Thesis Title

Candidate Full Name

Thesis to obtain the Master of Science Degree in

Aerospace Engineering

Supervisor(s): Prof. Full Name 1
Dr. Full Name 2

Examination Committee

Chairperson: Prof. Full Name 1
Supervisor: Prof. Full Name 2
Member of the Committee: Prof. Full Name 3

Month Year

Dedicated to someone special...

Declaration

I declare that this document is an original work of my own authorship and that it fulfills all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

Acknowledgments

A few words about the university, financial support, research advisor, dissertation readers, faculty or other professors, lab mates, other friends and family...

Resumo

Inserir o resumo em Português aqui com um máximo de 250 palavras e acompanhado de 4 a 6 palavras-chave.

Palavras-chave: palavra-chave1, palavra-chave2, palavra-chave3,...

Abstract

Insert your abstract here with a maximum of 250 words, followed by 4 to 6 keywords.

Keywords: keyword1, keyword2, keyword3,...

Contents

List of Tables

List of Figures

Nomenclature

Greek symbols

α	Angle of attack
β	Angle of side-slip
κ	Thermal conductivity coefficient
μ	Molecular viscosity coefficient
ρ	Density

Roman symbols

C_D	Coefficient of drag
C_L	Coefficient of lift
C_M	Coefficient of moment
p	Pressure
$\mathbf{u}$	Velocity vector
u, v, w	Velocity Cartesian components

Subscripts

∞	Free-stream condition
i, j, k	Computational indexes
n	Normal component
ref	Reference condition
x, y, z	Cartesian components

Superscripts

*	Adjoint
T	Transpose

Glossary

CFD	Computational Fluid Dynamics
CSM	Computational Structural Mechanics
MDO	Multidisciplinary Design Optimization
XDSM	eXtended Design Structure Matrix

Chapter 1

Introduction

Insert your chapter material here.

1.1 Motivation

Relevance of the subject.

1.2 Topic Overview

Provide an overview of the topic to be studied.

1.3 Objectives and Deliverables

Explicitly state the objectives set to be achieved with this thesis.

Also list the expected deliverables.

1.4 Thesis Outline

Briefly explain the contents of each chapter.

Chapter 2

Background

Insert your chapter material here.

2.1 Theoretical Overview

Some overview of the underlying theory about the topic...

Remember to define an acronym the first time it is used.

The full acronym can be Multidisciplinary Design Optimization (MDO), that includes both its long definition Multidisciplinary Design Optimization and short definition MDO.

2.2 Theoretical Model 1

The research should be supported with a comprehensive list of references. These should appear whenever necessary, in the limit, from the first to the last chapter.

A reference can be cited in any of the following ways:

- Citation mode #1 - [1]
- Citation mode #2 - Marta and Suleman [1]
- Citation mode #3 - [1]
- Citation mode #4 - Marta and Suleman [1]
- Citation mode #5 - [1]
- Citation mode #6 - Marta and Suleman 1
- Citation mode #7 - 1
- Citation mode #8 - Marta and Suleman
- Citation mode #9 - 2021

- Citation mode #10 - [2021]

The references may include books [1], articles in journals [2], part of a collection of books [3], articles in conferences [4], master theses [5] and PhD theses [6].

Several citations can be made simultaneously as [7, 8].

This is often the default bibliography style adopted (numbers following the citation order), according to the options:

`\usepackage{natbib}` in file `Thesis_Preamble.tex`,
`\bibliographystyle{abbrvnat}` in file `Thesis.tex`.

Notice however that this style can be changed from numerical citation order to authors' last name with the options:

`\usepackage[numbers]{natbib}` in file `Thesis_Preamble.tex`,
`\bibliographystyle{abbrvunsrtnat}` in file `Thesis.tex`.

Multiple citations are compressed when using the `sort&compress` option when loading the `natbib` package as `\usepackage[numbers,sort&compress]{natbib}` in file `Thesis_Preamble.tex`, resulting in citations like [9–23].

2.3 Theoretical Model 2

Other models.

Chapter 3

Implementation

Insert your chapter material here.

