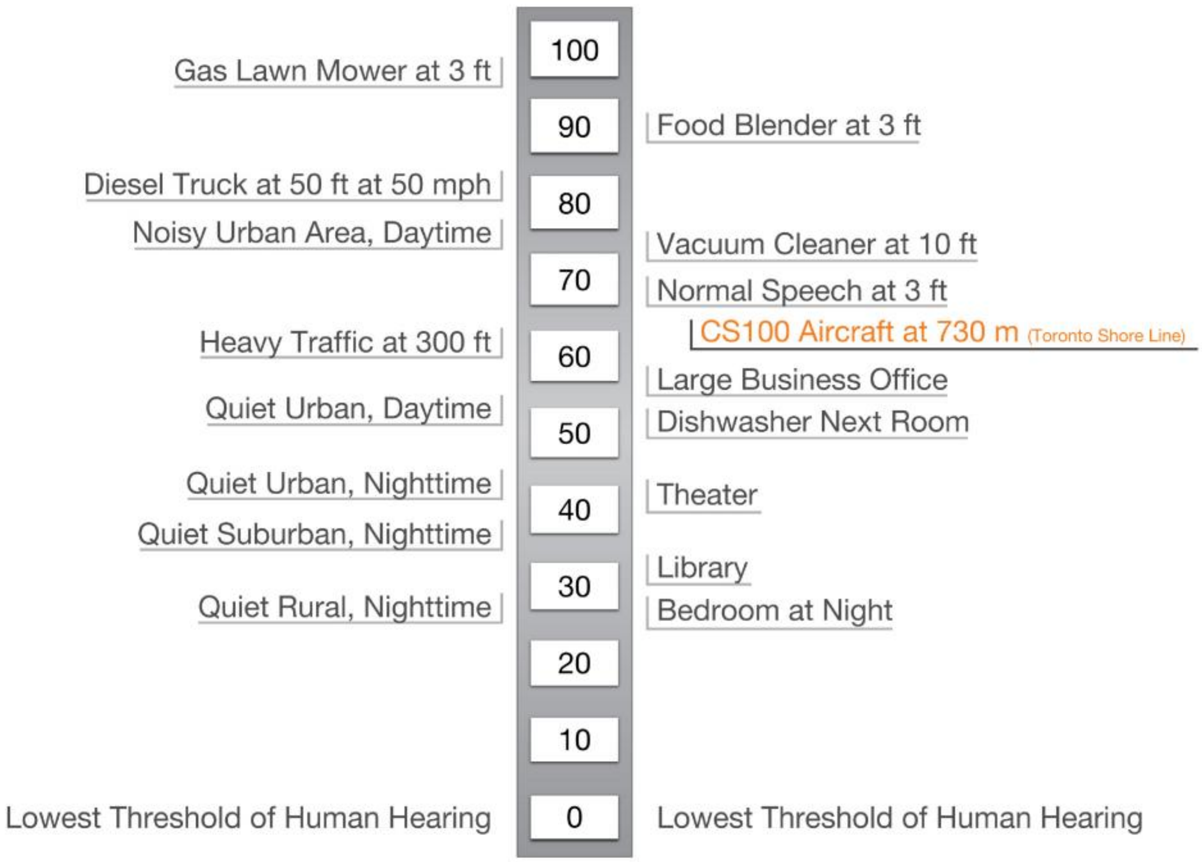
The 2010 Jacobs Study recommended sixteen mitigation measures to minimize noise impacts at BBTCA. These measures included recommendations relative to use of thrust reverse, ground run-up noise, land use, runway use, and flight paths. Using the base line noise levels identified in the Jacobs Study as a benchmark, BBTCA can work to implement the sixteen recommendations spelled out in the Jacobs Report. While no specific study has been done in the interim to determine the new noise baseline, one would expect that the overall noise impact of the airport will have decreased with the implementation of these and other noise abatement options. The noise from the CS100 operations can also be minimized through noise abatement mitigation. Many of the noise abatement options identified in the Jacobs Study could be applied to the CS100 operations as well.

