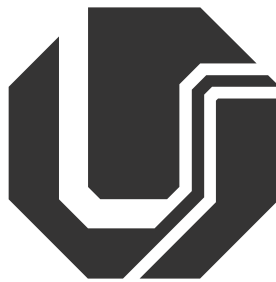


FEDERAL UNIVERSITY OF UBERLÂNDIA
FACULTY OF MECHANICAL ENGINEERING
UNDERGRADUATE COURSE IN AERONAUTICAL ENGINEERING



VÍTOR YUDI MANO ANDRADE

SEMIEMPIRICAL METHODS FOR PROPELLER NOISE
PREDICTION

UBERLÂNDIA, MG

2025

VÍTOR YUDI MANO ANDRADE

SEMIEMPIRICAL METHODS FOR PROPELLER NOISE
PREDICTION

Presented to the Faculty of Mechanical Engineering of the Federal University of Uberlândia as partial requirement for obtaining the degree in Aeronautical Engineering.

Supervisor: Prof. Dr. Odenir de Almeida, PhD

UBERLÂNDIA, MG

2025



UNIVERSIDADE FEDERAL DE UBERLÂNDIA

Coordenação do Curso de Graduação em Engenharia Aeronáutica
Rodovia BR 050, KM 78, Bloco 1D, 2º andar - Bairro Glória, Uberlândia-MG, CEP 38400-902

Telefone: (34) 2512-6768 - www.mecanica.ufu.br - coceaero@mecanica.ufu.br



ATA DE DEFESA - GRADUAÇÃO

Curso de Graduação em:	ENGENHARIA AERONÁUTICA				
Defesa de:	PROJETO DE CONCLUSÃO DE CURSO - FEMEC43100				
Data:	28/08/2025	Hora de início:	09:00	Hora de encerramento:	10:15
Matrícula do Discente:	11911EAR003				
Nome do Discente:	VITOR YUDI MANO ANDRADE				
Título do Trabalho:	Semiempirical methods for propeller noise prediction				
A carga horária curricular foi cumprida integralmente?				(X) Sim () Não	

Reuniu-se de forma híbrida, pela plataforma Microsoft Teams e na Sala de Reuniões da Faculdade de Engenharia Mecânica, Bloco 1DCG, Campus Glória, a Banca Examinadora designada pelo Colegiado do Curso de Graduação em Engenharia Aeronáutica, assim composta: Prof. Higor Luis Silva, FEMEC/UFU; Eng. Gilberto Bueno Luque Filho, EMBRAER, e Prof. Odenir de Almeida, FEMEC/UFU, orientador do candidato.

Iniciando os trabalhos, o(a) presidente da banca, Prof. Odenir de Almeida, apresentou a Comissão Examinadora e o candidato, agradeceu a presença do público, e concedeu ao discente a palavra, para a exposição do seu trabalho. A duração da apresentação do discente e o tempo de arguição e resposta foram conforme as normas do curso.

A seguir o(a) senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

Aprovado. Nota: 90.0

Nada mais havendo a tratar foram encerrados os trabalhos. Foi lavrada a presente ata que após lida e achada conforme foi assinada pela Banca Examinadora.



Documento assinado eletronicamente por **Higor Luis Silva, Professor(a) do Magistério Superior**, em 28/08/2025, às 10:07, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do [Decreto nº 8.539, de 8 de outubro de 2015](#).



Documento assinado eletronicamente por **Gilberto Bueno Luque Filho, Usuário Externo**, em 28/08/2025, às 10:08, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do [Decreto nº 8.539, de 8 de outubro de 2015](#).



Documento assinado eletronicamente por **Odenir de Almeida, Professor(a) do Magistério Superior**, em 28/08/2025, às 10:14, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do [Decreto nº 8.539, de 8 de outubro de 2015](#).



A autenticidade deste documento pode ser conferida no site https://www.sei.ufu.br/sei/controlador_externo.php?acao=documento_conferir&id_orgao_acesso_externo=0, informando o código verificador **6612656** e o código CRC **6C8F2D9E**.

Referência: Processo nº 23117.035866/2025-96

SEI nº 6612656

To my parents, for your unwavering love and support.

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to my advisor, Prof. Dr. Odenir de Almeida, for his guidance and patience. Additionally, this endeavour would not have been possible without the support from the Federal University of Uberlândia and the Faculty of Mechanical Engineering, especially the Laboratory of Experimental Aerodynamics (LAEX), which provided crucial articles and standards for the development of this work. Thanks should also go to all of my classmates and professors from the university, who undoubtedly impacted my formation as an engineer.

Words cannot express my gratitude to my parents and my sister for their feedback and moral support throughout all of my time as an undergraduate student. I am also thankful to my girlfriend, whom I have met during the writing of this work, whose support was crucial for finishing this endeavour.

Lastly, I would be remiss in not mentioning my friends, who provided me endless entertainment and helped me keep my motivation even through the toughest times. I would also like to thank my entire family for their continued love and support.

ABSTRACT

Propellers are one of the main devices utilised to power aircraft, and interest in them has resurged due to recent developments in UAVs and eVTOLs. It is known that propellers are the main source of noise in aircraft, which is a major factor for annoyance, and manufacturers continuously strive for lower noise levels due to increasingly stricter regulations and passenger comfort. In the conceptual phase of an aircraft, it is necessary to estimate its noise levels, and for the propellers, several prediction methods exist. The focus of this work is on semiempirical methods and an implementation of the SAE method to evaluate its accuracy when confronted with actual data. The results indicate that the SAE method has great accuracy in the far-field, with most of the estimated data being in the range of 3 dB of difference with the experimental data. However, in the near-field the results are worse, with errors as large as 20 dB when compared to experimental data. Since the SAE method relies on parameters commonly available at the start of a project and is inexpensive to employ, it should be used mainly in the conceptual phase of an aircraft.

Keywords: noise; propeller; prediction method; semiempirical; far-field; near-field.

RESUMO

Hélices são um dos principais dispositivos utilizados para a propulsão de aeronaves e houve renovação no interesse nelas devido aos recentes desenvolvimentos em UAVs e eVTOLs. Sabe-se que as hélices são a principal fonte de ruído em aeronaves, que é um fator primário de incômodo, e as fabricantes continuamente buscam a redução dos níveis de ruído emitidos, devido à regulação cada vez mais estrita e ao conforto dos passageiros. Na fase conceitual do projeto de uma aeronave, é necessário estimar os níveis de ruído e, para as hélices, uma série de métodos de predição existem. O foco deste trabalho são os métodos semiempíricos e a implementação do método SAE para avaliar sua precisão quando confrontado com dados experimentais. Os resultados mostram que o método SAE tem ótima precisão em far-field, com a maior parte dos dados estimados estando numa margem de erro de 3 dB em relação aos dados experimentais. Entretanto, os resultados mostram que, no procedimento para near-field, os erros chegam até 20 dB quando comparados aos dados experimentais. Como o método SAE depende de parâmetros comumente presentes no começo de um projeto de aeronave e tem um baixo custo de implementação, este deve ser utilizado, principalmente, na fase conceitual do projeto de uma aeronave.

Palavras-chave: ruído; hélice; método de predição; semiempíricos; far-field; near-field.

List of Figures

1.1	Evolution of heavy propeller-driven aircraft noise levels based on data from EASA (5).	2
1.2	Propeller types: (a) conventional; (b) prop-fan; (c) counter-rotating. Source: Self (6).	3
1.3	Embraer 120 Brasilia. Source: (14).	5
1.4	Multicopter drone. Source: (17).	5
1.5	Registered drones in Brazil by activity.	6
1.6	EH216-S. Source: (24).	7
2.1	Sources of aerodynamic noises. Adapted from (26).	9
2.2	Conventional propeller noise spectrum. Source: Self (6).	10
2.3	Characteristics of propeller rotational noise. Source: Magliozzi <i>et al.</i> (27).	10
2.4	Characteristics of propeller broadband noise. Source: Magliozzi <i>et al.</i> (27).	11
2.5	Characteristics of propeller narrow-band random noise. Source: Magliozzi <i>et al.</i> (27).	12
3.1	Far-field method condition for utilization. The red star indicates the location in which noise is to be estimated. Credits: Isabela Lie Mano Andrade.	16
3.2	Near-field method condition for utilization. The red star indicates the location in which noise is to be estimated. Credits: Isabela Lie Mano Andrade.	17
3.3	Using GRABIT to extract data points from images.	18
3.4	Visual representation of the prediction intervals.	19
3.5	Flowchart depicting the sequence of processes for the far-field noise prediction method.	21
3.6	Flowchart depicting the sequence of processes for the near-field noise prediction method.	22
3.7	Example of a box plot.	24
4.1	Structure of the chapter.	30
4.2	Structure of the sections present in this chapter.	30
4.3	Cessna 170 - Comparison between flyover data and predicted results.	33
4.4	PA-28 Turbo Arrow IV - Comparison between flyover data and predicted results.	33

4.5	Cessna 180 - Comparison between flyover data and predicted results.	34
4.6	PA-38 Tomahawk - Comparison between flyover data and predicted results. . .	34
4.7	King Air 200 - Comparison between flyover data and predicted results.	35
4.8	PA-42 Cheyenne - Comparison between flyover data and predicted results. . .	35
4.9	C-414 Chancellor - Comparison between flyover data and predicted results. . .	36
4.10	Baron 58P - Comparison between flyover data and predicted results.	36
4.11	C-425 Conquest I - Comparison between flyover data and predicted results. . .	37
4.12	Flight 2 - Port - Comparison between measured and predicted results.	38
4.13	Flight 2 - Port - Error between measured and predicted results.	39
4.14	Flight 2 - Starboard - Comparison between measured and predicted results. . .	39
4.15	Flight 2 - Starboard - Error between measured and predicted results.	40
4.16	Flight 3 - Port - Comparison between measured and predicted results.	40
4.17	Flight 3 - Port - Error between measured and predicted results.	41
4.18	Flight 3 - Starboard - Comparison between measured and predicted results. . .	41
4.19	Flight 3 - Starboard - Error between measured and predicted results.	42
B.1	Propeller RPM to tip speed conversion.	71
B.2	Acquire Mach number from tip speed.	72
B.3	Far-field partial level (FL1) based on power and tip speed.	72
B.4	Far-field partial level (FL2) based on blade count and propeller diameter. . . .	73
B.5	Far-field partial level (FL3) based on atmospheric absorption and spherical spreading of sound.	73
B.6	Obtain the directivity index (DI) with the azimuth angle as input.	74
B.7	Perceived noise level adjustment for 2 bladed propellers.	74
B.8	Perceived noise level adjustment for 3 bladed propellers.	75
B.9	Perceived noise level adjustment for 4 bladed propellers.	75
B.10	Perceived noise level adjustment for 6 and 8 bladed propellers.	76
B.11	Obtain the propeller helical tip speed based on the aircraft's forward speed. .	76
B.12	Near-field partial level (NL1) based on power and diameter.	77
B.13	Near-field partial level (NL2) based on tip speed and tip clearance.	77
B.14	Variation of overall, free-space propeller noise levels with axial position X/D fore and aft of propeller plane.	78
B.15	Effect of reflecting surfaces in the pressure field.	78
B.16	Near-field harmonic level distribution.	79

List of Tables

1.1	Prediction methods and their characteristics. Adapted from (8).	4
2.1	Semiempirical and empirical methods.	14
3.1	Conventional approach to interpreting the absolute magnitude of a correlation coefficient. Adapted from (47).	25
3.2	SAE - Sample calculation of far-field noise input parameters	27
3.3	SAE - Sample calculation of near-field noise input parameters	27
3.4	Flight test conditions. Source: Wilby <i>et al.</i> (54).	29
4.1	Comparison of the OASPL results acquired between the examples provided and the implementation developed. Subscript s relates to the source results, and the subscript i relates to the implementation results.	31
4.2	Comparison of the PNL results acquired between the examples provided and the implementation developed. Subscript s relates to the source results, and the subscript i relates to the implementation results.	31
4.3	Example of input parameters for far-field method validation. Data comes from Site 1 of Event 12 of the Cessna 170 aircraft data (Table I.1, Table I.2, Table I.11).	32
4.4	Example of input parameters for near-field method validation. Data comes from the port side propeller, Condition 1 of Flight 2 (Table II.1).	37
4.5	Comparison of the OASPL results to the measured data.	38
A.1	Polynomial coefficients for the curves shown in Figure B.1.	59
A.2	Polynomial coefficients for the curves shown in Figure B.2.	60
A.3	Polynomial coefficients for the curves shown in Figure B.3.	60
A.4	Polynomial coefficients for the curves shown in Figure B.4.	60
A.5	Polynomial coefficients for the curves shown in Figure B.5.	60
A.6	Polynomial coefficients for the curves shown in Figure B.6.	60
A.6	Polynomial coefficients for the curves shown in Figure B.6 (Continued).	61
A.7	Polynomial coefficients for the curves shown in Figure B.7.	61
A.7	Polynomial coefficients for the curves shown in Figure B.7 (Continued).	61
A.8	Polynomial coefficients for the curves shown in Figure B.8.	61

A.8 Polynomial coefficients for the curves shown in Figure B.8 (Continued).	62
A.9 Polynomial coefficients for the curves shown in Figure B.9.	62
A.9 Polynomial coefficients for the curves shown in Figure B.9 (Continued).	62
A.10 Polynomial coefficients for the curves shown in Figure B.10.	62
A.10 Polynomial coefficients for the curves shown in Figure B.10 (Continued).	63
A.11 Polynomial coefficients for the curves shown in Figure B.11.	63
A.12 Polynomial coefficients for the curves shown in Figure B.12.	63
A.13 Polynomial coefficients for the curves shown in Figure B.13.	64
A.14 Polynomial coefficients for the curves shown in Figure B.14.	64
A.14 Polynomial coefficients for the curves shown in Figure B.14 (Continued).	64
A.15 Polynomial coefficients for the curves shown in Figure B.15.	64
A.15 Polynomial coefficients for the curves shown in Figure B.15 (Continued).	64
A.15 Polynomial coefficients for the curves shown in Figure B.15 (Continued).	64
A.15 Polynomial coefficients for the curves shown in Figure B.15 (End).	65
A.16 Polynomial coefficients for the curves shown in Figure B.16.	65
A.17 Mean standard prediction error for the curves shown in Figure B.1.	66
A.18 Mean standard prediction error for the curves shown in Figure B.2.	66
A.19 Mean standard prediction error for the curves shown in Figure B.3.	66
A.20 Mean standard prediction error for the curves shown in Figure B.4.	67
A.21 Mean standard prediction error for the curves shown in Figure B.5.	67
A.22 Mean standard prediction error for the curves shown in Figure B.6.	67
A.23 Mean standard prediction error for the curves shown in Figure B.7.	67
A.24 Mean standard prediction error for the curves shown in Figure B.8.	67
A.25 Mean standard prediction error for the curves shown in Figure B.9.	68
A.26 Mean standard prediction error for the curves shown in Figure B.10.	68
A.27 Mean standard prediction error for the curves shown in Figure B.11.	68
A.28 Mean standard prediction error for the curves shown in Figure B.12.	69
A.29 Mean standard prediction error for the curves shown in Figure B.13.	69
A.30 Mean standard prediction error for the curves shown in Figure B.14.	69
A.31 Mean standard prediction error for the curves shown in Figure B.15.	69
A.32 Mean standard prediction error for the curves shown in Figure B.16.	70
D.1 Cessna 170 - Implementation results.	120
D.2 PA-28 Turbo Arrow IV - Implementation results.	120
D.3 Cessna 180 - Implementation results.	121
D.4 PA-38 Tomahawk - Implementation results.	121
D.5 King Air 200 - Implementation results.	121
D.6 PA-42 Cheyenne - Implementation results.	122
D.7 C-414 Chancellor - Implementation results.	122
D.8 Baron 58P - Implementation results.	123

D.9	C-425 Conquest I - Implementation results.	123
D.10	Cessna 170 - Hypothesis testing.	123
D.10	Cessna 170 - Hypothesis testing (Continued).	124
D.11	PA-28 Turbo Arrow IV - Hypothesis testing.	124
D.11	PA-28 Turbo Arrow IV - Hypothesis testing (Continued).	124
D.12	Cessna 180 - Hypothesis testing.	124
D.12	Cessna 180 - Hypothesis testing (Continued).	124
D.13	PA-38 Tomahawk - Hypothesis testing.	125
D.13	PA-38 Tomahawk - Hypothesis testing (Continued).	125
D.14	King Air 200 - Hypothesis testing.	125
D.14	King Air 200 - Hypothesis testing (Continued).	125
D.15	PA-42 Cheyenne - Hypothesis testing.	125
D.15	PA-42 Cheyenne - Hypothesis testing (Continued).	126
D.16	C-414 Chancellor - Hypothesis testing.	126
D.16	C-414 Chancellor - Hypothesis testing (Continued).	126
D.17	Baron 58P - Hypothesis testing.	126
D.17	Baron 58P - Hypothesis testing (Continued).	126
D.18	C-425 Conquest I - Hypothesis testing.	127
D.18	C-425 Conquest I - Hypothesis testing (Continued).	127
E.1	Prediction results - Port side.	129
E.1	Prediction results - Port side (Continued).	130
E.2	Prediction results - Starboard side.	131
E.2	Prediction results - Starboard side (Continued).	132
I.1	Aircraft specifications.	134
I.1	Aircraft specifications (Continued).	135
I.2	Cessna 170 - Level flyover noise data.	135
I.2	Cessna 170 - Level flyover noise data (Continued).	136
I.3	PA-28 Turbo Arrow IV - Level flyover noise data.	136
I.3	PA-28 Turbo Arrow IV - Level flyover noise data (Continued).	137
I.4	Cessna 180 - Level flyover noise data.	137
I.4	Cessna 180 - Level flyover noise data (Continued).	138
I.5	PA-38 Tomahawk - Level flyover noise data.	138
I.5	PA-38 Tomahawk - Level flyover noise data (Continued).	138
I.6	King Air 200 - Level flyover noise data.	139
I.6	King Air 200 - Level flyover noise data (Continued).	139
I.7	PA-42 Cheyenne - Level flyover noise data.	139
I.7	PA-42 Cheyenne - Level flyover noise data (Continued).	140
I.8	C-414 Chancellor - Level flyover noise data	140

I.8	C-414 Chancellor - Level flyover noise data (Continued).	141
I.9	Baron 58P - Level flyover noise data	141
I.9	Baron 58P - Level flyover noise data (Continued).	142
I.10	C-425 Conquest I - Level flyover noise data	142
I.10	C-425 Conquest I - Level flyover noise data (Continued).	143
I.11	Cessna 170 - Surface temperature data	143
I.12	PA-28 Turbo Arrow IV - Upper air temperature data	143
I.13	Cessna 180 - Surface temperature data	144
I.14	PA-38 Tomahawk - Surface temperature data	144
I.15	King Air 200 - Surface temperature data	145
I.16	PA-42 Cheyenne - Surface temperature data	145
I.17	C-414 Chancellor - Surface temperature data	145
I.18	C-425 Conquest I - Surface temperature data	146
II.1	Flight 2 - Test conditions	147
II.2	Flight 3 - Test conditions	148
II.3	Exterior microphone - Port side	149
II.3	Exterior microphone - Port side (Continued)	150
II.4	Exterior microphone - Starboard side	151
II.4	Exterior microphone - Starboard side (Continued)	152

List of Abbreviations and Acronyms

Anac Agência Nacional de Aviação Civil (National Civil Aviation Agency)

EASA European Union Aviation Safety Agency

EPNL Effective Perceived Noise Level

ESDU Engineering Sciences Data Unit

eVTOL Electric Vertical Take Off and Landing

FAA Federal Aviation Administration

IAS Indicated Airspeed

ICAO International Civil Aviation Organisation

OASPL Overall Sound Pressure Level

PNL Perceived Noise Level

SAE Society of Automotive Engineers

SISANT Sistema de Informação Sobre Aeronaves Não-Tripuladas (System of Unmanned Aircraft Information)

TAS True Airspeed

UAM Urban Air Mobility

UAV Unmanned Aerial Vehicle

VTOL Vertical Take Off and Landing

Contents

List of Figures	i
List of Tables	iii
List of Abbreviations and Acronyms	vii
1 Introduction	1
1.1 Problem description	1
1.2 Noise measurement and prediction	2
1.3 Motivation	4
1.4 Objectives	7
1.4.1 General objective	7
1.4.2 Specific objectives	7
1.5 Structure	7
2 Literature Review	9
2.1 Propeller noise sources	9
2.2 Semiempirical and empirical propeller noise prediction methods	13
2.3 Related works	13
3 Methods	15
3.1 On the selection of the SAE propeller noise prediction method	15
3.1.1 SAE method description	15
3.1.2 SAE method implementation	17
3.2 Statistical analysis techniques	22
3.2.1 Mean, standard deviation, and relative error	22
3.2.2 Box plot	24
3.2.3 Pearson correlation coefficient	24
3.2.4 Test of hypotheses	25
3.3 Experimental datasets	26
3.3.1 SAE sample calculations	26
3.3.2 Far-field experimental datasets	27

3.3.3	Near-field experimental datasets	28
4	Results	30
4.1	Overview of the presentation of the results	30
4.2	Comparison to the sample calculations provided by SAE	31
4.3	Validation of far-field method implementation	31
4.4	Validation of near-field method implementation	37
5	Discussion	43
5.1	On the comparison to the sample calculations provided by SAE	43
5.2	On the validation of the far-field method implementation	43
5.3	On the validation of the near-field method implementation	44
5.4	Utilization of the SAE method for eVTOLs and UAVs	44
6	Conclusion	46
6.1	Future studies	46
	References	48
	Glossary	56
	Appendices	58
A	Polynomial coefficients and curve fitting errors of the SAE method implementation	59
A.1	Polynomial coefficients	59
A.2	Estimated polynomial curve fitting error	65
B	Constructed plots for the SAE method implementation	71
C	MATLAB functions developed for implementation of the SAE method	80
D	Far-field method implementation validation results	119
D.1	Implementation results	120
D.2	Statistical hypothesis testing	123
E	Near-field method implementation validation results	128
	Annexes	133
I	Far-field experimental datasets	134
I.1	Aircraft specifications	134
I.2	Level flyover noise data	135
I.3	Meteorological data	143

II Near-field experimental datasets	147
--	------------

Introduction

1.1 Problem description

Noise can be defined as “unwanted sound”, and it is one of the main causes of community annoyance with aircraft in general. As early as 1931, Davis (1) published a work in the Journal of the Royal Aeronautical Society highlighting that “noise in an aircraft was a very great nuisance, was extreme and must be reduced.” In addition to the disturbances it generates, aircraft noise can adversely affect human health with prolonged exposure, as evidenced by several studies (2, 3).

Consequently, noise is a critical factor in the aviation domain, impacting the entire environment surrounding an aircraft. Passenger and crew comfort, noise pollution, and increasingly stringent rules compel companies and researchers to allocate resources towards noise prediction, measurement, and reduction.

The International Civil Aviation Organisation (ICAO) maintains a comprehensive annex, known as “Annex 16”, which establishes criteria for noise regulation. ICAO itself states that “The primary purpose of noise certification is to ensure that the latest available noise reduction technology is incorporated into aircraft design and that this is demonstrated by procedures that are relevant to day-to-day operations” (4). This trend of reduction of noise emissions can be observed in Figure 1.1.

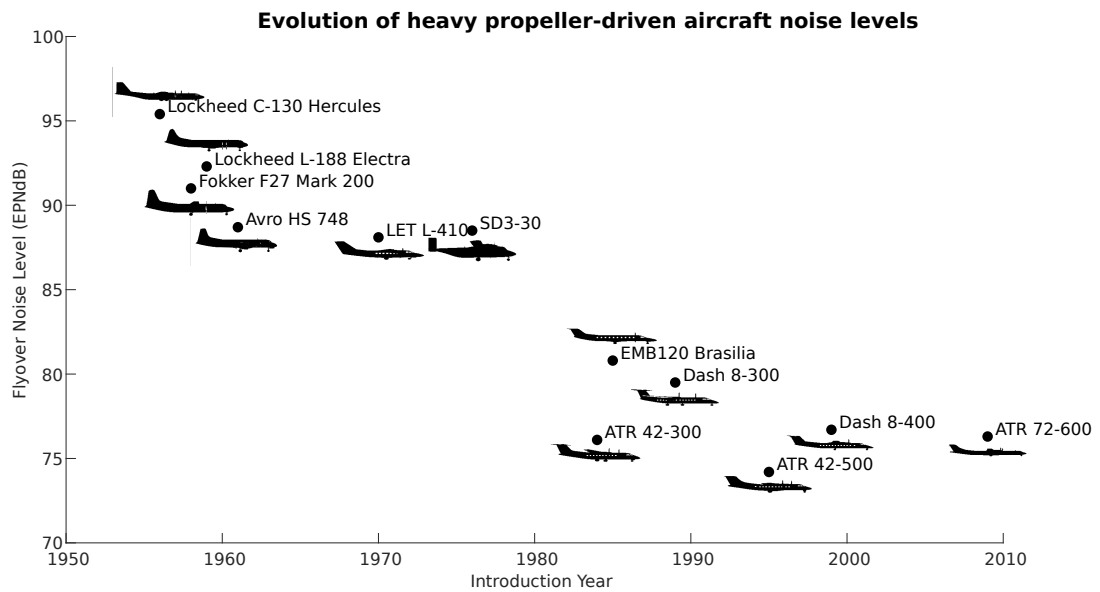


Figure 1.1 – Evolution of heavy propeller-driven aircraft noise levels based on data from EASA (5).

1.2 Noise measurement and prediction

Aircraft noise originates from a multitude of sources. These sources may pertain to the aircraft structure and engine, together with the interactions between these structures and the atmosphere. One of these sources is the propeller.

Propellers were the first means of powering aircraft; they can be described as an unshrouded, rotating set of blades. Although present in many different variations of blade shape and number, as shown in Figure 1.2, operationally all propellers are the same. Each blade acts as an airfoil, creating a pressure difference between its surfaces, inducing airflow, and consequently creating thrust (6).

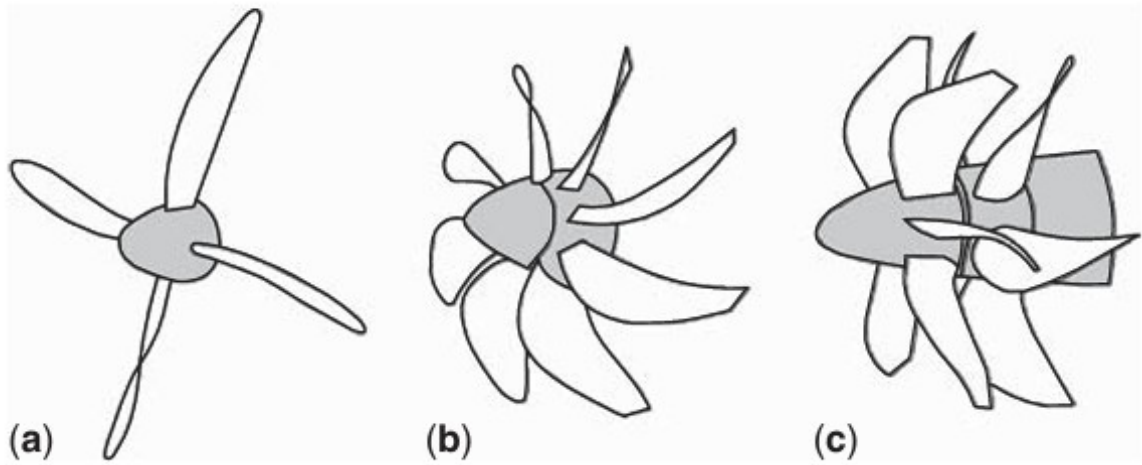


Figure 1.2 – Propeller types: (a) conventional; (b) prop-fan; (c) counter-rotating. Source: Self (6).

During the conceptual phase of any aircraft, it is essential to employ noise prediction methods to facilitate the adjustment of propeller parameters based on accurate estimates, hence achieving the intended noise levels (7).

Methods for predicting propeller noise have garnered significant interest since the early 20th century, with initial efforts dating back to 1919. Nevertheless, the absence of computers and constraints of experimental apparatus hindered advancements in the discipline until the 1950s (8).

From the 1950s to the 1970s, empirical methods were developed using geometric and operational parameters, without the need for complex calculations using computers. Renewed interest in the field of propeller noise prediction from the 1970s onwards led to the development of newer theoretical and empirical methods, as well as refinement of existing methods (8).

There are also a few methods, categorized as semiempirical, that consist of a mixture of theoretical developments and empirical data being used in conjunction to predict noise in propellers. Table 1.1 shows the types of prediction methods discussed above and their characteristics.

Theoretical propeller noise prediction methods are divided into three types: (a) those based on classical approaches, such as the one developed by Gutin (9); (b) those based on Lighthill's acoustic analogy (10); and (c) those that make use of computer fluid dynamics (11). Conversely, empirical methods are based on measurements and observations on propellers, relying on gross parameters to predict noise. Although generally accurate for far-field estimations, these methods are not as reliable for near-field noise prediction (8).

Characteristics	Methods		
	Empirical	Reduced Complex Theoretical	Detailed Theoretical
Calculation Platform	Graphs, hand held calculators or PC	PC or workstation	Workstation, mainframe or super computer
Input Complexity	Simple	Moderate	Complex
Input Source	Standalone	Standalone	External sources
Output Complexity	Limited to specific requirement	Somewhat limited	Capable of satisfying diverse objectives
Application	Preliminary design studies, certification retrofit evaluations, land use planning	Preliminary design studies, certification retrofit evaluations	Research programs, propeller or aircraft design, near field noise prediction for cabin comfort design or research

Table 1.1 – Prediction methods and their characteristics. Adapted from (8).

1.3 Motivation

Propeller-driven aircraft (Figure 1.3) are still relevant for airliners and the military, being an important alternative to jet aircraft. As Rathgeber and Sipes (12) demonstrate, 84 percent of noise emissions by aircraft during flyover at maximum continuous power can be traced back to propellers. Furthermore, recent developments for multirotor drones and Vertical Take Off and Landing (VTOL) aircraft have, as Alves *et al.* (13) point out, “re-introduced the propeller as the best-suited propulsion device for low-speed, low-cost, and accessible small aircraft.”



Figure 1.3 – Embraer 120 Brasilia. Source: (14).

Unmanned aerial vehicles (UAVs), also commonly known as drones (Figure 1.4), originally used in military operations, have, for the past few decades, increasingly been employed for other uses, such as agriculture, surveillance, scientific and recreational purposes. This can be proven with data from the Federal Aviation Administration (FAA) where, as of 2025, over a million drones have been registered, of those 420,825 are commercial drones and 383,007 have been registered for recreational fliers (15). Also, FAA’s Aerospace Forecast for the fiscal years of 2024-2044 (16) affirms that “unmanned aircraft systems (UAS or drones) have been experiencing healthy growth around the world over the past decade.”



Figure 1.4 – Multirotor drone. Source: (17).

Greater interest in UAVs is not restricted to commercial use but also in the scientific community, where Nex *et al.* (18) show that there is a growing trend in the number of scientific papers published on drones in the last two decades.

Furthermore, with data provided by the Brazilian National Civil Aviation Agency (Anac) through the System of Unmanned Aircraft Information (SISANT) (19, 20), it can be assessed that 39 percent of all registered drones in Brazil are for recreational use, as shown in Figure 1.5. Data from both the United States and Brazil indicate that a significant portion of drone usage is in cities, where noise and its perception are recognized as major obstacles to the widespread use of UAVs in urban environments (21).

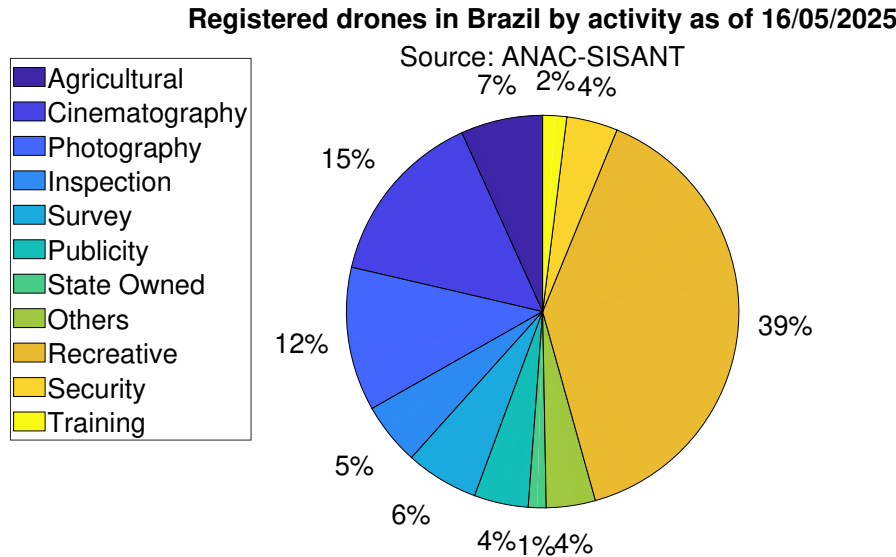


Figure 1.5 – Registered drones in Brazil by activity.

Another developing field of the aeronautical industry is Urban Air Mobility (UAM), which incorporates Electric Vertical Takeoff and Landing (eVTOL) aircraft. UAM is defined by Edwards and Price (22) as a “spectrum of new aviation capabilities serving densely populated areas with a variety of public and commercial services.” Some of the major players in the industry, such as Boeing and Airbus, have been making large investments in eVTOLs (23), and most recently, in 2023, Chinese company EHang’s EH216-S, shown in Figure 1.6, a passenger-carrying unmanned eVTOL, received an airworthiness certificate in China (24).



Figure 1.6 – EH216-S. Source: (24).

However, to successfully implement UAM services within cities, it is necessary to take into account the concerns of passengers and the general population. One of the main obstacles for potential users of eVTOLs as a means of urban transportation is noise, as evidenced by Edwards and Price (22), and Babetto *et al.* (25).

1.4 Objectives

1.4.1 General objective

The general objective of this work is the implementation of a semiempirical propeller noise prediction method and to compare the results obtained with the chosen method to actual data of real propellers.

1.4.2 Specific objectives

Specific objectives of this work are: (i) identification and review of existing propeller noise prediction methods, (ii) implementation of the chosen method, and (iii) validation of the chosen method via comparison with data of real propellers.

1.5 Structure

This dissertation is composed of six chapters, 53 figures and 85 tables. It also contains a glossary, where pertinent definitions are available. The first chapter is an introduction to the subject, where a description of the problem and motivation are expounded.

The second chapter is a literature review of the noise sources of propellers and the main existing empirical and semiempirical noise prediction methods. Additionally, works that explore similar objectives are discussed.

The third chapter examines the propeller noise prediction method employed, details the implementation process, and presents the experimental data utilized for validation. The fourth chapter delineates all the obtained outcomes, which consist of comparisons between experimental data and the results calculated with the implemented procedure.

The fifth chapter presents discussions of what can be drawn from the results that were presented in the previous chapter. Finally, in the sixth chapter, the conclusions and the future studies that can be drawn from the work developed throughout this dissertation are presented.

Literature Review

2.1 Propeller noise sources

A propeller is an open, rotating, bladed device utilized for the propulsion of an aircraft. Numerous propeller varieties exist, characterized by varying airfoil sections, number of blades, and blade shapes; yet, the mechanism of noise generation is typically the same across all.

Marte and Kurtz (26) define aerodynamic noise as “sound which is generated as a direct result of relative motion between a solid body or stream of fluid and the surrounding medium.” Noise in propellers can be divided into two main branches: periodic noise, also known as harmonic or tonal, and broadband noise. These can be divided into more categories, as shown in Figure 2.1. There is also a third minor category that encompasses narrow-band noise.

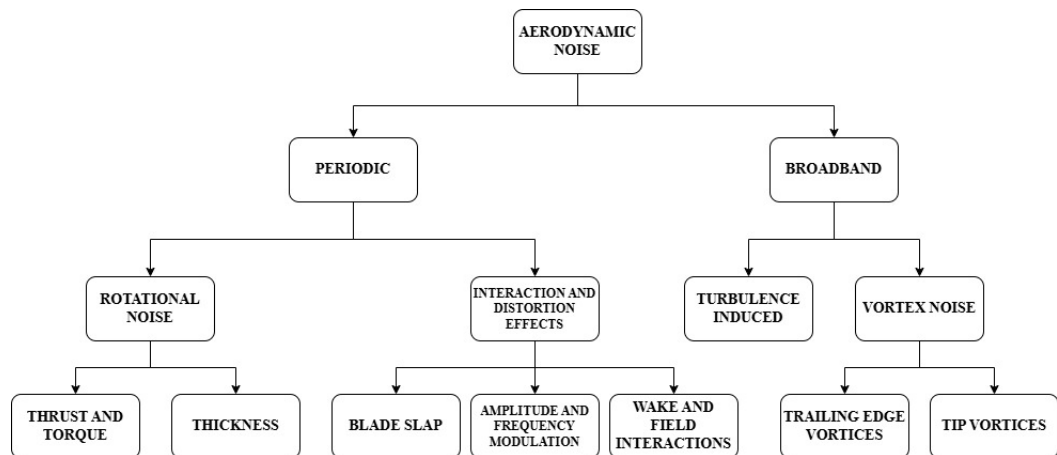


Figure 2.1 – Sources of aerodynamic noises. Adapted from (26).

Generally, the tonal noise components dominate at lower frequencies. As the frequency increases, broadband noise becomes more prevalent. This behaviour can be observed in Figure 2.2, which shows the noise spectrum of a conventional propeller.

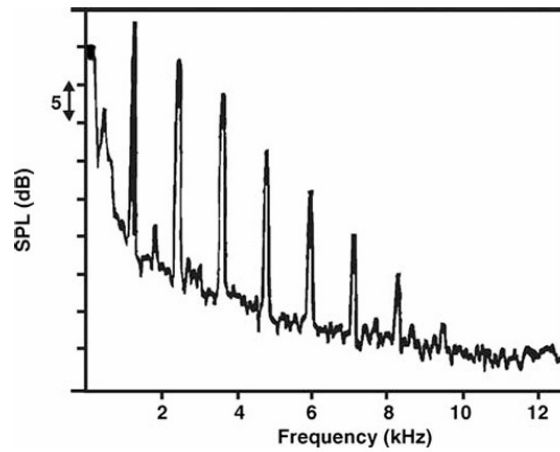


Figure 2.2 – Conventional propeller noise spectrum. Source: Self (6).

Harmonic noise is represented by a pulse that repeats at a constant rate. In the case of an ideal propeller with B number of blades and constant rotational speed N , the noise appears as a signal with fundamental frequency BN , which is called the blade passing frequency (BPF). The BPF is a key factor, not only in propellers but also in any bladed rotating machine, to determine its noise and vibration characteristics. Typically, many harmonics exist, occurring at integer multiples of the fundamental frequency (Figure 2.3).

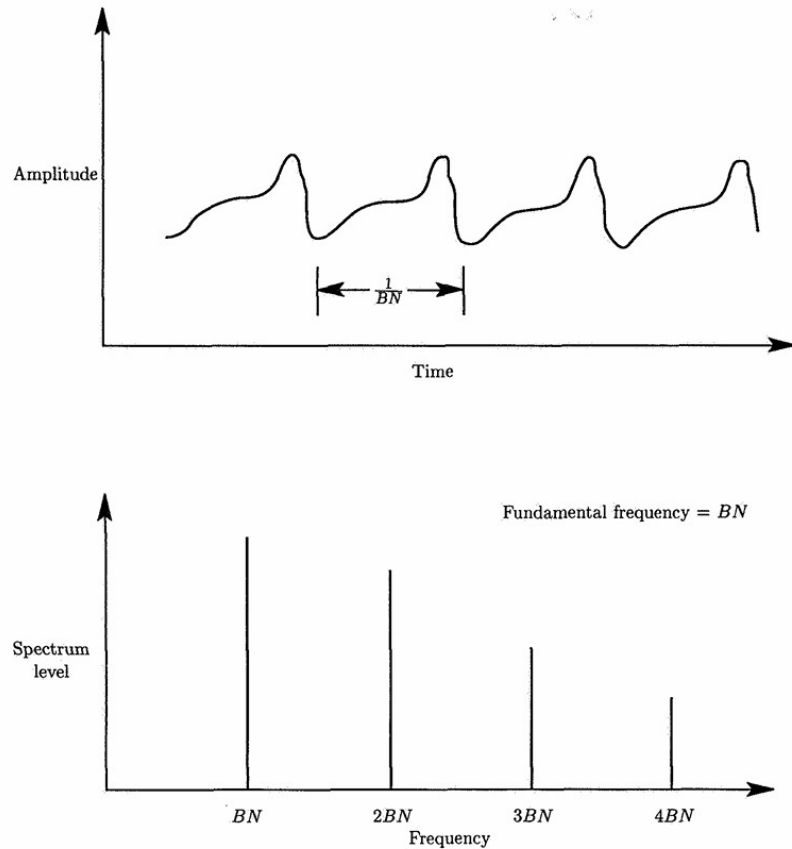


Figure 2.3 – Characteristics of propeller rotational noise. Source: Magliozzi *et al.* (27).