3.1 Numerical Model

Description of the numerical implementation of the models explained in Chapter 2.

If needed, pseudo-codes can be included as exemplified in Algorithm 1.

Algorithm 1 Euclid's algorithm

procedure EUCLID(a, b) ▷ The g.c.d. of a and b
    $r \leftarrow a \bmod b$
    while $r \neq 0$ **do** ▷ We have the answer if r is 0
        $a \leftarrow b$
        $b \leftarrow r$
        $r \leftarrow a \bmod b$
    end while
    return b ▷ The gcd is b
end procedure

3.2 Verification and Validation

Basic test cases to compare the implemented model against other numerical tools (verification) and experimental data (validation).

Chapter 4

Results

Insert your chapter material here.

4.1 Problem Description

Description of the baseline problem.

4.2 Baseline Solution

Analysis of the baseline solution.

4.3 Enhanced Solution

Quest for the optimal solution.

4.3.1 Figures

Insert your section material and possibly a few figures.

Make sure all figures presented are referenced in the text!

The caption should appear below the figure.

Images

By default, this document supports file types *.png,.pdf,.jpg,,.jpeg*.

See the documentation of package *graphicx* `https://www.ctan.org/tex-archive/macros/latex/required/graphics/` for other extensions support.

When referencing a figure, use the abbreviation Fig., unless it is the beginning of a sentence.

Figure 4.1 is an example and so is Fig. 4.2.

Figure 4.1: Caption for figure.

It is possible to include subfigures. Figure 4.2 is composed of three subfigures: Fig. 4.2a, 4.2b and 4.2c.

]fig1a

(a) Airbus A320.

(b) Bombardier CRJ200.

(c) Airbus A350.

Figure 4.2: Examples of aircraft.

Most aircraft have wings with large aspect ratios ($\mathcal{A}\!\!\!\mathcal{R}$= 8 – 15) for higher aerodynamic efficiency.

Drawings

Insert your subsection material and for instance a few drawings.

The schematic illustrated in Fig. 4.3 can represent some sort of algorithm.

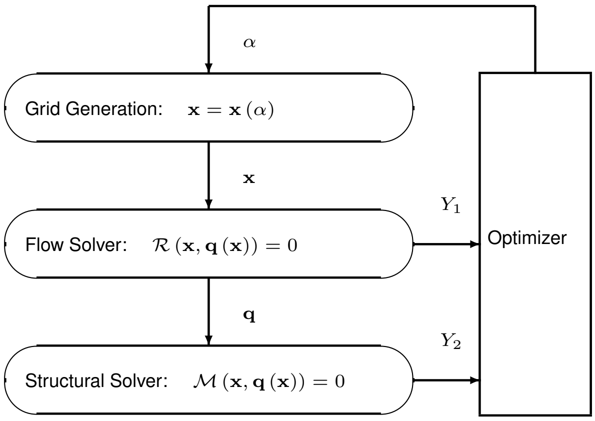

Figure 4.3: Schematic of some algorithm.

4.3.2 Equations

Equations can be inserted in different ways.

The simplest way is in a separate line as

$$\frac{\mathrm{d}q_{ijk}}{\mathrm{d}t} + \mathcal{R}_{ijk}(\boldsymbol{q}) = 0\,, \tag{4.1}$$

where each variable must properly defined.

If the equation is to be embedded in the text, it can be done like $\partial\mathcal{R}/\partial\boldsymbol{q} = 0$.

It may also be split in different lines like

$$\begin{aligned} \text{Minimize} \quad & Y(\boldsymbol{\alpha}, \boldsymbol{q}(\boldsymbol{\alpha})) \\ \text{with respect to} \quad & \boldsymbol{\alpha} \\ \text{subject to} \quad & \mathcal{R}(\boldsymbol{\alpha}, \boldsymbol{q}(\boldsymbol{\alpha})) = 0 \\ & C(\boldsymbol{\alpha}, \boldsymbol{q}(\boldsymbol{\alpha})) = 0\,. \end{aligned} \tag{4.2}$$

It is also possible to use subequations.