In addition noise abatement departure and arrival procedures could be developed that minimize the noise associated with these operations. These aircraft will be equipped with the most advanced navigation technology that allows for the operation of new generation procedures that can be designed to mitigate noise in ways that are not possible with conventional navigation. As a result of noise abatement measures and the continued introduction of new generation quieter aircraft, it is reasonable to assume that the airport noise environment would continue to decrease over time.

Aircraft certification noise levels are flown under precise and controlled conditions and provide a good indication as to the noise characteristics of an aircraft. The results are normalized to standard temperature and pressure conditions that allow these levels to translate to any airport around the world. However, the controlled regulations of the test do not allow for factoring noise mitigation and abatement into the test. When factored into the actual flying of the aircraft, noise mitigation and abatement can actually reduce the noise further. The mitigation measures outlined above could improve the noise levels on the ground during the actual flights even further than would be expected based upon the certificated noise levels alone.

Figure 3 below shows typical community noise levels that exist within our environment and compares those to the guaranteed CS100 aircraft noise level. Things such as a gas lawn mower at 100 feet or a vacuum cleaner at 10 feet are louder than the CS100 aircraft. The data for the CS100 aircraft is predicted at a distance of 730 meters during takeoff, which is roughly the distance to the Toronto's harbor edge (specifically Site 1 noise measurement location from the Jacobs study.)

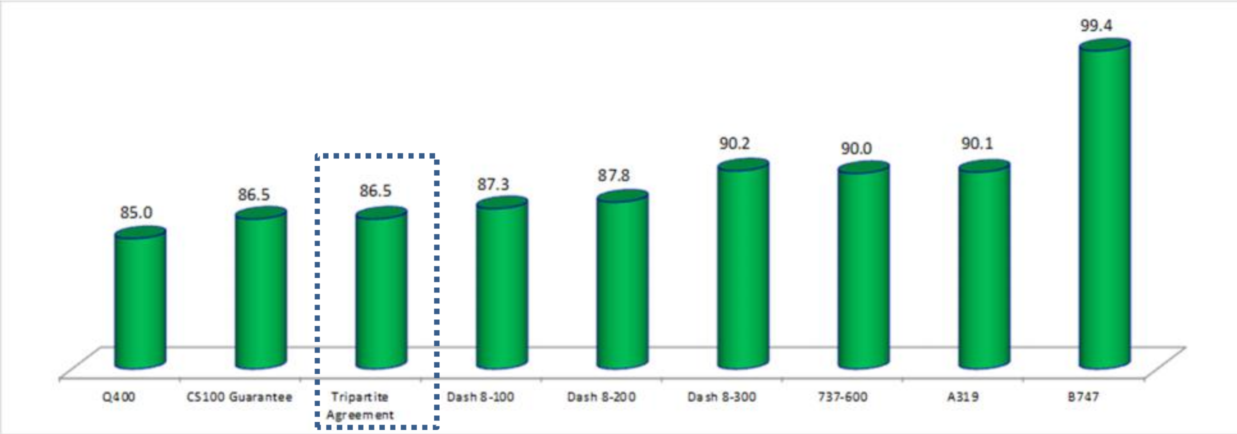
Figure 3 - Typical Community Noise Levels (db(A)) Compared to the CS100



(Data provided by Porter Airlines and verified by Tetra Tech AMT)