Broadband noise is a random non-periodic signal that contains components in all frequencies. In Figure 2.4, a typical broadband noise signal for propellers is represented. Lastly, narrow-band noise is almost periodic but contains energy that is spread out rather than concentrated in isolated frequencies (Figure 2.5).

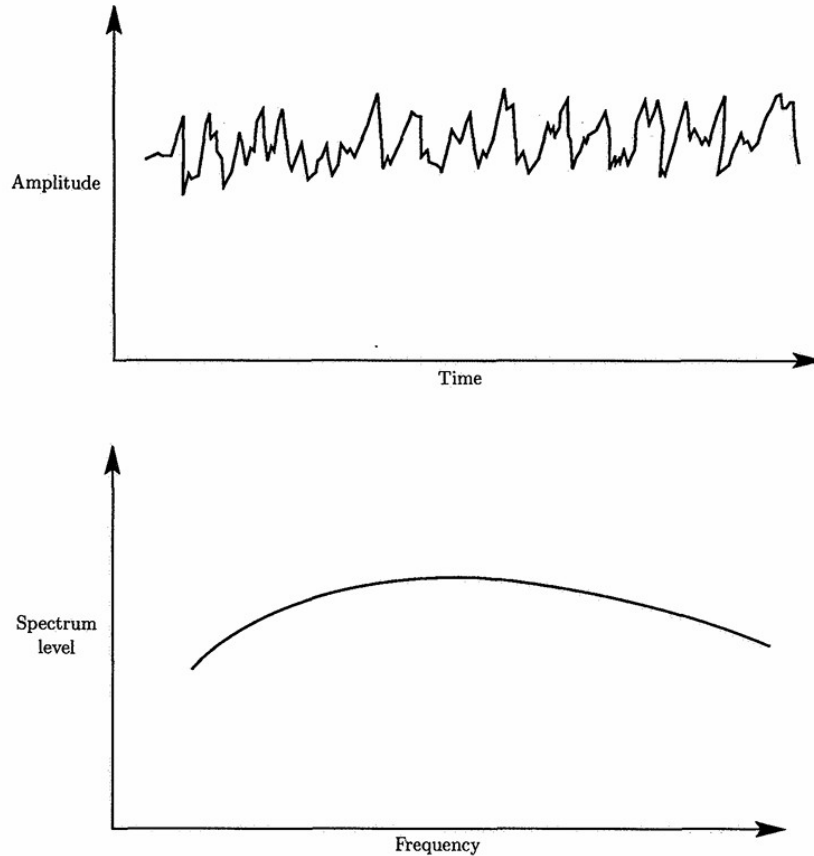


Figure 2.4 – Characteristics of propeller broadband noise. Source: Magliozzi *et al.* (27).

The first type of periodic noise is called rotational, which has two components (Figure 2.1), often classified as steady sources. At higher flight speeds these become dominant, relative to unsteady sources.

The first component is the thrust and torque noise, also known as loading noise. All real rotating airfoils have a pressure distribution in its blades when moving through the medium, usually air. The disturbance of the pressure field when the propeller is moving propagates as noise. Loading noise is more prevalent at low to moderate speeds (27, 26, 6).

The second component is known as thickness noise, which arises because of the finite thickness of the blade that displaces a volume of air in a periodic manner. The amplitude of the noise component is proportional to the blade volume, with frequency characteristics dependent on the blade cross section and rotational speed. It is generally more important at higher tip speeds (27, 26, 6).

The second type of periodic noise is the one generated due to interaction and distortion effects, commonly classified as unsteady sources, and can be divided further into three

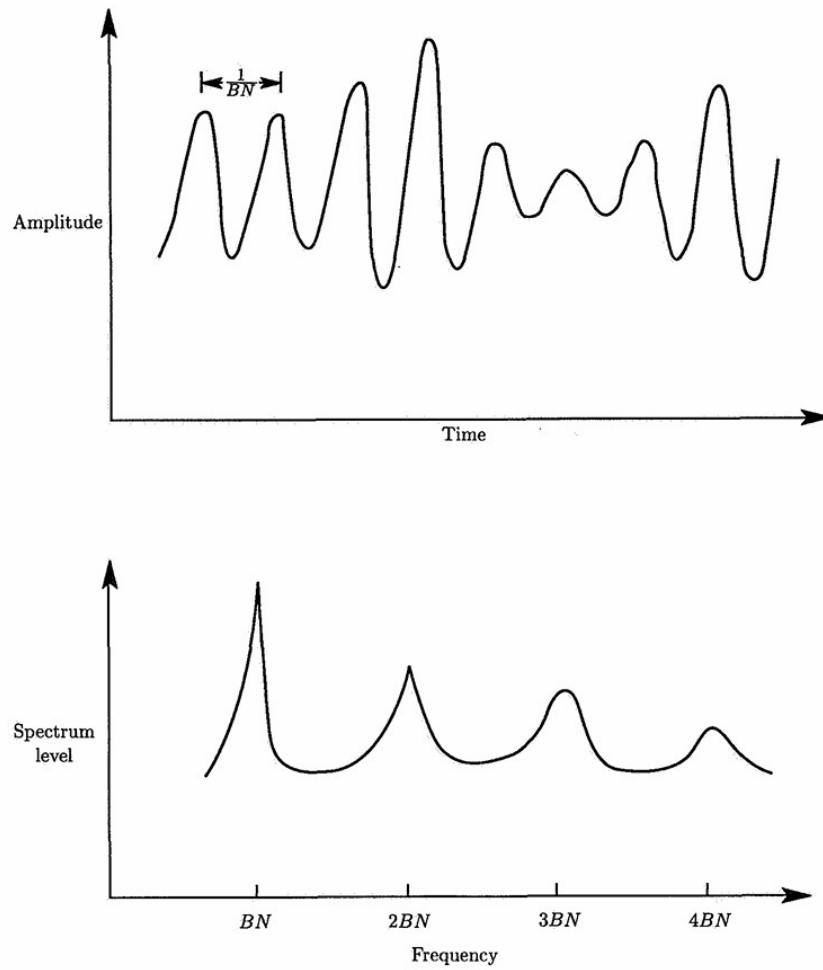


Figure 2.5 – Characteristics of propeller narrow-band random noise. Source: Magliozzi *et al.* (27).

categories (Figure 2.1). These arise mainly from the fact that propellers seldom operate in a completely clean inflow, generating periodic changes of loading on the blades, and are a significant source of noise at low-speed operation (6, 27).

Blade slap is the first type; it is a high-amplitude noise caused by impulsive fluctuating forces on the blades. These forces appear because of blade-vortex interaction, periodic stalling, and unstalling of a blade and shock wave formation (26).

The second type is amplitude and frequency modulation, which results from the periodic advance and retreat of the noise source relative to a stationary target. Finally, the third type is wake and field interactions, where the variation of angle of attack, and consequently, lift of the blades and its interaction when passing through a series of wakes is enough to be another source of periodic noise (26).

Upon analyzing broadband noise, one can identify two primary categories: turbulence induced and vortex noise. The first is produced because of small-scale turbulence in flow fields; although generally weak and inaudible, there can be amplification of noise due to interaction with the pressure field of a moving blade.

The second type of broadband noise is the vortex noise, which can be further divided into two categories. The first one is the noise resulting from trailing edge vortices, which occurs due to the development of a turbulent boundary layer over the trailing edge that results in fluctuating blade loading. A similar mechanism happens at the blade tips.

Another noise source can be identified when there is interaction of inflow turbulence with the blade leading edges. Under high turbulence and low speeds, it can be quite significant.

2.2 Semiempirical and empirical propeller noise prediction methods

Semiempirical and empirical prediction methods for propeller noise have been established since the inception of noise research. All utilize propeller parameters (e.g., diameter and number of blades) and the sound propagation path alongside flight and environmental conditions (e.g., aircraft speed and ambient temperature) to predict noise, either in the far-field and/or the near-field.

Far-field noise prediction is employed to assess ground-level sound during an aircraft's flight, including takeoff and approach phases. Conversely, near-field noise is anticipated when sound levels within an airplane cabin are of concern.

The way in which each method attains its estimated value can be divided into two broad categories: graphical technique and equations. The former relies on graphs, typically derived from actual data, to determine partial sound levels that, when summed up, constitute an overall sound level. The latter can be accomplished by either theoretical equations or linear regression of test data, which are employed to formulate a single equation for noise prediction.

Metzger (8, 11) lists a few of these propeller noise prediction methods, and, in conjunction with some others, Table 2.1 was constructed.

2.3 Related works

As early as 1969, Metzger *et al.* (37) estimated all harmonic levels and overall levels of propeller noise in the far-field and near-field using the Hamilton Standard empirical method and compared them with measured noise in a number of different flight conditions and propeller parameters.

Smith (33), whilst constructing his equation for far-field propeller noise prediction, also compares the results obtained with his method to real test data of multiple Cessna aircraft and to two other procedures: those of SAE (32) and Rathgeber (34).

Author	Year	Type	Far-field	Near-field
Bolt <i>et al.</i> (28)	1952	Graphical Technique	Yes	No
Franken <i>et al.</i> (29)	1958	Graphical Technique	Yes	Yes
Trillo (30)	1966	Graphical Technique	Yes	No
Magliozzi	1971	Graphical Technique	Yes	Yes
ESDU (31)	1976	Graphical Technique	Yes	Yes
SAE (32)	1977	Graphical Technique	Yes	Yes
Smith (33)	1981	Equation	Yes	No
Rathgeber (34)	1981	Equation	Yes	No
Galloway	1982	Equation	Yes	No
Dobrzynski (35)	1994	Equation	Yes	No
Samokhin (36)	2012	Equation	Yes	Yes

Table 2.1 – Semiempirical and empirical methods.

Wilford and Bonneau (38) report flyover noise measurements of two different turbo-prop aircraft, one being single engine while the other is a twin engine, under a variety of different propeller RPM, SHP, and aircraft speed. The collected data was compared to three propeller noise prediction methods: SAE’s (32), Smith’s (33) and Rathgeber’s (34).

J. F. Wilby and E. G. Wilby (39) made exterior and interior in-flight acoustic measurements of a twin-engined turboprop airplane under controlled conditions and compared the overall sound pressure levels acquired with predicted propeller noise levels using two methods: SAE’s (32) and one described in (40).

More recently, in 2020, Chenying *et al.* (41) calculated the overall sound pressure levels utilizing methods for far-field and near-field noise prediction from SAE (32), ESDU (31) and the method presented in (26). Following the implementation, the results are compared to turboprop aircraft noise test data.

Methods

3.1 On the selection of the SAE propeller noise prediction method

For this work, the method chosen for implementation was the one developed by SAE (32). Firstly, as Metzger (8) states, the SAE 1977 method has “received fairly wide use in industry for preliminary design studies and has been used by certification authorities to evaluate acoustic changes relating to retrofit of new propellers on existing planes.” Also, this procedure can be seen as the culmination of all previous works made in empirical prediction methods that use graphical techniques to calculate the sound levels.

Moreover, when compared to equation-based empirical prediction methods, such as those proposed by Smith (33) and Rathgeber (34), as well as older graphical techniques, it yields superior results when evaluated against real data (38, 41). Also, as noted by Riboldi *et al.* (42), Smith’s method requires propeller data that are not commonly available in the preliminary design stage.

Implementation complexity is another aspect that was considered. By nature, empirical and semiempirical methods are mostly regarded as straightforward and rapid solutions for preliminary calculations of noise levels. Thus, Samokhin’s method (36) was discarded, as well as Dobrzynski’s method (35), which, albeit of much easier implementation, lacked information regarding some of the constants necessary for constructing the estimation equation.

3.1.1 SAE method description

The SAE method is of the graphical technique type and presents a variety of graphs to calculate partial sound levels that take into account the geometry and operation of the propeller, environmental conditions, and aircraft parameters. The prediction curves were developed using the available propeller noise test data, which encompasses both in-flight

and static operation measurements. It establishes two procedures, one for far-field noise prediction and another for near-field noise prediction.

For both methods, the input parameters for propeller noise prediction are:

- Propeller diameter
- Number of blades per propeller
- RPM or tip speed
- Power input per propeller
- Location, relative to the propeller, of the point at which the noise is to be defined
- Flight speed
- Ambient temperature
- Number of propellers

The near-field method is employed to assess noise levels at the fuselage surface adjacent to the propeller, with a tip clearance not exceeding the propeller's diameter (Figure 3.2). If these conditions are not met, the far-field method should be utilized (Figure 3.1).

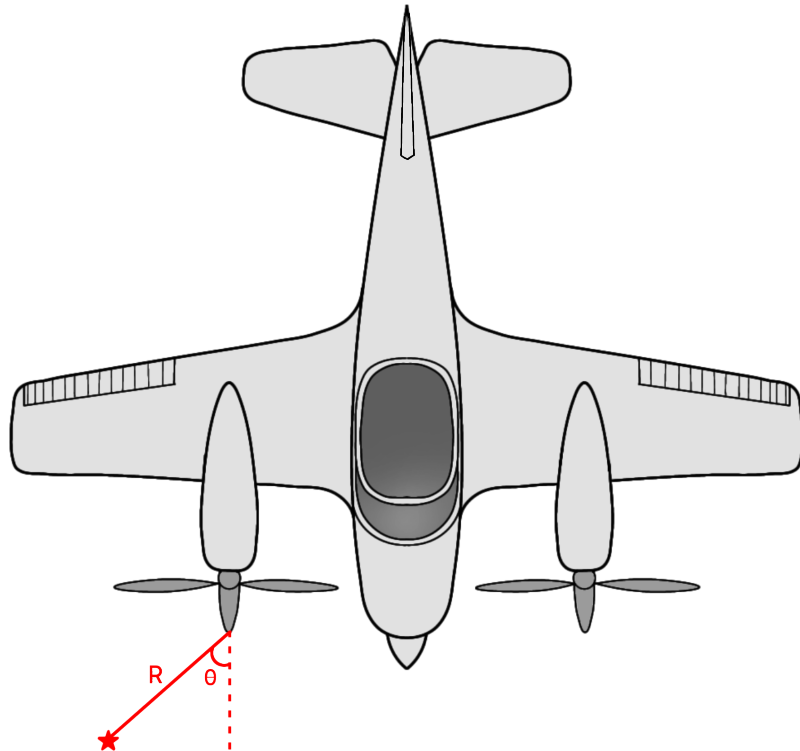


Figure 3.1 – Far-field method condition for utilization. The red star indicates the location in which noise is to be estimated. Credits: Isabela Lie Mano Andrade.

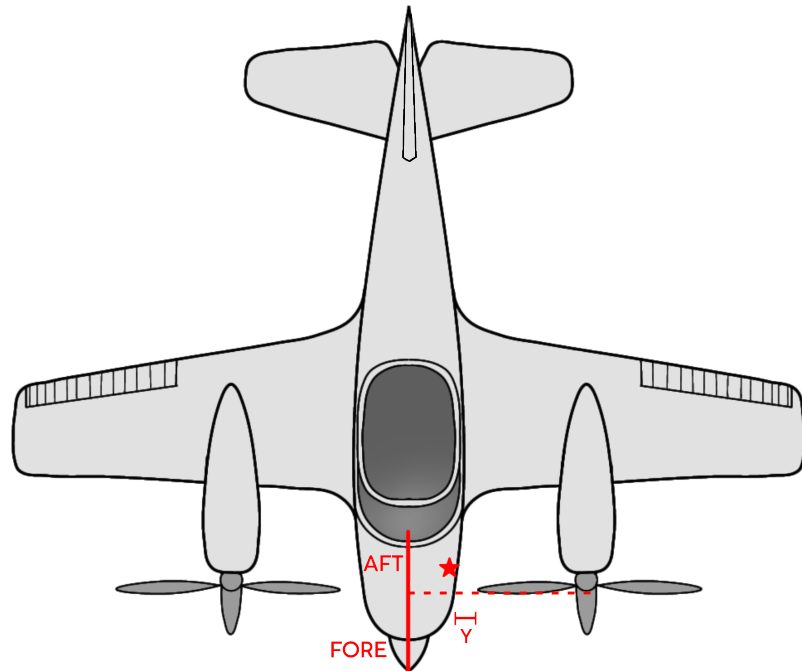


Figure 3.2 – Near-field method condition for utilization. The red star indicates the location in which noise is to be estimated. Credits: Isabela Lie Mano Andrade.

The far-field method allows the calculation of the overall sound pressure level (OASPL) and the perceived noise level (PNL). It also gives simple sums and subtractions to achieve the A-weighted noise level and the effective perceived noise level (EPNL) for takeoff and approach. The procedure takes into account corrections based on directivity, atmospheric absorption, and spherical spreading.

Conversely, using the near-field method, it is possible to calculate the OASPL and the harmonic distribution of the estimated noise. The procedure takes into account the effect of a reflecting surface in the sound field.

3.1.2 SAE method implementation

Firstly, to extract data points from the provided graphs, a function constructed for MATLAB called GRABIT (43) was utilized. GRABIT opens a graphical user interface program that allows image loading, after which data points can be extracted by axis calibration (Figure 3.3). Upon capture, GRABIT provides the user with the x- and y-coordinates of the points, relative to the location of the axis origin.

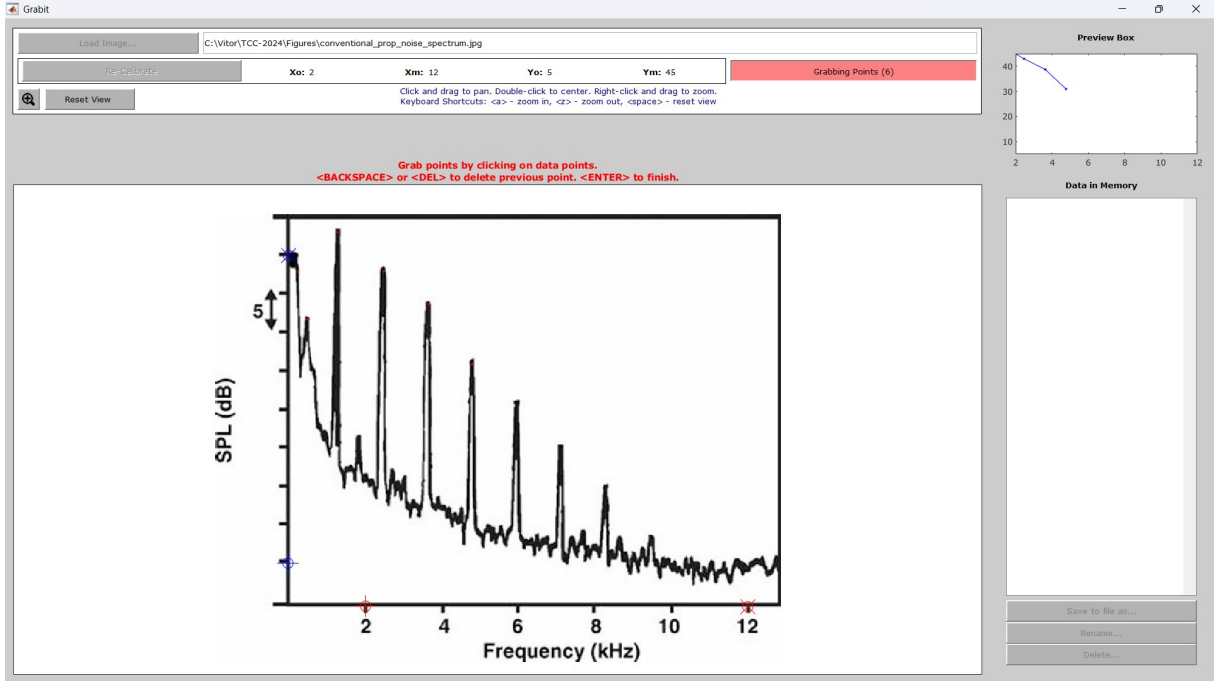


Figure 3.3 – Using GRABIT to extract data points from images.

With the extracted data points, the equations were constructed via polynomial curve fitting, using the MATLAB *polyfit* function (44). The calculated coefficients for each equation are presented in Appendix A. The polynomial models obey the following pattern,

$$x^n a_n + x^{n-1} a_{n-1} + \dots + x a_1 + a_0, n \geq 0 \quad (3.1)$$

where:

n : polynomial order;

a_n : polynomial coefficient.

Additionally, the MATLAB *polyval* function (45) was used to evaluate the points of interest for each equation. With these, plots of the curves were constructed, as shown in Appendix B. Besides the estimated value y , *polyval* also returns Δ , which represents the standard error for prediction. Thus, for a 95 percent prediction interval, the evaluated points can be represented by:

$$y \pm 2\Delta \quad (3.2)$$

The visual interpretation of the prediction interval is shown in Figure 3.4 and the mean standard error of prediction for each model is shown in Appendix A.

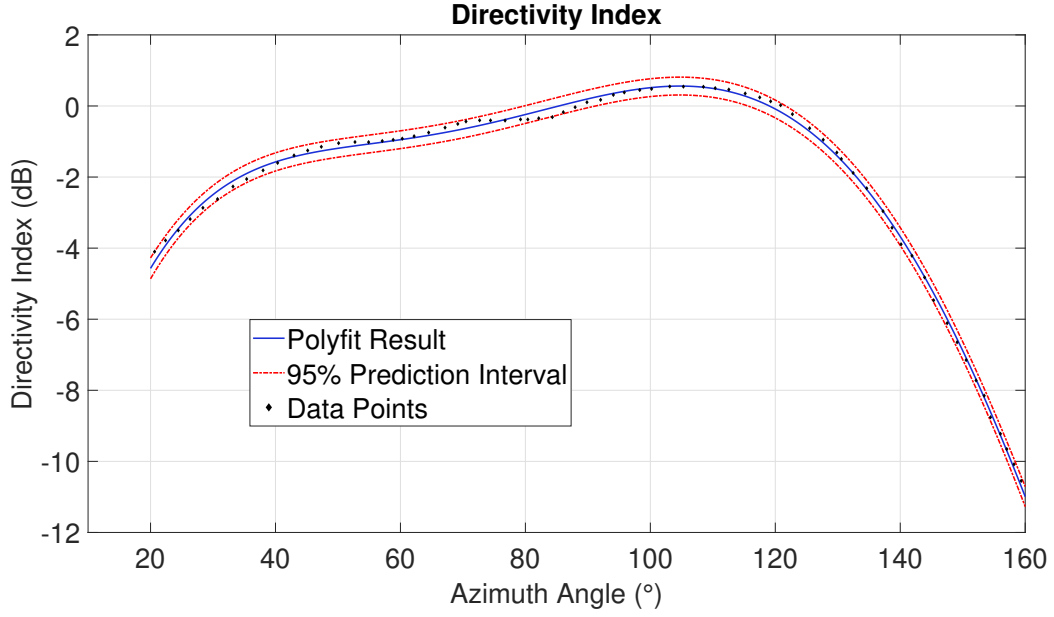


Figure 3.4 – Visual representation of the prediction intervals.

For each constructed model, a function was created to evaluate it at any desired point covered by the methods. These functions can be found in Appendix C. In exact curves, a simple *polyval* was used, whilst for the in-between values a linear interpolation method was utilized, as shown below,

$$y = \frac{y_0 \cdot (x_1 - x) + y_1 \cdot (x - x_0)}{(x_1 - x_0)} \quad (3.3)$$

where:

- y : estimated y-value at point x ;
- (x_0, y_0) : coordinates of the first known point;
- (x_1, y_1) : coordinates of the second known point;
- x : x-coordinate of the point to be estimated.

Lastly, two main functions were created that implement the methods described in (32). Both codes written for these functions can be found in Appendix C, under the names `SAE_FAR_FIELD.m` and `SAE_NEAR_FIELD.m`. The first is the far-field noise prediction method and returns the OASPL, PNL, A-weighted sound level, and EPNL for takeoff and approach (Figure 3.5). The second is the near-field noise prediction method and returns the OASPL and the harmonic distribution for all 10 levels (Figure 3.6).

In Figures 3.5 and 3.6, the following notation is utilized:

- FL1: far-field partial level 1, obtained from Figure B.3

- FL2: far-field partial level 2, obtained from Figure B.4
- FL3: far-field partial level 3, obtained from Figure B.5
- DI: directivity index, obtained from Figure B.6
- NC: correction based on the number of propellers
- NL1: near-field partial level 1, obtained from Figure B.12
- NL2: near-field partial level 2, obtained from Figure B.13
- BC: correction based on the number of blades
- XC: location correction, obtained from Figure B.14
- RC: reflection correction, obtained from Figure B.15

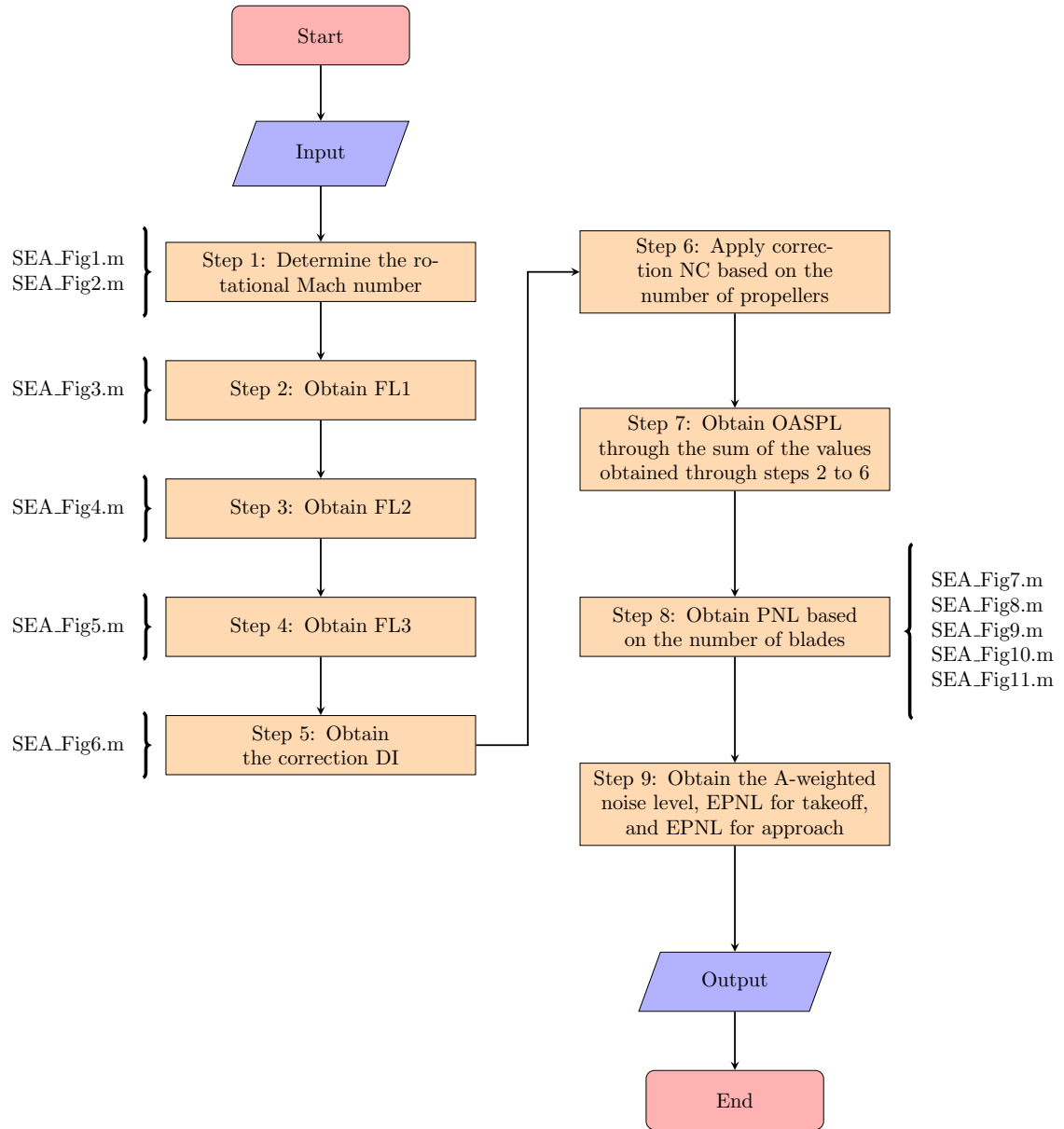


Figure 3.5 – Flowchart depicting the sequence of processes for the far-field noise prediction method.

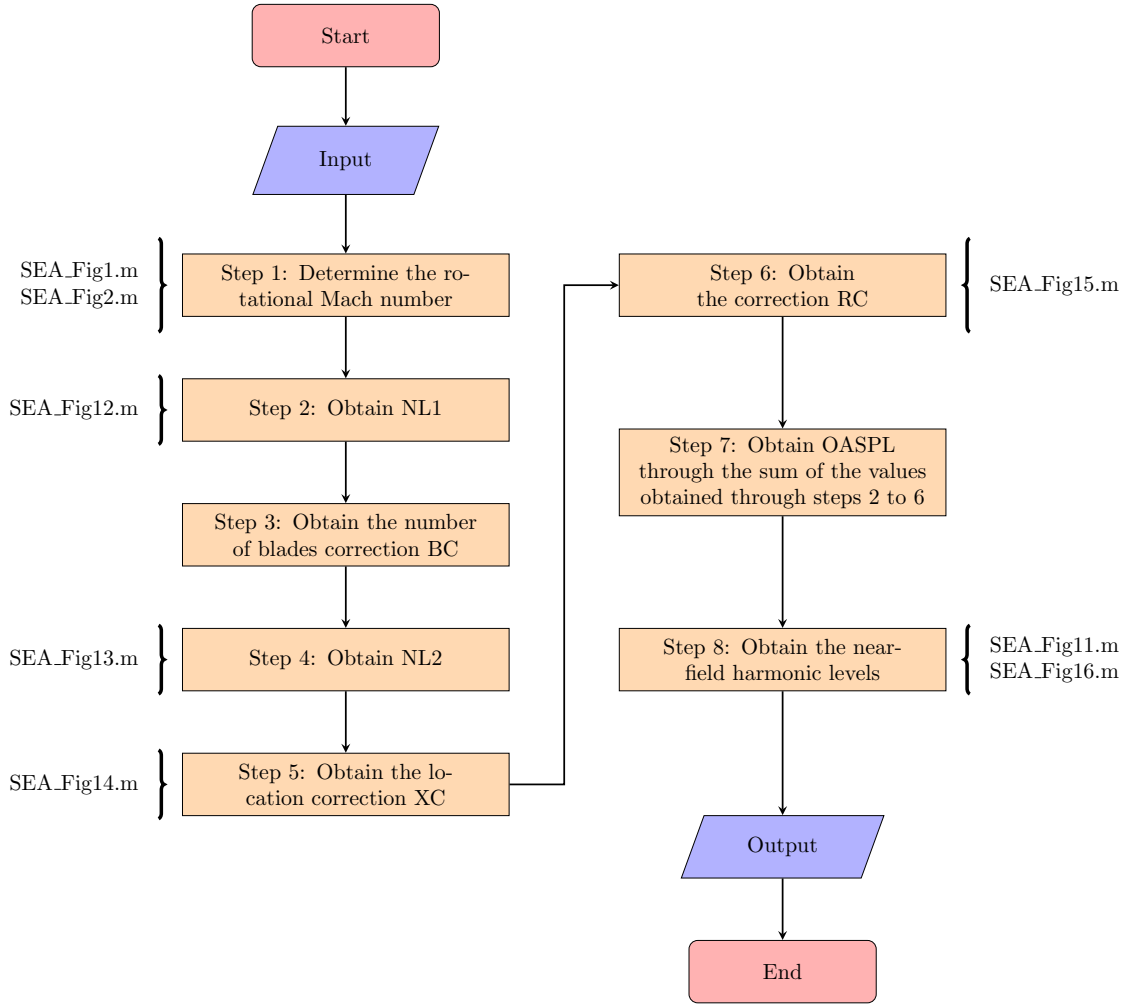


Figure 3.6 – Flowchart depicting the sequence of processes for the near-field noise prediction method.

3.2 Statistical analysis techniques

For this work, the following statistical analysis techniques were employed: mean, standard deviation, box plot, relative error, Pearson correlation coefficient and hypothesis testing.

3.2.1 Mean, standard deviation, and relative error

The arithmetic mean is a measure of central tendency. It is calculated by the following formula,

$$\bar{y} = \frac{\sum_{i=1}^n y_i}{n} \quad (3.4)$$

where:

$\bar{y}$: sample mean;

y_i : measurement;

n : number of samples.

The standard deviation is a measure of data variation. It is calculated by the following equation,

$$s = \sqrt{\frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n - 1}} \quad (3.5)$$

where:

s : standard deviation;

y_i : measurement;

n : number of samples;

$\bar{y}$: sample mean.

The relative error expresses the uncertainty of a measurement when compared to the actual value. It is obtained by the following equation,

$$\delta = \frac{|v_A - v_E|}{v_E} \cdot 100 \quad (3.6)$$

where:

δ : relative error (%);

v_A : observed value;

v_E : expected value.

3.2.2 Box plot

A box plot is a graphical method to detect outliers. It is constructed using intervals based on the interquartile range, which is another measure of sample variability based on the upper and lower quartiles. Analyzing Figure 3.7 it is easier to understand the elements that are used to construct a box plot and its interpretation.

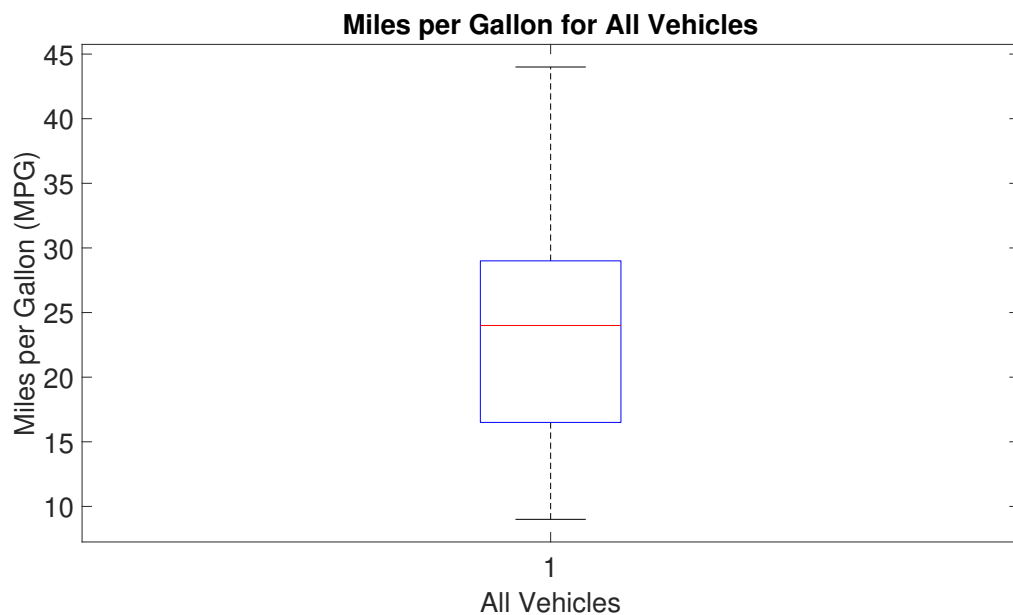


Figure 3.7 – Example of a box plot.

Firstly, the box, in blue, is constructed with its hinges drawn at the lower and upper quartiles. The red line inside the box represents the median of the data. By examining the length of the box it is possible to observe the sample's variability (46).

The upper and lower fences, with whiskers extending from the top and bottom of the box, represent the most extreme values that are not considered outliers. Any outliers are represented by a '+' symbol. By examining the lengths of the whiskers, it can be assessed whether the distribution of data is skewed in one of the directions (46).

3.2.3 Pearson correlation coefficient

Correlation is a measure of monotonic association between two variables; that is, if the value of variable 1 increases, so does the value of variable 2, or if the value of variable 1 decreases, so does the value of variable 2 (47).

One of the commonly used variables to measure linear association is the Pearson correlation coefficient which is a dimensionless measure of the covariance, that has values between -1 and 1. A perfect correlation has a value of -1 or 1 and it represents that all data points fall on a straight line.

To interpret a correlation coefficient based on the observed magnitude several approaches have been suggested. Table 3.1 shows one example.

Observed correlation coefficient	Interpretation
0.00-0.10	Negligible correlation
0.10-0.39	Weak correlation
0.40-0.69	Moderate correlation
0.70-0.89	Strong correlation
0.90-1.00	Very strong correlation

Table 3.1 – Conventional approach to interpreting the absolute magnitude of a correlation coefficient. Adapted from (47).

In this work, the Pearson correlation coefficient was calculated utilizing the MATLAB implementation of it, the *corrcoef* function (48). This function implements the following equation,

$$\rho_{AB} = \frac{\text{cov}(A, B)}{\sigma_A \sigma_B} \quad (3.7)$$

where:

ρ_{AB} : Pearson correlation coefficient;

$\text{cov}(A, B)$: covariance of A and B;

σ_A : standard deviation of A;

σ_B : standard deviation of B.

3.2.4 Test of hypotheses

Two hypotheses are constructed about one or more population parameters, one called the null hypothesis (H_0) and the alternative hypothesis (H_a). Through a chosen method, a test statistic can be computed from the sample data, which in turn is used as evidence to reject or not reject the null hypothesis (46).

In this work, the absolute mean error (μ) is the parameter to be analysed with the following hypotheses:

$$\begin{aligned} H_0 : \mu &> 3 \text{ dB} \\ H_a : \mu &\leq 3 \text{ dB} \end{aligned} \quad (3.8)$$

Another important value related to a hypothesis test is the observed significance level, commonly known as p -value. The p -value is used to reject the null hypothesis if it is less than a fixed significance level.

Lilliefors test

Lilliefors test is a normality test used to test the null hypothesis that data comes from a normally distributed population. In this work, the MATLAB implementation of the Lilliefors test, the function *lillietest* (49), is used.

The function returns the p -value for the normality test and if it is smaller than 0.05, the null hypothesis is rejected (i.e., it can be assumed that the data follows a normal distribution). Otherwise the null hypothesis cannot be rejected, thus the data is assumed to not follow a normal distribution.

t -test

t -test is a statistical method used to determine whether there is a significant difference between the means of two groups. This method has the assumption of data normality. In this work, the MATLAB implementation of the one-sample t -test, the function *ttest* (50), is used.

The function returns the p -value, which if smaller than 0.05, the null hypothesis is rejected, otherwise the null hypothesis cannot be rejected. It also returns the confidence interval, the test statistic, the degrees of freedom and the standard deviation.

Wilcoxon signed rank test

The Wilcoxon signed rank test is a non-parametric test (i.e., normality is not assumed) used to determine if there is a significant difference between the medians of two groups. In this work, the MATLAB implementation of the Wilcoxon signed rank test, the function *signrank* (51), is used.

The function returns the p -value, which if smaller than 0.05, the null hypothesis is rejected, otherwise the null hypothesis cannot be rejected. It also returns the test statistic and the z -statistic.

3.3 Experimental datasets

3.3.1 SAE sample calculations

In (32), SAE provides two examples for the application of far-field and near-field noise prediction methods. The given input parameters are present in Table 3.2 and Table 3.3.

Parameter	Value
Diameter	13.5 ft
Number of Blades	4
Power	3260 SHP
RPM	1020
Distance	584 ft
Azimuth	105°
Aircraft Speed	180 kts
Temperature	86 °F
Number of Propellers	4

Table 3.2 – SAE - Sample calculation of far-field noise input parameters

Parameter	Value
Diameter	9 ft
Number of Blades	3
Power	300 SHP
RPM	1584
Radial distance	1.25 ft
Fore/aft distance	0
Aircraft Speed	125 kts
Temperature	60 °F

Table 3.3 – SAE - Sample calculation of near-field noise input parameters

3.3.2 Far-field experimental datasets

The employed experimental datasets comes from the technical report authored by Newman *et al.* (52). The data was measured in the Summer and Fall of 1982 at Dulles International Airport, with the objective of obtaining noise data necessary for the proposed revision of noise standards for certification of small propeller-driven aircraft.

There were 18 aircraft chosen for the tests and for each one data was measured in takeoff and flyover at 500 ft. Additionally, the physical and performance attributes of each aircraft are presented in the report. Two noise measurement sites were utilized to measure data and were located on the flight track centerline 3000 ft apart on level ground. However, for the flyover data only 9 of the aircraft's data are presented in the report. Furthermore, meteorological data of the days when the tests occurred are presented. All the data used as input are presented in Annex I.

Since ground temperatures are provided for all aircraft, instead of utilizing the indicated airspeed (IAS) as input, the true airspeed (TAS) for each event was calculated by the following equation,

$$TAS = \frac{IAS}{\sqrt{\frac{\rho}{\rho_0}}} \quad (3.9)$$

where:

TAS : true airspeed;

IAS : indicated airspeed;

ρ : density at flight altitude;

ρ_0 : density at sea level.

In the implementation, the MATLAB function *atmos* (53) was used to estimate the temperatures and the densities at flight altitude. It was favoured over the MATLAB *atmosisa* function due to its capability of taking into account temperature offsets.