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_j}\left(\rho u_j\right) = 0\,, \tag{4.3a}$$

$$\frac{\partial}{\partial t}\left(\rho u_i\right) + \frac{\partial}{\partial x_j}\left(\rho u_i u_j + p\delta_{ij} - \tau_{ji}\right) = 0, \quad i = 1, 2, 3\,, \tag{4.3b}$$

$$\frac{\partial}{\partial t}\left(\rho E\right) + \frac{\partial}{\partial x_j}\left(\rho E u_j + p u_j - u_i \tau_{ij} + q_j\right) = 0\,. \tag{4.3c}$$

Notice that the equations should be punctuated as they are part of sentences, so a comma or a period should be put at the end of each of them, as exemplified in all the previous equations.

When referencing an equation, use the abbreviation Eq., unless it is the beginning of a sentence. The number of the equation should always be in parenthesis.

Equations (4.3a), (4.3b) and (4.3c) form the Navier–Stokes equations (Eq. (4.3)).

4.3.3 Tables

Insert your subsection material and for instance a few tables.

Make sure all tables presented are referenced in the text!

The caption should appear above the table.

Follow some guidelines when making tables:

- Avoid vertical lines;
- Avoid "boxing up" cells, usually 3 horizontal lines are enough: above, below, and after heading;
- Avoid double horizontal lines;
- Add enough space between rows.

Table 4.1: Table caption.

Model	C_L	C_D	C_{My}
Euler	0.083	0.021	-0.110
Navier–Stokes	0.078	0.023	-0.101

When referencing a table, use the abbreviation Tab., unless it is the beginning of a sentence.

Tables 4.2 and 4.3 are examples of tables with merging columns:

Table 4.2: Memory usage comparison (in MB).

	Virtual memory [MB]	
	Euler	Navier–Stokes
Wing only	1,000	2,000
Aircraft	5,000	10,000
(ratio)	$5.0\times$	$5.0\times$

An example with merging rows can be seen in Tab. 4.4.

If a table has too many columns, it can be scaled to fit the text width, as in Tab. 4.5.

4.3.4 Mixing

If necessary, a figure and a table can be put side-by-side as in Fig. 4.4

Table 4.3: Another table caption.

	$w = 2$			$w = 4$		
	$t = 0$	$t = 1$	$t = 2$	$t = 0$	$t = 1$	$t = 2$
$dir = 1$						
c	0.07	0.16	0.29	0.36	0.71	3.18
c	-0.86	50.04	5.93	-9.07	29.09	46.21
c	14.27	-50.96	-14.27	12.22	-63.54	-381.09
$dir = 0$						
c	0.03	1.24	0.21	0.35	-0.27	2.14
c	-17.90	-37.11	8.85	-30.73	-9.59	-3.00
c	105.55	23.11	-94.73	100.24	41.27	-25.73

Table 4.4: Yet another table caption.

ABC	header			
	1.1	2.2	3.3	4.4
IJK	group		0.5	0.6
			0.7	1.2

Table 4.5: Very wide table.

Variable	a	b	c	d	e	f	g	h	i	j
Test 1	10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000
Test 2	20,000	40,000	60,000	80,000	100,000	120,000	140,000	160,000	180,000	200,000

Legend		
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

Figure 4.4: Figure and table side-by-side.

Chapter 5

Conclusions

Insert your chapter material here.

5.1 Achievements

The major achievements of the present work.

5.2 Future Work

A few ideas for future work.

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Appendix A

Vector calculus

In case an appendix if deemed necessary, the whole document cannot exceed a total of 100 pages (in arabic page numbering).

Some definitions and vector identities are listed in the section below.

A.1 Vector identities

$$\nabla \times (\nabla \phi) = 0 \tag{A.1}$$

$$\nabla \cdot (\nabla \times \mathbf{u}) = 0 \tag{A.2}$$

Appendix B

Technical Datasheets

It is possible to add PDF files to the document, such as technical sheets of some equipment used in the work.

