Unmanned Solar Powered Airship Concept Evaluation

Critical Design Report

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Acronyms

EGSE Electrical Ground Support Equipment

EPS Electrical Power System

IRF Swedish Institute of Space Physics

ITPU Imaging and Tracking Payload Unit

ITU International Telecommunication Union

LTU Luleå University of Technology

MCC Motor Control and Communication

MGSE Mechanical Ground Support Equipment

MSE Mechanical Structure and Envelope

SPA Solar Powered Airship

SSC Swedish Space Corporation

U-SPACE Unmanned Solar Powered Airship Concept Evaluation

UAS Unmanned Aircraft System

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Chapter 1

Basic LaTex Commands

This section provides some basic useful LaTex commands. For further reference, search on Google where you will find plenty of useful LaTex blogs. **Remove this chapter later on...**

1.1 Figures

This is a figure example:

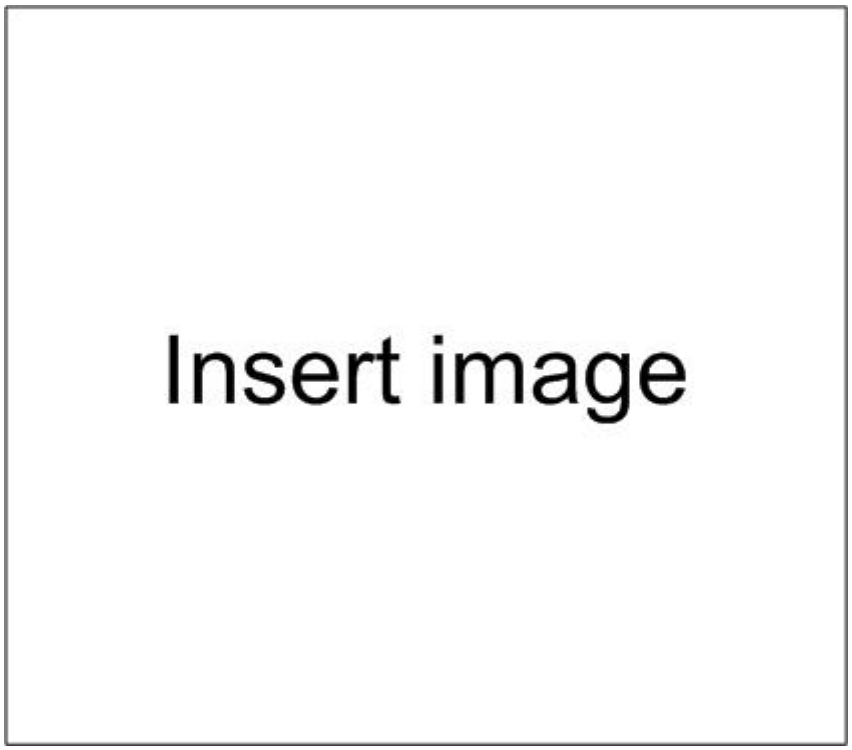


Figure 1.1 – *This is a figure caption*

You can also place figures side-by-side. An easy way is to use a "minipage" environment:

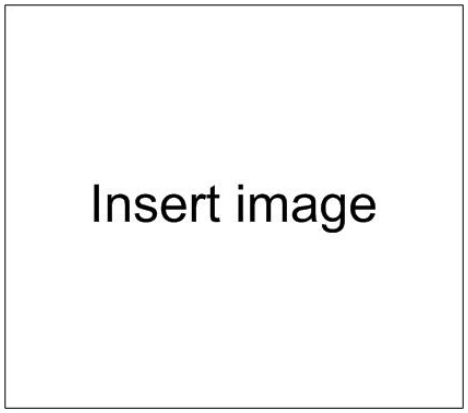


Figure 1.2 – *This is a figure caption*

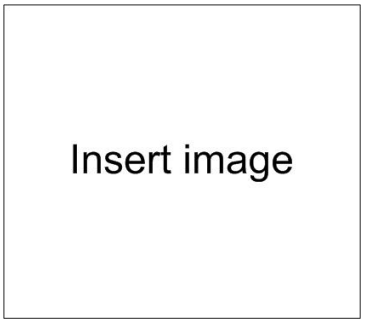
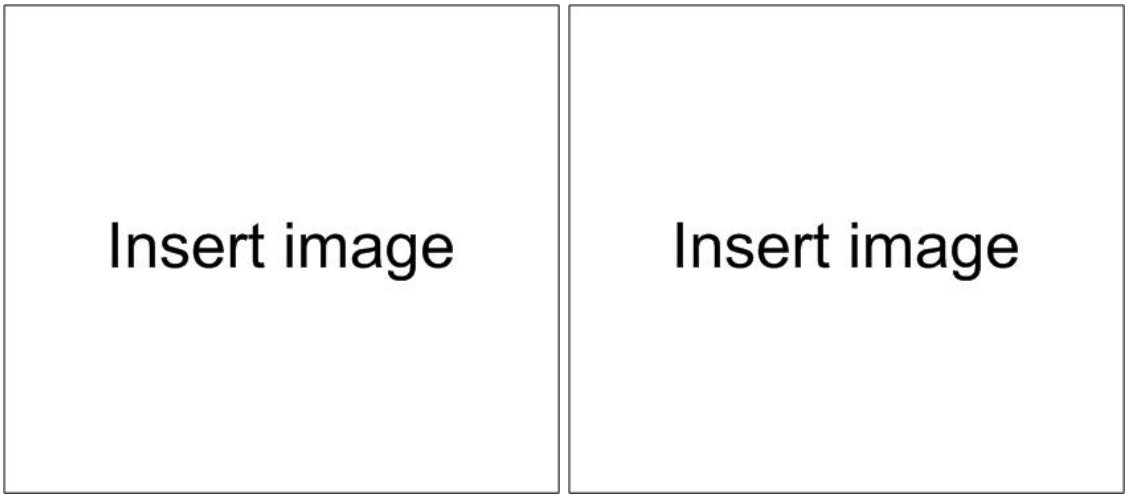