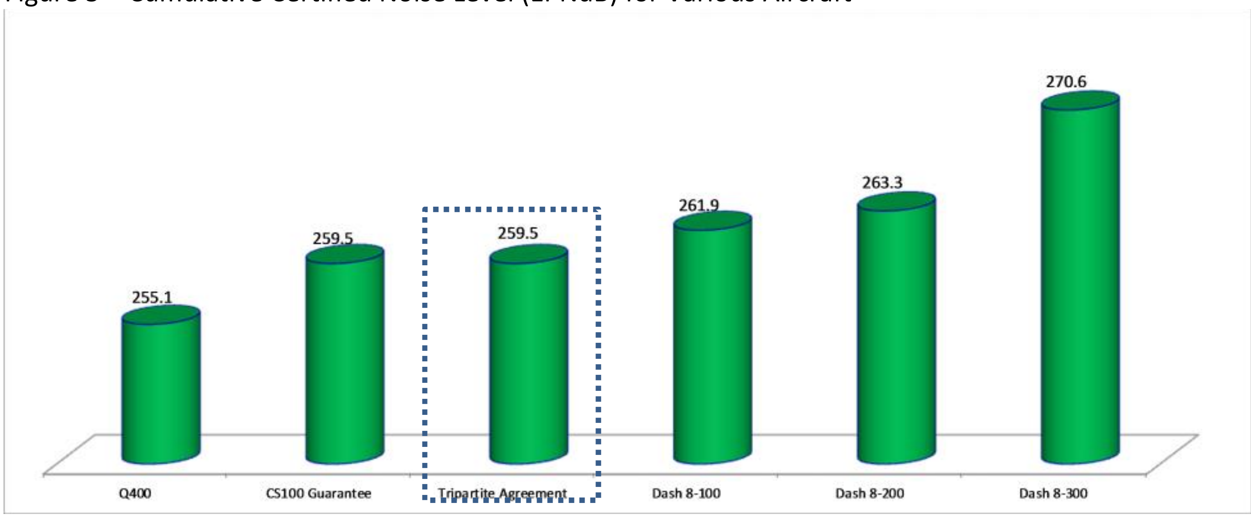
Figure 4 contains a graph showing the average certified noise levels (EPNdB) and Figure 5 contains a graph showing the cumulative certified noise levels (EPNdB) for various aircraft; including the Bombardier Q400, CS100, and the value dictated by the 1983 Tripartite Agreement. Both figures show that both of these Bombardier aircraft have and will have cumulative and average certified noise levels below 259.5 and 86.5 EPNdB respectively. You can see from the graphs that the Dash-8 series aircraft (100, 200, and 300) have cumulative and average certified noise levels that are above these values even though they are presently exempted from the Tripartite agreement and able to operate out of BBTCA.

Figure 4 – Average Certified Noise Level (EPNdB) for Various Aircraft



(Data provided by Porter Airlines and verified by Tetra Tech AMT)