B.1 Some Datasheet

See more options to include PDF files in `https://www.ctan.org/pkg/pdfpages`

Lightweight scanning lidar

Features

- *Application:* *Obstacle detection and navigation for small autonomous vehicles and drones*
- *Key features:* *Small and lightweight*
  *Upgradable through the **LightWare Studio** application*
- *Measuring range:* *0.2 … 50 m (80% reflective, large target)*
- *Size:* *53 mm x 44 mm x 37 mm*
- *Weight:* *48.3 grams*
- *Measuring speed:* *Up to 20,000 points per second (configurable)*
- *Interfaces:* *Serial, I2C and USB*
- *Integration:* *User APIs, **LightWare Studio***
- *Safety:* *Eye safe laser emission Class 1M*
- *Environmental:* *Open frame, no IP rating*

FM 654831

Table of contents

Product ordering codes

Model family	Model name	Model description
SF45	SF45/B (50 m)	Open frame scanning lidar sensor, max 50 m

Disclaimer

Information found in this document is used entirely at the reader's own risk and whilst every effort has been made to ensure its validity, neither LightWare Optoelectronics (Pty) Ltd nor its representatives make any warranties with respect to the accuracy of the information contained herein.

1. Overview

The SF45/B is a small, lightweight scanning lidar ideal for obstacle detection by small autonomous vehicles. The horizontal field of view can be adjusted from a few degrees up to 320 degrees to suit the application. Objects up to 50m away can be detected and avoided by finding clear pathways using simple navigation commands. The SF45/B is tolerant to changes in background lighting conditions, wind and noise.

The following capabilities are included in the SF45/B as standard:

- Streaming of live readings.
- Alarms when an obstacle is detected.
- Configurable update rate and scanning angle.
- Internal status monitoring.

Additional features may be added through ***LightWare Studio***:

- Servo driver for a second axis of motion.
- Measurement to the nearest detected surface (first return).
- Measurement to the farthest detected surface (last return).
- Selectable filters to adjust the dynamic response to moving targets.
- Navigation tools.
- Custom features.

The following communication interfaces are available:

- A micro USB port that connects to a PC running the ***LightWare Studio*** application for visualisation of results, to make configuration changes and for upgrading the firmware.
- A serial port (3.3V logic level) with configurable baud rate to connect to a host controller.
- An I2C serial bus (3.3V logic level, external pull up resistors required) with configurable address as an alternative to the serial port when multiple devices are connected on a common bus.
- Two general purpose outputs.

Application software support is available from the LightWare ***API*** repository.

The SF45/B scanning lidar is rated laser Class 1M eye safe. Do not view the laser with magnifying optics such as microscopes, binoculars or telescopes.

2. Specifications

Performance	
Range	0.2 … 50 m (white wall in daylight conditions)
Linear Resolution	1 cm
Angular Resolution	< 0.2 deg
Update rate	Up to 20,000 readings per second and 5 sweeps per second.
Accuracy	±10 cm
Connections	
Power supply voltage	4.5 V … 5.5 V
Power supply current	300 mA (typical)
Outputs & interfaces	Serial and I2C (3.3 V), micro USB, general purpose outputs
Mechanical	
Dimensions	53 mm x 44 mm x 37 mm
Weight	48g (excluding cables)
Optical	
Laser safety	Class 1M (refer to www.lightware.co.za/safety for full details)
Optical aperture	28 mm x 15 mm
Beam divergence	< 0.5°
Environmental	
Operating temperature	-10 … +50°C
Approvals	FDA: 1710193-000 (2019/08)
Enclosure rating	N/A
Accessories	
Main cable	7 way - individual wires, unterminated
USB cable	USB cable - DigiKey AE10418-ND
Default settings	
Serial port settings	115200 baud, 8 data bits, 1 stop bit, no parity, no handshaking
I2C address	0x66 (Hex), 102 (Dec)
Update rate	388 readings per second
Main cable connections	
1	GPIO / LED driver
2	GPIO / servo driver
3	TXD/SDA - serial data transmit or I2C data
4	RXD/SCL - serial data receive or I2C clock
5	GND - power supply negative
6	GND - power supply negative
7	+ 5 V - power supply positive (4.5 V to 5.5 V at 500 mA)