Figure 1.3 – *This is a figure caption*

An alternative is to use the "subfigure" command inside the "figure" environment. You need the

```
\usepackage[center]{subfigure}
```

command in your preamble. With this command, the figures will be labelled a, b, c etc.



(a) Caption for subfigure 1 (b) Caption for subfigure 2

Figure 1.4 – *General caption*

1.2 Tables

This is an example of a table:

Table 1.1 – *This is a table caption*

Header 1	**Header 2**	**Header 3**
Some text	Some text	Some text
Some more text	Some more text	Some more text

You can also do a table with multi-line cells:

Table 1.2 – *This is a table caption*

Header 1	**Header 2**	**Header 3**
Some long text that does not fit in a single-line table cell	Some text	Some text
Some more text	Another very long text that does not fit in a single-line table cell	Some more text

1.3 Equations

You can do simple in-line equations by using the "$" symbols around the equation: $2+2=4$. Remember always to use a the math- or equation environment when using variables like $+$, $=$, x^2, f_2 etc.

To write a numbered equation on its own line, use the "equation" environment:

$$T(s) = \frac{G(s)H(s)}{1 + G(s)H(s)} \tag{1.1}$$

You can also do multi-line equation by using the "split" - environment:

$$\begin{aligned} 2x + 4y &= 6 \\ 4y &= 6 - 2x \\ y &= 1.5 - 0.5x \end{aligned} \tag{1.2}$$

1.4 Citations, References and Acronyms

This is a citation[1].

This is a citation referring to a specific page in the cited work[1, p. 28].

You can also do multiple citations[1, 2].

This is a cross-reference to a figure/section/table/equation etc. in the latex document: see Figure 1.1.

Use acronyms consistently to provide an easy-reading text: The Unmanned Solar Powered Airship Concept Evaluation (U-SPACE) project rocks!

Chapter 2

Introduction

U-SPACE is a student project at the Rymdcampus of the Luleå University of Technology (LTU) in Kiruna under the supervision of Kjell Lundin and Alf Wikström. It is supported by the Swedish Institute of Space Physics (IRF) and LTU. The goal of the project is to prove the concept of a small scale student-built unmanned Solar Powered Airship (SPA) powered by solar cells. The solar cells are mounted on a gas-filled envelope, with forward propulsion being achieved by propellers mounted on the same envelope. The airship communicates over a wireless connection with a ground station or controller. This connection enables control over the airship, together with retrieval of housekeeping and scientific payload data.

The same concept of a SPA has attracted major interest in recent years [3, 4, 5, 6]. Such an airship could be used for a wide variety of applications, ranging from passenger and cargo transport [4] over scientific research [5] to planetary exploration [6]. These applications all benefit greatly from the advantages of a solar-powered airship: simple flight control, reduced fossil fuel consumption and access to long duration flights. Apart from these inherent strong points, other advantages of SPAs are the possibility for autonomous take-off and landing, the elimination of large infrastructures like airports and minimal weather constraints. Even though many researchers have investigated the possibilities of SPA's, few student-driven projects exist. **EXAMPLES OF STUDENT PROJECTS?** The above-mentioned advantages of SPA's and the fact that few student projects exist, were the main drivers for the creation of the U-SPACE project.

2.1 Hardware

Description of the hardware, including a block diagram

2.2 Software

Description of software, including operational modes

Chapter 3

Design Requirements

some text...

3.1 Functional Requirements

What function(s) does the system have to fulfill?

- A requirement
- Another requirement
- Etc...

3.2 Technical Requirements

What technical requirements constrain the system design? - e.g. mass, power, strength, stability etc.

- A requirement
- Another requirement
- Etc...

3.3 Fault Tolerance Design and Safety Concept

N/A, but comment on it. Refer to MGSE for safety concept

3.4 Materials

Briefly comment on it

Chapter 4

Mechanical Structure and Envelope

General introduction to the subsystem...

4.1 Functional and Technical Requirements

Based on PDR...

4.2 Mechanical and Structural Design

Explain the design including block diagrams, schematics, drawings, etc.
Just a suggestion for the subsections...