Figure 5 – Cumulative Certified Noise Level (EPNdB) for Various Aircraft



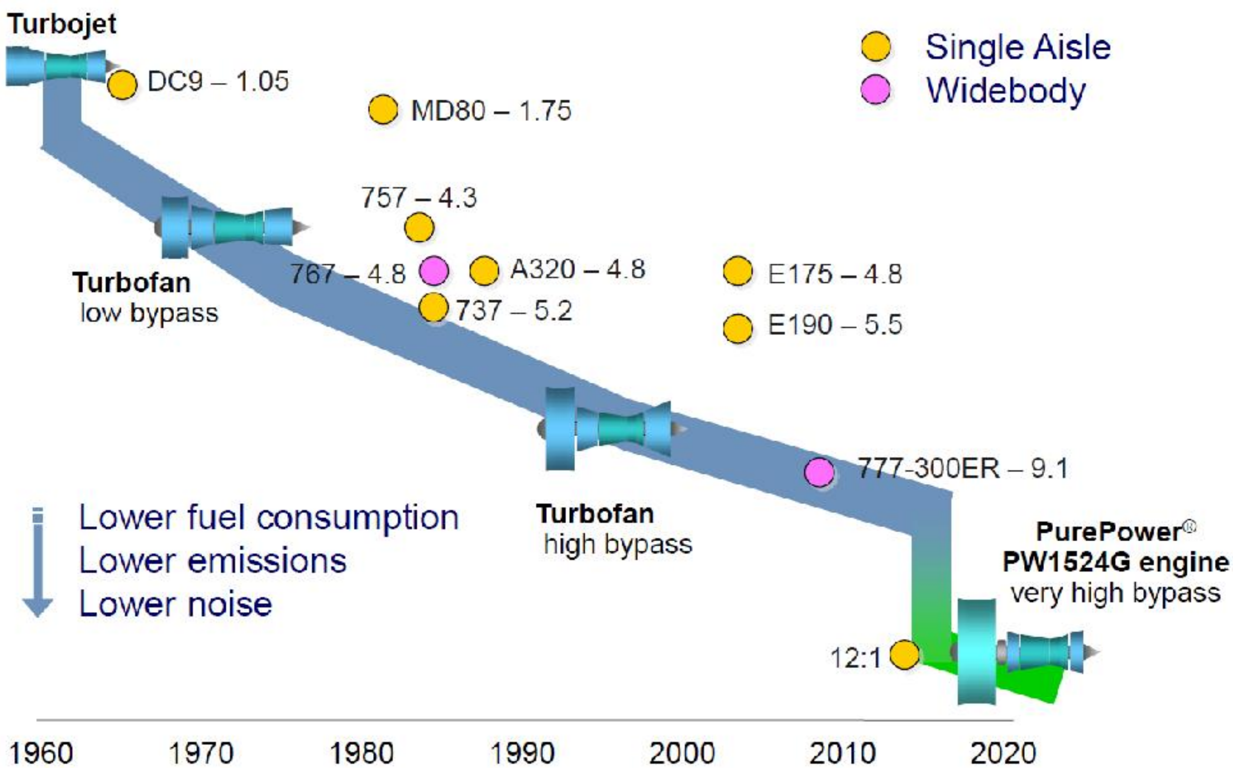
(Data provided by Porter Airlines and verified by Tetra Tech AMT)

According to the best available information, a small number of jet aircraft currently in production can be operated by commercial airline carriers that will have cumulative and average certified noise levels below 259.5 and 86.5 EPNdB respectively. Other commercial aircraft (such as the 737-600, A319 as shown in Figure 4) will not be able to operate below these noise levels, even with their re-engined variants. Should these other jet aircraft eventually be able to reduce their noise signatures or obtain exemptions, they would still have significant difficulty meeting safety and Transport Canada rules so as to operate from the shorter BBTC runway.

According to Bombardier, the CS100 aircraft is expecting to undergo certification prior to the planned first delivery scheduled for June 2014. A preliminary noise evaluation is planned for September/October of 2013. The Pratt & Whitney PW1524G engines have completed testing (as of January 2012) and were certified (on February 20, 2013 by Transport Canada) and will undergo noise testing in August 2013. A total of 9 engines participated in certification testing for over 2500 hours.

The PW1524G engines that will be on the CS100 aircraft are geared turbofan (GTF) engines with an ultra-high bypass ratio. The GTF architecture incorporates a gear system that significantly improves acoustics, fuel-burn, and emissions while reducing the number of parts in the engine. It has a 70%+ smaller noise footprint when compared to other current single aisle jet aircraft. Figure 6 illustrates the bypass ratio changes over the history of jet engine development with the corresponding reduction in noise, emissions, and fuel consumption.

Figure 6 – PW1500G Engine Change in Bypass Ratio Gives Significant reduction in fuel burn, noise, and emissions.



(Data provided by Porter Airlines and verified by Tetra Tech AMT)

In 2012, BBTCA had an average of 349 operations per day. These operations are from a large mix of personal aviation aircraft including single engine propeller, multi-engine propeller, and helicopters. The predominating personal aviation aircraft types are:

- Beechcraft Super King Air (350 or 200)
- Pilatus PC-12
- Mitsubishi MU-2
- Cessna C208
- Cessna C182
- Bell 206
- Agusta Westland AW139