Besides presenting the measured data, Newman *et al.* (52) developed corrections for a number of parameters that affect the final A-weighted noise level, such as atmospheric absorption, spherical spreading, and distance-duration effects. Thus, both the measured and corrected A-weighted noise level are presented for all aircrafts at takeoff and flyover at 500 ft.

It is important to note that, for comparison purposes to the implemented method, not all data provided was taken into consideration. For each aircraft, it was given more importance to the events which had different values for the parameters, so that the SAE method could be tested in a variety of configurations.

3.3.3 Near-field experimental datasets

The chosen experimental data comes from the technical report authored by Wilby *et al.* (54). The data was measured in May 1984, using the Gulfstream Aerospace Commander 695A aircraft, a twin-engined turboprop airplane. Additionally, propeller characteristics were also presented, with them being three-bladed, having a diameter of 106 inches, and having a minimum clearance between propeller tip and the fuselage of 14 inches.

Four flight tests were conducted, although in the report, many of the data parameters for Flight 1 and Flight 4 were missing. There were two microphones set up on the exterior of the fuselage and six microphones set up on the inside of the cabin. The sound pressure levels for all harmonic orders and the OASPL in each of the flight conditions are presented in the report and are also partially presented in Annex II.

The flights were conducted using 18 different test conditions (Table 3.4), where altitude, propeller RPM, power and aircraft speed were tweaked to accommodate the test objectives. The exact values for each parameter can be found in Annex II. Three nominal flight altitudes were selected: 10,000 ft, 15,000 ft and 30,000 ft. Wilby *et al.* (54)

also compared the measured data at each altitude with their implementation of the SAE method.

Condition	Remarks	Flight Pressure Altitude (ft)
1	Zero Pressure Diff.	10,000
2	Zero Pressure Diff.	10,000
3	Cabin Pressurized	10,000
4	Cabin Pressurized	10,000
5	Normal Cruise	15,000
6	Normal Cruise	15,000
7	Normal Cruise	15,000
8	Normal Cruise	15,000
9	Engines Diff. RPM	15,000
10	Engines Diff. RPM	15,000
11	Starboard Engine	15,000
12	Port Engine	15,000
13	Normal Cruise	30,000
14	Normal Cruise	30,000
15	Normal Cruise	30,000
16	Normal Cruise	30,000
17	Engines Diff. RPM	30,000
18	Engines Diff. RPM	30,000

Table 3.4 – Flight test conditions. Source: Wilby *et al.* (54).

On the difficulty of finding near-field experimental data

While searching for experimental data to be used for validation, it became apparent that near-field measurements of propeller noise have low availability, especially compared to far-field data. This can happen because of the difficulty of measurement or because the authors and companies do not make the data publicly available.

Another aspect that must be considered is that sometimes only partial data is available. For instance, Šulc *et al.* (55) presents the results only in graphs, which makes it more difficult to compare to the implemented prediction method. The same problem is found in the work developed by Spence *et al.* (56). Another example is from the article authored by Bonneau *et al.* (57), where it lacks the aircraft and propeller parameters.

Results

4.1 Overview of the presentation of the results

In this chapter the results obtained are presented, alongside comparisons, in the form of errors, to the experimental data. The objective of this chapter is to provide evidence to support that the model developed to implement the SAE method and that the procedure itself is sufficient for utilization when predicting noise at the far-field and near-field. In Figure 4.1, the structure of the chapter is shown.

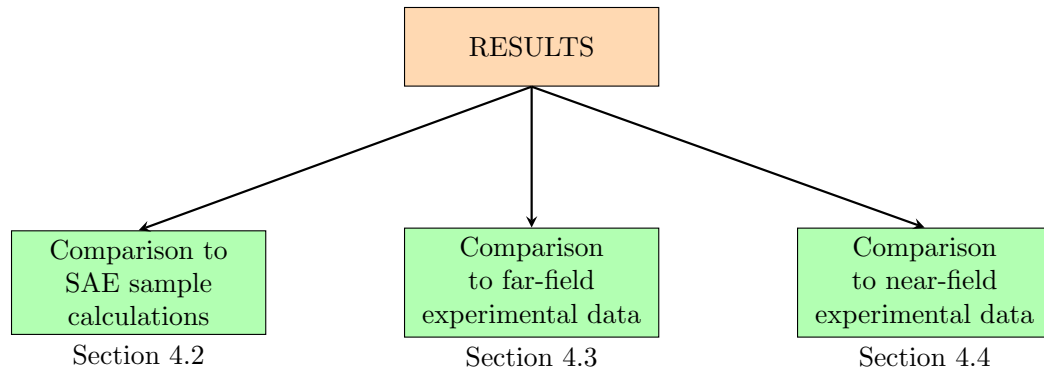


Figure 4.1 – Structure of the chapter.

Furthermore, for each section in this chapter, the structure shown in Figure 4.2 is used. The input parameters are fed to the MATLAB programs (Appendix C) which calculate the results. With the statistical methods introduced in the previous chapter, a comparison between the estimated values and experimental data is made, which are shown in the form of tables and figures.

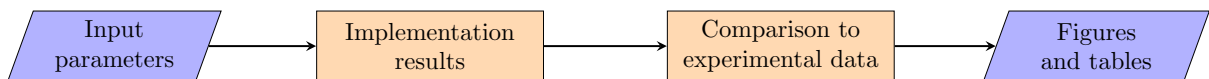


Figure 4.2 – Structure of the sections present in this chapter.

4.2 Comparison to the sample calculations provided by SAE

Using the input parameters presented in Table 3.2 and Table 3.3, the implementation developed in this work was used to compare how well the results match, as can be seen in Table 4.1, where the subscript s relates to the source results (i.e., the results evaluated by SAE in (32)) and the subscript i relates to the implementation results.

Method	$OASPL_s$ (dB)	$OASPL_i$ (dB)	Relative error (%)
Far-field	99.5	99.5761	0.0765
Near-field	136.0	137.3432	0.9874

Table 4.1 – Comparison of the OASPL results acquired between the examples provided and the implementation developed. Subscript s relates to the source results, and the subscript i relates to the implementation results.

Method	PNL_s (dB)	PNL_i (dB)	Relative error (%)
Far-field	100.5	100.5029	0.0028
Near-field	-	-	-

Table 4.2 – Comparison of the PNL results acquired between the examples provided and the implementation developed. Subscript s relates to the source results, and the subscript i relates to the implementation results.

It is apparent from examination of the results that the implementation behaves well, with very low relative errors in all cases, indicating that the polynomial fitting was successful in producing equations closely following the original graphs.

4.3 Validation of far-field method implementation

The input parameters utilized to calculate the results presented in this section come from the data collected by Newman *et al.* (52), which can be found in Annex I. For brevity, only one event and its input parameters are shown in Table 4.3. Each event has different values for each parameter, except for the azimuth angle (i.e., the angle relative to the propeller forward axis where noise is to be estimated), which was considered to be 90° and the geometric properties of the aircraft, such as diameter, number of blades, and number of propellers.

Parameter	Value
Diameter	6.85 ft
Number of Blades	2
Power	79.75 SHP
RPM	2225
Distance	294 ft
Azimuth	90°
Aircraft Speed	92.4006 kts
Temperature	69.7015 °F
Number of Propellers	1
Helical Tip Mach Number	0.6570

Table 4.3 – Example of input parameters for far-field method validation. Data comes from Site 1 of Event 12 of the Cessna 170 aircraft data (Table I.1, Table I.2, Table I.11).

The figures presented in this section relate to the results obtained through the implemented method of propeller noise prediction in the far-field. In each figure there are the A-weighted noise levels for each site, the error between the prediction and the experimental data, and the Pearson correlation coefficient for each set of curves. For instance, the value of the A-weighted noise level calculated for the input parameters from Table 4.3 can be seen in Figure 4.3, with an estimated value of 74.2 dB. The data used to build the figures can be found in Annex I and Appendix D.

Furthermore, a statistical hypothesis test was done with the absolute errors of each site and between the predicted values and the experimental data, both the measured data and the fully corrected data. According to (32), when utilizing the far-field method, a maximum of 3 dB difference is expected between the PNL of the prediction and the actual value. Since the A-weighted noise level is directly correlated to the PNL, the same error of 3 dB is expected. Therefore, in Appendix D, the mean of the absolute error, the standard deviation of the absolute error, and the results of the hypothesis testing are presented, where the indication that, with 95% confidence, the hypothesis that the mean of the absolute error is smaller or equal than 3 dB can be assumed is indicated where the null hypothesis is rejected.

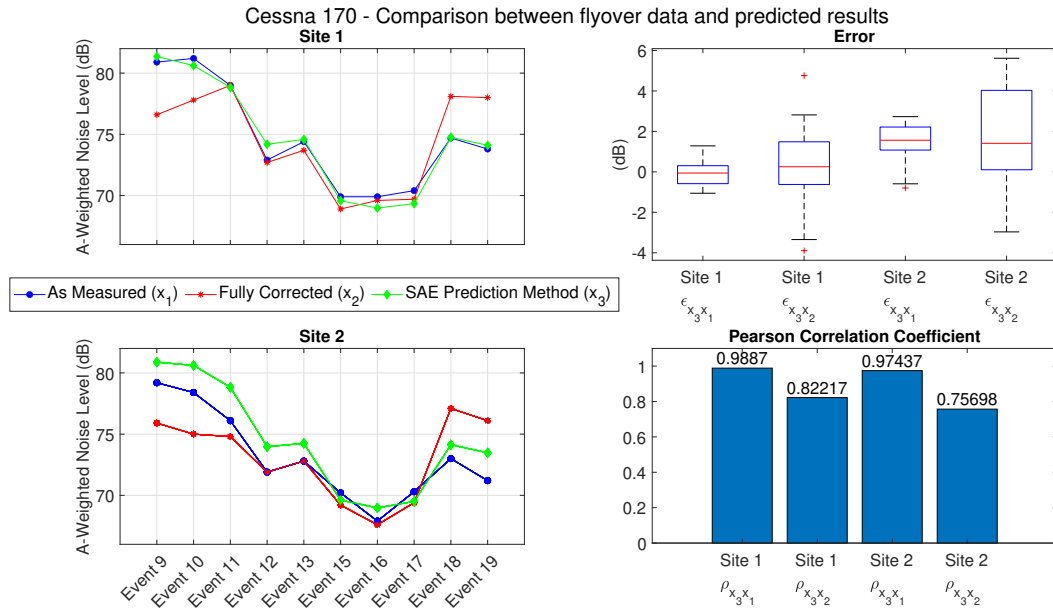


Figure 4.3 – Cessna 170 - Comparison between flyover data and predicted results.

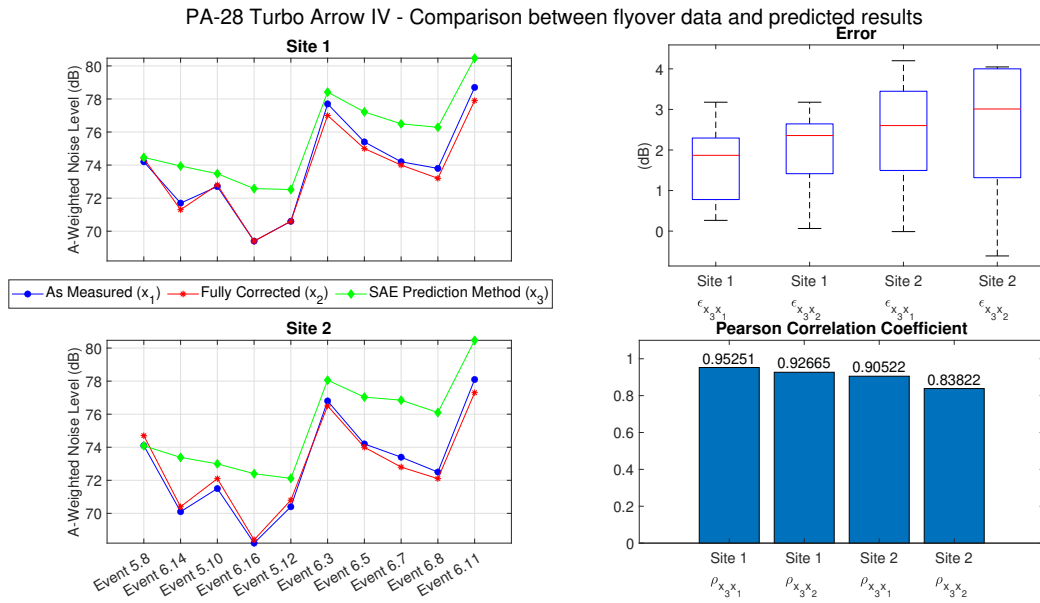


Figure 4.4 – PA-28 Turbo Arrow IV - Comparison between flyover data and predicted results.

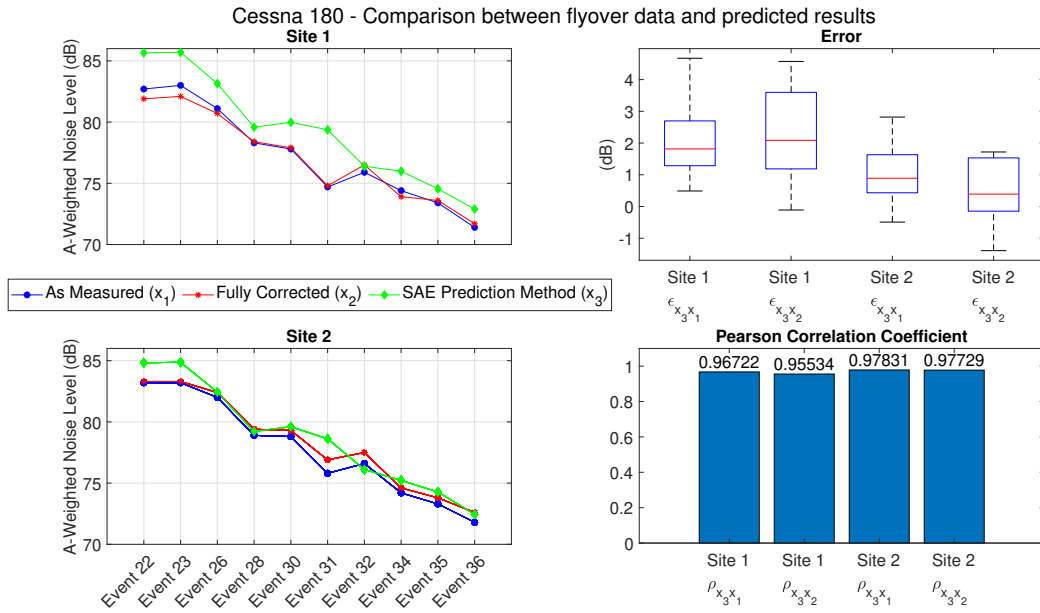


Figure 4.5 – Cessna 180 - Comparison between flyover data and predicted results.

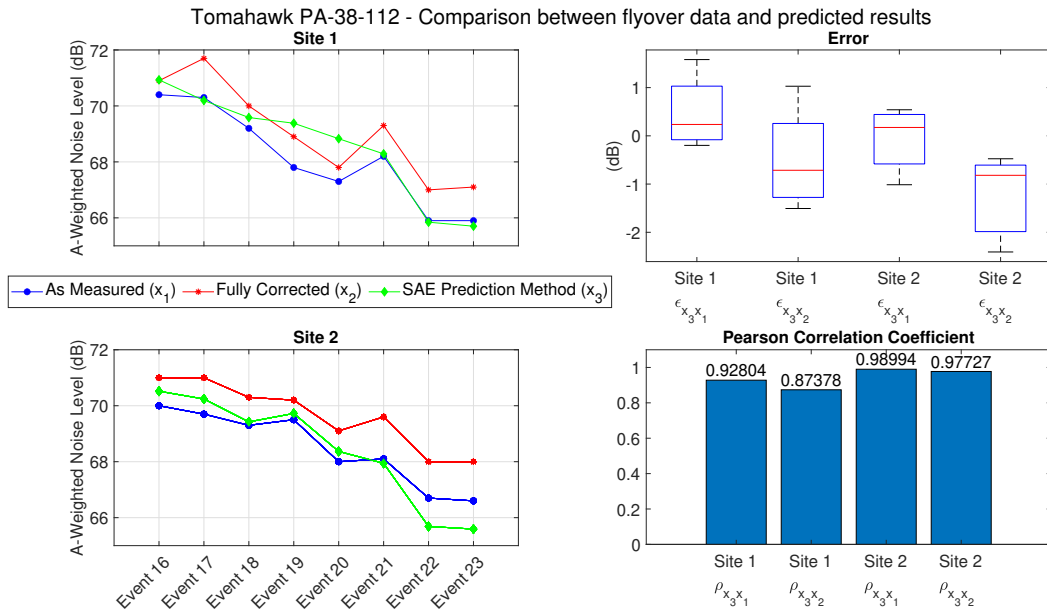


Figure 4.6 – PA-38 Tomahawk - Comparison between flyover data and predicted results.

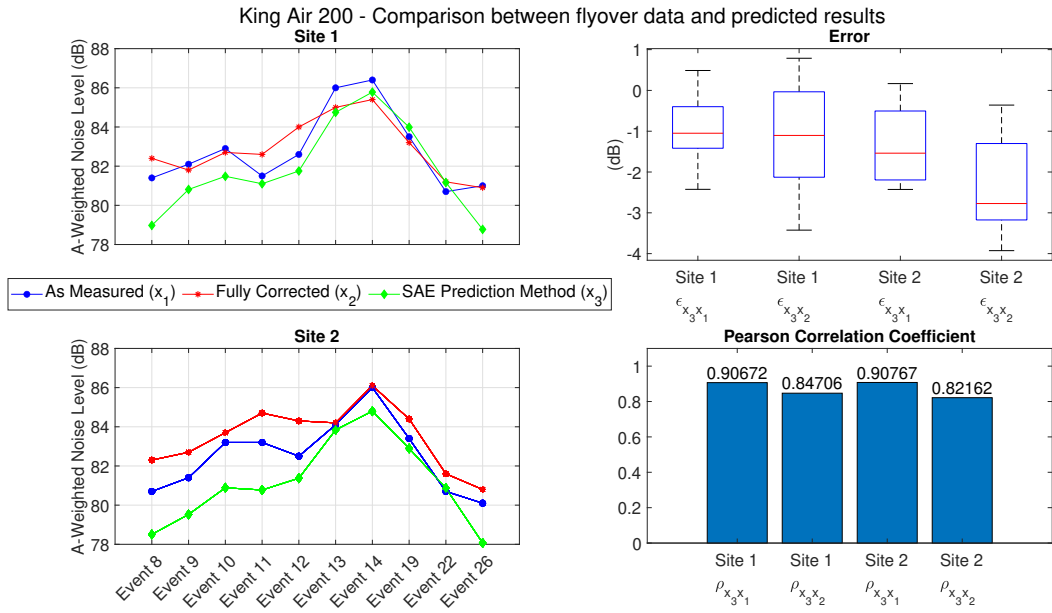


Figure 4.7 – King Air 200 - Comparison between flyover data and predicted results.

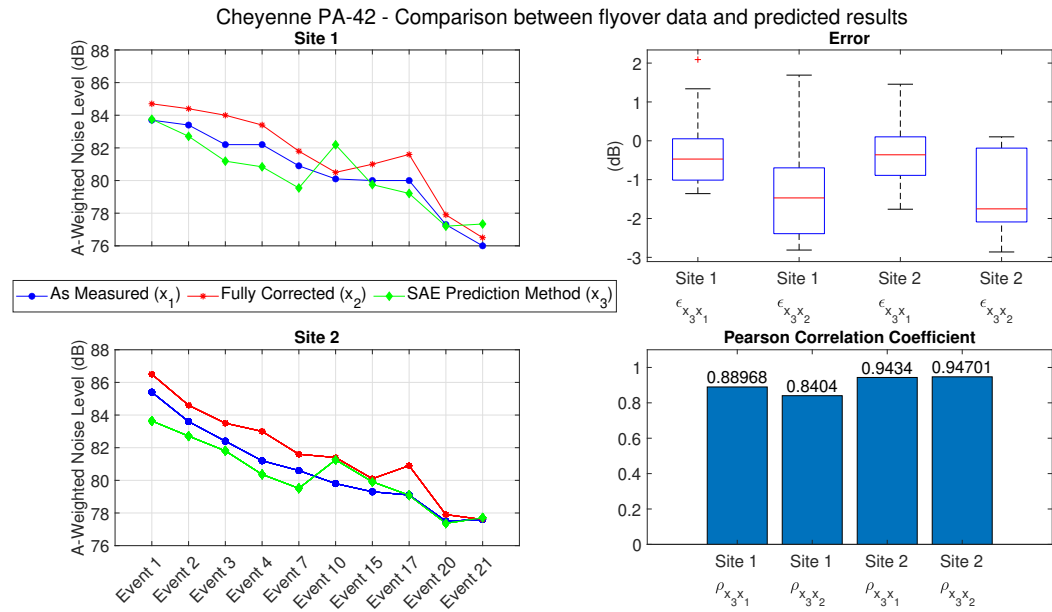


Figure 4.8 – PA-42 Cheyenne - Comparison between flyover data and predicted results.

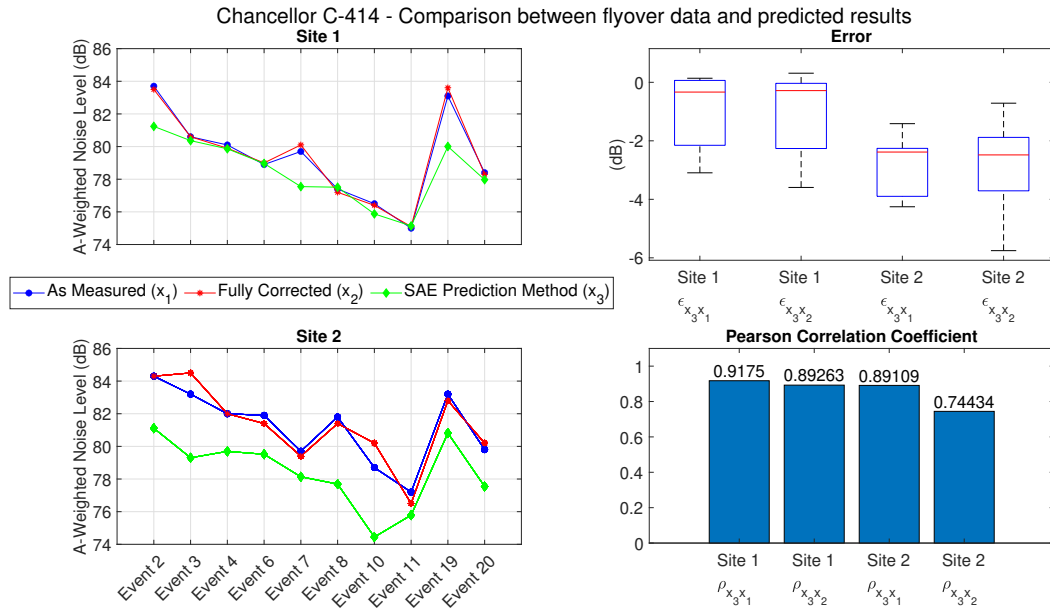


Figure 4.9 – C-414 Chancellor - Comparison between flyover data and predicted results.

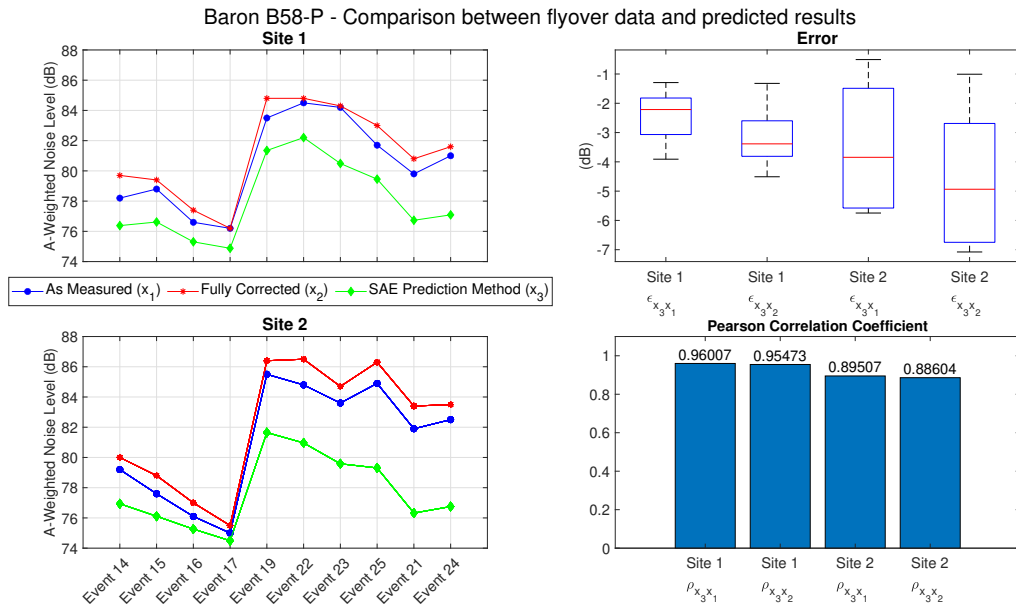


Figure 4.10 – Baron 58P - Comparison between flyover data and predicted results.

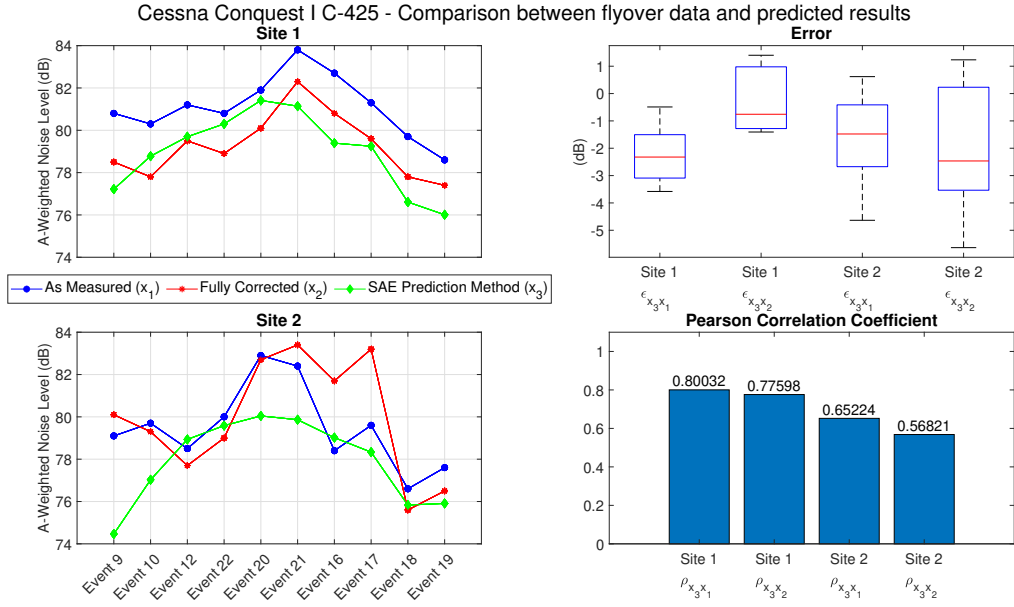


Figure 4.11 – C-425 Conquest I - Comparison between flyover data and predicted results.

4.4 Validation of near-field method implementation

The input parameters utilized to calculate results presented in this section come from the data collected by Wilby *et al.* (54), which can be found in Annex II. For brevity, only one condition from one flight and its input parameters are shown in Table 4.4. Each condition (Table 3.4) has different values for each parameter, except for the geometric properties of the aircraft and the distances, which relate to the location of the exterior microphone.

Parameter	Value
Diameter	8.8259 ft
Number of Blades	3
Power	633 SHP
RPM	1520
Radial distance	1.1812 ft
Fore/aft distance	0.25 ft
Aircraft Speed	236 kts
Temperature	50 °F

Table 4.4 – Example of input parameters for near-field method validation. Data comes from the port side propeller, Condition 1 of Flight 2 (Table II.1).

Firstly, in Table 4.5 the predicted OASPL ($OASPL_p$) is presented alongside the measured OASPL ($OASPL_m$) and the relative error (δ). The $OASPL_p$ values were calculated

through the mean of the predicted OASPL, present in Appendix E, for flights 2 and 3 in each condition for the corresponding altitude and RPM.

Altitude (ft)	RPM	Port			Starboard		
		OASPL _p	OASPL _m	δ (%)	OASPL _p	OASPL _m	δ (%)
10,000	Low	142.3087	138.2000	2.9730	142.7949	133.1000	7.2839
	High	142.8596	138.5000	3.1477	142.5226	132.9000	7.2405
15,000	Low	142.6715	136.2000	4.7515	142.7313	132.7000	7.5594
	High	143.0886	136.3000	4.9807	142.4546	132.5000	7.5129
30,000	Low	140.4959	131.8000	6.5978	140.7161	131.2000	7.2531
	High	140.9510	131.9000	6.8620	140.3274	131.8000	6.4699

Table 4.5 – Comparison of the OASPL results to the measured data.

Furthermore, the sound levels for each harmonic order for each condition for flights 2 and 3 were also calculated utilizing the implemented near-field prediction method. These can be visualized in the figures presented in this section and are also available in Appendix E. For instance, the SPL for each harmonic order calculated using the input parameters present in Table 4.4 can be found in Figure 4.12. It is important to salientize that in condition 11 the port side engine is turned off and in condition 12 the starboard side engine is turned off, therefore the SAE method is unable to estimate the noise level, thus the correlation coefficient is shown as NaN (not a number). Additionally, the error for each of the conditions are also presented.

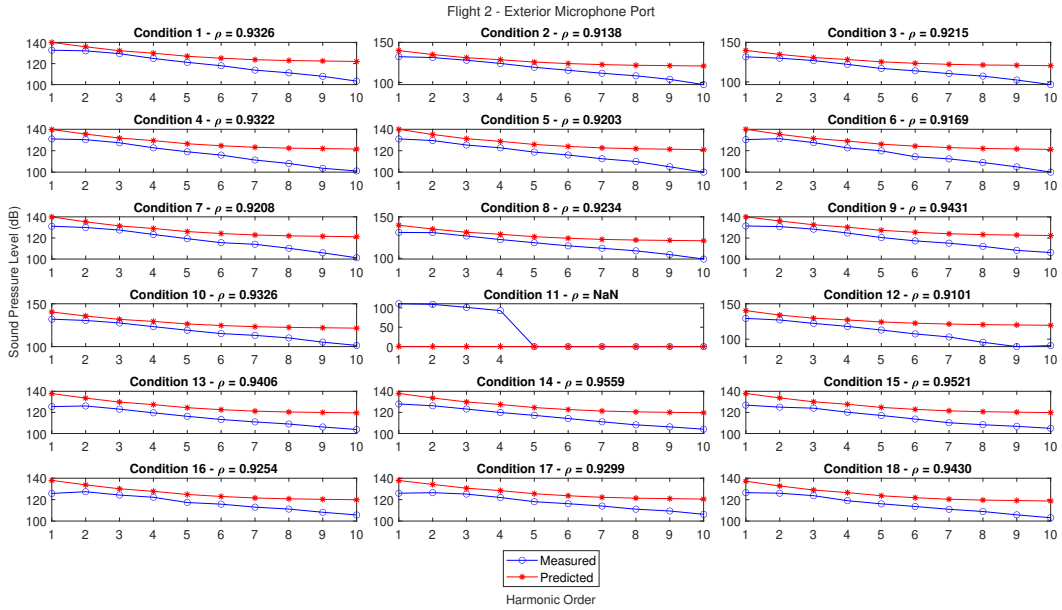


Figure 4.12 – Flight 2 - Port - Comparison between measured and predicted results.

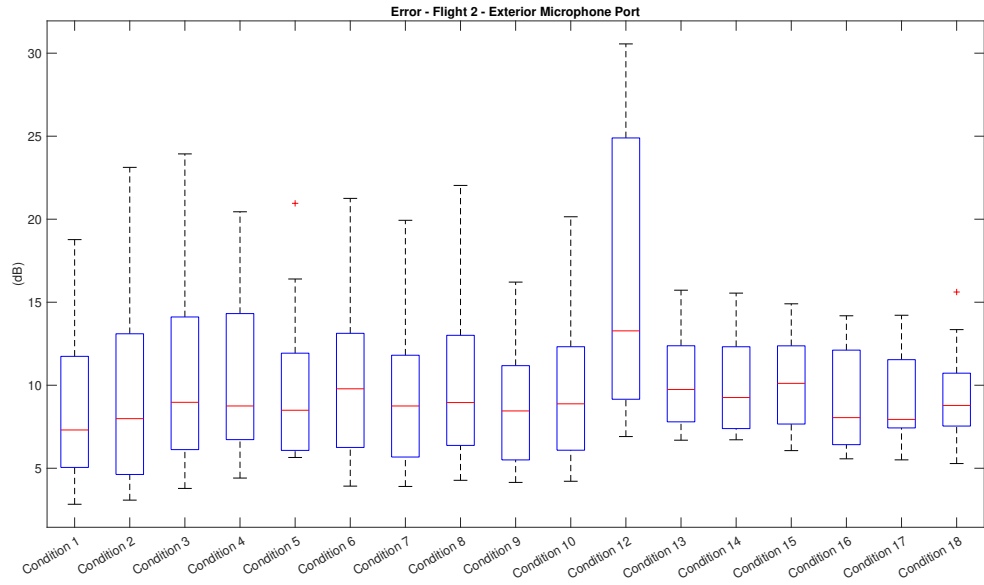


Figure 4.13 – Flight 2 - Port - Error between measured and predicted results.

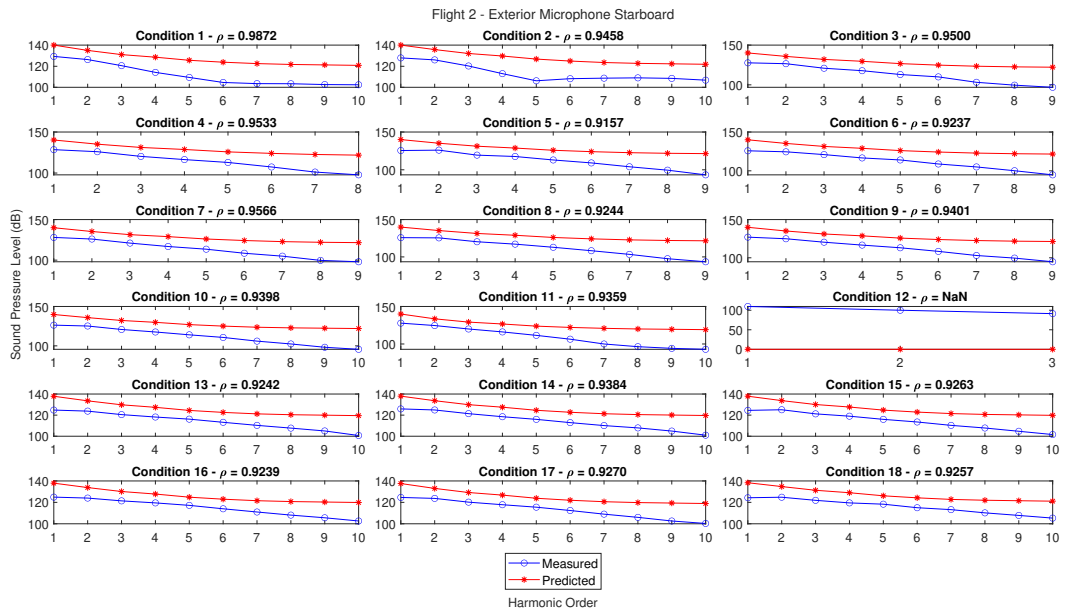


Figure 4.14 – Flight 2 - Starboard - Comparison between measured and predicted results.

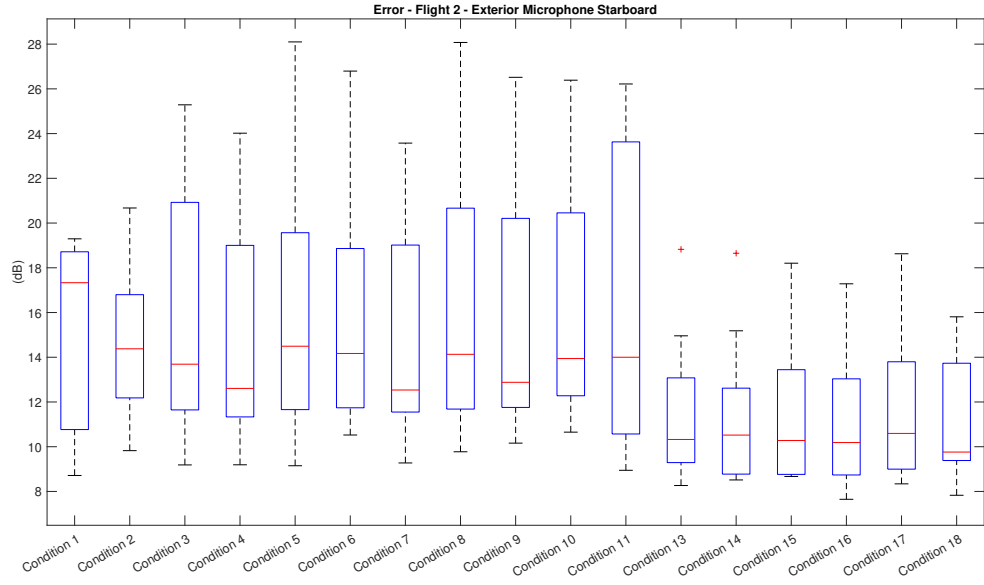


Figure 4.15 – Flight 2 - Starboard - Error between measured and predicted results.

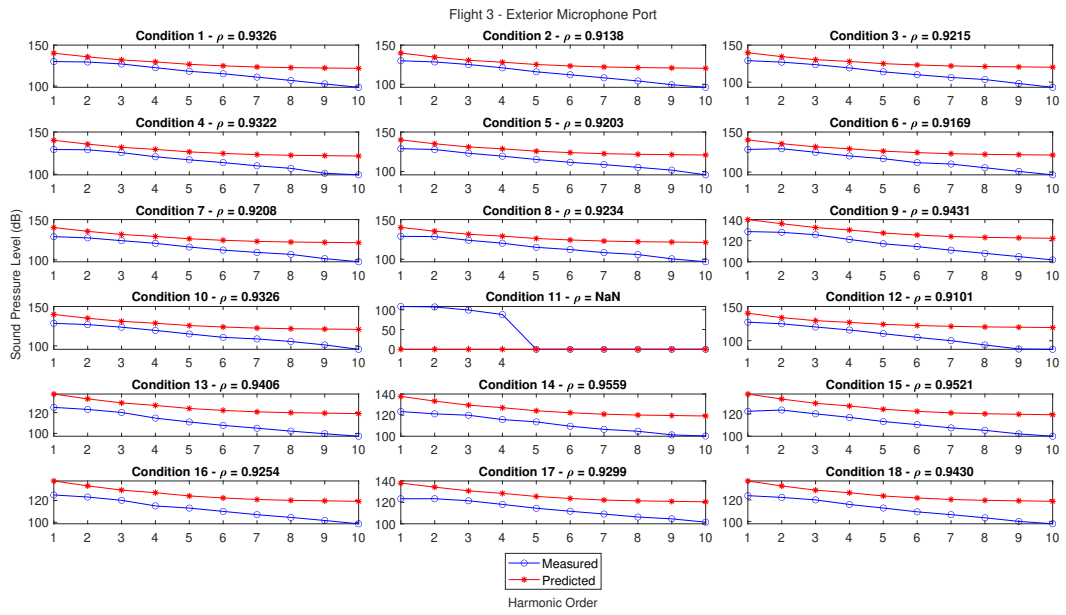


Figure 4.16 – Flight 3 - Port - Comparison between measured and predicted results.

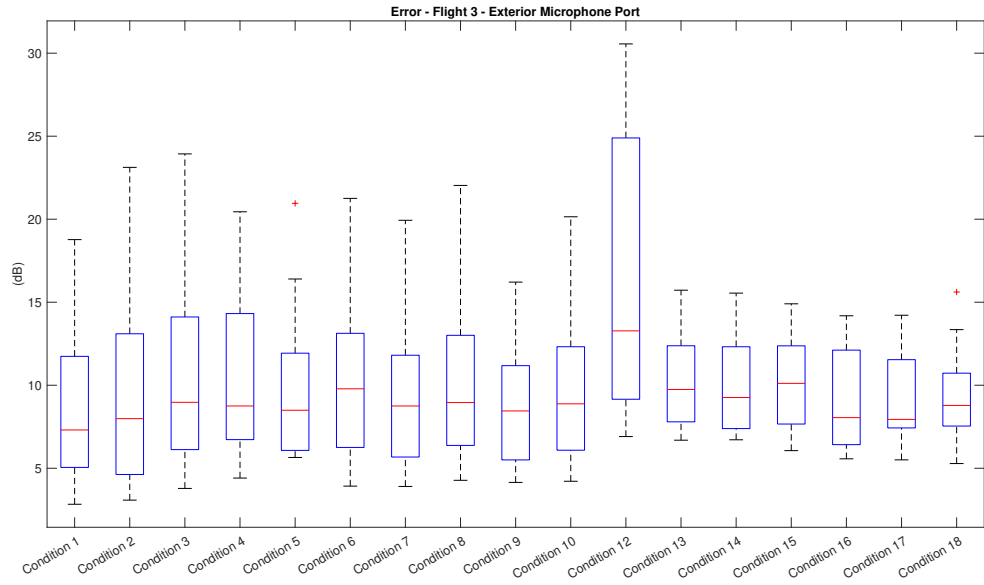


Figure 4.17 – Flight 3 - Port - Error between measured and predicted results.