4.2.1 Cargo Bay

4.2.2 Envelope

4.2.3 Harness

4.2.4 Motor Mounting

4.3 Mechanical Interfaces

How does the MSE system interact with the other subsystems?

4.3.1 Mechanical Interface Control Drawing

Could not really find what this is and if we need it... Morten?

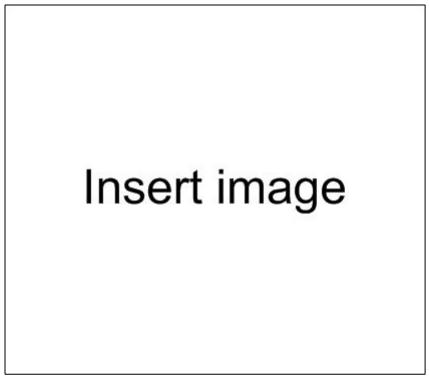


Figure 4.1 – *Design diagrams*

4.3.2 Accommodation Requirements

Same here...

4.4 Physical Properties

E.g. mass in launch configuration...

4.5 Structural and Mechanisms Analysis

This involves things like dynamic analysis and stress analysis, but as we didn't really do this, just briefly comment on it...

4.6 Mounting Attachments

Not sure what they mean with this... Attachment concept and foot pattern?

Chapter 5

Electrical Power System

General introduction to the subsystem...

5.1 Functional and Technical Requirements

Based on the PDR...

5.2 Power Distribution Block Diagram and Redundancy

Block diagram of the different power consumers...

5.3 Electrical Circuits

Explanation of all different circuits involved in the EPS subsystem...

Chapter 6

Motor Control and Communication

General introduction to the subsystem...

6.1 Functional and Technical Requirements

Based on the PDR...

6.2 ?

No real suggestions here for the sections... Just write about channel allocations, bit rate requirements, etc.

6.3 Electrical Circuits

Explanation of all different circuits involved in the subsystem...

Chapter 7

Imaging and Tracking Payload Unit

General introduction to the subsystem...

7.1 Functional and Technical Requirements

Based on the PDR...

7.2 ?

Again, no real suggestions here, but just describe your entire subsystem, including the software, autonomous functions, channel allocations, bit rate requirements, monitoring, etc.

7.3 Electrical Circuits

Explanation of all different circuits involved in the subsystem...

Chapter 8

Thermal Interfaces, Pyrotechnics and Electromagnetic Compatibility

N/A but just comment on all of it briefly...

8.1 Thermal Interfaces

Some comments... E.g. why not applicable?

8.2 Pyrotechnics Interface

Some comments... Why not applicable?

8.3 Electromagnetic Compatibility

Some comments, e.g. grounding...

Chapter 9

Test and Verification of Design

9.1 Design Verification Plan

9.1.1 Objectives and Responsibilities

Why and who?

9.1.2 Verification By Analysis

N/A, but comment on it briefly...

9.1.3 Verification By Test

Write about test procedures...

9.1.4 Verification Control System

Not sure if this is applicable, but if yes, then the answer should be github I guess...

9.2 Subsystem Test Matrices

Different tests presented as a matrix/table: rows are test modules, columns are possible testing techniques. Maybe one per subsystem? Also limited life time elements could be included here...

Chapter 10

Ground Support Equipment

10.1 Electrical Ground Support Equipment (EGSE)

Based on PDR...

10.1.1 Concept

10.1.2 Hardware Description

Instrument, user and network interface...

10.1.3 Software Description

10.1.4 Compliance

10.2 Mechanical Ground Support Equipment (MGSE)

Based on PDR...

Chapter 11

Project Management

11.1 Organisation and Responsibilities

11.1.1 Key Personnel and Responsibilities

11.1.2 Functional Organigram

11.1.3 Support Facilities

Esrange, IRF, etc.

11.1.4 Shipment

Might be useful to already give it some thought...

11.2 Relation With Support Facilities

11.2.1 Reporting and Monitoring

11.2.2 Reviews

11.2.3 Component Ordering

11.3 Financing

11.4 Schedule and Milestones

Updated from PDR...

11.5 Configuration Control

How are design changes tracked and discussed?

11.6 Deliverables

11.6.1 Hardware and Software

11.6.2 Documentation

11.6.3 Deliverable Items and Build Standard

Not absolutely clear what this means... Morten?

Bibliography

[1] In: ().

[2] In: ().

[3] Raven Aerostar. *High Altitude Airships*. 2012. URL: http://ravenaerostar.com/products/aerospace/high-altitude-airships.

[4] Nortávia. *Mission*. 2012. URL: http://www.id-nortavia.com/gaya/Mission.html.

[5] Julia Saba et al. *Science Enabled By A High Altitude Airship (HAA)*. 2012. URL: http://sec.gsfc.nasa.gov/th_poster_HAA.pdf.

[6] Anthony Colozza. *Airships for Planetary Exploration*. Tech. rep. Analex Corporation, 2004.

Appendix A

Some Appendix

some text...

Appendix B

Another Appendix

some text...