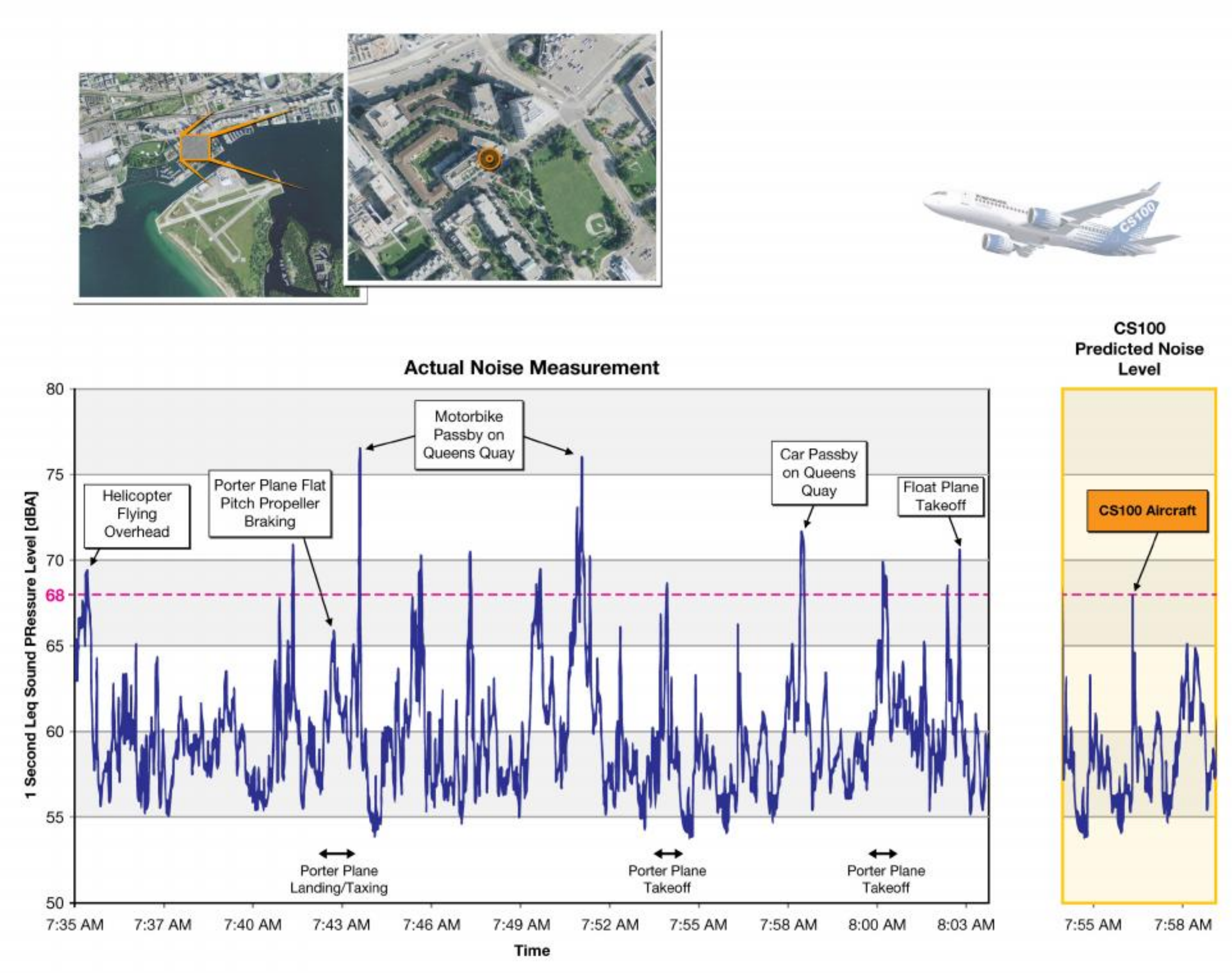
These aircraft are not subject to the same ICAO certification process that occurs with the Bombardier Dash 8 series or CS100 aircraft. Therefore, it is difficult to directly compare the certified noise from these planes to the guaranteed certified noise levels of the CS100. Additionally, personal aviation aircraft also fly a more dispersed flight path and altitude that results in a higher range in noise than with commercial flights. The flight paths from personal aviation aircraft often fly at low altitudes and therefore are closer to noise sensitive land use than what occurs with commercial aircraft and more predictable flight patterns.