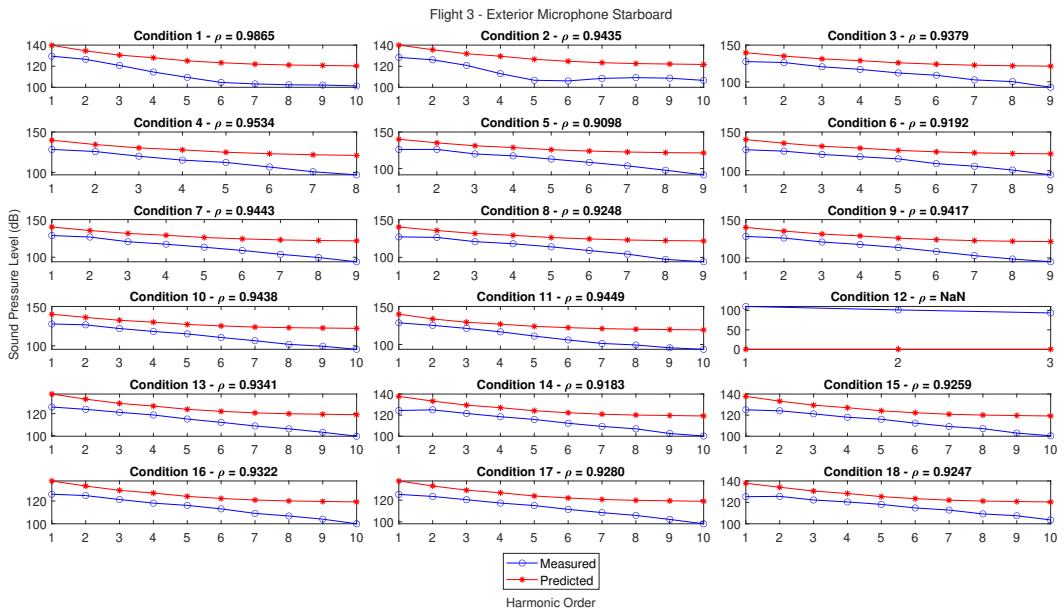


Figure 4.18 – Flight 3 - Starboard - Comparison between measured and predicted results.

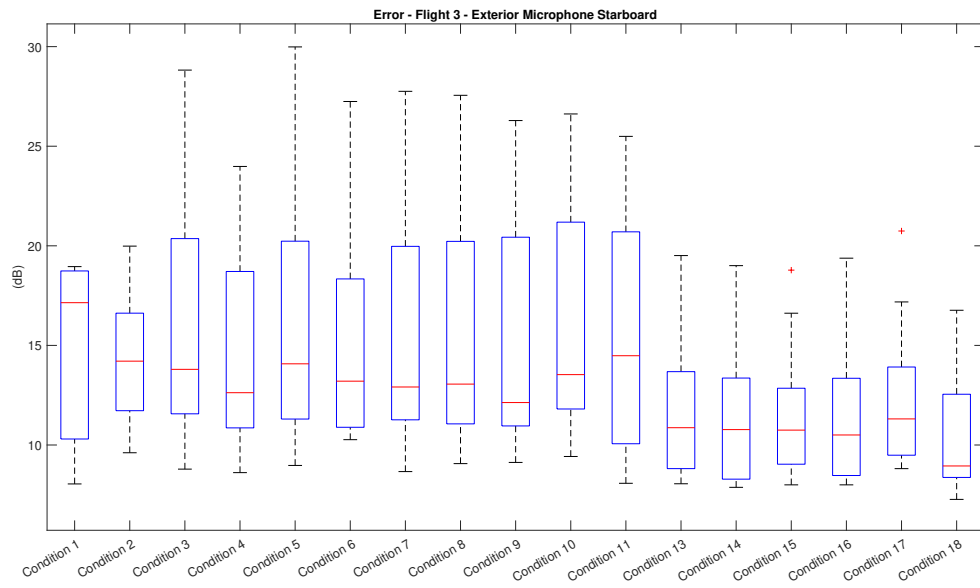


Figure 4.19 – Flight 3 - Starboard - Error between measured and predicted results.

Discussion

5.1 On the comparison to the sample calculations provided by SAE

From examination of the results presented in Table 4.1 it can be inferred that the implementation of the SAE method for propeller noise prediction in the far-field and near-field is very reliable when compared to the sample calculations provided by SAE, due to the low relative error in all cases. This indicates that the polynomial fitting was successful in producing equations closely following the original graphs.

The first source of error that can be observed is the method through which the data points were acquired, which relies on manual calibration of axis and manual data collection that may not be the most accurate way to acquire the data necessary to build the curve. Another source of error is the error associated with curve polynomial fitting, which can be found in the Appendix A.

5.2 On the validation of the far-field method implementation

By analyzing Figures 4.3 to 4.11 and the results presented in Appendix D, it can be seen that, for the most part, the predicted values are within the range of 3 dB of difference to the measured values that SAE considers would occur. Furthermore, most curves have a very strong or strong correlation, with very few instances of moderate correlation, indicating that the predicted results follow the trend of the measured data.

Initially it was thought that the predicted values would be closer to the fully corrected data, but that is not always true, with several instances of larger errors when compared to the errors between the estimated results and the measured data. This happens due to the different methods in which SAE and Newman *et al.* apply corrections, such as to atmospheric absorption and spherical spreading. Another source of error is the effects

that the SAE method does not take into account, such as ground reflection and Doppler frequency shift (27).

This indicates that the SAE far-field method is a reliable tool to predict aircraft propeller noise and can be useful, especially in conceptual projects where few parameters of the aircraft are available.

5.3 On the validation of the near-field method implementation

By analyzing Figures 4.12 to Figure 4.19 and the results presented in Appendix E, it can be seen that there is a very large error between the estimated harmonic levels and the measured data, reaching upward of 20 dB. However, despite the differences in values, for all conditions, there is a very strong correlation between the predicted results and the experimental data. Additionally, from Table 4.5, it is observed that the predicted OASPL has reasonable relative errors.

It is known that propeller noise prediction in the near-field is much more complicated, especially when considering empirical methods. This is because of the many effects that are not taken into account by the SAE method, such as: refraction effects (e.g., propagation through a fuselage boundary layer), fuselage scattering, wing shielding, and nonlinear propagation effects (27). Thus, this could explain why there is such a difference in the evaluated sound levels when compared to the measured data. Another aspect that must be considered is that some of the data that was utilized to build the SAE method comes from static tests, which might influence results for in-flight noise prediction. Although, it can be seen that, in conditions closer to the sample calculation provided by SAE, the results are much better.

In summary, the SAE near-field method should be used with caution. It can give reasonable estimates of the OASPL, especially when the flight speeds and RPM are lower. So, it is still a useful tool in the conceptual project phase, but its lower accuracy is an impediment to use outside of this situation.

5.4 Utilization of the SAE method for eVTOLs and UAVs

In its current state, the SAE method is not recommended for utilization in eVTOLs or UAVs, since it was built as a noise prediction tool for, first and foremost, traditional aircraft. For eVTOLs and UAVs, a reliable prediction procedure would have to take into account several effects, such as the ground effect, which as Hanson *et al.* (58) point out “have a substantial impact on the proliferation of propeller noise to the wider community

as well as the aerodynamic performance of propellers,” ground reflection (59, 60), and geometry of the propeller, such as tip design (61) and serrated trailing edge blades (62). Furthermore, rotor interactional effects can have a significant impact on eVTOL and UAV sound levels (63–65).

Even within the parameters that the SAE method already takes into consideration, some are still lacking for extensive use in eVTOLs and UAVs. For example, Baskaran *et al.* (66) demonstrate that 5-bladed propellers, which cannot be accounted for in the SAE method, are more effective in reducing noise when compared to 2-bladed and 3-bladed propellers. Another aspect is the number of propellers, which in the SAE method is limited to a maximum of 4, that significantly affect noise emission, especially in UAVs and eVTOLs, where there can be up to 10 propellers (67–69). Moreover, the SAE method is unable to predict noise for small-scale propellers (i.e., propeller diameter lower than 300 mm (70)) and for propellers with high RPM.

Although prediction noise for drones and eVTOLs are mainly made utilizing computational methods (71), there are a few empirical and semiempirical prediction models for broadband noise for UAM applications (72, 73).

Conclusion

From the work developed throughout this dissertation, it is possible to draw a myriad of conclusions. Firstly, the SAE method is very reliable for far-field propeller noise prediction and is of easy application, requiring parameters that are commonly available during the conceptual phase of the aircraft. On the other hand, for near-field noise estimation, albeit not as accurate as the far-field procedure, it can still be a useful tool, especially for estimating cabin noise in the early stages of an aircraft project. However, although these methods are great for traditional aircraft, they should not be used for UAVs and eVTOLs due to their limitations in taking into account various effects that are vital to the accuracy of the noise prediction method.

6.1 Future studies

It is very apparent that the development of empirical and semiempirical methods for propeller noise prediction has stagnated, with very few procedures being introduced in the 21st century. This can be explained with the good results that the older methods, such as the SAE method, achieve. Also, with the improvement of computers throughout the years, theoretical and computational estimation procedures are favored since they provide more accurate results. However, this does not diminish the importance of empirical and semiempirical methods, which are much less costly to employ and can supply fairly accurate results with fewer input parameters.

From these observations and the work developed throughout this dissertation, one could further the investigation of semiempirical methods for propeller noise prediction in many ways, such as:

- Improvement of the SAE method
- Acquisition of new noise data, especially in-flight
- Development of a new semiempirical method for drones and EVTOLs

Regarding the first point, the SAE method has some limitations, especially related to its input parameters. For instance, the noise of 5-bladed propeller aircraft cannot be estimated. Thus, it would be desirable to append this capability to the current SAE method.

Additionally, the SAE method was constructed utilizing data from in-flight and static operation. This creates, as shown in the Results chapter, errors, especially in in-flight near-field noise prediction. To reduce these differences, it might be desirable to acquire new noise data for a variety of aircraft with different geometric and performance characteristics. With this new dataset, an updated method for propeller noise prediction, both in the far-field and near-field, could be developed.

Lastly, with the increase of interest in drones and eVTOLs, it would be of great use for a new method to be developed to aid engineers during the conceptual phase of these aircraft. As with the SAE method, in-flight data would have to be collected for both categories, taking into account the several effects that cannot be ignored, such as ground reflection and rotor-rotor interactions.

References

- 1 DAVIS, A. H. Noise. **The Journal of the Royal Aeronautical Society**, Cambridge University Press (CUP), v. 35, n. 248, p. 675–710, Aug. 1931. ISSN 2398-4600. DOI: [10.1017/s0368393100113343](https://doi.org/10.1017/s0368393100113343).
- 2 BASNER, Mathias; CLARK, Charlotte; HANSELL, Anna; HILEMAN, James I; JANSSEN, Sabine; SHEPHERD, Kevin; SPARROW, Victor. Aviation Noise Impacts: State of the Science. **DOAJ (DOAJ: Directory of Open Access Journals)**, v. 19, n. 87, p. 41–50, Dec. 2017. DOI: [10.4103/nah.nah_104_16](https://doi.org/10.4103/nah.nah_104_16). Available from: <https://doaj.org/article/7341ca9eedc14b6e9a44081873d676c3>.
- 3 KALTENBACH, Martin; MASCHKE, Christian; KLINKE, Rainer. Health Consequences of Aircraft Noise. **Deutsches Ärzteblatt international**, Deutscher Ärzte-Verlag GmbH, Aug. 2008. ISSN 1866-0452. DOI: [10.3238/arztebl.2008.0548](https://doi.org/10.3238/arztebl.2008.0548).
- 4 INTERNATIONAL CIVIL AVIATION ORGANISATION (ICAO). **Reduction of Noise at Source**. Montreal, Canada, 2025. Available from: <https://www.icao.int/environmental-protection/pages/reduction-of-noise-at-source.aspx>. Visited on: 20 Mar. 2025.
- 5 EUROPEAN UNION AVIATION SAFETY AGENCY (EASA). **EASA Certification Noise Levels**. Available from: <https://www.easa.europa.eu/en/domains/environment/easa-certification-noise-levels>. Visited on: 25 June 2025.
- 6 SELF, Rod H. Propeller noise. **Encyclopedia of Aerospace Engineering**, Dec. 2010. DOI: [10.1002/9780470686652.eae339](https://doi.org/10.1002/9780470686652.eae339). Available from: <https://doi.org/10.1002/9780470686652.eae339>.
- 7 GUDMUNDSSON, Snorri. Thrust Modeling for Propellers. In: **GENERAL Aviation Aircraft Design**. Elsevier Inc., 2022. Chapter 15, p. 597–656.
- 8 METZGER, F. Bruce. **A Review of Propeller Noise Prediction Methodology: 1919-1994**. Hampton, Virginia 23681, June 1995. National Aeronautics and Space Administration (NASA).
- 9 GUTIN, L. **On the Sound Field of a Rotating Propeller**. Langley Field, Va., Oct. 1948. National Advisory Committee for Aeronautics.

- 10 LIGHTHILL, M. J. On Sound Generated Aerodynamically. I. General Theory. **Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences**, The Royal Society, v. 211, n. 1107, p. 564–587, Mar. 1952. ISSN 2053-9169. DOI: [10.1098/rspa.1952.0060](https://doi.org/10.1098/rspa.1952.0060).
- 11 METZGER, F. Bruce; PREISSER, John S. **Status of Propeller Noise Prediction Methods for General Aviation Aircraft**. Wichita, Kanas, May 1995. Society of Automotive Engineers (SAE).
- 12 RATHGEBER, Ronald K.; SIPES, Douglas E. **The Influence of Design Parameters on Light Propeller Aircraft Noise**. Business Aircraft Meeting Century II, Wichita, Apr. 1977. Society of Automotive Engineers (SAE).
- 13 ALVES, Pedro; SILVESTRE, Miguel; GAMBOA, Pedro. Aircraft Propellers—Is There a Future? **Energies**, MDPI AG, v. 13, n. 16, p. 4157, Aug. 2020. ISSN 1996-1073. DOI: [10.3390/en13164157](https://doi.org/10.3390/en13164157).
- 14 AIR CHARTER SERVICE. **Embraer 120**. 2025. Available from: <https://www.aircharter.com.br/en/aircraft-guide/private/embraer-brazil/embraer120> >. Visited on: 16 May 2025.
- 15 FEDERAL AVIATION ADMINISTRATION (FAA). **Drones by the Numbers**. 2025. Available from: <https://www.faa.gov/node/54496> >. Visited on: 16 May 2025.
- 16 FEDERAL AVIATION ADMINISTRATION (FAA). **Emerging Aviation Entrants: Unmanned Aircraft System and Advanced Air Mobility**. 2024. P. 46–58. Available from: <https://www.faa.gov/dataresearch/aviation/aerospaceforecasts/faa-aerospace-forecast-fy-2024-2044> >.
- 17 T-DRONES. **Multirotor Drone UAV: Everything You Need to Know**. May 2023. Available from: <https://www.t-drones.com/blog/multirotor-drone-guide.html> >. Visited on: 16 May 2025.
- 18 NEX, F.; ARMENAKIS, C.; CRAMER, M.; CUCCI, D.A.; GERKE, M.; HONKAVAARA, E.; KUKKO, A.; PERSELLO, C.; SKALOUD, J. UAV in the advent of the twenties: Where we stand and what is next. **ISPRS Journal of Photogrammetry and Remote Sensing**, Elsevier BV, v. 184, p. 215–242, Feb. 2022. ISSN 0924-2716. DOI: [10.1016/j.isprsjprs.2021.12.006](https://doi.org/10.1016/j.isprsjprs.2021.12.006).
- 19 AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL (ANAC). **DRONES CADASTRADOS**. Available from: <https://www.anac.gov.br/aceso-a-informacao/dados-abertos/areas-de-atuacao/aeronaves/drones-cadastrados> >. Visited on: 16 May 2025.

-
- 20 AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL (ANAC). **Metadados do conjunto de dados: Drones cadastrados**. Available from: <<https://www.anac.gov.br/aceso-a-informacao/dados-abertos/areas-de-atuacao/aeronaves/drones-cadastrados/9-drones-cadastrados>>. Visited on: 16 May 2025.
- 21 WATKINS, S; BURRY, J; MOHAMED, A; MARINO, M; PRUDDEN, S; FISHER, A; KLOET, N; JAKOBI, T; CLOTHIER, R. Ten questions concerning the use of drones in urban environments. **Building and Environment**, Elsevier BV, v. 167, p. 106458, Jan. 2020. ISSN 0360-1323. DOI: [10.1016/j.buildenv.2019.106458](https://doi.org/10.1016/j.buildenv.2019.106458).
- 22 EDWARDS, Thomas; PRICE, George. **eVTOL Passenger Acceptance**. Moffett Field, CA 94035-1000, Jan. 2020. National Aeronautics and Space Administration (NASA).
- 23 AARON, Karp. **Airbus, Boeing work toward autonomous eVTOL operations**. Feb. 2023. Available from: <<https://verticalmag.com/news/airbus-boeing-work-toward-autonomous-evtol-operations/>>. Visited on: 19 May 2025.
- 24 JASON, Pritchard. **EHang's EH216-S obtains standard Airworthiness Certificate from China's CAAC, certified aircraft delivered to Guangzhou customer**. Dec. 2023. Available from: <<https://evtolinsights.com/2023/12/ehangs-eh216-s-obtains-standard-airworthiness-certificate-from-chinas-caac-certified-aircraft-delivered-to-guangzhou-customer/>>. Visited on: 19 May 2025.
- 25 BABETTO, L.; KÖNIG, R.; FASSNACHT, J.; STUMPF, E. Study On Public Acceptance of EVTOL: Safety & Noise. en. **Deutsche Gesellschaft für Luft- und Raumfahrt - Lilienthal-Oberth e.V.**, Deutsche Gesellschaft für Luft- und Raumfahrt - Lilienthal-Oberth e.V., 2024. DOI: [10.25967/610319](https://doi.org/10.25967/610319).
- 26 MARTE, Jack E.; KURTZ, Donald W. **A Review of Aerodynamic Noise From Propellers, Rofors, and Lift Fans**. Pasadena, California, Jan. 1970. National Aeronautics and Space Administration (NASA).
- 27 MAGLIOZZI, B.; HANSON, D. B.; AMIET, R. K. Propeller and Propfan Noise. In: **AEROACOUSTICS of Flight Vehicles: Theory and Practice**. National Aeronautics and Space Administration (NASA), 1991. v. 1, p. 1-61.
- 28 BOLT, R. H.; LUKASIK, S. J.; NOLLE, A. W.; FROST, A. D. **Handbook of Acoustic Noise Control, Volume 1. Physical Acoustics**. Wright-Patterson Air Force Base, Ohio, Dec. 1952. Bolt, Beranek and Newman.
- 29 FRANKEN, Peter A.; JR., Edward M. Kerwin. **Methods of Flight Vehicle Noise Prediction**. Wright-Patterson Air Force Base, Ohio, 1958. Wright Air Development Center.

-
- 30 TRILLO, R.L. An empirical study of hovercraft propeller noise. **Journal of Sound and Vibration**, Elsevier BV, v. 3, n. 3, p. 476–509, May 1966. ISSN 0022-460X. DOI: [10.1016/0022-460x\(66\)90111-8](https://doi.org/10.1016/0022-460x(66)90111-8).
- 31 ANON. **Estimation of the maximum discrete frequency noise from isolated rotors and propellers**. Sept. 1976. Engineering Sciences Data Unit (ESDU).
- 32 ANON. **Prediction Procedure for Near-Field and Far-Field Propeller Noise**. 400 Commonwealth Drive. Warrendale, PA. 15096, May 1977. Society of Automotive Engineers (SAE).
- 33 SMITH, Michael H. **A Prediction Procedure for Propeller Aircraft Flyover Noise Based on Empirical Data**. Wichita, Kansas, Apr. 1981. Society of Automotive Engineers (SAE).
- 34 RATHGEBER, Ronald K. **The Development of a Flyover Noise Prediction Technique Using Multiple Linear Regression Analysis**. Wichita, Kansas, Apr. 1981. Society of Automotive Engineers (SAE).
- 35 DOBRZYNSKI, Werner. A general prediction procedure for light propeller driven aeroplane flyover noise signatures. In: INTER-NOISE and NOISE-CON Congress and Conference Proceedings, InterNoise94. Yokohama, JAPAN, 1994. P. 271–274.
- 36 SAMOKHIN, V. F. Semiempirical method for estimating the noise of a propeller. **Journal of Engineering Physics and Thermophysics**, Springer Science and Business Media LLC, v. 85, n. 5, p. 1157–1166, Sept. 2012. ISSN 1573-871X. DOI: [10.1007/s10891-012-0758-y](https://doi.org/10.1007/s10891-012-0758-y).
- 37 METZGER, Frederick B.; MAGLIOZZI, Bernard; TOWLE, George B.; GRAY, Larry. A STUDY OF PROPELLER NOISE RESEARCH. In: AERODYNAMIC Noise. University of Toronto Press, Dec. 1969. P. 371–386. DOI: [10.3138/9781487582869-018](https://doi.org/10.3138/9781487582869-018).
- 38 WILFORD, D.; BONNEAU, H. Flyover noise measurements for turbo-prop aircraft. In: 8TH Aeroacoustics Conference. American Institute of Aeronautics and Astronautics, Apr. 1983. DOI: [10.2514/6.1983-746](https://doi.org/10.2514/6.1983-746).
- 39 WILBY, J. F.; WILBY, E. G. Measurements of propeller noise in a light turboprop airplane. **Journal of Aircraft**, American Institute of Aeronautics and Astronautics (AIAA), v. 26, n. 1, p. 40–47, Jan. 1989. ISSN 1533-3868. DOI: [10.2514/3.45721](https://doi.org/10.2514/3.45721).
- 40 UNGAR, Eric E.; WILBY, John; PINKEL, B.; GALAITSIS, A.; HAYDEN, Richard; SMULLIN, Joseph; WHITE, Robert; BLISS, Donald. **A Guide for Estimation of Aeroacoustic Loads on Flight Vehicle Surfaces**. Wright-Patterson Air Force Base, Ohio 45433, Feb. 1977. Air Force Flight Dynamics Laboratory.
- 41 CHENYING HU JINTATO GU, Fei Gao. The research on propeller noise prediction method for turboprop aircraft. In: 32ND Congress of the International Council of the Aeronautical Sciences. 2020.

-
- 42 RIBOLDI, Carlo E.D.; TRAINELLI, Lorenzo; MARIANI, Luca; ROLANDO, Alberto; SALUCCI, Francesco. Predicting the effect of electric and hybrid-electric aviation on acoustic pollution. **Noise Mapping**, Walter de Gruyter GmbH, v. 7, n. 1, p. 35–56, Jan. 2020. ISSN 2084-879X. DOI: [10.1515/noise-2020-0004](https://doi.org/10.1515/noise-2020-0004).
- 43 DOKE, Jiro. **GRABIT**. Available from: <<https://www.mathworks.com/matlabcentral/fileexchange/7173-grabit>>. Visited on: 3 June 2025.
- 44 MATHWORKS,INC. **polyfit**. Available from: <<https://www.mathworks.com/help/matlab/ref/polyfit.html>>. Visited on: 3 June 2025.
- 45 MATHWORKS,INC. **polyval**. Available from: <<https://www.mathworks.com/help/matlab/ref/polyval.html>>. Visited on: 3 June 2025.
- 46 MENDENHALL, William; SINCICH, Terry. **Statistics for Engineering and the Sciences**. Ed. by Sally Yagan. 5th. Upper Sadle River, New Jersey 07458: Pearson Prentice Hall, 2007. ISBN 0-13-187706-2.
- 47 SCHOBER, Patrick; BOER, Christa; SCHWARTE, Lothar A. Correlation Coefficients: Appropriate Use and Interpretation. **Anesthesia amp; Analgesia**, Ovid Technologies (Wolters Kluwer Health), v. 126, n. 5, p. 1763–1768, May 2018. ISSN 0003-2999. DOI: [10.1213/ane.0000000000002864](https://doi.org/10.1213/ane.0000000000002864).
- 48 MATHWORKS,INC. **corrcoef**. Available from: <<https://www.mathworks.com/help/matlab/ref/corrcoef.html>>. Visited on: 19 June 2025.
- 49 MATHWORKS,INC. **lillietest**. Available from: <<https://www.mathworks.com/help/stats/lillietest.html>>. Visited on: 19 June 2025.
- 50 MATHWORKS,INC. **ttest**. Available from: <<https://www.mathworks.com/help/stats/ttest.html>>. Visited on: 19 June 2025.
- 51 MATHWORKS,INC. **signrank**. Available from: <<https://www.mathworks.com/help/stats/signrank.html>>. Visited on: 19 June 2025.
- 52 NEWMAN, J. Steven; BLAND, Tyrone L.; DABOIN, Sharon A. **Noise Levels and Data Analyses for Small Prop-Driven Aircraft**. 800 Independence Ave., SW Washington, D.C. 20591, Aug. 1983. Federal Aviation Administration, Office of Environment and Energy, Noise Abatement Division, Noise Technology Branch.
- 53 SARTORIUS, Sky. **Standard Atmosphere Functions**. Available from: <<https://www.mathworks.com/matlabcentral/fileexchange/28135-standard-atmosphere-functions>>. Visited on: 3 June 2025.
- 54 WILBY, J. F.; MCDANIEL, C. D.; WILBY, E. G. **In-Flight Acoustic Measurements on a Light Twin-Engine Turboprop Airplane**. Hampton, Virginia 23665, Nov. 1985. National Aeronautics and Space Administration (NASA).

-
- 55 ŠULC, J.; HOFR, J.; BENDA, L. Exterior noise on the fuselage of light propeller driven aircraft in flight. **Journal of Sound and Vibration**, Elsevier BV, v. 84, n. 1, p. 105–120, Sept. 1982. ISSN 0022-460X. DOI: [10.1016/0022-460x\(82\)90435-7](https://doi.org/10.1016/0022-460x(82)90435-7).
- 56 SPENCE, P.; TRACY, M.; TAKALLU, M. Near-field noise of a pusher propeller. In: 12TH Aeroacoustic Conference. American Institute of Aeronautics and Astronautics, Apr. 1989. DOI: [10.2514/6.1989-1096](https://doi.org/10.2514/6.1989-1096).
- 57 BONNEAU, H.; WILFORD, D.F.; WOOD, L.K. An investigation of in-flight near-field propeller noise generation and transmission. In: ADVISORY GROUP FOR AEROSPACE RESEARCH and DEVELOPMENT. AGARD Conference Proceedings No.366 - Aerodynamics and Acoustics of Propellers. 40 Chigwell Lane, Loughton, Essex: AGARD, Oct. 1984.
- 58 HANSON, Liam; JAWAHAR, Hasan Kamliya; VEMURI, SH. S.; AZARPEYVAND, Mahdi. Experimental investigation of propeller noise in ground effect. **Journal of Sound and Vibration**, Elsevier BV, v. 559, p. 117751, Sept. 2023. ISSN 0022-460X. DOI: [10.1016/j.jsv.2023.117751](https://doi.org/10.1016/j.jsv.2023.117751).
- 59 AI, Yan-ting; WU, Yuhang; WANG, Zhi; XIANG, Song. Numerical Simulation of Aerodynamic Noise of Intelligent Propeller Aircraft Considering Ground Reflection. In: 2019 IEEE International Conference on Smart Internet of Things (SmartIoT). IEEE, Aug. 2019. P. 427–431. DOI: [10.1109/smartiot.2019.00076](https://doi.org/10.1109/smartiot.2019.00076).
- 60 BOUSSARD, P.; CARIDI, D.; BOUTHÉON, A.; MINARD, A.; BANDOPADHYAY, S. Drone and eVTOL flyover noise simulation Comprehensive process from aeroacoustics to sound quality. In: PROCEEDINGS of the 10th Convention of the European Acoustics Association Forum Acusticum 2023. European Acoustics Association, Jan. 2022. (FA2023), p. 995–1002. DOI: [10.61782/fa.2023.1282](https://doi.org/10.61782/fa.2023.1282).
- 61 HANSON, Liam P.; BASKARAN, Kabilan; PULLIN, Shaun F.; ZHOU, Beckett Yx; ZANG, Bin; AZARPEYVAND, Mahdi. Aeroacoustic and Aerodynamic Characteristics of Propeller Tip Geometries. In: 28TH AIAA/CEAS Aeroacoustics 2022 Conference. American Institute of Aeronautics and Astronautics, June 2022. DOI: [10.2514/6.2022-3075](https://doi.org/10.2514/6.2022-3075).
- 62 PANG, Ethan; CAMBRAY, Aleix; REZGUI, Djamel; AZARPEYVAND, Mahdi; SHOWKAT ALI, Syamir A. Investigation Towards a Better Understanding of Noise Generation from UAV Propellers. In: 2018 AIAA/CEAS Aeroacoustics Conference. American Institute of Aeronautics and Astronautics, June 2018. DOI: [10.2514/6.2018-3450](https://doi.org/10.2514/6.2018-3450).
- 63 ALVAREZ, Eduardo; CRITCHFIELD, Tyler; NING, Andrew; SCHENK, Austin. Rotor-on-Rotor Aeroacoustic Interactions of Multirotor in Hover. In: PROCEED-

- INGS of the Vertical Flight Society 76th Annual Forum. The Vertical Flight Society, Oct. 2020. P. 1–12. DOI: [10.4050/f-0076-2020-16489](https://doi.org/10.4050/f-0076-2020-16489).
- 64 LEE, Hakjin; LEE, Duck-Joo. Rotor interactional effects on aerodynamic and noise characteristics of a small multirotor unmanned aerial vehicle. **Physics of Fluids**, AIP Publishing, v. 32, n. 4, Apr. 2020. ISSN 1089-7666. DOI: [10.1063/5.0003992](https://doi.org/10.1063/5.0003992).
- 65 KIM, Hojin; LEE, Jinwhuy; LEE, Donguk; YEE, Kwanjung. Improved Conceptual Design of eVTOL Aircraft: Considering Rotor–Rotor Interactional Effects. **International Journal of Aeronautical and Space Sciences**, Springer Science and Business Media LLC, v. 26, n. 3, p. 863–882, Feb. 2025. ISSN 2093-2480. DOI: [10.1007/s42405-025-00888-9](https://doi.org/10.1007/s42405-025-00888-9).
- 66 BASKARAN, Kabilan; JAMALUDDIN, Nur Syafiqah; CELIK, Alper; REZGUI, Djamel; AZARPEYVAND, Mahdi. Effects of number of blades on propeller noise. **Journal of Sound and Vibration**, Elsevier BV, v. 572, p. 118176, Mar. 2024. ISSN 0022-460X. DOI: [10.1016/j.jsv.2023.118176](https://doi.org/10.1016/j.jsv.2023.118176).
- 67 TINNEY, Charles E.; SIROHI, Jayant. Multirotor Drone Noise at Static Thrust. **AIAA Journal**, American Institute of Aeronautics and Astronautics (AIAA), v. 56, n. 7, p. 2816–2826, July 2018. ISSN 1533-385X. DOI: [10.2514/1.j056827](https://doi.org/10.2514/1.j056827).
- 68 ZHANG, Jiechao; LIU, Yaolong; ZHENG, Yao. Overall eVTOL aircraft design for urban air mobility. **Green Energy and Intelligent Transportation**, Elsevier BV, v. 3, n. 2, p. 100150, Apr. 2024. ISSN 2773-1537. DOI: [10.1016/j.geits.2024.100150](https://doi.org/10.1016/j.geits.2024.100150).
- 69 WANG, Sen; LIMA PEREIRA, Lourenço Tércio; RAGNI, Daniele. Design exploration of UAM vehicles. **Aerospace Science and Technology**, Elsevier BV, v. 160, p. 110058, May 2025. ISSN 1270-9638. DOI: [10.1016/j.ast.2025.110058](https://doi.org/10.1016/j.ast.2025.110058).
- 70 FATTAH, Ryu J.; CHEN, Weijie; WU, Han; WU, Yan; ZHANG, Xin. Noise measurements of generic small-scale propellers. In: 25TH AIAA/CEAS Aeroacoustics Conference. American Institute of Aeronautics and Astronautics, May 2019. DOI: [10.2514/6.2019-2498](https://doi.org/10.2514/6.2019-2498).
- 71 PASCIONI, Kyle; RIZZI, Stephen A. Tonal Noise Prediction of a Distributed Propulsion Unmanned Aerial Vehicle. In: 2018 AIAA/CEAS Aeroacoustics Conference. American Institute of Aeronautics and Astronautics, June 2018. DOI: [10.2514/6.2018-2951](https://doi.org/10.2514/6.2018-2951).
- 72 GILL, Hyunjune; LEE, Seongkyu. Development of New Empirical Rotor Broadband Noise Prediction Models for Urban Air Mobility Applications. In: AIAA SCITECH 2024 Forum. American Institute of Aeronautics and Astronautics, Jan. 2024. DOI: [10.2514/6.2024-2473](https://doi.org/10.2514/6.2024-2473).

-
- 73 HUA, Jie; MANKBADI, Reda R. Prediction and Control of Broadband Noise Associated with Advanced Air Mobility—A Review. **Applied Sciences**, MDPI AG, v. 14, n. 18, p. 8455, Sept. 2024. ISSN 2076-3417. DOI: [10.3390/app14188455](https://doi.org/10.3390/app14188455).
- 74 INTERNATIONAL ELECTROTECHNICAL COMMISSION. **Effective perceived noise level**. Available from: <<https://www.electropedia.org/iev/iev.nsf/display?openform&ievref=801-29-15>>. Visited on: 12 June 2025.
- 75 INTERNATIONAL ELECTROTECHNICAL COMMISSION. **Perceived noise level**. Available from: <<https://www.electropedia.org/iev/iev.nsf/display?openform&ievref=801-29-11>>. Visited on: 12 June 2025.
- 76 INTERNATIONAL ELECTROTECHNICAL COMMISSION. **Sound pressure level**. Available from: <<https://www.electropedia.org/iev/iev.nsf/display?openform&ievref=801-22-07>>. Visited on: 12 June 2025.
- 77 INTERNATIONAL ELECTROTECHNICAL COMMISSION. **Weighted sound pressure level**. Available from: <<https://www.electropedia.org/iev/iev.nsf/display?openform&ievref=801-22-14>>. Visited on: 12 June 2025.

Glossary

A-Weighting

One of the standard frequency weighting; it gives more value to frequencies in the middle of human hearing when compared to a flat audio decibel measurement. It is the standard for determining hearing damage and noise pollution. Its unit is dBA.

Effective Perceived Noise Level

Level in decibels of the time integral of the antilogarithm of one-tenth of the tone-corrected perceived noise level, over the duration of an aircraft flyover; the reference duration is 10 s. It purports to represent subjective noisiness and tends to be 2 dB or 3 dB greater than A-weighted sound exposure level (74).

Interquartile Range

The interquartile range is the distance between the upper and lower quartiles (46).

Lower Quartile

The lower quartile for a data set is the 25th percentile (46).

Median

The median (or midquartile) for a data set is the 50th percentile (46).

Overall Sound Pressure Level

Measure of the total acoustic noise intensity, representing the combined loudness of multiple frequencies within a sound spectrum.

Perceived Noise Level

Frequency-weighted sound pressure level in decibels, obtained by a stated procedure that combines the sound pressure levels in the 24 one-third octave bands centered on 50 Hz and 10 kHz. It is intended to approximate judged perceived noise level (75).

Percentile

The 100pth percentile of a data set is a value of y located so that 100p% of the area under the relative frequency distribution for the data lies to the left of the 100pth percentile and 100(1-p)% of the area lies to its right. For example, if your grade in an industrial engineering class was located at the 84th percentile, then 84% of the grades were lower than your grade and 16% were higher (46).

Sound Pressure Level

Logarithm of the ratio of a given sound pressure to the reference sound pressure, which is usually $20\mu Pa$ for airborne sound and $1\mu Pa$ in media other than air. Sound pressure level in decibels is 20 times the logarithm to the base ten of the ratio (76).

Upper Quartile

The upper quartile for a data set is the 75th percentile (46).

Weighted Sound Pressure Level

Logarithm of the ratio of a given sound pressure to the reference sound pressure of $20\mu Pa$ being obtained with a standard frequency weighting and with a standard exponential time weighting. Sound level in decibels is twenty times the logarithm to the base ten of that ratio (77).

Appendices

Polynomial coefficients and curve fitting errors of the SAE method implementation

All of the polynomial coefficients were calculated using MATLAB's *polyfit* function, with the extracted data points as input. It follows Equation 3.1.

A.1 Polynomial coefficients

Curve	a_1	a_0
6 ft	0.0947	2.4850
7 ft	0.1120	-0.3497
8 ft	0.1280	0.6695
9 ft	0.1438	0.5068
10 ft	0.1620	-3.0072
11 ft	0.1773	-1.1040
12 ft	0.1915	0.3530
13 ft	0.2090	-1.9989
14 ft	0.2237	-0.1995
15 ft	0.2391	1.5397
16 ft	0.2545	1.6754
18 ft	0.2897	-2.3934
20 ft	0.3261	-4.2768
22 ft	0.3540	-1.4447
25 ft	0.3973	2.8693

Table A.1 – Polynomial coefficients for the curves shown in Figure B.1.

Curve	a_1	a_0
-25 °F	$9.7994 \cdot 10^{-4}$	0.0021
0 °F	$9.5321 \cdot 10^{-4}$	0.0050
25 °F	$9.2884 \cdot 10^{-4}$	0.0045
50 °F	$9.0146 \cdot 10^{-4}$	0.0082
75 °F	$8.7672 \cdot 10^{-4}$	0.0082
100 °F	$8.6213 \cdot 10^{-4}$	0.0039
125 °F	$8.4562 \cdot 10^{-4}$	0.0025

Table A.2 – Polynomial coefficients for the curves shown in Figure B.2.

Curve	a_1	a_0
0.4M	15.7003	32.4269
0.5M	15.6580	36.5440
0.6M	15.4847	40.6768
0.7M	15.5962	43.6395
0.8M	15.8356	46.9138
0.9M	15.8333	50.8810

Table A.3 – Polynomial coefficients for the curves shown in Figure B.3.

Curve	a_1	a_0
2 Blades	-19.9598	26.7249
3 Blades	-20.1826	24.0418
4 Blades	-20.2102	20.9050
6 Blades	-19.9825	17.8331
8 Blades	-20.1220	15.4445

Table A.4 – Polynomial coefficients for the curves shown in Figure B.4.

Curve	a_3	a_2	a_1	a_0
Overall	-	-	-20.5528	55.6193
Perceived	-1.2365	6.9411	-32.6372	61.8014

Table A.5 – Polynomial coefficients for the curves shown in Figure B.5.

Curve	a_5	a_4	a_3
Azimuth	$2.9391 \cdot 10^{-9}$	$-1.5305 \cdot 10^{-6}$	$2.8079 \cdot 10^{-4}$

Table A.6 – Polynomial coefficients for the curves shown in Figure B.6.

Curve	a_2	a_1	a_0
Azimuth	−0.0235	0.9407	−16.0068

Table A.6 – Polynomial coefficients for the curves shown in Figure B.6 (Continued).

Curve	a_6	a_5	a_4	a_3
0.5M	$-8.5015 \cdot 10^{-7}$	$9.7524 \cdot 10^{-5}$	−0.0045	0.1063
0.6M	$-3.9871 \cdot 10^{-6}$	$-3.6760 \cdot 10^{-4}$	0.0133	−0.2382
0.7M	$3.8613 \cdot 10^{-6}$	$-3.8304 \cdot 10^{-4}$	0.0150	−0.2945
0.8M	$2.1243 \cdot 10^{-6}$	$-2.1209 \cdot 10^{-4}$	0.0088	−0.1795
0.85M	$1.2910 \cdot 10^{-6}$	$-1.4054 \cdot 10^{-4}$	0.0060	−0.1276
0.9M	$-3.1103 \cdot 10^{-7}$	$-6.7424 \cdot 10^{-6}$	0.0018	−0.0669

Table A.7 – Polynomial coefficients for the curves shown in Figure B.7.

Curve	a_2	a_1	a_0
0.5M	−1.2432	5.5256	−6.3379
0.6M	2.2312	−11.4659	25.9587
0.7M	3.0228	−16.1384	36.2081
0.8M	1.9406	−11.2237	29.0058
0.85M	1.4271	−8.5288	24.0055
0.9M	1.0496	−7.8427	25.9509

Table A.7 – Polynomial coefficients for the curves shown in Figure B.7 (Continued).