One method to illustrate the potential noise associated with the CS100 operations is to compare its guaranteed noise levels to the measured noise levels from other aircraft and general community noises surrounding BBTCA. The Jacobs Report contains measurement data of aircraft and general community noise activities that can be directly compared with the CS100. This includes noise operations of the Dash-8 Q400, various other aircraft and roadway traffic noise.

Figure 7 reproduces Figure II-4 from the Jacobs Report that shows one second continuous A-weighted noise levels from a sound level meter that was located along the City of Toronto's shore area, just north of the runway, a location that would be consistent with a sideline/lateral measurement position. The data shows noise events from various source noise values which range from approximately 63 to 77 db(A). Most of the roadway traffic events measured in high 60's to low 70's db(A). Dash-8 Q400 operations ranged from 65 to 70 db(A). Other aircraft events measured from 69 db(A) to 72 db(A).

On the right side of the figure is what the magnitude of a CS100 aircraft will look like for comparison purposes. While there is no direct conversion from EPNL to an instantaneous db(A) level, it is possible to provide an estimated equivalent db(A) level. Based upon the guaranteed noise level of the CS100 aircraft, it is predicted that the noise level at the same location along the shore would be approximately 68 db(A). This noise level is within the same range as the measured Q400 aircraft and is lower than the other measured aircraft and traffic noise sources. A useful side note from the measurement data is that the measured db(A) noise level of the Q400 aircraft is consistent with the EPNL noise level predicted to occur based upon its certification data.

Figure 7 – CS100 Guaranteed Noise Level Compared to Measured Noise Levels (db(A))



Reproduced From Fgure 11-4: Attended Sound Level Monitoring Leq(1s), Location #1, May 22, 2009 Between 07:35 and 08:05 (North Winds, 20 km/h)

Bill Bishop Toronto City Airport – Noise Management Study – Interim Report" prepared by Jacobs Consultancy Canada Inc. for Toronto Port Authority (TPA) in 2010

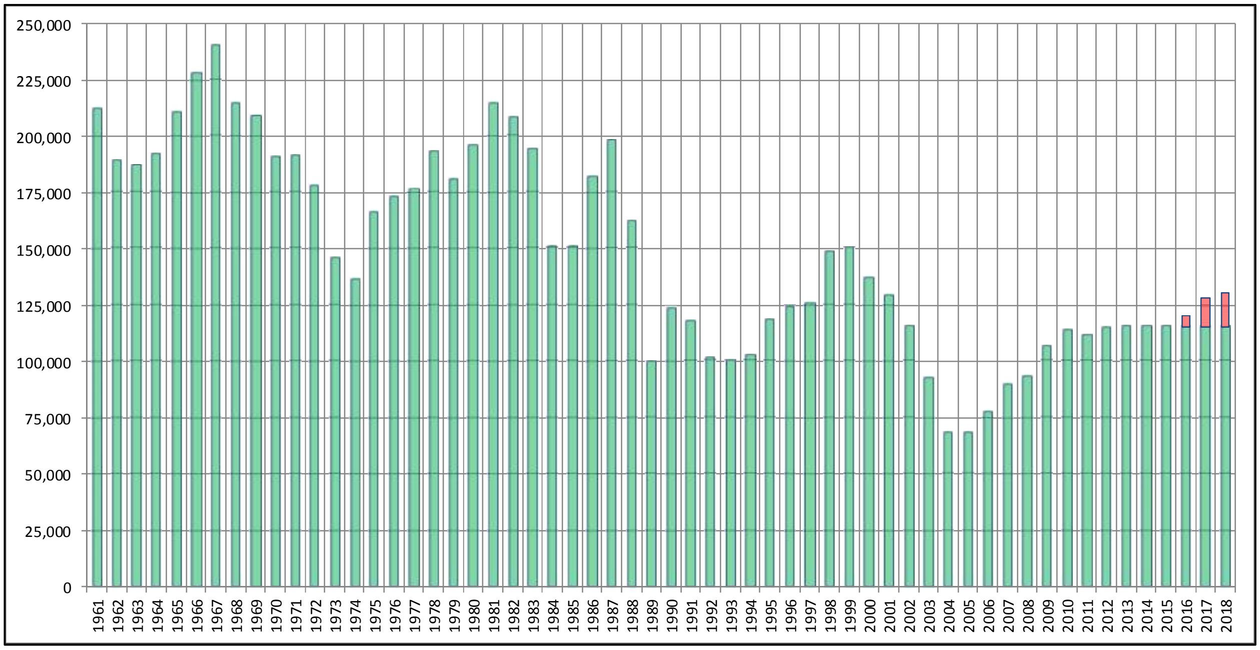
(Original plot from Billy Bishop Toronto City Airport- Noise Management Study- Interim Report, Prepared by Jacobs Consultancy, February, 2010, with CS100 Predicted Noise Level yellow chart added by Tetra Tech AMT)