Curve	a_6	a_5	a_4	a_3
0.5M	$4.6684 \cdot 10^{-7}$	$-8.5322 \cdot 10^{-5}$	0.0049	−0.1250
0.6M	$-4.4519 \cdot 10^{-7}$	$-2.7947 \cdot 10^{-6}$	0.0019	−0.0681
0.7M	$-2.8777 \cdot 10^{-6}$	$2.2601 \cdot 10^{-4}$	−0.0067	0.0941
0.8M	$-2.7359 \cdot 10^{-6}$	$2.4744 \cdot 10^{-4}$	−0.0089	0.1603
0.85M	$-1.9057 \cdot 10^{-6}$	$1.8719 \cdot 10^{-4}$	−0.0073	0.1416
0.9M	$-1.3970 \cdot 10^{-6}$	$1.3532 \cdot 10^{-4}$	−0.0052	0.1023

Table A.8 – Polynomial coefficients for the curves shown in Figure B.8.

Curve	a_2	a_1	a_0
0.5M	1.5945	−10.4210	28.9773
0.6M	0.9968	−7.0805	22.4210
0.7M	−0.6237	1.0353	7.0315
0.8M	−1.5177	6.5395	−4.7670
0.85M	−1.4185	6.3518	−4.1181
0.9M	−1.0390	4.6372	0.0804

Table A.8 – Polynomial coefficients for the curves shown in Figure B.8 (Continued).

Curve	a_6	a_5	a_4	a_3
0.5M	$−5.3352 \cdot 10^{-6}$	$4.6881 \cdot 10^{-4}$	−0.0163	0.2839
0.6M	$−4.1449 \cdot 10^{-6}$	$3.5664 \cdot 10^{-4}$	−0.0120	0.2009
0.7M	$−2.0096 \cdot 10^{-6}$	$1.7501 \cdot 10^{-4}$	−0.0060	0.1023
0.8M	$−2.0562 \cdot 10^{-6}$	$1.7425 \cdot 10^{-4}$	−0.0057	0.0919
0.85M	$−3.9434 \cdot 10^{-7}$	$3.0794 \cdot 10^{-5}$	$−9.0602 \cdot 10^{-4}$	0.0122
0.9M	$−9.6409 \cdot 10^{-7}$	$8.9568 \cdot 10^{-5}$	−0.0034	0.0659

Table A.9 – Polynomial coefficients for the curves shown in Figure B.9.

Curve	a_2	a_1	a_0
0.5M	−2.5899	10.9116	−11.5269
0.6M	−1.7245	6.4386	−2.2016
0.7M	−0.8973	3.1662	2.9005
0.8M	−0.7220	1.9110	6.7546
0.85M	−0.0565	−0.6612	11.0191
0.9M	−0.7014	3.3729	2.3665

Table A.9 – Polynomial coefficients for the curves shown in Figure B.9 (Continued).

Curve	a_6	a_5	a_4	a_3
0.5M	$−3.0633 \cdot 10^{-6}$	$2.5268 \cdot 10^{-4}$	−0.0080	0.1210
0.6M	$−3.4747 \cdot 10^{-6}$	$2.8717 \cdot 10^{-4}$	−0.0091	0.1392
0.7M	$−3.7521 \cdot 10^{-6}$	$3.1776 \cdot 10^{-4}$	−0.0105	0.1680
0.8M	$−3.8051 \cdot 10^{-6}$	$3.2358 \cdot 10^{-4}$	−0.0107	0.1719
0.85M	$−3.7179 \cdot 10^{-6}$	$3.1656 \cdot 10^{-4}$	−0.0104	0.1674
0.9M	$−3.5015 \cdot 10^{-6}$	$2.8980 \cdot 10^{-4}$	−0.0092	0.1361

Table A.10 – Polynomial coefficients for the curves shown in Figure B.10.

Curve	a_2	a_1	a_0
0.5M	−0.8679	1.9504	7.0537
0.6M	−1.0166	2.5086	6.8331
0.7M	−1.3369	4.2281	3.9946
0.8M	−1.3698	4.3985	3.9189
0.85M	−1.3189	4.0956	5.2640
0.9M	−0.9130	1.4785	12.5558

Table A.10 – Polynomial coefficients for the curves shown in Figure B.10 (Continued).

Curve	a_2	a_1	a_0
400 ft/s	0.0017	0.3468	391.0951
500 ft/s	0.0017	0.2068	495.1458
600 ft/s	0.0017	0.1329	596.1569
700 ft/s	0.0015	0.0970	698.7165
800 ft/s	0.0014	0.0668	799.5212
900 ft/s	0.0012	0.0865	899.1269
1000 ft/s	0.0011	0.0800	998.0619

Table A.11 – Polynomial coefficients for the curves shown in Figure B.11.

Curve	a_1	a_0
6 ft	15.0685	99.8804
7 ft	15.2517	96.9789
8 ft	15.1919	94.5644
10 ft	15.1789	90.9536
12 ft	15.2680	87.1806
14 ft	15.3709	83.9944
16 ft	15.3655	82.0680
20 ft	15.0544	79.0935
25 ft	15.1956	74.9233

Table A.12 – Polynomial coefficients for the curves shown in Figure B.12.

Curve	a_1	a_0
0.4M	-24.3933	-25.4029
0.5M	-21.8203	-21.4499
0.6M	-19.1611	-17.4598
0.7M	-16.5189	-13.4022
0.8M	-14.2967	-9.7775
0.9M	-11.6940	-5.7878

Table A.13 – Polynomial coefficients for the curves shown in Figure B.13.

Curve	a_8	a_7	a_6	a_5	a_4
0.05	$3.0502 \cdot 10^6$	$3.4193 \cdot 10^6$	$-1.1601 \cdot 10^7$	$9.8710 \cdot 10^6$	$-4.1550 \cdot 10^6$
0.1	$-1.8469 \cdot 10^5$	$9.5127 \cdot 10^5$	$-1.5734 \cdot 10^6$	$1.2786 \cdot 10^6$	$-5.8470 \cdot 10^6$
0.2	$-3.2624 \cdot 10^4$	$1.0922 \cdot 10^5$	$-1.5196 \cdot 10^5$	$1.1333 \cdot 10^5$	$-4.8680 \cdot 10^4$
0.3	$-2.1624 \cdot 10^3$	$8.9405 \cdot 10^3$	$-1.5429 \cdot 10^4$	$1.4435 \cdot 10^4$	$-7.9974 \cdot 10^3$

Table A.14 – Polynomial coefficients for the curves shown in Figure B.14.

Curve	a_3	a_2	a_1	a_0
0.05	$9.8235 \cdot 10^5$	$-1.3243 \cdot 10^5$	$9.4807 \cdot 10^3$	-279.5363
0.1	$1.5712 \cdot 10^5$	$-2.4591 \cdot 10^4$	$2.0609 \cdot 10^3$	-71.4593
0.2	$1.2082 \cdot 10^4$	$-1.6883 \cdot 10^3$	113.1642	-2.5132
0.3	$2.7375 \cdot 10^3$	-609.4058	75.6984	-3.8044

Table A.14 – Polynomial coefficients for the curves shown in Figure B.14 (Continued).

Curve	a_{17}	a_{16}	a_{15}	a_{14}
Circular Wall	-	-	$7.6794 \cdot 10^6$	$-1.6560 \cdot 10^6$
Flat Wall	$1.6888 \cdot 10^7$	$-3.3694 \cdot 10^7$	$2.6550 \cdot 10^6$	$3.2543 \cdot 10^7$

Table A.15 – Polynomial coefficients for the curves shown in Figure B.15.

Curve	a_{13}	a_{12}	a_{11}	a_{10}
Circular Wall	$9.3103 \cdot 10^6$	$3.3181 \cdot 10^6$	$-4.6583 \cdot 10^6$	$6.3993 \cdot 10^5$
Flat Wall	$-1.3847 \cdot 10^7$	$-1.2562 \cdot 10^7$	$7.6231 \cdot 10^6$	$2.4472 \cdot 10^6$

Table A.15 – Polynomial coefficients for the curves shown in Figure B.15 (Continued).

Curve	a_9	a_8	a_7	a_6
Circular Wall	$6.4451 \cdot 10^5$	$-2.2741 \cdot 10^5$	$-9.7481 \cdot 10^3$	$2.1168 \cdot 10^4$
Flat Wall	$-1.9462 \cdot 10^6$	$-2.5136 \cdot 10^5$	$2.7054 \cdot 10^5$	$1.4147 \cdot 10^4$

Table A.15 – Polynomial coefficients for the curves shown in Figure B.15 (Continued).

Curve	a_5	a_4	a_3	a_2	a_1	a_0
Circular Wall	$-4.7228 \cdot 10^3$	-614.8524	330.4991	-18.0014	3.5006	4.1361
Flat Wall	$-2.0920 \cdot 10^4$	-697.8976	850.5598	24.2328	-7.9894	5.9983

Table A.15 – Polynomial coefficients for the curves shown in Figure B.15 (End).

Curve	a_4	a_3	a_2	a_1	a_0
Fundamental	-535.1498	$1.2603 \cdot 10^3$	$-1.1150 \cdot 10^3$	433.5968	-63.0646
Harmonic 2	$-1.2546 \cdot 10^3$	$3.0005 \cdot 10^3$	$-2.6360 \cdot 10^3$	$1.0362 \cdot 10^3$	-170.5409
Harmonic 3	$-1.0302 \cdot 10^3$	$2.4662 \cdot 10^3$	$-2.1437 \cdot 10^3$	834.9955	-145.9906
Harmonic 4	-921.6639	$2.3006 \cdot 10^3$	$-2.0836 \cdot 10^3$	845.4122	-154.5079
Harmonic 5	-664.2894	$1.7891 \cdot 10^3$	$-1.7227 \cdot 10^3$	734.3587	-142.6896
Harmonic 6	137.1268	-245.5147	181.9629	-44.8675	-26.8335
Harmonic 7	643.2894	$-1.5679 \cdot 10^3$	$1.4493 \cdot 10^3$	-572.5104	52.3842
Harmonic 8	559.2556	$-1.3483 \cdot 10^3$	$-1.2396 \cdot 10^3$	-485.7054	38.3770
Harmonic 9	541.9557	$-1.3321 \cdot 10^3$	$1.2513 \cdot 10^3$	-501.6844	41.9817
Harmonic 10	382.8647	-928.0667	874.4646	-349.0483	18.9154

Table A.16 – Polynomial coefficients for the curves shown in Figure B.16.

A.2 Estimated polynomial curve fitting error

In this section, the mean standard prediction error $\overline{\Delta}$ is presented for each one of the curves shown in Appendix A and Appendix B.

Curve	$\overline{\Delta}$
6 ft	0.4251
7 ft	0.6154
8 ft	0.6244
9 ft	0.7311
10 ft	0.5703
11 ft	1.6498
12 ft	1.0413
13 ft	1.2490
14 ft	1.0268
15 ft	1.2931
16 ft	0.7494
18 ft	1.3323
20 ft	1.5649
22 ft	1.9602
25 ft	3.2081

Table A.17 – Mean standard prediction error for the curves shown in Figure B.1.

Curve	$\overline{\Delta}$
-25 °F	0.0026
0 °F	0.0021
25 °F	0.0024
50 °F	0.0019
75 °F	0.0018
100 °F	0.0023
125 °F	0.0018

Table A.18 – Mean standard prediction error for the curves shown in Figure B.2.

Curve	$\overline{\Delta}$
0.4M	0.1805
0.5M	0.1539
0.6M	0.1650
0.7M	0.1306
0.8M	0.1725
0.9M	0.2102

Table A.19 – Mean standard prediction error for the curves shown in Figure B.3.

Curve	$\overline{\Delta}$
2 Blades	0.1309
3 Blades	0.1491
4 Blades	0.1552
6 Blades	0.0856
8 Blades	0.1455

Table A.20 – Mean standard prediction error for the curves shown in Figure B.4.

Curve	$\overline{\Delta}$
Overall	0.6001
Perceived	0.3250

Table A.21 – Mean standard prediction error for the curves shown in Figure B.5.

Curve	$\overline{\Delta}$
Azimuth	0.2530

Table A.22 – Mean standard prediction error for the curves shown in Figure B.6.

Curve	$\overline{\Delta}$
0.5M	0.1177
0.6M	0.0966
0.7M	0.1479
0.8M	0.1539
0.85M	0.1292
0.9M	0.1425

Table A.23 – Mean standard prediction error for the curves shown in Figure B.7.

Curve	$\overline{\Delta}$
0.5M	0.1730
0.6M	0.2132
0.7M	0.2152
0.8M	0.1612
0.85M	0.1114
0.9M	0.1086

Table A.24 – Mean standard prediction error for the curves shown in Figure B.8.

Curve	$\overline{\Delta}$
0.5M	0.2239
0.6M	0.1715
0.7M	0.0863
0.8M	0.0817
0.85M	0.0746
0.9M	0.1315

Table A.25 – Mean standard prediction error for the curves shown in Figure B.9.

Curve	$\overline{\Delta}$
0.5M	0.1809
0.6M	0.2107
0.7M	0.2219
0.8M	0.2006
0.85M	0.1622
0.9M	0.1801

Table A.26 – Mean standard prediction error for the curves shown in Figure B.10.

Curve	$\overline{\Delta}$
400 ft/s	9.0850
500 ft/s	6.0468
600 ft/s	5.1711
700 ft/s	3.0304
800 ft/s	2.5856
900 ft/s	2.5649
1000 ft/s	2.9680

Table A.27 – Mean standard prediction error for the curves shown in Figure B.11.

Curve	$\overline{\Delta}$
6 ft	0.1140
7 ft	0.1332
8 ft	0.1254
10 ft	0.0977
12 ft	0.1178
14 ft	0.1084
16 ft	0.0964
20 ft	0.0963
25 ft	0.1423

Table A.28 – Mean standard prediction error for the curves shown in Figure B.12.

Curve	$\overline{\Delta}$
0.4 M	0.0413
0.5 M	0.0536
0.6 M	0.0372
0.7 M	0.0370
0.8 M	0.0535
0.9 M	0.0469

Table A.29 – Mean standard prediction error for the curves shown in Figure B.13.

Curve	$\overline{\Delta}$
0.05	0.1299
0.1	0.0591
0.2	0.0312
0.3	0.0359

Table A.30 – Mean standard prediction error for the curves shown in Figure B.14.

Curve	$\overline{\Delta}$
Circular Wall	0.1299
Flat Wall	0.0591

Table A.31 – Mean standard prediction error for the curves shown in Figure B.15.

Curve	$\overline{\Delta}$
Fundamental	0.2189
Harmonic 2	0.2079
Harmonic 3	0.2183
Harmonic 4	0.1544
Harmonic 5	0.1392
Harmonic 6	0.1290
Harmonic 7	0.2379
Harmonic 8	0.1372
Harmonic 9	0.1686
Harmonic 10	0.1387

Table A.32 – Mean standard prediction error for the curves shown in Figure B.16.

Constructed plots for the SAE method implementation

All plots were constructed using the curve coefficients presented in Appendix A. The axis limits were based on the graphs available in (32).

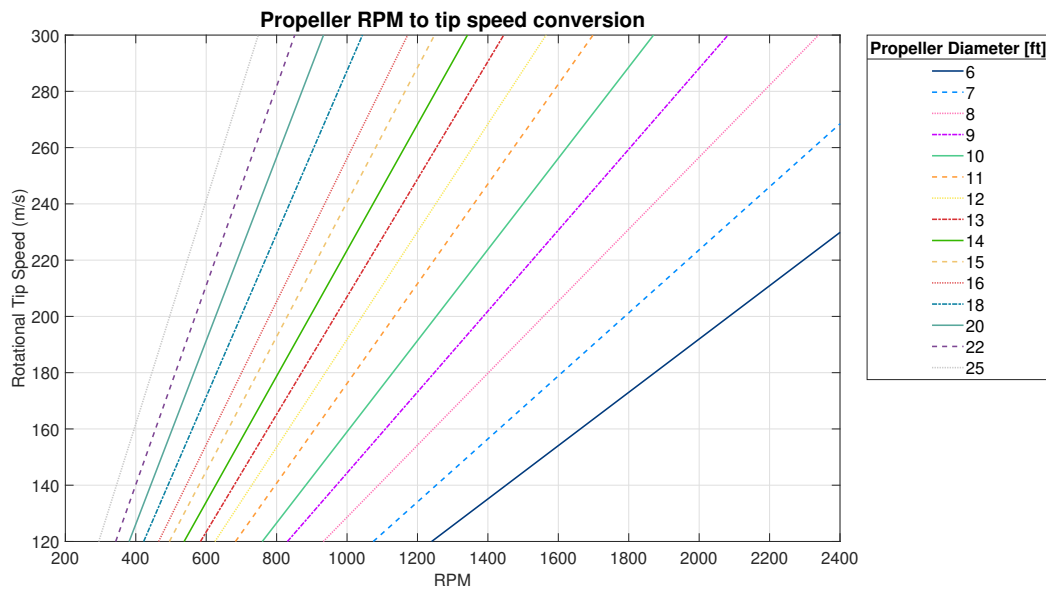


Figure B.1 – Propeller RPM to tip speed conversion.

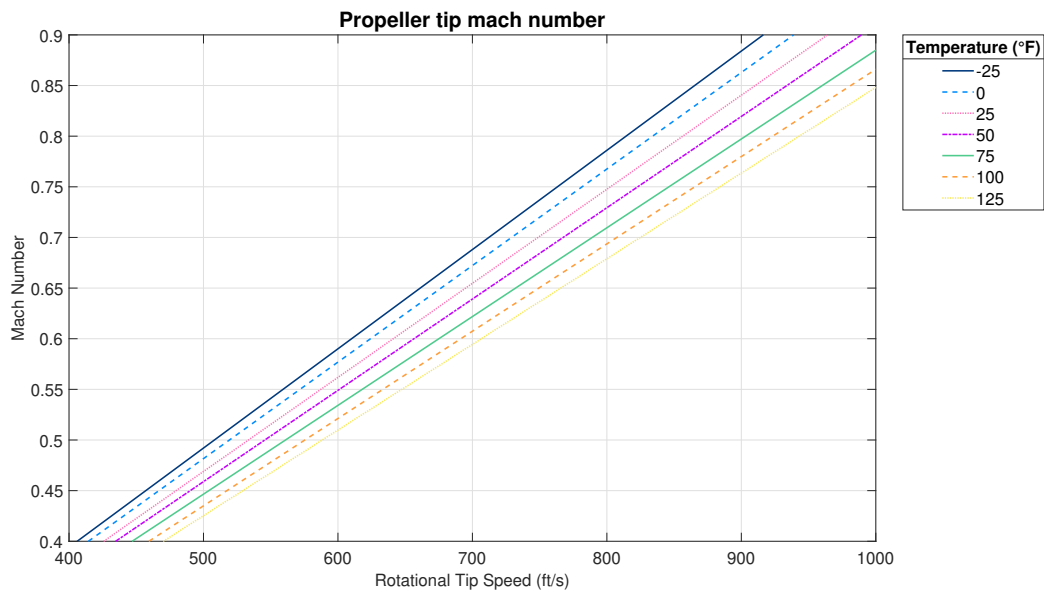


Figure B.2 – Acquire Mach number from tip speed.

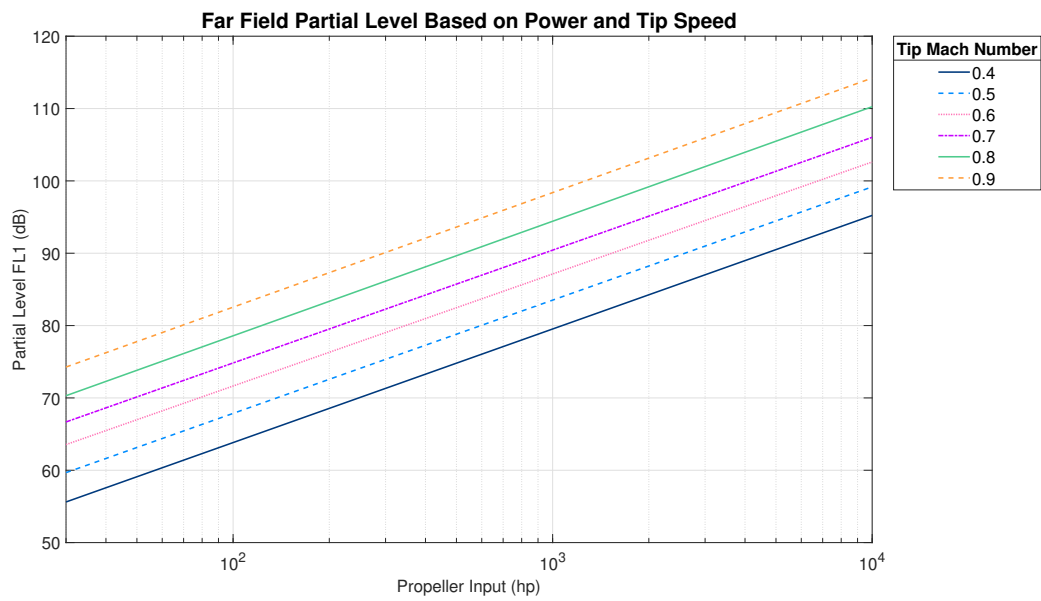


Figure B.3 – Far-field partial level (FL1) based on power and tip speed.

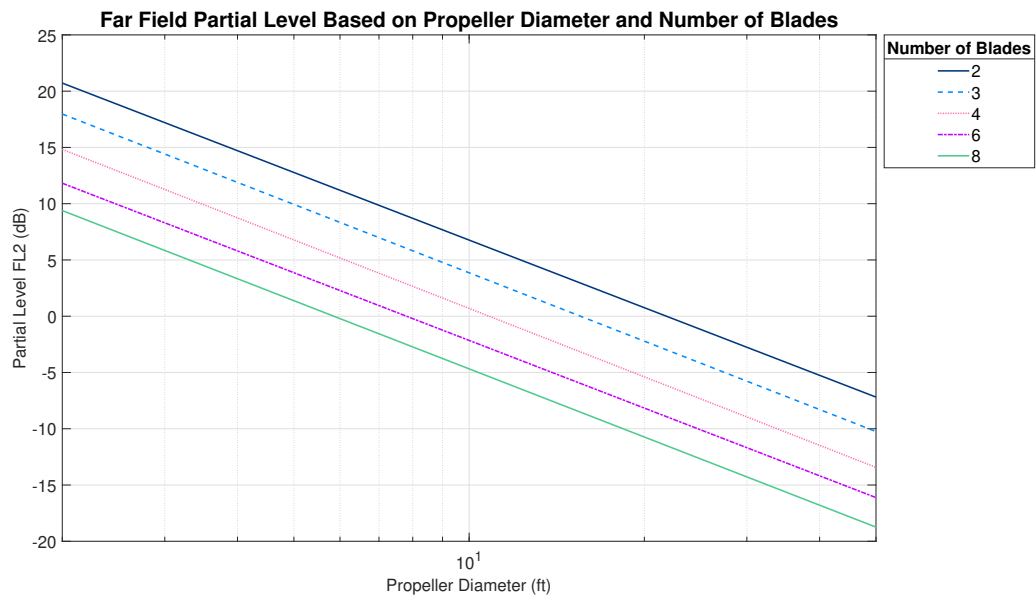


Figure B.4 – Far-field partial level (FL2) based on blade count and propeller diameter.

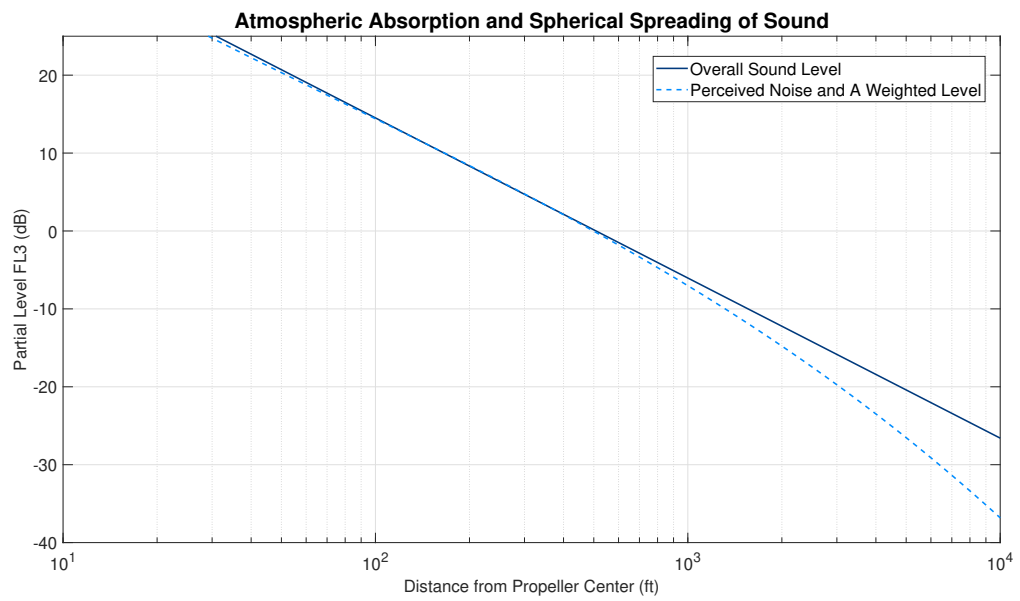


Figure B.5 – Far-field partial level (FL3) based on atmospheric absorption and spherical spreading of sound.

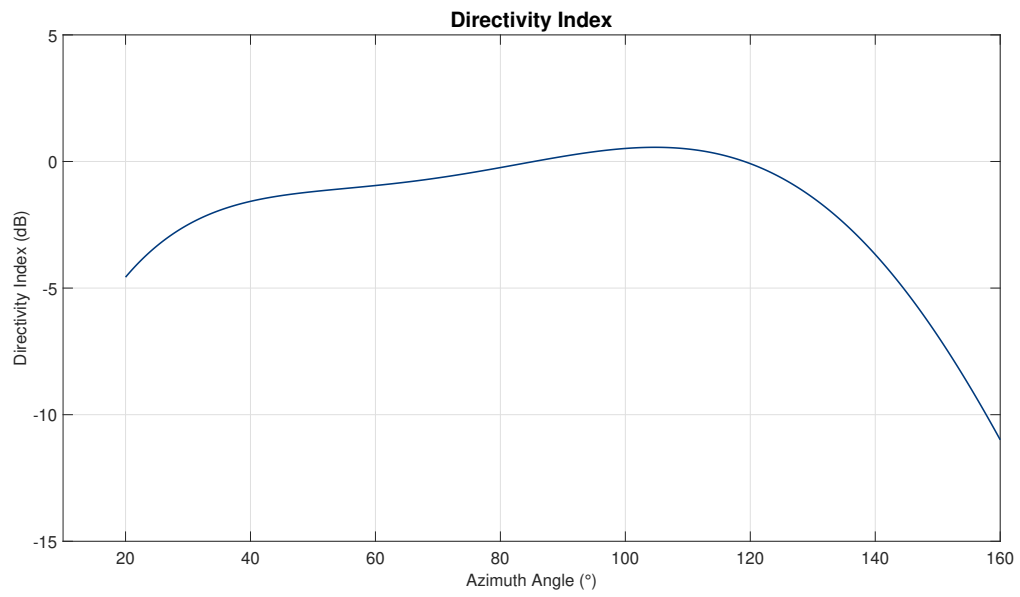


Figure B.6 – Obtain the directivity index (DI) with the azimuth angle as input.

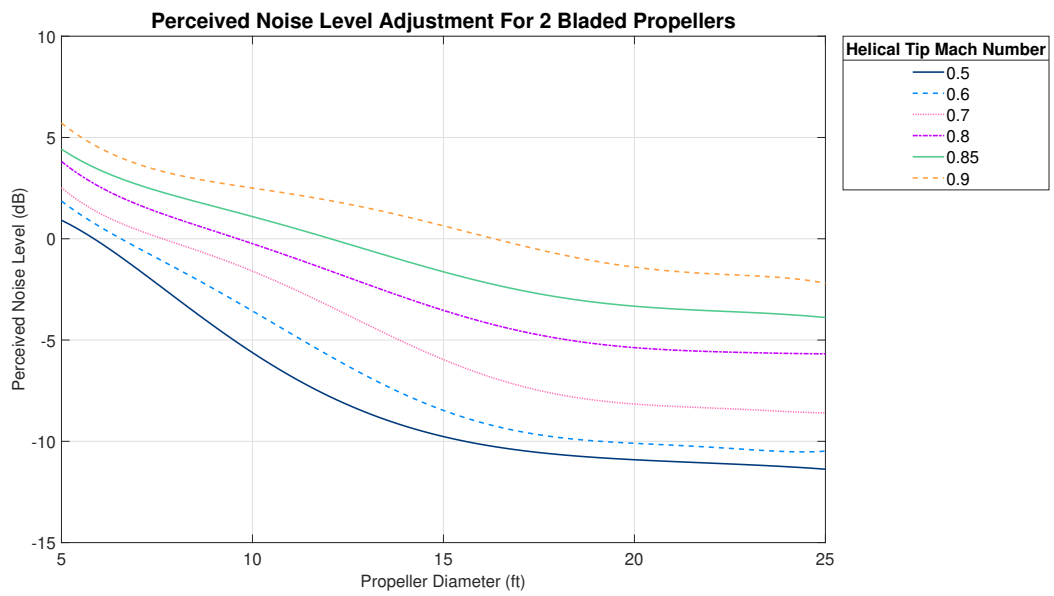


Figure B.7 – Perceived noise level adjustment for 2 bladed propellers.

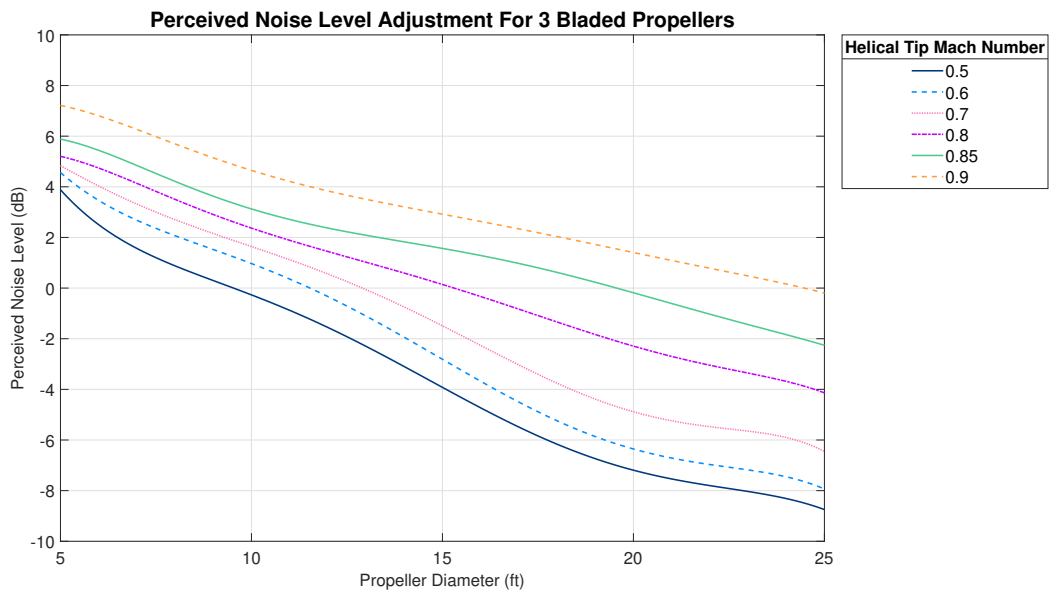


Figure B.8 – Perceived noise level adjustment for 3 bladed propellers.

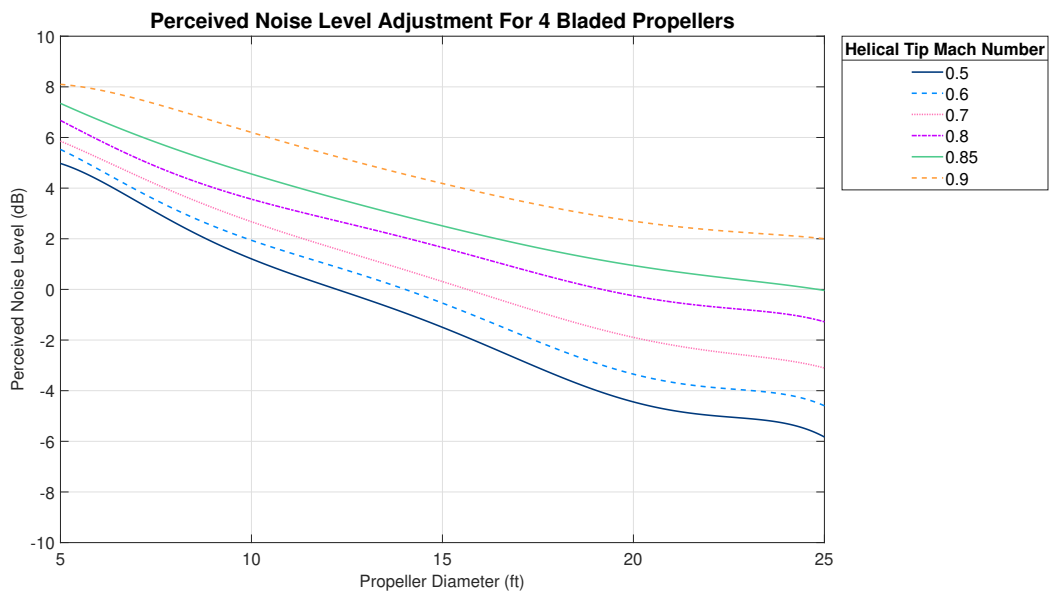


Figure B.9 – Perceived noise level adjustment for 4 bladed propellers.

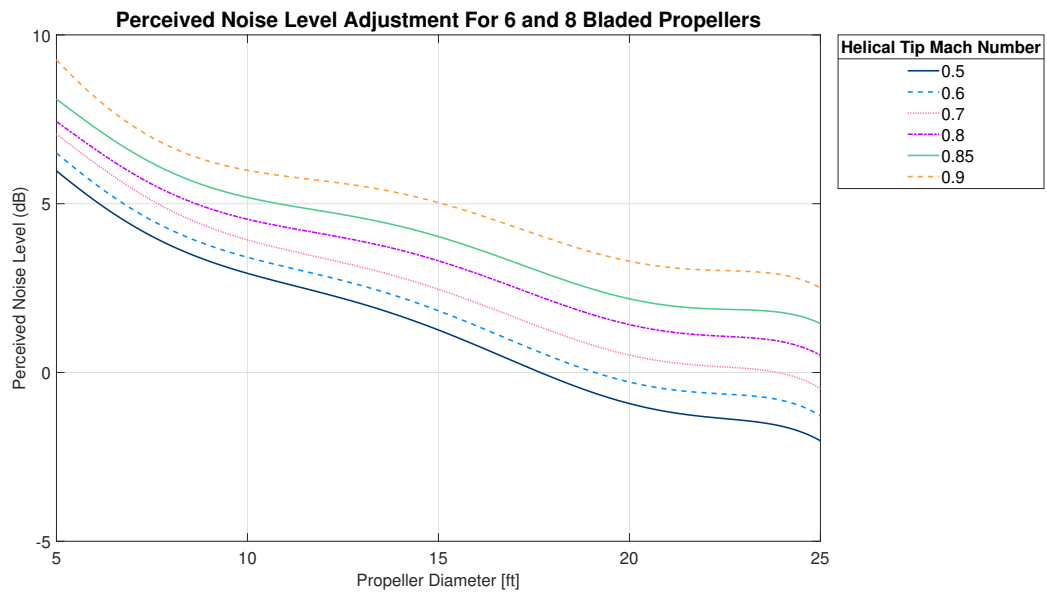


Figure B.10 – Perceived noise level adjustment for 6 and 8 bladed propellers.

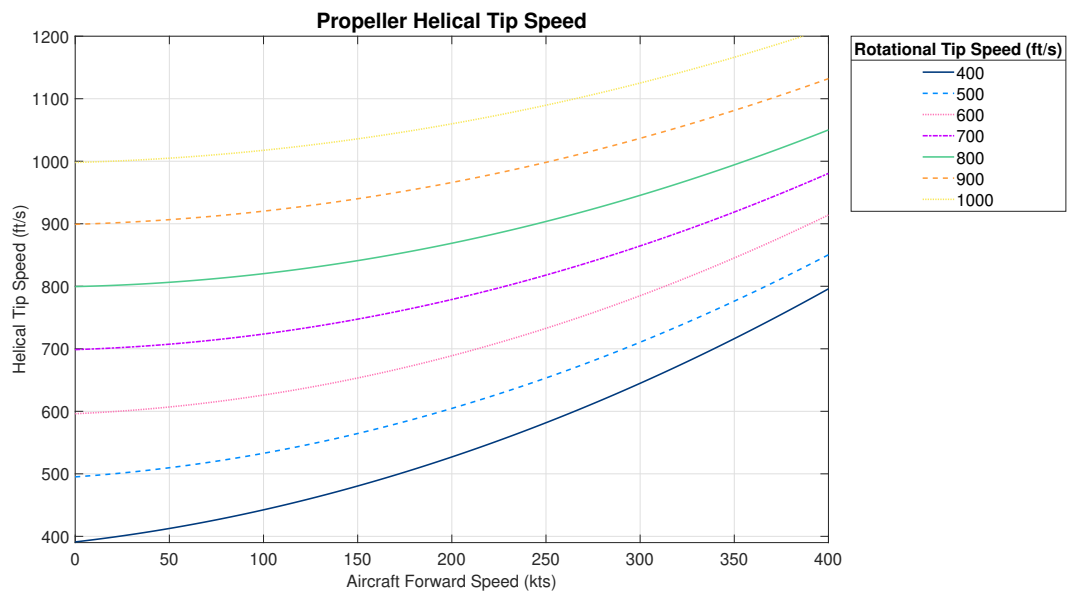


Figure B.11 – Obtain the propeller helical tip speed based on the aircraft's forward speed.

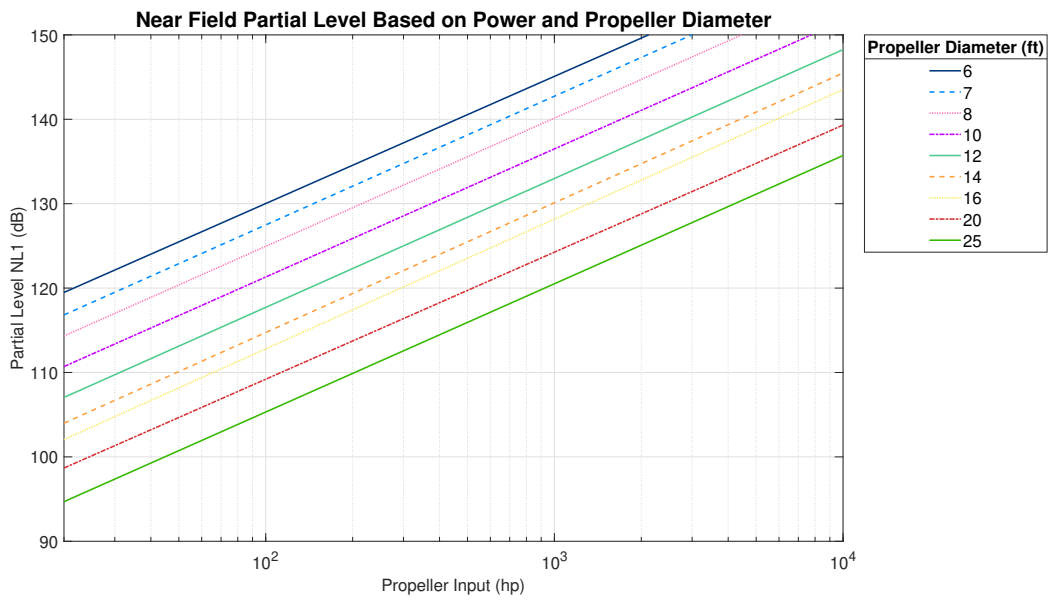


Figure B.12 – Near-field partial level (NL1) based on power and diameter.

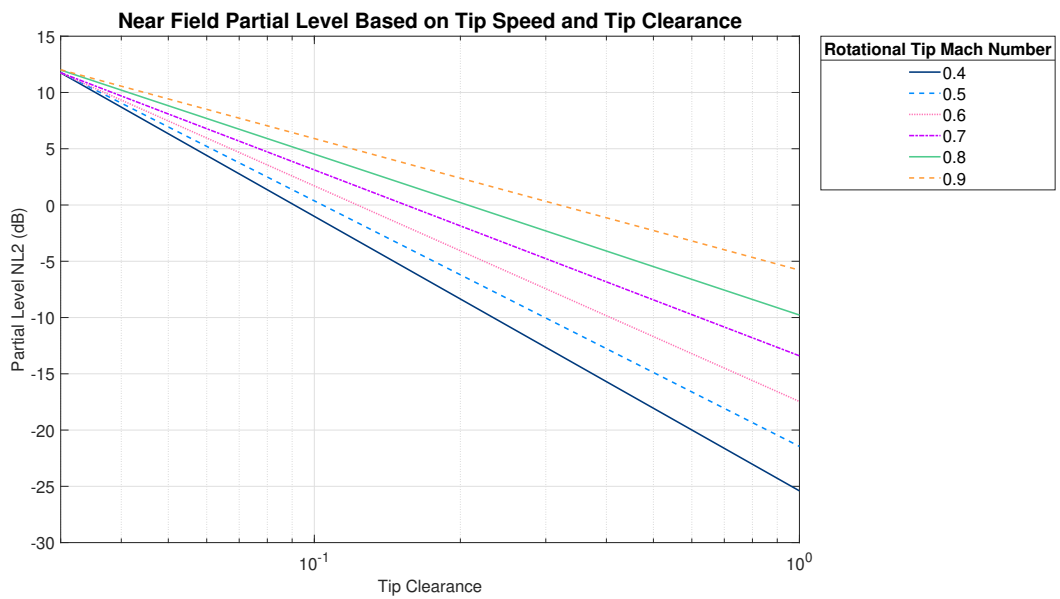


Figure B.13 – Near-field partial level (NL2) based on tip speed and tip clearance.