4.0 REVIEW OF HISTORICAL AND FUTURE BBTCA OPERATIONAL COUNTS

According to the Toronto Port Authority (TPA), the annual aircraft operations for BBTCA in the year 2012 numbered 114,576. For 2013, the annual aircraft operations are expected to be approximately 115,165. With the addition of the CS100 aircraft in the fleet mix from 2016 to 2018, the annual aircraft operations will be slightly higher than 2013. It is estimated that 2016 will have 115,394 flight operations, 2017 will have 115,456, and 2018 will have 115,467. The CS100 would add 4,960, 12,742 and 15,303 flight operations, respectively.

Figure 8 below shows the historical and forecast annual aircraft operations for BBTCA from 1961 to 2008. The pink bars above the blue bars on the far right are the additional CS100 aircraft operations. You can see from the graph that the forecasted 2018 operations are half of the 1967 high. The 2001 annual aircraft operations were 129,505, which is more than the 2018 forecast of 115,467. With the addition of the CS100 operations to the 2018 forecast, this combined 2018 forecast is now approximately equal to the actual 2001 operations.

Figure 8 - Historical and Forecast Annual Aircraft Operations for BBTCA from 1961-2018



(Data provided by Porter Airlines and verified by Tetra Tech AMT)

5.0 REVIEW OF BBTCA HISTORICAL NOISE REGULATIONS

According to the Tripartite Agreement, aircraft/helicopter operations at BBTCA are limited by the 1990 NEF contours prepared in April 1978 by the Federal Ministry of Transport. The NEF 28 contour, produced by modeling the 95 percentile annual operations at the airport, must remain within the limits of the official NEF 25 contour (1990). The modeled NEF 28 contour may only exceed the official NEF 25 contour (1990) between the two designated points (marked as “X” and “Y” on the official plan), which is situated at the western most limits of the airport property.

Therefore, since the noise contour controls the total amount of noise generated by the airport, it limits the amount of daily and therefore annual operations. Adding the CS100 aircraft to the airport’s fleet mix will not change this requirement as set forth in the agreement. The NEF limit will continue to provide a continuation of the historical limitations on the overall noise levels at the airport.

Through this agreement, the airport has two levels of protection against the increase in noise. First, there are the certification limits that ensure that only quieter aircraft are allowed to operate at this airport. Second, and more importantly, there is the cumulative NEF limitation that effectively limits loud aircraft, how many aircraft can operate, and how they are flown in order to stay below this strict cumulative standard.

It is important to note that a NEF 25 noise standard is much more stringent of a criterion then the typical NEF 30 to 35 used by other airports throughout the world for countries using the NEF metric. Plus the NEF limit is applied to land use that is very close to the airport. Regarding the NEF metric, Transport

Canada states, "This metric allows us to predict a community's response to aircraft noise. If the NEF level is greater than 35, complaints are likely to be high. Anything above 25 is likely to produce some level of annoyance. Land planners can use this system to ensure that land use in the vicinity of an airport is compatible with that airport." The cumulative noise limitation at BBTCA is a very restrictive limitation that effectively restricts the airport to only allowing quiet aircraft; otherwise the limit could not be met. The only airports that we are aware of that have such low limitations are located in national park-like settings, not near a downtown urban center where the ambient noise levels are actually higher than the airport noise.