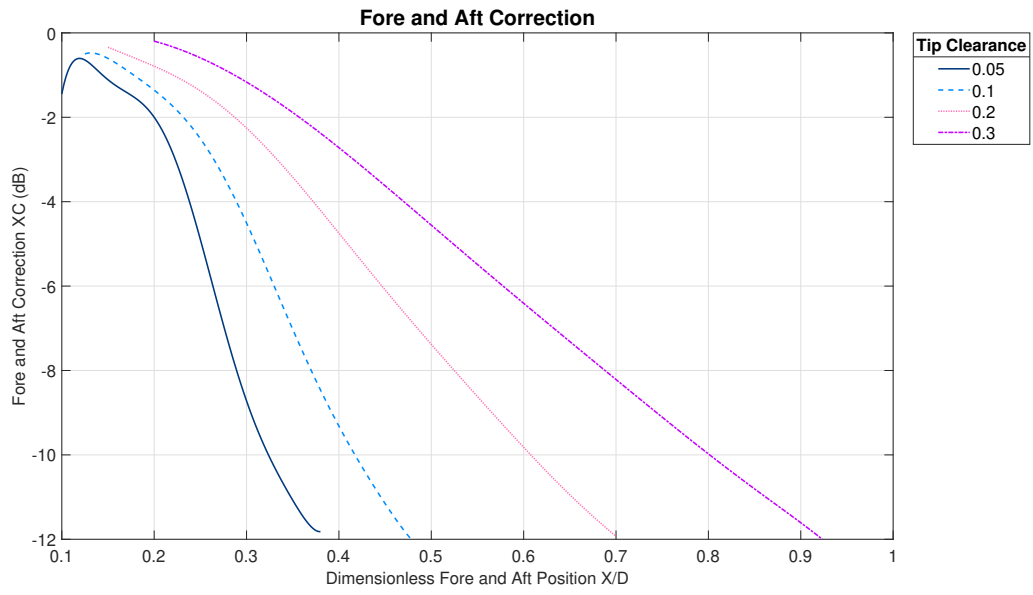


Figure B.14 – Variation of overall, free-space propeller noise levels with axial position X/D fore and aft of propeller plane.

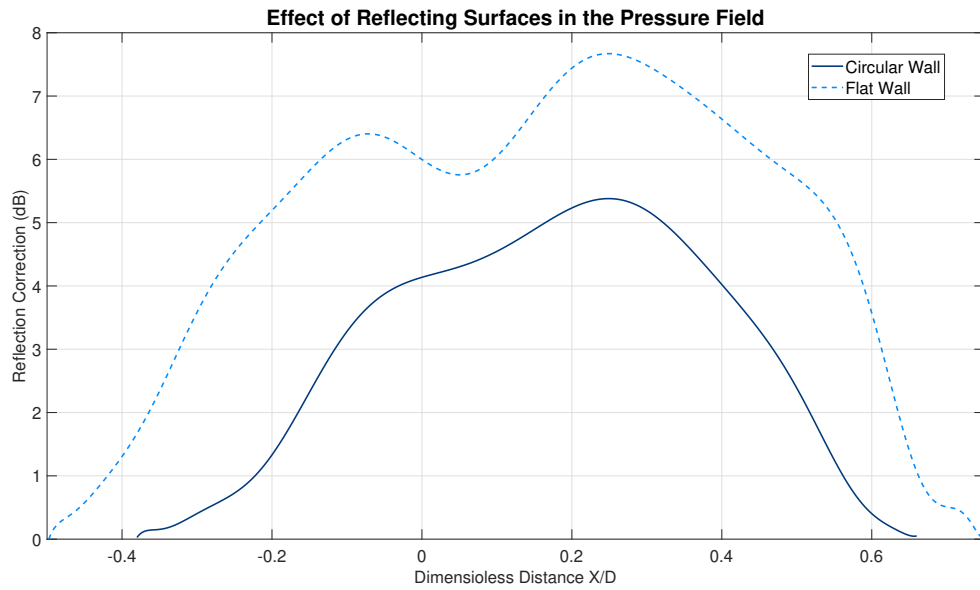


Figure B.15 – Effect of reflecting surfaces in the pressure field.

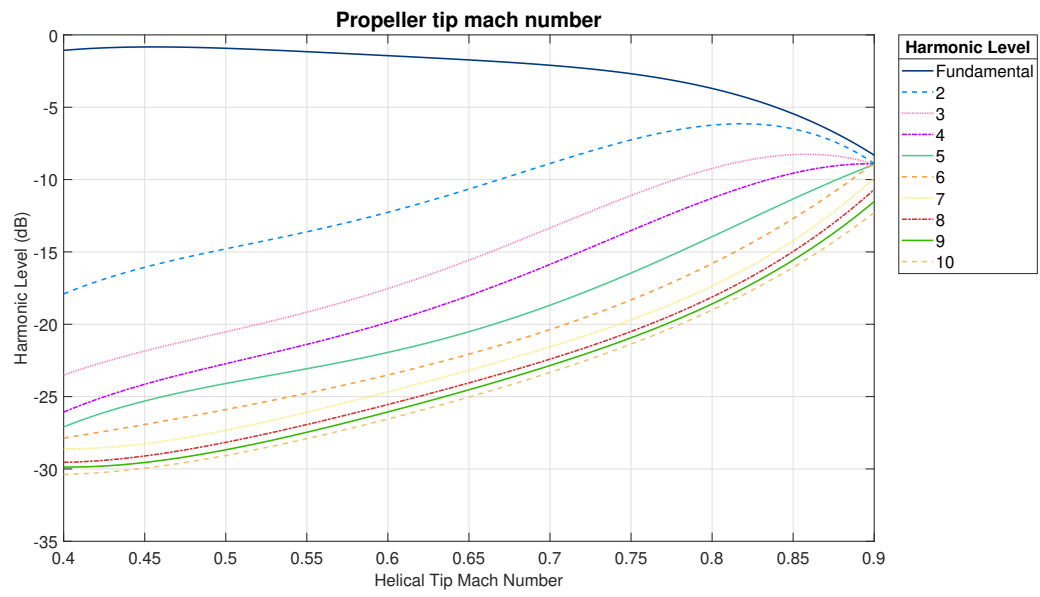


Figure B.16 – Near-field harmonic level distribution.

MATLAB functions developed for implementation of the SAE method

Here are presented all functions created to implement both the far-field and near-field noise prediction methods.

linear_interpolation.m

```

1 %% Linear interpolation function
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the following equation:
5 %  $y = (y_0(x_1 - x) + y_1(x - x_0)) / (x_1 - x_0)$ 
6 %% Input Parameters:
7 % (x0,y0) = coordinates of the first known point
8 % (x1,y1) = coordinates of the second known point
9 % x = x-coordinate of the point where you want to estimate
   the y-value
10 %% Output Parameters:
11 % y = Estimated y-value at point x
12
13 function y = linear_interpolation(x0,y0,x1,y1,x)
14     y = (y0 * (x1 - x) + y1 * (x - x0)) / (x1 - x0);
15     return
16 end

```

SEA_Fig1.m

```

1 %% Function SEA Figure 1
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 1 (RPM to Tip
   Speed conversion)

```

```

5 %% Input Parameters:
6 % PROP_RPM = Propeller rotation per minute
7 % PROP_DIAMETER = Propeller diameter [ft]
8 %% Output Parameters:
9 % ROT_TIP_SPEED = Rotational tip speed [m/s]
10 %To call it: ROT_TIP_SPEED = SEA_Fig1(PROP_RPM,PROP_DIAMETER)
11
12 function ROT_TIP_SPEED = SEA_Fig1(PROP_RPM,PROP_DIAMETER)
13     load("SEA_CurvesFig1.mat");
14     ROT_TIP_SPEED = 0;
15
16     switch PROP_DIAMETER
17         case 6
18             p = [SEA_Curves_Fig1.a(1) SEA_Curves_Fig1.b(1)];
19         case 7
20             p = [SEA_Curves_Fig1.a(2) SEA_Curves_Fig1.b(2)];
21         case 8
22             p = [SEA_Curves_Fig1.a(3) SEA_Curves_Fig1.b(3)];
23         case 9
24             p = [SEA_Curves_Fig1.a(4) SEA_Curves_Fig1.b(4)];
25         case 10
26             p = [SEA_Curves_Fig1.a(5) SEA_Curves_Fig1.b(5)];
27         case 11
28             p = [SEA_Curves_Fig1.a(6) SEA_Curves_Fig1.b(6)];
29         case 12
30             p = [SEA_Curves_Fig1.a(7) SEA_Curves_Fig1.b(7)];
31         case 13
32             p = [SEA_Curves_Fig1.a(8) SEA_Curves_Fig1.b(8)];
33         case 14
34             p = [SEA_Curves_Fig1.a(9) SEA_Curves_Fig1.b(9)];
35         case 15
36             p = [SEA_Curves_Fig1.a(10) SEA_Curves_Fig1.b(10)
37                 ];
38         case 16
39             p = [SEA_Curves_Fig1.a(11) SEA_Curves_Fig1.b(11)
40                 ];
41         case 18
42             p = [SEA_Curves_Fig1.a(12) SEA_Curves_Fig1.b(12)
43                 ];

```

```

41     case 20
42         p = [SEA_Curves_Fig1.a(13) SEA_Curves_Fig1.b(13)
43             ];
44     case 22
45         p = [SEA_Curves_Fig1.a(14) SEA_Curves_Fig1.b(14)
46             ];
47     case 25
48         p = [SEA_Curves_Fig1.a(15) SEA_Curves_Fig1.b(15)
49             ];
50     otherwise
51         if (PROP_DIAMETER > 6 && PROP_DIAMETER < 7)
52             ROT_TIP_SPEED = linear_interpolation(6,
53                 SEA_Fig1(PROP_RPM,6),7,SEA_Fig1(PROP_RPM
54                 ,7),PROP_DIAMETER);
55             return
56         elseif (PROP_DIAMETER > 7 && PROP_DIAMETER < 8)
57             ROT_TIP_SPEED = linear_interpolation(7,
58                 SEA_Fig1(PROP_RPM,7),8,SEA_Fig1(PROP_RPM
59                 ,8),PROP_DIAMETER);
60             return
61         elseif (PROP_DIAMETER > 8 && PROP_DIAMETER < 9)
62             ROT_TIP_SPEED = linear_interpolation(8,
63                 SEA_Fig1(PROP_RPM,8),9,SEA_Fig1(PROP_RPM
64                 ,9),PROP_DIAMETER);
65             return
66         elseif (PROP_DIAMETER > 9 && PROP_DIAMETER < 10)
67             ROT_TIP_SPEED = linear_interpolation(9,
68                 SEA_Fig1(PROP_RPM,9),10,SEA_Fig1(PROP_RPM
69                 ,10),PROP_DIAMETER);
70             return
71         elseif (PROP_DIAMETER > 10 && PROP_DIAMETER < 11)
72             ROT_TIP_SPEED = linear_interpolation(10,
73                 SEA_Fig1(PROP_RPM,10),11,SEA_Fig1(PROP_RPM
74                 ,11),PROP_DIAMETER);
75             return
76         elseif (PROP_DIAMETER > 11 && PROP_DIAMETER < 12)
77             ROT_TIP_SPEED = linear_interpolation(11,
78                 SEA_Fig1(PROP_RPM,11),12,SEA_Fig1(PROP_RPM
79                 ,12),PROP_DIAMETER);

```

```

65         return
66     elseif (PROP_DIAMETER > 12 && PROP_DIAMETER < 13)
67         ROT_TIP_SPEED = linear_interpolation(12,
            SEA_Fig1(PROP_RPM,12),13,SEA_Fig1(PROP_RPM
            ,13),PROP_DIAMETER);
68         return
69     elseif (PROP_DIAMETER > 13 && PROP_DIAMETER < 14)
70         ROT_TIP_SPEED = linear_interpolation(13,
            SEA_Fig1(PROP_RPM,13),14,SEA_Fig1(PROP_RPM
            ,14),PROP_DIAMETER);
71         return
72     elseif (PROP_DIAMETER > 14 && PROP_DIAMETER < 15)
73         ROT_TIP_SPEED = linear_interpolation(14,
            SEA_Fig1(PROP_RPM,14),15,SEA_Fig1(PROP_RPM
            ,15),PROP_DIAMETER);
74         return
75     elseif (PROP_DIAMETER > 15 && PROP_DIAMETER < 16)
76         ROT_TIP_SPEED = linear_interpolation(15,
            SEA_Fig1(PROP_RPM,15),16,SEA_Fig1(PROP_RPM
            ,16),PROP_DIAMETER);
77         return
78     elseif (PROP_DIAMETER > 16 && PROP_DIAMETER < 18)
79         ROT_TIP_SPEED = linear_interpolation(16,
            SEA_Fig1(PROP_RPM,16),18,SEA_Fig1(PROP_RPM
            ,18),PROP_DIAMETER);
80         return
81     elseif (PROP_DIAMETER > 18 && PROP_DIAMETER < 20)
82         ROT_TIP_SPEED = linear_interpolation(18,
            SEA_Fig1(PROP_RPM,18),20,SEA_Fig1(PROP_RPM
            ,20),PROP_DIAMETER);
83         return
84     elseif (PROP_DIAMETER > 20 && PROP_DIAMETER < 22)
85         ROT_TIP_SPEED = linear_interpolation(20,
            SEA_Fig1(PROP_RPM,20),22,SEA_Fig1(PROP_RPM
            ,22),PROP_DIAMETER);
86         return
87     elseif (PROP_DIAMETER > 22 && PROP_DIAMETER < 25)
88         ROT_TIP_SPEED = linear_interpolation(22,
            SEA_Fig1(PROP_RPM,22),25,SEA_Fig1(PROP_RPM

```

```

,25),PROP_DIAMETER);
89     return
90 else
91     disp('Can only calculate for values of
          PROP_DIAMETER between 6 and 25 ft')
92     return
93 end
94 end
95
96 ROT_TIP_SPEED = polyval(p,PROP_RPM);
97 return
98 end

```

SEA_Fig2.m

```

1 %% Function SEA Figure 2
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 2 (Acquire
   Mach Number from Tip Speed)
5 %% Input Parameters:
6 % TEMP = Temperature [F]
7 % TIP_SPEED = Propeller tip speed [ft/sec]
8 %% Output Parameters:
9 % M = Mach number[~]
10 % To call it: M = SEA_Fig2(TIP_SPEED,TEMP)
11
12 function M = SEA_Fig2(TIP_SPEED,TEMP)
13     load("SEA_CurvesFig2.mat")
14     M = 0;
15
16     switch TEMP
17     case -25
18         p = [SEA_Curves_Fig2.a(1) SEA_Curves_Fig2.b(1)];
19     case 0
20         p = [SEA_Curves_Fig2.a(2) SEA_Curves_Fig2.b(2)];
21     case 25
22         p = [SEA_Curves_Fig2.a(3) SEA_Curves_Fig2.b(3)];
23     case 50
24         p = [SEA_Curves_Fig2.a(4) SEA_Curves_Fig2.b(4)];

```

```

25     case 75
26         p = [SEA_Curves_Fig2.a(5) SEA_Curves_Fig2.b(5)];
27     case 100
28         p = [SEA_Curves_Fig2.a(6) SEA_Curves_Fig2.b(6)];
29     case 125
30         p = [SEA_Curves_Fig2.a(7) SEA_Curves_Fig2.b(7)];
31     otherwise
32         if (TEMP > -25 && TEMP < 0)
33             M = linear_interpolation(-25,SEA_Fig2(
34                 TIP_SPEED,-25),0,SEA_Fig2(TIP_SPEED,0),
35                 TEMP);
36             return
37         elseif (TEMP > 0 && TEMP < 25)
38             M = linear_interpolation(0,SEA_Fig2(TIP_SPEED
39                 ,0),25,SEA_Fig2(TIP_SPEED,25),TEMP);
40             return
41         elseif (TEMP > 25 && TEMP < 50)
42             M = linear_interpolation(25,SEA_Fig2(
43                 TIP_SPEED,25),50,SEA_Fig2(TIP_SPEED,50),
44                 TEMP);
45             return
46         elseif (TEMP > 50 && TEMP < 75)
47             M = linear_interpolation(50,SEA_Fig2(
48                 TIP_SPEED,50),75,SEA_Fig2(TIP_SPEED,75),
49                 TEMP);
50             return
51         elseif (TEMP > 75 && TEMP < 100)
52             M = linear_interpolation(75,SEA_Fig2(
53                 TIP_SPEED,75),100,SEA_Fig2(TIP_SPEED,100),
54                 TEMP);
55             return
56         elseif (TEMP > 100 && TEMP < 125)
57             M = linear_interpolation(100,SEA_Fig2(
58                 TIP_SPEED,100),125,SEA_Fig2(TIP_SPEED,125)
59                 ,TEMP);
60             return
61         else
62             disp ("Can only calculate for temperatures
63                 between -25F and 125F")

```

```

52         return
53     end
54
55 end
56
57 M = polyval(p,TIP_SPEED);
58 return
59
60 end

```

SEA_Fig3.m

```

1 %% Function SEA Figure 3
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 3 (Far Field
   Partial Level Based on Power and Tip Speed)
5 %% Input Parameters:
6 % M = Mach number [~]
7 % PROP_INPUT_HP = Propeller input horsepower [HP]
8 %% Output Parameters:
9 % PL_FL1 = Partial Level FL1 [db]
10 % To call it: PL_FL1 = SEA_Fig3(PROP_INPUT_HP,M)
11
12 function PL_FL1 = SEA_Fig3(PROP_INPUT_HP,M)
13     load("SEA_CurvesFig3.mat")
14     PL_FL1 = 0;
15
16     switch M
17     case 0.4
18         p = [SEA_Curves_Fig3.a(1) SEA_Curves_Fig3.b(1)];
19     case 0.5
20         p = [SEA_Curves_Fig3.a(2) SEA_Curves_Fig3.b(2)];
21     case 0.6
22         p = [SEA_Curves_Fig3.a(3) SEA_Curves_Fig3.b(3)];
23     case 0.7
24         p = [SEA_Curves_Fig3.a(4) SEA_Curves_Fig3.b(4)];
25     case 0.8
26         p = [SEA_Curves_Fig3.a(5) SEA_Curves_Fig3.b(5)];
27     case 0.9

```

```

28         p = [SEA_Curves_Fig3.a(6) SEA_Curves_Fig3.b(6)];
29     otherwise
30         if (M > 0.4 && M < 0.5)
31             PL_FL1 = linear_interpolation(0.4,SEA_Fig3(
                 PROP_INPUT_HP,0.4),0.5,SEA_Fig3(
                 PROP_INPUT_HP,0.5),M);
32         return
33     elseif (M > 0.5 && M < 0.6)
34         PL_FL1 = linear_interpolation(0.5,SEA_Fig3(
                 PROP_INPUT_HP,0.5),0.6,SEA_Fig3(
                 PROP_INPUT_HP,0.6),M);
35         return
36     elseif (M > 0.6 && M < 0.7)
37         PL_FL1 = linear_interpolation(0.6,SEA_Fig3(
                 PROP_INPUT_HP,0.6),0.7,SEA_Fig3(
                 PROP_INPUT_HP,0.7),M);
38         return
39     elseif (M > 0.7 && M < 0.8)
40         PL_FL1 = linear_interpolation(0.7,SEA_Fig3(
                 PROP_INPUT_HP,0.7),0.8,SEA_Fig3(
                 PROP_INPUT_HP,0.8),M);
41         return
42     elseif (M > 0.8 && M < 0.9)
43         PL_FL1 = linear_interpolation(0.8,SEA_Fig3(
                 PROP_INPUT_HP,0.8),0.9,SEA_Fig3(
                 PROP_INPUT_HP,0.9),M);
44         return
45     else
46         disp("Can only calculate for values of Mach
                 between 0.4 and 0.9")
47         return
48     end
49
50 end
51
52 PL_FL1 = polyval(p,log10(PROP_INPUT_HP)); %Logarithmic
53     scale
54
55 return

```

55 end

SEA_Fig4.m

```
1 %% Function SEA Figure 4
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 4 (Far Field
   Partial Level Based on Blade Count and Propeller Diameter)
5 %% Input Parameters:
6 % N_OF_BLADES = Number of blades [~]
7 % PROP_DIAMENTER = Propeller diameter [ft]
8 %% Output Parameters:
9 % PL_FL2 = Partial Level FL2 [dB]
10 % To call it: PL_FL2 = SEA_Fig4(PROP_DIAMENTER,N_OF_BLADES)
11
12 function PL_FL2 = SEA_Fig4(PROP_DIAMENTER,N_OF_BLADES)
13     load("SEA_CurvesFig4.mat")
14     PL_FL2 = 0;
15
16     switch N_OF_BLADES
17         case 2
18             p = [SEA_Curves_Fig4.a(1) SEA_Curves_Fig4.b(1)];
19         case 3
20             p = [SEA_Curves_Fig4.a(2) SEA_Curves_Fig4.b(2)];
21         case 4
22             p = [SEA_Curves_Fig4.a(3) SEA_Curves_Fig4.b(3)];
23         case 6
24             p = [SEA_Curves_Fig4.a(4) SEA_Curves_Fig4.b(4)];
25         case 8
26             p = [SEA_Curves_Fig4.a(5) SEA_Curves_Fig4.b(5)];
27         otherwise
28             if (N_OF_BLADES == 5)
29                 PL_FL2 = linear_interpolation(4,PL_FL2(
                    PROP_DIAMENTER,4),6,PL_FL2(PROP_DIAMENTER
                    ,6),N_OF_BLADES);
30                 return
31             elseif (N_OF_BLADES == 7)
32                 PL_FL2 = linear_interpolation(6,PL_FL2(
                    PROP_DIAMENTER,6),8,PL_FL2(PROP_DIAMENTER
```

```

,8),N_OF_BLADES);
33     return
34     else
35         disp ("Can only calculate for integer number
              of blades between 2 and 8")
36     end
37 end
38
39 PL_FL2 = polyval(p,log10(PROP_DIAMETER));
40 return
41 end

```

SEA_Fig5.m

```

1 %% Function SEA Figure 5
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 5 (
    Atmospheric Absorption and Spherical Spreading of Sound)
5 %% Input Parameters:
6 % DIST = Distance from propeller center [ft]
7 % MODE = Which curve to select (1 -> Overall; 2 -> Perceived)
8 %% Output Parameters:
9 % PL_FL3 = Partial Level FL3 [dB]
10 % To call it: PL_FL3 = SEA_Fig5(DIST,MODE)
11
12 function PL_FL3 = SEA_Fig5(DIST,MODE)
13
14     load("SEA_CurvesFig5.mat")
15     switch MODE
16     case 1
17         p = curve_Overall;
18     case 2
19         p = curve_Perceived;
20     otherwise
21         disp("Modes available: 1 -> Overall; 2 ->
              Perceived")
22     return
23 end
24

```

```
25     PL_FL3 = polyval(p,log10(DIST));
26 end
```

SEA_Fig6.m

```
1 %% Function SEA Figure 6
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 6 (Directivity
   Index)
5 %% Input Parameters:
6 % AZIMUTH = Azimuth Angle [degrees]
7 %% Output Parameters:
8 % DI = Directivity Index [dB]
9 % To call it: DI = SEA_Fig6(AZIMUTH)
10
11 function DI = SEA_Fig6(AZIMUTH)
12
13     if (AZIMUTH > 180)
14         AZIMUTH = 360 - AZIMUTH;
15     end
16
17     load("SEA_CurvesFig6.mat")
18     p = curve_Azimuth;
19     DI = polyval(p,AZIMUTH);
20 end
```

SEA_Fig7.m

```
1 %% Function SEA Figure 7
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 7 (Perceived
   Noise Level Adjustment - 2 Bladed Propellers)
5 %% Input Parametes:
6 % PROP_DIAMETER = Propeller Diameter [ft]
7 % MACH = Helical Tip Mach Number [~]
8 % OASPL = Overall Sound Pressure Level [dB]
9 %% Output Parameters:
10 % PNL = Perceived Noise Level [PNdB]
11 % To call it: PNL = SEA_Fig7(PROP_DIAMETER,MACH,OASPL)
```

```

12
13 function PNL = SEA_Fig7(PROP_DIAMETER,MACH,OASPL)
14
15     load("SEA_CurvesFig7.mat")
16     PNL = 0;
17
18     switch MACH
19         case 0.5
20             p = [SEA_Curves_Fig7.a(1),SEA_Curves_Fig7.b(1),
21                 SEA_Curves_Fig7.c(1), ...
22                 SEA_Curves_Fig7.d(1),SEA_Curves_Fig7.e(1),
23                 SEA_Curves_Fig7.f(1), ...
24                 SEA_Curves_Fig7.g(1)];
25         case 0.6
26             p = [SEA_Curves_Fig7.a(2),SEA_Curves_Fig7.b(2),
27                 SEA_Curves_Fig7.c(2), ...
28                 SEA_Curves_Fig7.d(2),SEA_Curves_Fig7.e(2),
29                 SEA_Curves_Fig7.f(2), ...
30                 SEA_Curves_Fig7.g(2)];
31         case 0.7
32             p = [SEA_Curves_Fig7.a(3),SEA_Curves_Fig7.b(3),
33                 SEA_Curves_Fig7.c(3), ...
34                 SEA_Curves_Fig7.d(3),SEA_Curves_Fig7.e(3),
35                 SEA_Curves_Fig7.f(3), ...
36                 SEA_Curves_Fig7.g(3)];
37         case 0.8
38             p = [SEA_Curves_Fig7.a(4),SEA_Curves_Fig7.b(4),
39                 SEA_Curves_Fig7.c(4), ...
40                 SEA_Curves_Fig7.d(4),SEA_Curves_Fig7.e(4),
41                 SEA_Curves_Fig7.f(4), ...
42                 SEA_Curves_Fig7.g(4)];
43         case 0.85
44             p = [SEA_Curves_Fig7.a(5),SEA_Curves_Fig7.b(5),
45                 SEA_Curves_Fig7.c(5), ...
46                 SEA_Curves_Fig7.d(5),SEA_Curves_Fig7.e(5),
47                 SEA_Curves_Fig7.f(5), ...
48                 SEA_Curves_Fig7.g(5)];
49         case 0.9
50             p = [SEA_Curves_Fig7.a(6),SEA_Curves_Fig7.b(6),

```

```

SEA_Curves_Fig7.c(6), ...
41     SEA_Curves_Fig7.d(6),SEA_Curves_Fig7.e(6),
        SEA_Curves_Fig7.f(6), ...
42     SEA_Curves_Fig7.g(6)];
43 otherwise
44     if (MACH > 0.5 && MACH < 0.6)
45         PNL = linear_interpolation(0.5,SEA_Fig7(
            PROP_DIAMETER,0.5,OASPL),0.6,SEA_Fig7(
            PROP_DIAMETER,0.6,OASPL),MACH);
46         return
47     elseif (MACH > 0.6 && MACH < 0.7)
48         PNL = linear_interpolation(0.6,SEA_Fig7(
            PROP_DIAMETER,0.6,OASPL),0.7,SEA_Fig7(
            PROP_DIAMETER,0.7,OASPL),MACH);
49         return
50     elseif (MACH > 0.7 && MACH < 0.8)
51         PNL = linear_interpolation(0.7,SEA_Fig7(
            PROP_DIAMETER,0.7,OASPL),0.8,SEA_Fig7(
            PROP_DIAMETER,0.8,OASPL),MACH);
52         return
53     elseif (MACH > 0.8 && MACH < 0.85)
54         PNL = linear_interpolation(0.8,SEA_Fig7(
            PROP_DIAMETER,0.8,OASPL),0.85,SEA_Fig7(
            PROP_DIAMETER,0.85,OASPL),MACH);
55         return
56     elseif (MACH > 0.85 && MACH < 0.9)
57         PNL = linear_interpolation(0.85,SEA_Fig7(
            PROP_DIAMETER,0.85,OASPL),0.9,SEA_Fig7(
            PROP_DIAMETER,0.9,OASPL),MACH);
58         return
59     else
60         disp("Can only calculate for helical tip mach
            number between 0.5 and 0.9")
61         return
62     end
63 end
64
65 PNL = OASPL + polyval(p,PROP_DIAMETER);
66

```

67 `end`

SEA_Fig8.m

```
1 %% Function SEA Figure 8
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 8 (Perceived
   Noise Level Adjustment - 3 Bladed Propellers)
5 %% Input Parameters:
6 % PROP_DIAMETER = Propeller Diameter [ft]
7 % MACH = Helical Tip Mach Number [~]
8 % OASPL = Overall Sound Pressure Level [dB]
9 %% Output Parameters:
10 % PNL = Perceived Noise Level [PNdB]
11 % To call it: PNL = SEA_Fig8(PROP_DIAMETER,MACH,OASPL)
12
13 function PNL = SEA_Fig8(PROP_DIAMETER,MACH,OASPL)
14
15     load("SEA_CurvesFig8.mat")
16     PNL = 0;
17
18     switch MACH
19         case 0.5
20             p = [SEA_Curves_Fig8.a(1),SEA_Curves_Fig8.b(1),
21                 SEA_Curves_Fig8.c(1), ...
22                 SEA_Curves_Fig8.d(1),SEA_Curves_Fig8.e(1),
23                 SEA_Curves_Fig8.f(1), ...
24                 SEA_Curves_Fig8.g(1)];
25         case 0.6
26             p = [SEA_Curves_Fig8.a(2),SEA_Curves_Fig8.b(2),
27                 SEA_Curves_Fig8.c(2), ...
28                 SEA_Curves_Fig8.d(2),SEA_Curves_Fig8.e(2),
29                 SEA_Curves_Fig8.f(2), ...
30                 SEA_Curves_Fig8.g(2)];
31         case 0.7
32             p = [SEA_Curves_Fig8.a(3),SEA_Curves_Fig8.b(3),
33                 SEA_Curves_Fig8.c(3), ...
34                 SEA_Curves_Fig8.d(3),SEA_Curves_Fig8.e(3),
35                 SEA_Curves_Fig8.f(3), ...
```

```

30         SEA_Curves_Fig8.g(3)];
31     case 0.8
32         p = [SEA_Curves_Fig8.a(4),SEA_Curves_Fig8.b(4),
33             SEA_Curves_Fig8.c(4), ...
34             SEA_Curves_Fig8.d(4),SEA_Curves_Fig8.e(4),
35             SEA_Curves_Fig8.f(4), ...
36             SEA_Curves_Fig8.g(4)];
37     case 0.85
38         p = [SEA_Curves_Fig8.a(5),SEA_Curves_Fig8.b(5),
39             SEA_Curves_Fig8.c(5), ...
40             SEA_Curves_Fig8.d(5),SEA_Curves_Fig8.e(5),
41             SEA_Curves_Fig8.f(5), ...
42             SEA_Curves_Fig8.g(5)];
43     case 0.9
44         p = [SEA_Curves_Fig8.a(6),SEA_Curves_Fig8.b(6),
45             SEA_Curves_Fig8.c(6), ...
46             SEA_Curves_Fig8.d(6),SEA_Curves_Fig8.e(6),
47             SEA_Curves_Fig8.f(6), ...
48             SEA_Curves_Fig8.g(6)];
49     otherwise
50         if (MACH > 0.5 && MACH < 0.6)
51             PNL = linear_interpolation(0.5,SEA_Fig8(
52                 PROP_DIAMETER,0.5,OASPL),0.6,SEA_Fig8(
53                 PROP_DIAMETER,0.6,OASPL),MACH);
54             return
55         elseif (MACH > 0.6 && MACH < 0.7)
56             PNL = linear_interpolation(0.6,SEA_Fig8(
57                 PROP_DIAMETER,0.6,OASPL),0.7,SEA_Fig8(
58                 PROP_DIAMETER,0.7,OASPL),MACH);
59             return
60         elseif (MACH > 0.7 && MACH < 0.8)
61             PNL = linear_interpolation(0.7,SEA_Fig8(
62                 PROP_DIAMETER,0.7,OASPL),0.8,SEA_Fig8(
63                 PROP_DIAMETER,0.8,OASPL),MACH);
64             return
65         elseif (MACH > 0.8 && MACH < 0.85)
66             PNL = linear_interpolation(0.8,SEA_Fig8(
67                 PROP_DIAMETER,0.8,OASPL),0.85,SEA_Fig8(
68                 PROP_DIAMETER,0.85,OASPL),MACH);

```

```

55         return
56     elseif (MACH > 0.85 && MACH < 0.9)
57         PNL = linear_interpolation(0.85,SEA_Fig8(
            PROP_DIAMETER,0.85,OASPL),0.9,SEA_Fig8(
            PROP_DIAMETER,0.9,OASPL),MACH);
58         return
59     else
60         disp("Can only calculate for helical tip mach
            number between 0.5 and 0.9")
61         return
62     end
63 end
64
65 PNL = OASPL + polyval(p,PROP_DIAMETER);
66
67 end

```

SEA_Fig9.m

```

1  %% Function SEA Figure 9
2  % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3  %% Description:
4  % Implements the graph contained within Figure 9 (Perceived
    Noise Level Adjustment - 4 Bladed Propellers)
5  %% Input Parameters:
6  % PROP_DIAMETER = Propeller Diameter [ft]
7  % MACH = Helical Tip Mach Number [~]
8  % OASPL = Overall Sound Pressure Level [dB]
9  %% Output Parameters:
10 % PNL = Perceived Noise Level [PNdB]
11 % To call it: PNL = SEA_Fig9(PROP_DIAMETER,MACH,OASPL)
12
13 function PNL = SEA_Fig9(PROP_DIAMETER,MACH,OASPL)
14
15     load("SEA_CurvesFig9.mat")
16     PNL = 0;
17
18     switch MACH
19         case 0.5
20             p = [SEA_Curves_Fig9.a(1),SEA_Curves_Fig9.b(1),

```

```

21         SEA_Curves_Fig9.c(1), ...
22         SEA_Curves_Fig9.d(1),SEA_Curves_Fig9.e(1),
23         SEA_Curves_Fig9.f(1), ...
24         SEA_Curves_Fig9.g(1)];
25 case 0.6
26     p = [SEA_Curves_Fig9.a(2),SEA_Curves_Fig9.b(2),
27         SEA_Curves_Fig9.c(2), ...
28         SEA_Curves_Fig9.d(2),SEA_Curves_Fig9.e(2),
29         SEA_Curves_Fig9.f(2), ...
30         SEA_Curves_Fig9.g(2)];
31 case 0.7
32     p = [SEA_Curves_Fig9.a(3),SEA_Curves_Fig9.b(3),
33         SEA_Curves_Fig9.c(3), ...
34         SEA_Curves_Fig9.d(3),SEA_Curves_Fig9.e(3),
35         SEA_Curves_Fig9.f(3), ...
36         SEA_Curves_Fig9.g(3)];
37 case 0.8
38     p = [SEA_Curves_Fig9.a(4),SEA_Curves_Fig9.b(4),
39         SEA_Curves_Fig9.c(4), ...
40         SEA_Curves_Fig9.d(4),SEA_Curves_Fig9.e(4),
41         SEA_Curves_Fig9.f(4), ...
42         SEA_Curves_Fig9.g(4)];
43 case 0.85
44     p = [SEA_Curves_Fig9.a(5),SEA_Curves_Fig9.b(5),
45         SEA_Curves_Fig9.c(5), ...
46         SEA_Curves_Fig9.d(5),SEA_Curves_Fig9.e(5),
47         SEA_Curves_Fig9.f(5), ...
48         SEA_Curves_Fig9.g(5)];
49 case 0.9
50     p = [SEA_Curves_Fig9.a(6),SEA_Curves_Fig9.b(6),
51         SEA_Curves_Fig9.c(6), ...
52         SEA_Curves_Fig9.d(6),SEA_Curves_Fig9.e(6),
53         SEA_Curves_Fig9.f(6), ...
54         SEA_Curves_Fig9.g(6)];
55 otherwise
56     if (MACH > 0.5 && MACH < 0.6)
57         PNL = linear_interpolation(0.5,SEA_Fig9(
58             PROP_DIAMETER,0.5,OASPL),0.6,SEA_Fig9(
59             PROP_DIAMETER,0.6,OASPL),MACH);

```

```

46         return
47     elseif (MACH > 0.6 && MACH < 0.7)
48         PNL = linear_interpolation(0.6,SEA_Fig9(
            PROP_DIAMETER,0.6,OASPL),0.7,SEA_Fig9(
            PROP_DIAMETER,0.7,OASPL),MACH);
49         return
50     elseif (MACH > 0.7 && MACH < 0.8)
51         PNL = linear_interpolation(0.7,SEA_Fig9(
            PROP_DIAMETER,0.7,OASPL),0.8,SEA_Fig9(
            PROP_DIAMETER,0.8,OASPL),MACH);
52         return
53     elseif (MACH > 0.8 && MACH < 0.85)
54         PNL = linear_interpolation(0.8,SEA_Fig9(
            PROP_DIAMETER,0.8,OASPL),0.85,SEA_Fig9(
            PROP_DIAMETER,0.85,OASPL),MACH);
55         return
56     elseif (MACH > 0.85 && MACH < 0.9)
57         PNL = linear_interpolation(0.85,SEA_Fig9(
            PROP_DIAMETER,0.85,OASPL),0.9,SEA_Fig9(
            PROP_DIAMETER,0.9,OASPL),MACH);
58         return
59     else
60         disp("Can only calculate for helical tip mach
            number between 0.5 and 0.9")
61         return
62     end
63 end
64
65 PNL = OASPL + polyval(p,PROP_DIAMETER);
66
67 end

```

SEA_Fig10.m

```

1 %% Function SEA Figure 10
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 10 (Perceived
    Noise Level Adjustment - 6 and 8 Bladed Propellers)
5 %% Input Parameters:

```

```

6  % PROP_DIAMETER = Propeller Diameter [ft]
7  % MACH = Helical Tip Mach Number [~]
8  % OASPL = Overall Sound Pressure Level [dB]
9  %% Output Parameters:
10 % PNL = Perceived Noise Level [PNdB]
11 % To call it: PNL = SEA_Fig10(PROP_DIAMETER,MACH,OASPL)
12
13 function PNL = SEA_Fig10(PROP_DIAMETER,MACH,OASPL)
14
15     load("SEA_CurvesFig10.mat")
16     PNL = 0;
17
18     switch MACH
19         case 0.5
20             p = [SEA_Curves_Fig10.a(1),SEA_Curves_Fig10.b(1),
21                 SEA_Curves_Fig10.c(1), ...
22                 SEA_Curves_Fig10.d(1),SEA_Curves_Fig10.e(1),
23                 SEA_Curves_Fig10.f(1), ...
24                 SEA_Curves_Fig10.g(1)];
25         case 0.6
26             p = [SEA_Curves_Fig10.a(2),SEA_Curves_Fig10.b(2),
27                 SEA_Curves_Fig10.c(2), ...
28                 SEA_Curves_Fig10.d(2),SEA_Curves_Fig10.e(2),
29                 SEA_Curves_Fig10.f(2), ...
30                 SEA_Curves_Fig10.g(2)];
31         case 0.7
32             p = [SEA_Curves_Fig10.a(3),SEA_Curves_Fig10.b(3),
33                 SEA_Curves_Fig10.c(3), ...
34                 SEA_Curves_Fig10.d(3),SEA_Curves_Fig10.e(3),
35                 SEA_Curves_Fig10.f(3), ...
36                 SEA_Curves_Fig10.g(3)];
37         case 0.8
38             p = [SEA_Curves_Fig10.a(4),SEA_Curves_Fig10.b(4),
39                 SEA_Curves_Fig10.c(4), ...
40                 SEA_Curves_Fig10.d(4),SEA_Curves_Fig10.e(4),
41                 SEA_Curves_Fig10.f(4), ...
42                 SEA_Curves_Fig10.g(4)];
43         case 0.85
44             p = [SEA_Curves_Fig10.a(5),SEA_Curves_Fig10.b(5),

```

```

37         SEA_Curves_Fig10.c(5), ...
38         SEA_Curves_Fig10.d(5),SEA_Curves_Fig10.e(5),
39         SEA_Curves_Fig10.f(5), ...
40         SEA_Curves_Fig10.g(5)];
41     case 0.9
42         p = [SEA_Curves_Fig10.a(6),SEA_Curves_Fig10.b(6),
43             SEA_Curves_Fig10.c(6), ...
44             SEA_Curves_Fig10.d(6),SEA_Curves_Fig10.e(6),
45             SEA_Curves_Fig10.f(6), ...
46             SEA_Curves_Fig10.g(6)];
47     otherwise
48         if (MACH > 0.5 && MACH < 0.6)
49             PNL = linear_interpolation(0.5,SEA_Fig10(
50                 PROP_DIAMETER,0.5,OASPL),0.6,SEA_Fig10(
51                 PROP_DIAMETER,0.6,OASPL),MACH);
52             return
53         elseif (MACH > 0.6 && MACH < 0.7)
54             PNL = linear_interpolation(0.6,SEA_Fig10(
55                 PROP_DIAMETER,0.6,OASPL),0.7,SEA_Fig10(
56                 PROP_DIAMETER,0.7,OASPL),MACH);
57             return
58         elseif (MACH > 0.7 && MACH < 0.8)
59             PNL = linear_interpolation(0.7,SEA_Fig10(
60                 PROP_DIAMETER,0.7,OASPL),0.8,SEA_Fig10(
61                 PROP_DIAMETER,0.8,OASPL),MACH);
62             return
63         elseif (MACH > 0.8 && MACH < 0.85)
64             PNL = linear_interpolation(0.8,SEA_Fig10(
65                 PROP_DIAMETER,0.8,OASPL),0.85,SEA_Fig10(
66                 PROP_DIAMETER,0.85,OASPL),MACH);
67             return
68         elseif (MACH > 0.85 && MACH < 0.9)
69             PNL = linear_interpolation(0.85,SEA_Fig10(
70                 PROP_DIAMETER,0.85,OASPL),0.9,SEA_Fig10(
71                 PROP_DIAMETER,0.9,OASPL),MACH);
72             return
73         else
74             disp("Can only calculate for helical tip mach
75                 number between 0.5 and 0.9")

```

```

61         return
62     end
63 end
64
65     PNL = OASPL + polyval(p,PROP_DIAMETER);
66
67 end

```

SEA_Fig11.m

```

1  %% Function SEA Figure 11
2  % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3  %% Description:
4  % Implements the graph contained within Figure 11 (Propeller
   Helical Tip Speed)
5  %% Input Parameters:
6  % AIRCRAFT_FWD_SPEED = Aircraft Forward Speed [knots]
7  % ROT_TIP_SPEED = Rotational Tip Speed [ft/s]
8  %% Output Parameters:
9  % HELICAL_TIP_SPEED = Helical Tip Speed [ft/s]
10 % To call it: HELICAL_TIP_SPEED =
11 % SEA_Fig11(AIRCRAFT_FWD_SPEED,ROT_TIP_SPEED)
12
13 function HELICAL_TIP_SPEED = SEA_Fig11(AIRCRAFT_FWD_SPEED,
   ROT_TIP_SPEED)
14
15     load("SEA_CurvesFig11.mat")
16     HELICAL_TIP_SPEED = 0;
17
18     switch ROT_TIP_SPEED
19         case 400
20             p = [SEA_Curves_Fig11.a(1) SEA_Curves_Fig11.b(1)
   SEA_Curves_Fig11.c(1)];
21         case 500
22             p = [SEA_Curves_Fig11.a(2) SEA_Curves_Fig11.b(2)
   SEA_Curves_Fig11.c(2)];
23         case 600
24             p = [SEA_Curves_Fig11.a(3) SEA_Curves_Fig11.b(3)
   SEA_Curves_Fig11.c(3)];
25         case 700

```

```

26         p = [SEA_Curves_Fig11.a(4) SEA_Curves_Fig11.b(4)
27              SEA_Curves_Fig11.c(4)];
28     case 800
29         p = [SEA_Curves_Fig11.a(5) SEA_Curves_Fig11.b(5)
30              SEA_Curves_Fig11.c(5)];
31     case 900
32         p = [SEA_Curves_Fig11.a(6) SEA_Curves_Fig11.b(6)
33              SEA_Curves_Fig11.c(6)];
34     case 1000
35         p = [SEA_Curves_Fig11.a(7) SEA_Curves_Fig11.b(7)
36              SEA_Curves_Fig11.c(7)];
37     otherwise
38         if (ROT_TIP_SPEED > 400 && ROT_TIP_SPEED < 500)
39             HELICAL_TIP_SPEED = linear_interpolation(400,
40                 SEA_Fig11(AIRCRAFT_FWD_SPEED,400),500,
41                 SEA_Fig11(AIRCRAFT_FWD_SPEED,500),
42                 ROT_TIP_SPEED);
43         return
44     elseif (ROT_TIP_SPEED > 500 && ROT_TIP_SPEED <
45             600)
46         HELICAL_TIP_SPEED = linear_interpolation(500,
47             SEA_Fig11(AIRCRAFT_FWD_SPEED,500),600,
48             SEA_Fig11(AIRCRAFT_FWD_SPEED,600),
49             ROT_TIP_SPEED);
50         return
51     elseif (ROT_TIP_SPEED > 600 && ROT_TIP_SPEED <
52             700)
53         HELICAL_TIP_SPEED = linear_interpolation(600,
54             SEA_Fig11(AIRCRAFT_FWD_SPEED,600),700,
55             SEA_Fig11(AIRCRAFT_FWD_SPEED,700),
56             ROT_TIP_SPEED);
57         return
58     elseif (ROT_TIP_SPEED > 700 && ROT_TIP_SPEED <
59             800)
60         HELICAL_TIP_SPEED = linear_interpolation(700,
61             SEA_Fig11(AIRCRAFT_FWD_SPEED,700),800,
62             SEA_Fig11(AIRCRAFT_FWD_SPEED,800),
63             ROT_TIP_SPEED);
64         return

```

```

46         elseif (ROT_TIP_SPEED > 800 && ROT_TIP_SPEED <
47             900)
48             HELICAL_TIP_SPEED = linear_interpolation(800,
49                 SEA_Fig11(AIRCRAFT_FWD_SPEED,800),900,
50                 SEA_Fig11(AIRCRAFT_FWD_SPEED,900),
51                 ROT_TIP_SPEED);
52             return
53         elseif (ROT_TIP_SPEED > 900 && ROT_TIP_SPEED <
54             1000)
55             HELICAL_TIP_SPEED = linear_interpolation(900,
56                 SEA_Fig11(AIRCRAFT_FWD_SPEED,900),1000,
57                 SEA_Fig11(AIRCRAFT_FWD_SPEED,1000),
58                 ROT_TIP_SPEED);
59             return
60         else
61             disp("Can only calculate for rotational speed
62                 between 400 ft/s and 1000 ft/s")
63             return
64         end
65     end
66     HELICAL_TIP_SPEED = polyval(p,AIRCRAFT_FWD_SPEED);
67 end

```

SEA_Fig12.m

```

1  %% Function SEA Figure 12
2  % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3  %% Description
4  % Implements the graph contained within Figure 12 (Near Field
5  % Partial Level Based on Power and Diameter)
6  %% Input Parameters:
7  % POWER = Power [HP]
8  % PROP_DIAMETER = Propeller diameter [ft]
9  %% Output Parameters:
10 % PL_NL1 = Partial level NL1 [dB]
11 %To call it: PL_NL1 = SEA_Fig12(PROP_RPM,PROP_DIAMETER)
12 function PL_NL1 = SEA_Fig12(POWER,PROP_DIAMETER)

```

```

13     load("SEA_CurvesFig12.mat")
14     PL_NL1 = 0;
15
16     switch PROP_DIAMETER
17     case 6
18         p = [SEA_Curves_Fig12.a(1) SEA_Curves_Fig12.b(1)
19             ];
19     case 7
20         p = [SEA_Curves_Fig12.a(2) SEA_Curves_Fig12.b(2)
21             ];
21     case 8
22         p = [SEA_Curves_Fig12.a(3) SEA_Curves_Fig12.b(3)
23             ];
23     case 10
24         p = [SEA_Curves_Fig12.a(4) SEA_Curves_Fig12.b(4)
25             ];
25     case 12
26         p = [SEA_Curves_Fig12.a(5) SEA_Curves_Fig12.b(5)
27             ];
27     case 14
28         p = [SEA_Curves_Fig12.a(6) SEA_Curves_Fig12.b(6)
29             ];
29     case 16
30         p = [SEA_Curves_Fig12.a(7) SEA_Curves_Fig12.b(7)
31             ];
31     case 20
32         p = [SEA_Curves_Fig12.a(8) SEA_Curves_Fig12.b(8)
33             ];
33     case 25
34         p = [SEA_Curves_Fig12.a(9) SEA_Curves_Fig12.b(9)
35             ];
35     otherwise
36         if (PROP_DIAMETER > 6 && PROP_DIAMETER < 7)
37             PL_NL1 = linear_interpolation(6,SEA_Fig12(
38                 POWER,6),7,SEA_Fig12(POWER,7),
39                 PROP_DIAMETER);
38         return
39     elseif (PROP_DIAMETER > 7 && PROP_DIAMETER < 8)
40         PL_NL1 = linear_interpolation(7,SEA_Fig12(

```

```

        POWER,7),8,SEA_Fig12(POWER,8),
        PROP_DIAMETER);
41     return
42 elseif (PROP_DIAMETER > 8 && PROP_DIAMETER < 10)
43     PL_NL1 = linear_interpolation(8,SEA_Fig12(
        POWER,8),10,SEA_Fig12(POWER,10),
        PROP_DIAMETER);
44     return
45 elseif (PROP_DIAMETER > 10 && PROP_DIAMETER < 12)
46     PL_NL1 = linear_interpolation(10,SEA_Fig12(
        POWER,10),12,SEA_Fig12(POWER,12),
        PROP_DIAMETER);
47     return
48 elseif (PROP_DIAMETER > 12 && PROP_DIAMETER < 14)
49     PL_NL1 = linear_interpolation(12,SEA_Fig12(
        POWER,12),14,SEA_Fig12(POWER,14),
        PROP_DIAMETER);
50     return
51 elseif (PROP_DIAMETER > 14 && PROP_DIAMETER < 16)
52     PL_NL1 = linear_interpolation(14,SEA_Fig12(
        POWER,14),16,SEA_Fig12(POWER,16),
        PROP_DIAMETER);
53     return
54 elseif (PROP_DIAMETER > 16 && PROP_DIAMETER < 20)
55     PL_NL1 = linear_interpolation(16,SEA_Fig12(
        POWER,16),20,SEA_Fig12(POWER,20),
        PROP_DIAMETER);
56     return
57 elseif (PROP_DIAMETER > 20 && PROP_DIAMETER < 25)
58     PL_NL1 = linear_interpolation(20,SEA_Fig12(
        POWER,20),25,SEA_Fig12(POWER,25),
        PROP_DIAMETER);
59     return
60 else
61     disp("Can only calculate for propeller
        diameters between 6 and 25 ft")
62     return
63 end
64 end

```

```

65
66     PL_NL1 = polyval(p,log10(POWER));
67 end

```

SEA_Fig13.m

```

1  %% Function SEA Figure 13
2  % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3  %% Description:
4  % Implements the graph contained within Figure 13 (Near Field
   Partial Level Based on Tip Speed and Tip Clearance)
5  %% Input Parameters:
6  % ROT_TIP_MACH = Rotational tip Mach (tip speed) [~]
7  % TIP_CLEARANCE = Radial distance over diameter (Y/D) [~]
8  %% Output Parameters:
9  % PL_NL2 = Partial level NL2 [dB]
10 %To call it: PL_NL2 = SEA_Fig13(TIP_CLEARANCE,ROT_TIP_MACH)
11
12 function PL_NL2 = SEA_Fig13(TIP_CLEARANCE,ROT_TIP_MACH)
13     load("SEA_CurvesFig13.mat")
14     PL_NL2 = 0;
15
16     switch ROT_TIP_MACH
17     case 0.4
18         p = [SEA_Curves_Fig13.a(1) SEA_Curves_Fig13.b(1)
19             ];
19     case 0.5
20         p = [SEA_Curves_Fig13.a(2) SEA_Curves_Fig13.b(2)
21             ];
21     case 0.6
22         p = [SEA_Curves_Fig13.a(3) SEA_Curves_Fig13.b(3)
23             ];
23     case 0.7
24         p = [SEA_Curves_Fig13.a(4) SEA_Curves_Fig13.b(4)
25             ];
25     case 0.8
26         p = [SEA_Curves_Fig13.a(5) SEA_Curves_Fig13.b(5)
27             ];
27     case 0.9
28         p = [SEA_Curves_Fig13.a(6) SEA_Curves_Fig13.b(6)

```

```

];
29     otherwise
30         if (ROT_TIP_MACH > 0.4 && ROT_TIP_MACH < 0.5)
31             PL_NL2 = linear_interpolation(0.4,SEA_Fig13(
                TIP_CLEARANCE,0.4),0.5,SEA_Fig13(
                TIP_CLEARANCE,0.5),ROT_TIP_MACH);
32             return
33         elseif (ROT_TIP_MACH > 0.5 && ROT_TIP_MACH < 0.6)
34             PL_NL2 = linear_interpolation(0.5,SEA_Fig13(
                TIP_CLEARANCE,0.5),0.6,SEA_Fig13(
                TIP_CLEARANCE,0.6),ROT_TIP_MACH);
35             return
36         elseif (ROT_TIP_MACH > 0.6 && ROT_TIP_MACH < 0.7)
37             PL_NL2 = linear_interpolation(0.6,SEA_Fig13(
                TIP_CLEARANCE,0.6),0.7,SEA_Fig13(
                TIP_CLEARANCE,0.7),ROT_TIP_MACH);
38             return
39         elseif (ROT_TIP_MACH > 0.7 && ROT_TIP_MACH < 0.8)
40             PL_NL2 = linear_interpolation(0.7,SEA_Fig13(
                TIP_CLEARANCE,0.7),0.8,SEA_Fig13(
                TIP_CLEARANCE,0.8),ROT_TIP_MACH);
41             return
42         elseif (ROT_TIP_MACH > 0.8 && ROT_TIP_MACH < 0.9)
43             PL_NL2 = linear_interpolation(0.8,SEA_Fig13(
                TIP_CLEARANCE,0.8),0.9,SEA_Fig13(
                TIP_CLEARANCE,0.9),ROT_TIP_MACH);
44             return
45         else
46             disp("Can only calculate for Mach values
                between 0.4 and 0.9")
47             return
48         end
49     end
50
51     PL_NL2 = polyval(p,log10(TIP_CLEARANCE));
52
53 end

```

```

1 %% Function SEA Figure 14
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 14 (Variation
5 % of overall, free-space propeller noise levels with
6 % axial position X/D fore and aft of propeller plane)
7 %% Input Parameters:
8 % FORE_AFT_POSITION = Axial position X/D Fore and Aft of
9 % propeller plane [~]
10 % TIP_CLEARANCE = Radial distance over diameter (Y/D) [~]
11 %% Output Parameters:
12 % XC = Fore and aft correction [dB]
13 %To call it: XC = SEA_Fig14(FORE_AFT_POSITION,TIP_CLEARANCE)
14
15 function XC = SEA_Fig14(FORE_AFT_POSITION,TIP_CLEARANCE)
16     load("SEA_CurvesFig14.mat")
17     XC = 0;
18
19     switch TIP_CLEARANCE
20     case 0.05
21         p = [SEA_Curves_Fig14.a(1),SEA_Curves_Fig14.b(1),
22             SEA_Curves_Fig14.c(1), ...
23             SEA_Curves_Fig14.d(1),SEA_Curves_Fig14.e(1),
24             SEA_Curves_Fig14.f(1), ...
25             SEA_Curves_Fig14.g(1),SEA_Curves_Fig14.h(1),
26             SEA_Curves_Fig14.i(1)];
27
28         if (FORE_AFT_POSITION < 0.1)
29             XC = 0;
30             return
31         elseif (FORE_AFT_POSITION > 0.4)
32             XC = -12;
33             return
34         end
35     case 0.1
36         p = [SEA_Curves_Fig14.a(2),SEA_Curves_Fig14.b(2),
37             SEA_Curves_Fig14.c(2), ...
38             SEA_Curves_Fig14.d(2),SEA_Curves_Fig14.e(2),

```

```

33         SEA_Curves_Fig14.f(2), ...
34         SEA_Curves_Fig14.g(2),SEA_Curves_Fig14.h(2),
35         SEA_Curves_Fig14.i(2)];
36
37     if (FORE_AFT_POSITION < 0.125)
38         XC = 0;
39         return
40     elseif (FORE_AFT_POSITION > 0.475)
41         XC = -12;
42         return
43     end
44 case 0.2
45     p = [SEA_Curves_Fig14.a(3),SEA_Curves_Fig14.b(3),
46         SEA_Curves_Fig14.c(3), ...
47         SEA_Curves_Fig14.d(3),SEA_Curves_Fig14.e(3),
48         SEA_Curves_Fig14.f(3), ...
49         SEA_Curves_Fig14.g(3),SEA_Curves_Fig14.h(3),
50         SEA_Curves_Fig14.i(3)];
51
52     if (FORE_AFT_POSITION < 0.15)
53         XC = 0;
54         return
55     elseif (FORE_AFT_POSITION > 0.7)
56         XC = -12;
57         return
58     end
59 case 0.3
60     p = [SEA_Curves_Fig14.a(4),SEA_Curves_Fig14.b(4),
61         SEA_Curves_Fig14.c(4), ...
62         SEA_Curves_Fig14.d(4),SEA_Curves_Fig14.e(4),
63         SEA_Curves_Fig14.f(4), ...
64         SEA_Curves_Fig14.g(4),SEA_Curves_Fig14.h(4),
65         SEA_Curves_Fig14.i(4)];
66
67     if (FORE_AFT_POSITION < 0.15)
68         XC = 0;
69         return
70     elseif (FORE_AFT_POSITION > 0.925)
71         XC = -12;

```

```

64         return
65     end
66     otherwise
67         if (TIP_CLEARANCE > 0.05 && TIP_CLEARANCE < 0.1)
68             XC = linear_interpolation(0.05,SEA_Fig14(
                FORE_AFT_POSITION,0.05),0.1,SEA_Fig14(
                FORE_AFT_POSITION,0.1),TIP_CLEARANCE);
69             return
70         elseif (TIP_CLEARANCE > 0.1 && TIP_CLEARANCE <
            0.2)
71             XC = linear_interpolation(0.1,SEA_Fig14(
                FORE_AFT_POSITION,0.1),0.2,SEA_Fig14(
                FORE_AFT_POSITION,0.2),TIP_CLEARANCE);
72             return
73         elseif (TIP_CLEARANCE > 0.2 && TIP_CLEARANCE <
            0.3)
74             XC = linear_interpolation(0.2,SEA_Fig14(
                FORE_AFT_POSITION,0.2),0.3,SEA_Fig14(
                FORE_AFT_POSITION,0.3),TIP_CLEARANCE);
75             return
76         else
77             disp("Can only calculate for tip clearance
                between 0.05 and 0.3");
78             return
79         end
80     end
81
82     XC = polyval(p,FORE_AFT_POSITION);
83
84 end

```

SEA_Fig15.m

```

1 %% Function SEA Figure 15
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 15 (Effect of
    reflecting
5 % surfaces in the pressure field)
6 %% Input Parameters:

```

```

7 % FORE_AFT_POSITION = Axial position X/D Fore and Aft of
  propeller plane [~]
8 % MODE = if MODE = 1 -> Flat Wall; MODE = 2 -> Circular Wall
9 %% Output Parameters:
10 % RC = Reflection correction [dB]
11 %To call it: RC = SEA_Fig15(FORE_AFT_POSITION,MODE)
12
13 function RC = SEA_Fig15(FORE_AFT_POSITION,MODE)
14     load("SEA_CurvesFig15.mat")
15
16     switch MODE
17     case 1
18         p = curve_FlatWall;
19     case 2
20         p = curve_CircularWall;
21     end
22
23     RC = polyval(p,FORE_AFT_POSITION);
24
25 end

```

SEA_Fig16.m

```

1 %% Function SEA Figure 16
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 %% Description:
4 % Implements the graph contained within Figure 16 (Near Field
  Harmonic
5 % Level Distribution)
6 %% Input Parameters:
7 % HELICAL_TIP_MACH = Helical tip Mach number [~]
8 % OASPL = Overall Sound Pressure Level [dB]
9 % HL_CHOICE = if HL_CHOICE = 1 -> Fundamental; else HL_CHOICE
  = n <= 10 -> n
10 %% Output Parameters
11 % HL = Harmonic Level [dB]
12 %To call it: HL = SEA_Fig16(HELICAL_TIP_MACH,OASPL,HL_CHOICE)
13
14 function HL = SEA_Fig16(HELICAL_TIP_MACH,OASPL,HL_CHOICE)
15     load("SEA_CurvesFig16.mat")

```

```

16
17     if (HL_CHOICE < 1 || HL_CHOICE > 10)
18         disp("Can only calculate for Harmonic Levels between
19             1 and 10");
20     return
21 end
22
23 p = [SEA_Curves_Fig16.a(HL_CHOICE),SEA_Curves_Fig16.b(
24     HL_CHOICE),SEA_Curves_Fig16.c(HL_CHOICE), ...
25     SEA_Curves_Fig16.d(HL_CHOICE),
26     SEA_Curves_Fig16.e(HL_CHOICE)];
27
28 HL = OASPL + polyval(p,HELICAL_TIP_MACH);
29
30 end

```

SAE_FAR_FIELD.m

```

1 %% SAE Far-field propeller noise prediction
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 % Source: [1] AIR1407_PredictionProcedureForNear-FieldAndFar-
4 %         FieldPropellerNoise
5 %% Description:
6 % Implements the procedure described in [1] for far-field
7 % propeller noise prediction
8 %% Input Parameters:
9 % PROP_DIAMETER = Propeller diameter [ft]
10 % N_OF_BLADES = Number of blades per propeller
11 % POWER = Power input per propeller [hp]
12 % RPM = Rotations per minute
13 % DIST = Location relative to the propeller of the point at
14 %        which noise is to be defined [ft]
15 % AZIMUTH = Angle relative to propeller forward axis where
16 %           noise is to be defined[degrees]
17 % SPEED = Flight speed [knots]
18 % TEMP = Ambient temperature [F]
19 % N_OF_PROP = Number of propellers
20 % MACH_HELICAL_TIP = Helical tip Mach number [~] (if you don'
21 %                  t have this value, input -1 to calculate it)
22 %% Output Parameters:

```

```

18 % OASPL = Overall Sound Pressure Level [dB]
19 % PNL = Perceived Noise Level [PNdB]
20 % AWNL = A-Weighted Noise Level [dBA]
21 % EPNL_TO = Effective Perceived Noise Level in Take-Off [
    EPNdB]
22 % EPNL_A = Effective Perceived Noise Level in Approach [EPNdB
    ]
23 % To call it: [OASPL,PNL,AWNL,EPNL_TO,EPNL_A] =
24 % SEA_FAR_FIELD(PROP_DIAMETER,N_OF_BLADES,POWER,RPM,DIST,
    AZIMUTH,SPEED,TEMP,N_OF_PROP)
25
26 function [OASPL,PNL,AWNL,EPNL_TO,EPNL_A] = SAE_FAR_FIELD(
    PROP_DIAMETER,N_OF_BLADES,POWER,RPM,DIST,AZIMUTH,SPEED,
    TEMP,N_OF_PROP,MACH_HELICAL_TIP)
27
28 %% Step 1:
29 % Determine the rotational tip Mach number from Fig.1 and
    Fig.2
30
31 % Fig 1: RPM to Tip Speed conversion
32 TIP_SPEED = SEA_Fig1(RPM,PROP_DIAMETER);
33
34 % Fig 2: Acquire Mach Number from Tip Speed
35 MACH = SEA_Fig2(TIP_SPEED*3.28084,TEMP);
36
37 %% Step 2:
38 % Obtain FL1 from Fig. 3. This is a partial level based
    on the power input to the propeller and its rotational
    tip speed.
39
40 % Fig 3: Far Field Partial Level Based on Power and Tip
    Speed
41 FL1 = SEA_Fig3(POWER,MACH);
42
43 %% Step 3:
44 % Obtain FL2 from Fig. 4. This is an adjustment for
    diameter and number of blades.
45
46 % Fig 4: Far Field Partial Level Based on Blade Count and

```

```

47         Propeller Diameter
48     FL2 = SEA_Fig4(PROP_DIAMETER,N_OF_BLADES);
49
50     %% Step 4:
51     % Obtain FL3, from Fig. 5. This adjustment accounts for
52     % atmospheric absorption
53     % and spherical spreading of the sound to the location of
54     % interest.
55
56     % Fig 5: Atmospheric Absorption and Spherical Spreading
57     % of Sound
58     FL3 = SEA_Fig5(DIST,1);
59
60     %% Step 5:
61     % Obtain the correction (Di) for the directivity pattern
62     % from Fig. 6, where 0 degrees
63     % is on the propeller axis in the forward direction,
64     % (Note: The pattern is symmetrical about the propeller
65     % axis, thus the directivity index
66     % for 260 degrees is the same as that for 100 degrees).
67
68     % Fig 6: Directivity Index
69     DI = SEA_Fig6(AZIMUTH);
70
71     %% Step 6:
72     % Apply the following corrections, NC, for number of
73     % propellers: 1 propeller add 0; 2 propellers add 3; 4
74     % propellers add 6
75
76     switch N_OF_PROP
77     case 1
78         NC = 0;
79     case 2
80         NC = 3;
81     case 4
82         NC = 6;
83     otherwise
84         disp("Can only calculate for 1, 2 or 4 propellers
85             ")

```

```

77         return
78     end
79
80     %% Step 7:
81     % The overall sound pressure level is the sum of the data
      from steps 2 through 6
82
83     OASPL = FL1 + FL2 + FL3 + DI + NC;
84
85     %% Step 8:
86     % The Perceived Noise Level (PNL) may be obtained from
      Fig. 7 for two bladed propellers, Fig. 8
87     %for three bladed propellers, Fig. 9 for four bladed
      propellers, or Fig. 10 for six and eight bladed
88     %propellers. The Helical Tip Mach Number (the vector sum
      of the Aircraft Forward Speed and the
89     %Rotational Tip Speed) needed to enter Fig. 7 through 10
      are found by use of Fig. 11 and 2. To calcu-
90     %late A-weighted sound pressure level in dBA subtract 14
      dB from the PNL. If EPNdB is desired,
91     %subtract 4 dB from PNL for a take-off case of 2 dB from
      PNL for an approach case.
92
93     if (MACH_HELICAL_TIP == -1)
94         % Fig 11: Propeller Helical Tip Speed
95         HELICAL_TIP_SPEED = SEA_Fig11(SPEED,TIP_SPEED
          *3.28084);
96         MACH_HELICAL_TIP = SEA_Fig2(HELICAL_TIP_SPEED,TEMP);
97     end
98
99     switch N_OF_BLADES
100     case 2
101         % Fig 7: Perceived Noise Level Adjustment - 2
          Bladed Propellers
102         PNL = SEA_Fig7(PROP_DIAMETER,MACH_HELICAL_TIP,
          OASPL);
103     case 3
104         % Fig 8: Perceived Noise Level Adjustment - 3
          Bladed Propellers

```

```

105         PNL = SEA_Fig8(PROP_DIAMETER,MACH_HELICAL_TIP,
106             OASPL);
107     case 4
108         % Fig 9: Perceived Noise Level Adjustment - 4
109         % Bladed Propellers
110         PNL = SEA_Fig9(PROP_DIAMETER,MACH_HELICAL_TIP,
111             OASPL);
112     case 6
113         % Fig 10: Perceived Noise Level Adjustment - 6
114         % and 8 Bladed Propellers
115         PNL = SEA_Fig10(PROP_DIAMETER,MACH_HELICAL_TIP,
116             OASPL);
117     case 8
118         % Fig 10: Perceived Noise Level Adjustment - 6
119         % and 8 Bladed Propellers
120         PNL = SEA_Fig10(PROP_DIAMETER,MACH_HELICAL_TIP,
121             OASPL);
122     otherwise
123         disp("Can only calculate for propellers with 2,
124             3, 4, 6, or 8 blades")
125     end
126
127     % Other possible noise levels
128     AWNL = PNL - 14;
129     EPNL_TO = PNL - 4;
130     EPNL_A = PNL - 2;
131 end

```

SAE_NEAR_FIELD.m

```

1 %% SAE Near-field propeller noise prediction
2 % Author: Vitor Yudi Mano Andrade (vymandrade@gmail.com)
3 % Source: [1] AIR1407_PredictionProcedureForNear-FieldAndFar-
4 % FieldPropellerNoise
5 %% Description:
6 % Implements the procedure described in [1] for near-field
7 % propeller noise prediction
8 %% Input Parameters:
9 % PROP_DIAMETER = Propeller diameter [ft]

```

```

8 % N_OF_BLADES = Number of blades per propeller
9 % POWER = Power input per propeller [hp]
10 % RPM = Rotations per minute
11 % RADIAL_DIST = Minimum clearance between propeller tip and
    fuselage [ft]
12 % FORE_AFT_DIST = Distance relative to propeller's plane [ft]
13 % SPEED = Flight speed [knots]
14 % TEMP = Ambient temperature [F]
15 % WALL_TYPE = if WALL_TYPE == 1 -> Flat; WALL_TYPE == 2 ->
    Circular
16 % MACH_HELICAL_TIP = Helical tip Mach number [~] (if you don'
    t have this value, input -1 to calculate it)
17 %% Output Parameters:
18 % OASPL = Overall Sound Pressure Level [dB]
19 % HL = Harmonic Levels from Fundamental to 10 [dB]
20 % To call it: [OASPL,HL] =
21 % SEA_NEAR_FIELD(PROP_DIAMETER,N_OF_BLADES,POWER,RPM,
    RADIAL_DIST,FORE_AFT_DIST,SPEED,TEMP)
22
23 function [OASPL,HL] = SAE_NEAR_FIELD(PROP_DIAMETER,
    N_OF_BLADES,POWER,RPM,RADIAL_DIST,FORE_AFT_DIST,SPEED,TEMP
    ,WALL_TYPE,MACH_HELICAL_TIP)
24     %% Step 1:
25     % Determine the rotational tip Mach number by calculation
        or from Fig. 1 and 2
26
27     % Fig 1: RPM to Tip Speed conversion
28     TIP_SPEED = SEA_Fig1(RPM,PROP_DIAMETER);
29
30     % Fig 2: Acquire Mach Number from Tip Speed
31     MACH = SEA_Fig2(TIP_SPEED*3.28084,TEMP);
32
33     %% Step 2:
34     % Obtain NL1 from Fig, 12. This gives a partial level
        based on the power absorbed by the propeller
35     % and its diameter.
36
37     % Fig 12: Near Field Partial Level Based on Power and
        Diameter

```

```

38     NL1 = SEA_Fig12(POWER,PROP_DIAMETER);
39
40     %% Step 3:
41     % Obtain the number of blades correction, BC
42
43     switch N_OF_BLADES
44     case 2
45         BC = 6;
46     case 3
47         BC = 2.5;
48     case 4
49         BC = 0;
50     case 6
51         BC = -3.5;
52     case 8
53         BC = -6;
54     otherwise
55         disp("Can only calculate for number of blades 2,
56             3, 4, 6 or 8")
57     end
58
59     %% Step 4:
60     % Obtain NL2 from Fig. 13. This is an adjustment for tip
61     % speed and distance in the plane of rotation.
62
63     % Fig 13: Near Field Partial Level Based on Tip Speed and
64     % Tip Clearance
65     TIP_CLEARANCE = RADIAL_DIST/PROP_DIAMETER;
66     NL2 = SEA_Fig13(TIP_CLEARANCE,MACH);
67
68     %% Step 5:
69     % Obtain the location correction XC, for fore and aft
70     % distance from Fig. 14.
71
72     % Fig 14: Variation of overall, free-space propeller
73     % noise levels with
74     % axial position X/D fore and aft of propeller plane
75     FORE_AFT_POSITION = FORE_AFT_DIST/PROP_DIAMETER;
76     XC = SEA_Fig14(FORE_AFT_POSITION,TIP_CLEARANCE);

```

```

72
73     %% Step 6:
74     % Obtain the reflection correction, RC, for the effect of
75     % a reflecting surface (fuselage) in the sound
76     % field from Mg. 15.
77
78     % Fig 15: Effect of reflecting surfaces in the pressure
79     % field
80     RC = SEA_Fig15(FORE_AFT_POSITION,WALL_TYPE);
81
82     %% Step 7:
83     % The overall sound pressure level is the sum of the
84     % levels obtained in steps 2 through 6.
85
86     OASPL = NL1 + BC + NL2 + XC + RC;
87
88     %% Step 8:
89     % The near-field harmonic; distribution of the noise
90     % estimated in step 7 is found from Fig. 16 using
91     % Fig. 11 and 2 to determine the Helical Tip Mach Number
92     % with forward speed.
93
94     % Fig 11 and 2:
95     if MACH_HELICAL_TIP == -1
96         HELICAL_TIP_SPEED = SEA_Fig11(SPEED,TIP_SPEED
97         *3.28084);
98         MACH_HELICAL_TIP = SEA_Fig2(HELICAL_TIP_SPEED,TEMP);
99     end
100
101     % Fig 16: Near Field Harmonic Level Distribution
102     HL = zeros(10,1);
103     for i = 1:10
104         HL(i) = SEA_Fig16(MACH_HELICAL_TIP,OASPL,i);
105     end
106 end

```

Far-field method implementation validation results

All results related to the validation of the far-field propeller noise prediction method that was implemented in this work are presented in this Appendix. The following notation is utilized:

AL_i : A-weighted noise level obtained through the implemented method;

AL_{am} : A-weighted noise level as measured, presented in Annex I;

AL_{fc} : fully corrected A-weighted noise level, presented in Annex I;

$\delta_{x_3x_1}$: relative error between AL_i and AL_{am} ;

$\delta_{x_3x_2}$: relative error between AL_i and AL_{fc} ;

$H_{x_3x_1}$: hypothesis testing (Equation 3.8) of the mean of the absolute error between AL_i and AL_{am} ;

$H_{x_3x_2}$: hypothesis testing (Equation 3.8) of the mean of the absolute error between AL_i and AL_{fc} ;

μ : mean of the absolute error;

σ : standard deviation of the absolute error;

p_{norm} : p -value related to the Liliefors test;

p_{test} : p -value related to the chosen test.

D.1 Implementation results

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
9	81.3588	0.5671	6.2125	80.8795	2.1206	6.5606
10	80.6155	0.7198	3.6189	80.6155	2.8259	7.4873
11	78.8285	0.2171	0.2171	78.8285	3.5854	5.3857
12	74.1847	1.7623	2.0422	73.9752	2.8863	2.8863
13	74.5874	0.2518	1.2040	74.2455	1.9856	1.9856
15	69.5763	0.4645	0.9802	69.6080	0.8433	0.5896
16	68.8763	1.3214	0.8691	68.9763	1.5852	2.0360
17	69.3421	1.5027	0.5135	69.5025	1.1344	0.1477
18	74.7517	0.0693	4.2871	74.1313	1.5498	3.8504
19	74.1041	0.4121	4.9947	73.4739	3.1937	3.4508

Table D.1 – Cessna 170 - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
5.8	74.4646	0.3566	0.0868	74.0876	0.0167	0.8198
6.14	73.9429	3.1282	3.7068	73.3866	4.6884	4.2423
5.10	73.4778	1.0699	0.9310	72.9952	2.0912	1.2416
6.16	72.5776	4.5786	4.5786	72.4001	6.1585	5.8481
5.12	72.5199	2.7193	2.7193	72.1168	2.4387	1.8600
6.3	78.4153	0.9206	1.8380	78.0593	1.6398	2.0383
6.5	77.2172	2.4101	2.9563	77.0335	3.8188	4.0994
6.7	76.4944	3.0922	3.3708	76.8474	4.6967	5.5596
6.8	76.2873	3.3703	4.2176	76.1001	4.9657	5.5480
6.11	80.4697	2.2487	3.2987	80.4697	3.0342	4.1006

Table D.2 – PA-28 Turbo Arrow IV - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
22	85.6586	3.5776	4.5893	84.8319	1.9614	1.8390
23	85.6972	3.2497	4.3815	84.8670	2.0037	1.8812
26	83.1440	2.5203	3.0284	82.4322	0.5270	0.0390
28	79.5853	1.6416	1.5119	79.2222	0.4084	0.2239
30	79.9825	2.8053	2.6733	79.6040	1.0202	0.3833
31	79.3718	6.2540	6.1120	78.6184	3.7182	2.2346
32	76.3896	0.6450	0.1444	76.1093	0.6406	1.7944
34	75.9863	2.1322	2.8232	75.2198	1.3744	0.8308
35	74.5516	1.5690	1.2969	74.2768	1.3326	0.6460
36	72.8918	2.0893	1.6622	72.4257	0.9091	0.2029

Table D.3 – Cessna 180 - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
16	70.9321	0.7599	0.0453	70.5194	0.7420	0.6769
17	70.1936	0.1514	2.1010	70.2043	0.7752	1.0700
18	69.5855	0.5571	0.5921	69.4227	0.1771	1.2479
19	69.3811	2.3319	0.6892	69.7246	0.3231	0.6773
20	68.8284	2.2711	1.5169	68.3665	0.5390	1.0615
21	68.2865	0.1268	1.4625	67.9428	0.2308	2.3810
22	65.8450	0.0835	1.7329	65.6862	1.5199	3.4026
23	65.7020	0.3005	2.0835	65.5923	1.5130	3.5407

Table D.4 – PA-38 Tomahawk - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
8	78.9756	2.9784	4.1559	78.5056	2.7192	4.6104
9	80.8107	0.5704	1.2094	79.5252	2.3032	3.8389
10	81.4828	1.7095	1.4718	80.8870	2.7801	3.3609
11	81.1014	0.4891	1.8143	80.7729	2.9172	4.6365
12	81.7536	1.0247	2.6743	81.3745	1.3643	3.4704
13	84.7478	1.4560	0.2967	83.8404	0.3087	0.4271
14	85.7798	0.7178	0.4447	84.7983	1.3973	1.5118
19	83.9884	0.5849	0.9476	82.8955	0.6050	1.7826
22	81.1662	0.5777	0.0416	80.8673	0.2073	0.8980
26	78.7725	2.7499	2.6297	78.0680	2.5368	3.3811

Table D.5 – King Air 200 - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
1	83.7514	0.0614	1.1200	83.6389	2.0622	3.3076
2	82.7104	0.8269	2.0019	82.7104	1.0641	2.3336
3	81.1880	1.2312	3.3476	81.8070	0.7197	2.0276
4	80.8402	1.6543	3.0693	80.3629	1.0309	3.1773
7	79.5439	1.6763	2.7581	79.5115	1.3505	2.5594
10	82.1903	2.6096	2.0997	81.2562	1.8248	0.1766
15	79.7493	0.3134	1.5441	79.9117	0.7713	0.2351
17	79.2096	0.9880	2.9294	79.0891	0.0138	2.2385
20	77.2035	0.1248	0.8941	77.3721	0.1650	0.6776
21	77.3382	1.7607	1.0956	77.7017	0.1310	0.1310

Table D.6 – PA-42 Cheyenne - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
2	81.2372	2.9424	2.7099	81.1115	3.7823	3.7823
3	80.3630	0.2941	0.2941	79.3023	4.6847	6.1511
4	79.8636	0.2951	0.0455	79.6944	2.8117	2.8117
6	78.9650	0.0824	0.0443	79.5174	2.9092	2.3128
7	77.5470	2.7013	3.1872	78.1369	1.9612	1.5908
8	77.5113	0.1438	0.4033	77.6908	5.0235	4.5568
10	75.8752	0.8167	0.6869	74.4458	5.4056	7.1748
11	75.1393	0.1857	0.0523	75.7864	1.8310	0.9328
19	80.0063	3.7229	4.2987	80.8149	2.8667	2.3974
20	77.9699	0.5486	0.4216	77.5422	2.8294	3.3140

Table D.7 – C-414 Chancellor - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
14	76.3797	2.3277	4.1660	76.9351	2.8597	3.8311
15	86.6186	2.7682	3.5030	76.1114	1.9182	3.4119
16	75.3068	1.6882	2.7044	75.2642	1.0983	2.2543
17	74.8794	1.7331	1.7331	74.4925	0.6767	1.3344
19	81.3491	2.5760	4.0695	81.6474	4.5060	5.5007
22	82.2015	2.7201	3.0642	80.9624	4.5255	6.4019
23	80.4889	4.4075	4.5209	79.5813	4.8070	6.0433
25	79.4534	2.7498	4.2730	79.3087	6.5857	8.1011
21	76.7328	3.8436	5.0337	76.3226	6.8100	8.4861
24	77.0906	4.8264	5.5262	76.7521	6.9671	8.0813

Table D.8 – Baron 58P - Implementation results.

Event	Site 1			Site 2		
	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$	$AL_i(dB)$	$\delta_{x_3x_1}$	$\delta_{x_3x_2}$
9	77.2197	4.4311	1.6310	74.4647	5.8601	7.0354
10	78.7775	1.8960	1.2564	77.0260	3.3551	2.8676
12	79.6961	1.8521	0.2467	78.9337	0.5524	1.5877
22	80.3009	0.6177	1.7756	79.5866	0.5167	0.7426
20	81.4100	0.5983	1.6355	80.0441	3.4450	3.2115
21	81.1399	3.1744	1.4096	79.8651	3.0763	4.2384
16	79.3936	3.9980	1.7405	79.0191	0.7897	3.2814
17	79.2461	2.5263	0.4446	78.3334	1.5912	5.8493
18	76.6092	3.8780	0.5306	75.8309	1.0040	0.3055
19	76.0092	3.2962	1.7969	75.9097	2.1782	0.7716

Table D.9 – C-425 Conquest I - Implementation results.