6.0 CONCLUSION

Historically, jet aircraft have been louder than propeller aircraft due to the nature of their design. Over time, design changes have reduced jet noise significantly, but jets are still louder than propeller aircraft. With the CS100 aircraft and its ultra-high bypass ration engine, it will be the first commercial jet aircraft to have noise characteristics on par or quieter than regional turboprop aircraft. The CS100 guaranteed average certification level is quieter than the older Dash 8 (100, 200 and 300 series) turboprop aircraft that were the work horse of the regional turboprop aircraft industry, and it is comparable with the modern Q400 version. The Dash 8 aircraft have successfully operated at BBTCA using one of these series of aircraft for over 20 years. This revolutionary engine design advancement allows the CS100 aircraft to be quieter or on par with these same aircraft.

This report presents an assessment of the impact of the addition of the CS100 aircraft on noise levels at BBTCA. The findings and conclusions of the report are summarized below.

- The guaranteed noise level of the CS100 was found to be either equivalent or quieter than the average certified noise level of other aircraft that already successfully operate at BBTCA under the current agreement. The average EPNdB guaranteed by Bombardier will be below 86.5 dB. For an aircraft, this average EPNdB of 86.5 dB is very quiet. On an energy basis, that is at least 17% quieter than the Dash 8 100, 26% quieter than the Dash 8 200, and 57% quieter than the Dash 8 300. These aircraft have all operated out of BBTCA for over 20 years as named aircraft within the tripartite agreement. The CS100 aircraft is anticipated to be on par with the levels of the Q400 aircraft that successfully operates now at the airport.

- It is not necessary to wait for the CS100 to be fully certified to understand its noise level. The CS100 noise footprint will be certified using an approved and much regulated test based on international standards (ICAO) and consistent with all other aircraft. The noise certification process is applicable to all airports including BBTCA and does not need to operate from BBTCA to be measured specifically at the airport. Based on the guarantee, the airline can be comfortable that the CS100 will either meet the actual measured guarantee level (average of 86.5 or less) or Porter can decline the deliveries.

- The guaranteed average certified noise level provides for a more efficient and effective method of illustrating the quiet features of this aircraft reflecting all modes of flight. Its single number rating has been found to be more understandable to the general public when comparing various aircraft noise characteristics than using the individual measurement point components.

- The revolutionary engine design of the CS100 and its sound level characteristics were described in the report and the guaranteed noise level of the aircraft was compared to actual measured noise data from the downtown Toronto area. The predicted noise level of the CS100 was compared to a variety of other aircraft and to typical community noise levels in the airport environment. The data showed that the predicted noise levels from CS100 operations are typically less than the noise from other noise sources such as highway vehicles and other aircraft. The ambient noise conditions in an urban environment such as downtown Toronto is higher than the noise from CS100 aircraft operations.

- While the manufacturer of the CS100 is not able to provide guarantee values at the individual three measurement points, they are able to commit to a cumulative noise level of under 259.5 EPNdB and average of equal to or less than 86.5 EPNdB. The Tripartite Agreement can be amended to allow for the use of the CS100 provided it meets an average EPNdB level of 86.5 or less and designate the CS100 a named allowed aircraft much like the exemption provided for the Dash-8 series of aircraft in the 1985 amendment.

- Through the tripartite agreement the airport has two levels of strict noise limitations that protect against increases in noise. Most importantly is the cumulative NEF limitation that effectively limits against loud aircraft, how many aircraft can operate, and how they are flown in order to stay below this strict cumulative standard. The cumulative NEF 25 noise limitation at BBTCA is a very restrictive limitation that effectively limits the airport to only quiet aircraft; otherwise the limit could not be met.