D.2 Statistical hypothesis testing

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	0.5349	0.4188	Assumed	0.3577
Site 1 - $H_{x_3x_2}$	1.9019	1.6595	Assumed	0.1411
Site 2 - $H_{x_3x_1}$	1.6015	0.7084	Assumed	0.5000
Site 2 - $H_{x_3x_2}$	2.5626	1.8579	Assumed	0.5000

Table D.10 – Cessna 170 - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	$8.5552 \cdot 10^{-9}$
Site 1 - $H_{x_3x_2}$	t -test	Rejected	0.0330
Site 2 - $H_{x_3x_1}$	t -test	Rejected	$7.5469 \cdot 10^{-5}$
Site 2 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.2378

Table D.10 – Cessna 170 - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	1.7467	0.9053	Assumed	0.2410
Site 1 - $H_{x_3x_2}$	2.0267	1.0238	Assumed	0.5000
Site 2 - $H_{x_3x_1}$	2.4221	1.2925	Assumed	0.5000
Site 2 - $H_{x_3x_2}$	2.5621	1.3437	Assumed	0.1652

Table D.11 – PA-28 Turbo Arrow IV - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	$8.8837 \cdot 10^{-4}$
Site 1 - $H_{x_3x_2}$	t -test	Rejected	0.0074
Site 2 - $H_{x_3x_1}$	t -test	Cannot be rejected	0.0955
Site 2 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.1648

Table D.11 – PA-28 Turbo Arrow IV - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	2.0559	1.1780	Assumed	0.5000
Site 1 - $H_{x_3x_2}$	2.1980	1.4167	Assumed	0.5000
Site 2 - $H_{x_3x_1}$	1.0816	0.76634	Assumed	0.1306
Site 2 - $H_{x_3x_2}$	0.7966	0.6751	Assumed	0.2386

Table D.12 – Cessna 180 - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	0.0160
Site 1 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.0535
Site 2 - $H_{x_3x_1}$	t -test	Rejected	$1.2035 \cdot 10^{-5}$
Site 2 - $H_{x_3x_2}$	t -test	Rejected	$1.3745 \cdot 10^{-6}$

Table D.12 – Cessna 180 - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	0.5591	0.4188	Assumed	0.0950
Site 1 - $H_{x_3x_2}$	0.8796	1.6595	Assumed	0.2582
Site 2 - $H_{x_3x_1}$	0.4940	0.7084	Assumed	0.4626
Site 2 - $H_{x_3x_2}$	1.2131	1.8579	Assumed	0.0501

Table D.13 – PA-38 Tomahawk - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	$6.1852 \cdot 10^{-6}$
Site 1 - $H_{x_3x_2}$	t -test	Rejected	$3.9764 \cdot 10^{-6}$
Site 2 - $H_{x_3x_1}$	t -test	Rejected	$9.6874 \cdot 10^{-8}$
Site 2 - $H_{x_3x_2}$	t -test	Rejected	$1.9666 \cdot 10^{-4}$

Table D.13 – PA-38 Tomahawk - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	1.1430	0.7248	Assumed	0.5000
Site 1 - $H_{x_3x_2}$	1.2958	1.0565	Assumed	0.5000
Site 2 - $H_{x_3x_1}$	1.4100	0.8743	Assumed	0.2881
Site 2 - $H_{x_3x_2}$	2.3265	1.2619	Assumed	0.1560

Table D.14 – King Air 200 - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	$1.0006 \cdot 10^{-5}$
Site 1 - $H_{x_3x_2}$	t -test	Rejected	$3.2215 \cdot 10^{-4}$
Site 2 - $H_{x_3x_1}$	t -test	Rejected	$1.3801 \cdot 10^{-4}$
Site 2 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.0629

Table D.14 – King Air 200 - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	0.9035	0.6570	Assumed	0.5000
Site 1 - $H_{x_3x_2}$	1.7132	0.7657	Assumed	0.5000
Site 2 - $H_{x_3x_1}$	0.7478	0.5831	Assumed	0.5000
Site 2 - $H_{x_3x_2}$	1.3942	1.0607	Assumed	0.2364

Table D.15 – PA-42 Cheyenne - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	$1.6582 \cdot 10^{-6}$
Site 1 - $H_{x_3x_2}$	t -test	Rejected	$2.4227 \cdot 10^{-4}$
Site 2 - $H_{x_3x_1}$	t -test	Rejected	$3.3103 \cdot 10^{-7}$
Site 2 - $H_{x_3x_2}$	t -test	Rejected	$4.9551 \cdot 10^{-4}$

Table D.15 – PA-42 Cheyenne - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	0.9553	1.1484	Cannot be assumed	0.0064
Site 1 - $H_{x_3x_2}$	0.9923	1.3016	Cannot be assumed	0.0017
Site 2 - $H_{x_3x_1}$	2.7757	1.0282	Assumed	0.0801
Site 2 - $H_{x_3x_2}$	2.8657	1.6295	Assumed	0.5000

Table D.16 – C-414 Chancellor - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	Wilcoxon signed rank test	Rejected	0.0020
Site 1 - $H_{x_3x_2}$	Wilcoxon signed rank test	Rejected	0.0029
Site 2 - $H_{x_3x_1}$	t -test	Cannot be rejected	0.2539
Site 2 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.4001

Table D.16 – C-414 Chancellor - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	2.3999	0.9014	Assumed	0.0888
Site 1 - $H_{x_3x_2}$	3.1499	0.9607	Assumed	0.5000
Site 2 - $H_{x_3x_1}$	3.3722	1.9919	Assumed	0.3562
Site 2 - $H_{x_3x_2}$	4.4722	2.2260	Assumed	0.5000

Table D.17 – Baron 58P - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	0.0323
Site 1 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.6832
Site 2 - $H_{x_3x_1}$	t -test	Cannot be rejected	0.7154
Site 2 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.9670

Table D.17 – Baron 58P - Hypothesis testing (Continued).

	μ	σ	Normality	p_{norm}
Site 1 - $H_{x_3x_1}$	2.1298	1.1066	Assumed	0.5000
Site 1 - $H_{x_3x_2}$	1.0667	0.4391	Cannot be assumed	0.0221
Site 2 - $H_{x_3x_1}$	1.7892	1.3744	Assumed	0.5000
Site 2 - $H_{x_3x_2}$	2.4289	1.8445	Assumed	0.5000

Table D.18 – C-425 Conquest I - Hypothesis testing.

	Test Used	Null Hypothesis	p_{test}
Site 1 - $H_{x_3x_1}$	t -test	Rejected	0.0173
Site 1 - $H_{x_3x_2}$	Wilcoxon signed rank test	Rejected	$9.7656 \cdot 10^{-4}$
Site 2 - $H_{x_3x_1}$	t -test	Rejected	0.0106
Site 2 - $H_{x_3x_2}$	t -test	Cannot be rejected	0.1766

Table D.18 – C-425 Conquest I - Hypothesis testing (Continued).

Near-field method implementation validation results

All results related to the validation of the near-field propeller noise prediction method that was implemented in this work are presented in this Appendix.

Condition	Flight	OASPL (dB)	Harmonic Level (dB)				
			1	2	3	4	5
1	2	143.0828	140.2659	136.0521	132.3313	129.9502	127.0252
	3	142.8838	140.1413	135.7298	131.9409	129.5372	126.6034
2	2	142.3752	139.8216	134.8492	130.8803	128.4255	125.4847
	3	142.3274	139.8352	134.6597	130.6299	128.1609	125.2234
3	2	142.3752	139.8509	134.7829	130.7850	128.3233	125.3837
	3	142.1569	139.6923	134.4219	130.3644	127.8894	124.9545
4	2	142.5878	139.7817	135.5400	131.8093	129.4249	126.4984
	3	142.8838	140.1739	135.6719	131.8525	129.4394	126.5027
5	2	142.5875	139.9933	135.1494	131.2202	128.7756	125.8342
	3	142.6377	140.0933	135.0911	131.1132	128.6562	125.7157
6	2	142.6203	139.9689	135.2981	131.4236	128.9941	126.0539
	3	142.7524	140.1233	135.3863	131.4907	129.0552	126.1143
7	2	142.5875	139.9316	135.2743	131.4041	128.9758	126.0358
	3	142.7200	140.0757	135.3840	131.5029	129.0714	126.1310
8	2	142.5875	139.9316	135.2743	131.4041	128.9758	126.0358
	3	142.7200	140.0757	135.3840	131.5029	129.0714	126.1310
9	2	143.1298	140.1988	136.2660	132.6469	130.3027	127.3965
	3	143.0475	140.1222	136.1761	132.5520	130.2059	127.2986
10	2	143.0171	140.3671	135.6922	131.8163	129.3864	126.4462
	3	142.4853	139.8786	135.0733	131.1561	128.7147	125.7733
11	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
12	2	142.5259	140.3255	134.0091	129.6703	127.1560	124.2854
	3	142.3532	140.1902	133.7030	129.3219	126.8052	123.9509
13	2	140.6515	137.8779	133.5503	129.7899	127.3956	124.4650
	3	140.4406	137.7768	133.1426	129.2799	126.8538	123.9142
14	2	140.7762	138.0027	133.6751	129.9147	127.5203	124.5898
	3	140.4801	137.7609	133.2850	129.4744	127.0640	124.1280
15	2	140.7762	137.9439	133.7695	130.0625	127.6863	124.7634
	3	140.4801	137.7702	133.2682	129.4489	127.0358	124.0991
16	2	140.7914	137.9348	133.8218	130.1367	127.7682	124.8490
	3	140.4801	137.7702	133.2682	129.4489	127.0358	124.0991
17	2	140.9110	137.8484	134.2108	130.7057	128.4067	125.5293
	3	140.9909	137.9614	134.2523	130.7189	128.4083	125.5230
18	2	139.9574	137.2266	132.7830	128.9832	126.5762	123.6412
	3	140.1253	137.4567	132.8365	128.9784	126.5536	123.6142

Table E.1 – Prediction results - Port side.

Condition	Flight	Harmonic Level (dB)				
		6	7	8	9	10
1	2	125.1466	123.7415	122.9397	122.5038	122.0713
	3	124.7354	123.3486	122.5423	122.1082	121.6725
2	2	123.6537	122.3186	121.4996	121.0682	120.6226
	3	123.4078	122.0909	121.2675	120.8363	120.3868
3	2	123.5599	122.2334	121.4123	120.9810	120.5336
	3	123.1463	121.8378	121.0123	120.5810	120.1298
4	2	124.6213	123.2187	122.4163	121.9806	121.5477
	3	124.6400	123.2617	122.4532	122.0198	121.5826
5	2	123.9940	122.6471	121.8310	121.3992	120.9560
	3	123.8870	122.5545	121.7349	121.3035	120.8573
6	2	124.2019	122.8392	122.0269	121.5944	121.1543
	3	124.2667	122.9101	122.0963	121.6642	121.2229
7	2	124.1830	122.8190	122.0070	121.5745	121.1346
	3	124.2804	122.9196	122.1068	121.6744	121.2340
8	2	124.1830	122.8190	122.0070	121.5745	121.1346
	3	124.2804	122.9196	122.1068	121.6744	121.2340
9	2	125.5059	124.0747	123.2795	122.8402	122.4118
	3	125.4085	123.9786	123.1830	122.7439	122.3153
10	2	124.5945	123.2321	122.4198	121.9873	121.5471
	3	123.9305	122.5801	121.7648	121.3329	120.8904
11	2	-	-	-	-	-
	3	-	-	-	-	-
12	2	122.5645	121.3412	120.4950	120.0586	119.5874
	3	122.2443	121.0334	120.1841	119.7462	119.2719
13	2	122.5924	121.1978	120.3934	119.9585	119.5243
	3	122.0598	120.6937	119.8822	119.4496	119.0101
14	2	122.7171	121.3225	120.5181	120.0833	119.6490
	3	122.2638	120.8830	120.0752	119.6415	119.2048
15	2	122.8829	121.4741	120.6732	120.2369	119.8051
	3	122.2364	120.8581	120.0496	119.6162	119.1790
16	2	122.9657	121.5512	120.7517	120.3148	119.8838
	3	122.2364	120.8581	120.0496	119.6162	119.1790
17	2	123.6308	122.1727	121.3844	120.9403	120.5155
	3	123.6259	122.1742	121.3843	120.9415	120.5159
18	2	121.7751	120.3913	119.5842	119.1503	118.7142
	3	121.7589	120.3915	119.5804	119.1477	118.7085

Table E.1 – Prediction results - Port side (Continued).

Condition	Flight	OASPL (dB)	Harmonic Level (dB)				
			1	2	3	4	5
1	2	142.6959	140.1671	135.1138	131.1204	128.6597	125.7199
	3	142.2699	139.8011	134.5452	130.4919	128.0178	125.0824
2	2	142.9982	140.1824	135.9241	132.1877	129.8014	126.8740
	3	142.9648	140.2223	135.8109	132.0219	129.6183	126.6845
3	2	142.9010	140.1357	135.7861	132.0182	129.6213	126.6899
	3	142.3315	139.6384	135.0888	131.2538	128.8359	125.8979
4	2	142.7958	140.2766	135.1917	131.1889	128.7260	125.7866
	3	142.3289	139.8962	134.5127	130.4226	127.9411	125.0100
5	2	142.5875	139.9933	135.1494	131.2202	128.7756	125.8342
	3	142.7200	140.1756	135.1735	131.1955	128.7385	125.7980
6	2	142.6203	139.9689	135.2981	131.4236	128.9941	126.0539
	3	142.8336	140.2044	135.4675	131.5719	129.1364	126.1955
7	2	142.5875	139.9316	135.2743	131.4041	128.9758	126.0358
	3	142.8013	140.1570	135.4653	131.5842	129.1527	126.2123
8	2	142.5875	139.9316	135.2743	131.4041	128.9758	126.0358
	3	142.8013	140.1570	135.4653	131.5842	129.1527	126.2123
9	2	142.4821	139.8801	135.0601	131.1383	128.6957	125.7544
	3	142.4272	139.8158	135.0250	131.1124	128.6722	125.7309
10	2	142.7263	139.8036	135.8514	132.2250	129.8781	126.9703
	3	143.0475	140.1597	136.1235	132.4662	130.1078	127.1937
11	2	142.1308	139.9497	133.5457	129.1851	126.6694	123.8070
	3	142.1319	139.9312	133.6159	129.2774	126.7630	123.8924
12	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
13	2	140.6515	137.8779	133.5503	129.7899	127.3956	124.4650
	3	140.4406	137.7768	133.1426	129.2799	126.8538	123.9142
14	2	140.7762	138.0027	133.6751	129.9147	127.5203	124.5898
	3	140.4801	137.7609	133.2850	129.4744	127.0640	124.1280
15	2	140.7762	137.9439	133.7695	130.0625	127.6863	124.7634
	3	140.4801	137.7702	133.2682	129.4489	127.0358	124.0991
16	2	140.7914	137.9348	133.8218	130.1367	127.7682	124.8490
	3	140.4801	137.7702	133.2682	129.4489	127.0358	124.0991
17	2	140.2853	137.5960	133.0356	129.1970	126.7780	123.8398
	3	140.3695	137.7042	133.0743	129.2131	126.7874	123.8479
18	2	141.4182	138.3194	134.7579	131.2834	128.9973	126.1289
	3	140.8665	137.8481	134.1145	130.5714	128.2569	125.3690

Table E.2 – Prediction results - Starboard side.

Condition	Flight	Harmonic Level (dB)				
		6	7	8	9	10
1	2	123.8950	122.5672	121.7464	121.3150	120.8679
	3	123.2731	121.9633	121.1382	120.7069	120.2560
2	2	124.9977	123.5967	122.7938	122.3584	121.9252
	3	124.8165	123.4297	122.6233	122.1892	121.7536
3	2	124.8184	123.4259	122.6209	122.1863	121.7517
	3	124.0382	122.6643	121.8547	121.4216	120.9836
4	2	123.9641	122.6391	121.8176	121.3863	120.9386
	3	123.2108	121.9122	121.0844	120.6529	120.1995
5	2	123.9940	122.6471	121.8310	121.3992	120.9560
	3	123.9693	122.6368	121.8172	121.3858	120.9396
6	2	124.2019	122.8392	122.0269	121.5944	121.1543
	3	124.3479	122.9913	122.1775	121.7453	121.3041
7	2	124.1830	122.8190	122.0070	121.5745	121.1346
	3	124.3617	123.0009	122.1881	121.7557	121.3153
8	2	124.1830	122.8190	122.0070	121.5745	121.1346
	3	124.3617	123.0009	122.1881	121.7557	121.3153
9	2	123.9125	122.5635	121.7478	121.3160	120.8732
	3	123.8870	122.5353	121.7204	121.2884	120.8462
10	2	125.0804	123.6510	122.8553	122.4163	121.9877
	3	125.3071	123.8855	123.0878	122.6499	122.2201
11	2	122.0934	120.8766	120.0288	119.5916	119.1188
	3	122.1714	120.9480	120.1019	119.6655	119.1943
12	2	-	-	-	-	-
	3	-	-	-	-	-
13	2	122.5924	121.1978	120.3934	119.9585	119.5243
	3	122.0598	120.6937	119.8822	119.4496	119.0101
14	2	122.7171	121.3225	120.5181	120.0833	119.6490
	3	122.2638	120.8830	120.0752	119.6415	119.2048
15	2	122.8829	121.4741	120.6732	120.2369	119.8051
	3	122.2364	120.8581	120.0496	119.6162	119.1790
16	2	122.9657	121.5512	120.7517	120.3148	119.8838
	3	122.2364	120.8581	120.0496	119.6162	119.1790
17	2	121.9807	120.6078	119.7980	119.3649	118.9268
	3	121.9932	120.6267	119.8153	119.3826	118.9433
18	2	124.2292	122.7643	121.9778	121.5323	121.1082
	3	123.4725	122.0230	121.2325	120.7902	120.3642

Table E.2 – Prediction results - Starboard side (Continued).

Annexes

Far-field experimental datasets

Data from (52) that was used for validation of the implementation of the far-field prediction method developed in this work is presented. The following notations are utilized:

MCP: maximum continuous power

IAS: indicated aircraft speed

M_h : helical tip Mach number

Alt: altitude

AL_{am} : A-weighted noise level as measured

AL_{fc} : A-weighted noise level fully corrected

I.1 Aircraft specifications

Aircraft	MCP (hp)	Propeller Shaft RPM	Engine Type
Cessna 170	145	2550	Piston
PA-28 Turbo Arrow IV	180	2700	Piston
Cessna 180	230	2375	Piston
PA-38 Tomahawk	112	2350	Piston
King Air 200	850	2000	Turboprop
PA-42 Cheyenne	720	2000	Turboprop
C-414 Chancellor	310	2700	Piston
Baron 58P	325	2700	Piston
C-425 Conquest I	450	1900	Turboprop

Table I.1 – Aircraft specifications.

Aircraft	Number of Engines	Propeller	
		Number of Blades	Diameter (in)
Cessna 170	1	2	82.2
PA-28 Turbo Arrow IV	1	3	76
Cessna 180	1	2	76
PA-38 Tomahawk	1	2	72
King Air 200	2	3	98.5
PA-42 Cheyenne	2	3	95
C-414 Chancellor	2	3	76.5
Baron 58P	2	3	78
C-425 Conquest I	2	3	93.4

Table I.1 – Aircraft specifications (Continued).

I.2 Level flyover noise data

Event	Power (%)	RPM	IAS (kts)	M_h
9	65	2450	109	0.7250
10	65	2450	109	0.7240
11	65	2450	109	0.7240
12	55	2225	91	0.6570
13	55	2225	91	0.6570
15	45	1900	74	0.5610
16	45	1900	78	0.5610
17	45	1900	74	0.5600
18	65	2450	104	0.7200
19	65	2450	104	0.7240

Table I.2 – Cessna 170 - Level flyover noise data.

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
9	199	80.9	76.6	210	79.2	75.9
10	216	81.2	77.8	216	78.4	75.0
11	264	79.0	79.0	264	76.1	74.8
12	294	72.9	72.7	301	71.9	71.9
13	281	74.4	73.7	292	72.8	72.8
15	273	69.9	68.9	272	70.2	69.2
16	292	69.9	69.6	292	67.9	67.6
17	280	70.4	69.7	275	70.3	69.4
18	415	74.7	78.1	445	73.0	77.1
19	449	73.8	78.0	482	71.2	76.1

Table I.2 – Cessna 170 - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
5.8	55	2500	95	0.7449
6.14	55	2400	119	0.7272
5.10	55	2400	98	0.7176
6.16	55	2300	120	0.6997
5.12	55	2300	100	0.6893
6.3	75	2575	140	0.7848
6.5	75	2500	141	0.7635
6.7	75	2450	140	0.7502
6.8	75	2400	142	0.7360
6.11	100	2575	160	0.7936

Table I.3 – PA-28 Turbo Arrow IV - Level flyover noise data.

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
5.8	510	74.2	74.4	532	74.1	74.7
6.14	482	71.7	71.3	513	70.1	70.4
5.10	504	72.7	72.8	532	71.5	72.1
6.16	498	69.4	69.4	508	68.2	68.4
5.12	498	70.6	70.6	521	70.4	70.8
6.3	467	77.7	77.0	486	76.8	76.5
6.5	481	75.4	75.0	491	74.2	74.0
6.7	490	74.2	74.0	471	73.4	72.8
6.8	472	73.8	73.2	482	72.5	72.1
6.11	465	78.7	77.9	465	78.1	77.3

Table I.3 – PA-28 Turbo Arrow IV - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
22	100	2600	162	0.8500
23	100	2600	160	0.8500
26	75	2600	145	0.8400
28	75	2425	151	0.7900
30	75	2450	153	0.8000
31	75	2425	120	0.7800
32	50	2450	119	0.7700
34	50	2350	130	0.7600
35	50	2300	131	0.7400
36	50	2200	124	0.7100

Table I.4 – Cessna 180 - Level flyover noise data.

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
22	461	82.7	81.9	506	83.2	83.3
23	459	83.0	82.1	504	83.2	83.3
26	479	81.1	80.7	519	82.0	82.4
28	503	78.3	78.4	524	78.9	79.4
30	505	77.8	77.9	527	78.8	79.3
31	508	74.7	74.8	553	75.8	76.9
32	530	75.9	76.5	547	76.6	77.5
34	477	74.4	73.9	520	74.2	74.6
35	509	73.4	73.6	525	73.3	73.8
36	513	71.4	71.7	539	71.8	72.6

Table I.4 – Cessna 180 - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
16	75	2410	98	0.6780
17	75	2410	100	0.6790
18	70	2350	95	0.6610
19	70	2350	97	0.6620
20	65	2300	90	0.6470
21	65	2300	90	0.6470
22	55	2170	85	0.6100
23	55	2170	85	0.6100

Table I.5 – PA-38 Tomahawk - Level flyover noise data.

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
16	526	70.4	70.9	551	70.0	71.0
17	572	70.3	71.7	569	69.7	71.0
18	541	69.2	70.0	551	69.3	70.3
19	554	67.8	68.9	533	69.5	70.2
20	525	67.3	67.8	553	68.0	69.1
21	558	68.2	69.3	580	68.1	69.6
22	555	65.9	67.0	565	66.7	68.0
23	564	65.9	67.1	571	66.6	68.0

Table I.5 – PA-38 Tomahawk - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
8	85	1700	235	0.7400
9	85	1750	235	0.7570
10	85	1800	230	0.7700
11	85	1850	232	0.7890
12	85	1900	232	0.8060
13	85	1950	231	0.8230
14	85	2000	234	0.8420
19	95	1900	240	0.8110
22	71	1900	214	0.7950
26	47	1900	195	0.7830

Table I.6 – King Air 200 - Level flyover noise data.

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
8	552	81.4	82.4	582	80.7	82.3
9	488	82.1	81.8	564	81.4	82.7
10	490	82.9	82.7	524	83.2	83.7
11	557	81.5	82.6	578	83.2	84.7
12	572	82.6	84.0	597	82.5	84.3
13	455	86.0	85.0	504	84.1	84.2
14	453	86.4	85.4	506	86.0	86.1
19	488	83.5	83.2	552	83.4	84.4
22	525	80.7	81.2	543	80.7	81.6
26	496	81.0	80.9	537	80.1	80.8

Table I.6 – King Air 200 - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
1	100	2000	240	0.8210
2	100	1950	236	0.8020
3	100	1900	236	0.7850
4	100	1850	236	0.7690
7	100	1750	230	0.7320
10	100	1900	210	0.7690
15	75	1900	209	0.7680
17	75	1900	205	0.7650
20	50	1900	183	0.7530
21	50	1900	183	0.7530

Table I.7 – PA-42 Cheyenne - Level flyover noise data.

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
1	548	83.7	84.7	555	85.4	86.5
2	551	83.4	84.4	551	83.6	84.6
3	593	82.2	84.0	553	82.4	83.5
4	561	82.2	83.4	592	81.2	83.0
7	548	80.9	81.8	550	80.6	81.6
10	522	80.1	80.5	580	79.8	81.4
15	551	80.0	81.0	541	79.3	80.1
17	584	80.0	81.6	592	79.1	80.9
20	531	77.3	77.9	521	77.5	77.9
21	523	76.0	76.5	502	77.6	77.6

Table I.7 – PA-42 Cheyenne - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
1	89	2650	176	0.8290
2	89	2600	176	0.8150
3	89	2550	176	0.8010
4	75	2600	154	0.8050
7	75	2500	160	0.7790
10	75	2450	160	0.7650
15	75	2300	162	0.7240
17	75	2250	163	0.7100
20	75	2700	147	0.8300
21	75	2500	162	0.7800

Table I.8 – C-414 Chancellor - Level flyover noise data

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
1	491.3	83.7	83.5	498.3	84.3	84.3
2	500.5	80.6	80.6	564.0	83.2	84.5
3	488.8	80.1	79.9	498.2	82.0	82.0
4	505.9	78.9	79.0	475.4	81.9	81.4
7	518.7	79.7	80.1	485.4	79.7	79.4
10	490.5	77.4	77.2	480.7	81.8	81.4
15	493.0	76.5	76.4	579.0	78.7	80.2
17	504.4	75.0	75.1	469.0	77.2	76.5
20	525.1	83.1	83.6	479.4	83.2	82.8
21	495.0	78.4	78.3	519.4	79.8	80.2

Table I.8 – C-414 Chancellor - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
14	67	2450	163	0.7870
15	67	2400	166	0.7740
16	67	2300	164	0.7440
17	67	2200	164	0.7150
19	97	2600	194	0.8460
22	97	2600	194	0.8460
23	75	2600	176	0.8360
25	75	2600	176	0.8360
21	50	2600	145	0.8230
24	50	2600	145	0.8230

Table I.9 – Baron 58P - Level flyover noise data

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
14	575.5	78.2	79.7	540.6	79.2	80.0
15	527.4	78.8	79.4	558.4	77.6	78.8
16	540.1	76.6	77.4	542.7	76.1	77.0
17	501.1	76.2	76.2	523.4	75.0	75.5
19	565.1	83.5	84.8	546.4	85.5	86.4
22	513.3	84.5	84.8	590.3	84.8	86.5
23	503.0	84.2	84.3	557.2	83.6	84.7
25	565.3	81.7	83.0	574.6	84.9	86.3
21	551.2	79.8	80.8	577.3	81.9	83.4
24	529.4	81.0	81.6	550.0	82.5	83.5

Table I.9 – Baron 58P - Level flyover noise data (Continued).

Event	Power (%)	RPM	IAS (kts)	M_h
9	90	1650	210	0.6849
10	90	1750	200	0.7109
12	90	1850	200	0.7443
22	90	1875	205	0.7588
20	100	1900	215	0.7705
21	100	1900	215	0.7705
16	75	1900	190	0.7552
17	75	1900	190	0.7552
18	50	1900	170	0.7440
19	50	1900	170	0.7440

Table I.10 – C-425 Conquest I - Level flyover noise data

Event	Site 1			Site 2		
	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)	Alt (ft)	AL_{am} (dB)	AL_{fc} (dB)
14	402	80.8	78.5	548	79.1	80.1
15	395	80.3	77.8	481	79.7	79.3
16	424	81.2	79.5	462	78.5	77.7
17	418	80.8	78.9	453	80.0	79.0
19	421	81.9	80.1	491	82.9	82.7
22	434	83.8	82.3	501	82.4	83.4
23	418	82.7	80.8	436	78.4	81.7
25	425	81.3	79.6	471	79.6	83.2
21	415	79.7	77.8	453	76.6	75.6
24	444	78.6	77.4	449	77.6	76.5

Table I.10 – C-425 Conquest I - Level flyover noise data (Continued).

I.3 Meteorological data

Time	Temperature (°F)
5:53	61
6:53	65
7:54	68
8:51	71
9:52	73
10:53	75
11:53	76
12:15	77

Table I.11 – Cessna 170 - Surface temperature data

Alt above ground (ft)	Temperature (°F)
0	68
246	71
709	75

Table I.12 – PA-28 Turbo Arrow IV - Upper air temperature data

Time	Temperature (°F)
9:56	77
10:15	77
10:30	78
10:45	77
10:57	77
11:17	76
11:31	78
11:46	77
11:55	76
12:14	80
12:31	80
12:46	78
12:54	79

Table I.13 – Cessna 180 - Surface temperature data

Time	Temperature (°F)
5:39	71
5:53	71
6:22	72
6:55	72
7:10	74
7:27	77
7:50	79
8:06	80
8:22	81
8:37	82
8:52	83
9:10	83
9:25	84
9:53	84
10:53	86

Table I.14 – PA-38 Tomahawk - Surface temperature data

Time	Temperature (°F)
6:45	64
6:53	64
7:15	65
7:30	66
7:53	67
8:15	68
8:30	69
8:43	70
8:53	71

Table I.15 – King Air 200 - Surface temperature data

Time	Temperature (°F)
6:46	66
6:54	66
7:05	66
7:20	66
7:47	66
7:52	66
8:20	66
8:53	70
12:53	70
1:53	70
2:53	70
3:53	70

Table I.16 – PA-42 Cheyenne - Surface temperature data

Time	Temperature (°F)
12:53	84
1:31	84
1:54	84
2:54	84
3:51	84

Table I.17 – C-414 Chancellor - Surface temperature data

Time	Temperature (°F)
7:52	44
8:52	49
9:52	55
10:50	58

Table I.18 – C-425 Conquest I - Surface temperature data

Near-field experimental datasets

Data from (54) that was used for validation of the implementation of the near-field prediction method in this work is presented. The following notation is utilized:

IAS: indicated aircraft speed

OAT: outside air temperature

Condition	IAS (kts)	OAT (°F)	Propeller			
			Port		Starboard	
			RPM	Power (SHP)	RPM	Power (SHP)
1	236	50	1573	663	1520	633
2	235	49	1525	627	1570	654
3	232	49	1525	627	1570	646
4	234	49	1573	614	1520	672
5	222	35	1530	629	1530	629
6	226	35	1533	630	1533	630
7	228	35	1530	629	1530	629
8	228	35	1530	629	1530	629
9	227	34	1575	648	1520	629
10	229	34	1525	674	1570	613
11	170	30	0	0	1515	592
12	170	30	1520	625	0	0
13	168	-23	1538	419	1538	419
14	168	-23	1538	427	1538	427
15	174	-23	1538	427	1538	427
16	175	-23	1540	427	1540	427
17	173	-23	1570	420	1518	406
18	174	-23	1523	384	1573	452

Table II.1 – Flight 2 - Test conditions

Condition	IAS (kts)	OAT (°F)	Propeller			
			Port		Starboard	
			RPM	Power (SHP)	RPM	Power (SHP)
1	233	53	1573	647	1520	625
2	233	53	1525	627	1573	655
3	230	53	1525	611	1570	597
4	230	53	1573	647	1518	632
5	220	38	1530	637	1530	645
6	227	38	1533	646	1533	654
7	230	38	1530	645	1530	653
8	230	38	1530	645	1530	653
9	233	39	1573	647	1520	625
10	230	39	1525	627	1573	647
11	183	38	0	0	1515	600
12	173	38	1520	617	0	0
13	170	-19	1525	415	1525	415
14	174	-19	1528	416	1528	416
15	173	-19	1528	416	1528	416
16	173	-19	1528	416	1528	416
17	175	-19	1570	428	1518	414
18	174	-19	1520	398	1570	420

Table II.2 – Flight 3 - Test conditions

Condition	Flight	Harmonic Level (dB)				
		1	2	3	4	5
1	2	132.8	132.2	129.5	124.9	121.2
	3	130.0	129.4	127.0	122.5	118.1
2	2	132.2	131.1	127.8	123.8	119.0
	3	130.0	128.5	125.2	121.0	115.9
3	2	131.7	130.0	127.0	122.2	117.0
	3	129.0	127.0	123.6	119.2	113.9
4	2	131.0	130.3	127.4	122.7	119.0
	3	129.3	129.0	125.6	120.7	117.1
5	2	131.0	129.5	125.3	122.7	119.0
	3	129.3	129.0	125.6	120.7	117.1
6	2	130.3	131.2	127.5	122.6	119.8
	3	128.2	129.1	124.7	120.1	116.7
7	2	131.1	129.9	127.5	123.3	119.3
	3	128.8	127.3	123.8	120.5	115.9
8	2	131.2	131.0	126.9	122.6	118.8
	3	128.9	128.5	123.9	120.2	115.0
9	2	131.5	130.9	128.5	124.8	120.5
	3	128.7	128.0	125.7	121.2	117.1
10	2	132.0	130.5	127.6	123.3	119.1
	3	128.6	127.0	123.7	119.6	115.1
11	2	110.6	109.1	101.3	92.9	-
	3	108.3	107.1	99.3	88.0	-
12	2	129.3	127.1	122.3	118.0	112.9
	3	127.1	124.8	120.1	115.7	110.3
13	2	125.5	126.1	123.1	119.6	116.3
	3	125.0	123.0	120.1	114.7	111.0
14	2	128.0	126.3	123.2	119.9	117.2
	3	123.4	121.2	119.9	117.2	114.2
15	2	126.9	125.0	124.0	120.2	117.1
	3	122.3	123.4	120.0	116.8	113.1
16	2	125.8	127.4	124.3	122.2	117.3
	3	125.0	123.1	120.1	115.0	113.0
17	2	126.0	126.5	125.2	122.0	118.1
	3	123.4	123.4	121.5	118.1	114.5
18	2	126.5	126.0	123.7	119.0	116.1
	3	123.9	122.3	120.0	115.8	112.5

Table II.3 – Exterior microphone - Port side

Condition	Flight	Harmonic Level (dB)				
		6	7	8	9	10
1	2	118.0	113.8	111.2	107.9	103.3
	3	115.1	111.0	107.0	102.7	98.6
2	2	115.3	111.6	108.4	104.0	97.5
	3	112.1	108.2	104.2	99.4	96.1
3	2	114.0	110.5	107.3	102.4	96.6
	3	110.0	106.3	103.5	98.1	93.0
4	2	115.9	111.3	108.1	103.6	101.1
	3	113.8	110.0	107.0	101.2	99.3
5	2	116.0	112.5	109.9	105.0	100.0
	3	111.6	108.7	105.2	101.7	95.7
6	2	114.3	112.3	108.9	104.8	99.9
	3	111.7	110.0	105.4	100.8	96.5
7	2	115.5	114.0	110.2	105.9	101.2
	3	112.1	109.2	106.8	101.5	97.6
8	2	115.0	112.1	109.0	104.5	99.1
	3	112.2	108.3	105.9	100.5	96.8
9	2	117.3	115.1	112.1	108.3	106.2
	3	114.4	111.0	108.0	104.9	101.8
10	2	115.2	113.1	110.1	105.2	101.4
	3	110.8	108.8	105.5	101.2	95.6
11	2	-	-	-	-	-
	3	-	-	-	-	-
12	2	107.4	103.1	95.6	89.5	90.9
	3	104.9	100.1	93.9	88.0	87.5
13	2	113.3	111.0	109.0	106.2	103.8
	3	107.7	105.0	102.2	99.7	97.3
14	2	114.2	111.1	108.2	106.3	104.1
	3	109.5	106.5	104.7	101.3	100.2
15	2	113.7	110.2	108.3	106.8	104.9
	3	122.3	123.4	120.0	116.8	113.1
16	2	115.8	113.0	111.2	108.2	105.7
	3	110.0	107.0	104.5	101.7	98.7
17	2	116.2	114.0	111.1	109.4	106.3
	3	111.7	109.1	106.3	104.6	101.5
18	2	113.6	111.0	108.9	105.8	103.1
	3	109.0	106.4	103.5	100.2	98.0

Table II.3 – Exterior microphone - Port side (Continued)

Condition	Flight	Harmonic Level (dB)				
		1	2	3	4	5
1	2	129.4	126.4	120.6	114.2	109.4
	3	129.5	126.5	120.7	114.5	109.4
2	2	128.0	126.1	120.3	113.0	106.2
	3	128.5	126.2	120.9	113.0	106.7
3	2	127.7	126.6	120.9	117.8	113.0
	3	127.6	126.3	120.5	117.0	112.1
4	2	128.5	126.0	120.3	116.4	112.9
	3	128.5	125.9	120.1	115.3	112.4
5	2	125.5	126.0	119.4	117.6	113.0
	3	126.1	126.2	120.0	117.4	113.0
6	2	125.8	124.5	120.9	116.8	114.0
	3	127.0	125.2	121.0	118.0	115.2
7	2	128.0	126.0	121.0	116.8	113.5
	3	128.8	126.8	120.6	117.3	113.3
8	2	125.8	125.5	120.3	117.1	112.9
	3	127.1	126.4	120.8	118.0	113.9
9	2	127.0	124.9	120.4	116.6	113.1
	3	128.0	125.9	120.8	117.5	113.6
10	2	126.3	125.2	120.8	117.6	114.0
	3	127.8	126.7	122.0	118.3	115.2
11	2	127.8	124.6	120.0	116.1	111.5
	3	128.5	125.2	121.2	116.7	111.1
12	2	109.6	100.0	91.3	-	-
	3	110.2	101.4	93.6	-	-
13	2	124.8	123.8	120.5	118.2	116.2
	3	126.0	123.9	121.2	118.8	115.1
14	2	125.9	124.9	121.4	118.5	116.0
	3	124.4	125.0	121.6	118.5	115.9
15	2	124.5	125.1	121.2	119.0	116.0
	3	125.0	124.1	121.2	118.0	116.1
16	2	124.9	124.0	121.4	119.5	117.2
	3	126.0	124.8	121.3	118.1	116.1
17	2	124.6	123.7	120.2	117.8	115.5
	3	125.3	123.4	120.4	117.3	115.0
18	2	124.3	124.8	121.9	119.5	118.3
	3	125.3	125.6	122.2	120.4	118.1

Table II.4 – Exterior microphone - Starboard side

Condition	Flight	Harmonic Level (dB)				
		6	7	8	9	10
1	2	104.6	103.5	103.4	102.6	102.4
	3	104.6	103.2	102.4	102.1	101.3
2	2	108.2	108.7	109.0	108.5	106.8
	3	106.1	108.5	109.2	108.7	106.6
3	2	110.0	103.2	99.6	96.9	-
	3	109.0	102.7	100.3	92.6	-
4	2	107.4	101.2	97.8	-	-
	3	106.8	100.9	97.1	-	-
5	2	109.1	104.0	99.5	93.3	-
	3	108.5	103.7	97.7	91.4	-
6	2	108.8	105.0	100.1	94.8	-
	3	109.0	105.7	100.7	94.5	-
7	2	108.5	104.9	99.7	98.0	-
	3	109.0	103.9	99.6	94.0	-
8	2	108.3	103.4	97.6	93.5	-
	3	109.0	104.3	97.4	94.2	-
9	2	108.4	103.0	99.6	94.8	-
	3	108.4	103.0	98.0	95.0	-
10	2	110.7	106.0	102.4	98.2	95.6
	3	110.6	106.5	101.9	99.5	95.6
11	2	106.4	100.0	96.4	94.2	92.9
	3	106.0	101.4	99.4	95.7	93.7
12	2	-	-	-	-	-
	3	-	-	-	-	-
13	2	113.2	110.3	107.7	105.0	100.7
	3	112.1	108.8	106.2	103.1	99.5
14	2	112.9	110.1	107.9	104.9	101.0
	3	112.3	109.3	107.0	102.6	100.2
15	2	113.5	110.3	107.8	104.7	101.6
	3	112.4	109.2	107.2	103.0	100.4
16	2	114.0	111.0	108.1	105.6	102.6
	3	113.0	109.0	106.7	103.9	99.8
17	2	112.4	109.0	106.0	102.6	100.3
	3	111.5	108.5	105.9	102.2	98.2
18	2	115.0	113.2	110.2	107.8	105.3
	3	114.8	112.8	109.2	107.5	103.6

Table II.4 – Exterior microphone - Starboard side (Continued)