

## Bachelor-Thesis

# Human-Machine Interface for Operating a Blimb

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# Declaration of Originality

I hereby declare that the written work I have submitted entitled

## **Human-Machine Interface for Operating a Blimb**

is original work which I alone have authored and which is written in my own words.<sup>1</sup>

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# Abstract

Hier kommt der Abstact hin ...



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Lorenz Meier

Alexander Rudyk





# Symbols

## Symbols

|                      |                              |
|----------------------|------------------------------|
| $\phi, \theta, \psi$ | roll, pitch and yaw angle    |
| $b$                  | gyroscope bias               |
| $\Omega_m$           | 3-axis gyroscope measurement |

## Indices

|     |        |
|-----|--------|
| $x$ | x axis |
| $y$ | y axis |

## Acronyms and Abbreviations

|     |                                      |
|-----|--------------------------------------|
| ETH | Eidgenössische Technische Hochschule |
| EKF | Extended Kalman Filter               |
| IMU | Inertial Measurement Unit            |
| UAV | Unmanned Aerial Vehicle              |
| UKF | Unscented Kalman Filter              |



# Chapter 1

## Introduction

1.1 Context

1.2 Goals

1.3 System Overview

1.4 Similar Systems and their HMI

1.5 Structure of the Report



## Chapter 2

# Einige wichtige Hinweise zum Arbeiten mit L<sup>A</sup>T<sub>E</sub>X

Nachfolgend wird die Codierung einiger oft verwendeten Elemente kurz beschrieben. Das Einbinden von Bildern ist in L<sup>A</sup>T<sub>E</sub>X nicht ganz unproblematisch und hängt auch stark vom verwendeten Compiler ab. Typisches Format für Bilder in L<sup>A</sup>T<sub>E</sub>X ist EPS<sup>1</sup>.

### 2.1 Gliederungen

Ein Text kann mit den Befehlen `\chapter{.}`, `\section{.}`, `\subsection{.}` und `\subsubsection{.}` gegliedert werden.

### 2.2 Referenzen und Verweise

Literaturreferenzen werden mit dem Befehl `\cite{.}` erzeugt. Ein Beispiel: [?]. Zur Erzeugung von Fussnoten wird der Befehl `\footnote{.}` verwendet. Auch hier ein Beispiel<sup>2</sup>.

Querverweise im Text werden mit `\label{.}` verankert und mit `\ref{.}` erzeugt. Beispiel einer Referenz auf das zweite Kapitel: Kapitel 2.

### 2.3 Aufzählungen

Folgendes Beispiel einer Aufzählung ohne Numerierung,

- Punkt 1
- Punkt 2

wurde erzeugt mit:

```
\begin{itemize}
  \item Punkt 1
  \item Punkt 2
\end{itemize}
```

Folgendes Beispiel einer Aufzählung mit Numerierung,

1. Punkt 1

---

<sup>1</sup>Encapsulated Postscript

<sup>2</sup>Bla bla.

## 2. Punkt 2

wurde erzeugt mit:

```
\begin{enumerate}
  \item Punkt 1
  \item Punkt 2
\end{enumerate}
```

Folgendes Beispiel einer Auflistung,

**P1** Punkt 1

**P2** Punkt 2

wurde erzeugt mit:

```
\begin{description}
  \item[P1] Punkt 1
  \item[P2] Punkt 2
\end{description}
```

## 2.4 Erstellen einer Tabelle

Ein Beispiel einer Tabelle:

Table 2.1: Daten der Fahrzyklen ECE, EUDC, NEFZ.

| Kennzahl                     | Einheit | ECE   | EUDC  | NEFZ   |
|------------------------------|---------|-------|-------|--------|
| Dauer                        | s       | 780   | 400   | 1180   |
| Distanz                      | km      | 4.052 | 6.955 | 11.007 |
| Durchschnittsgeschwindigkeit | km/h    | 18.7  | 62.6  | 33.6   |
| Leerlaufanteil               | %       | 36    | 10    | 27     |

Die Tabelle wurde erzeugt mit:

```
\begin{table}[h]
\begin{center}
\caption{Daten der Fahrzyklen ECE, EUDC, NEFZ.}\vspace{1ex}
\label{tab:tabnefz}
\begin{tabular}{ll|ccc}
\hline
Kennzahl & Einheit & ECE & EUDC & NEFZ \\ \hline
Dauer & s & 780 & 400 & 1180 \\
Distanz & km & 4.052 & 6.955 & 11.007 \\
Durchschnittsgeschwindigkeit & km/h & 18.7 & 62.6 & 33.6 \\
Leerlaufanteil & \% & 36 & 10 & 27 \\
\hline
\end{tabular}
\end{center}
\end{table}
```

## 2.5 Einbinden einer EPS-Graphik

Das Einbinden von Graphiken kann wie folgt bewerkstelligt werden:

```
\begin{figure}[h]
  \centering
  \includegraphics[width=0.75\textwidth]{pics/k_surf.eps}
  \caption{Ein Bild.}
  \label{pics:k_surf}
\end{figure}
```

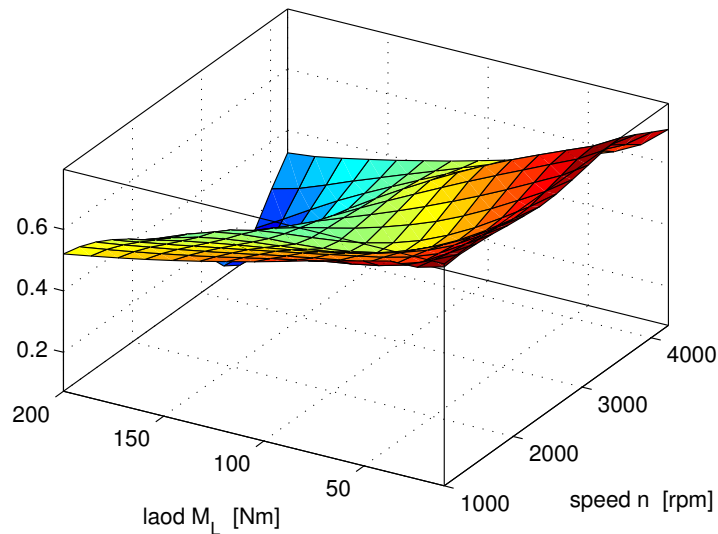


Figure 2.1: Ein Bild.

oder bei zwei Bildern nebeneinander mit:

```
\begin{figure}[h]
  \begin{minipage}[t]{0.48\textwidth}
    \includegraphics[width = \textwidth]{pics/cycle_we.eps}
  \end{minipage}
  \hfill
  \begin{minipage}[t]{0.48\textwidth}
    \includegraphics[width = \textwidth]{pics/cycle_ml.eps}
  \end{minipage}
  \caption{Zwei Bilder nebeneinander.}
  \label{pics:cycle}
\end{figure}
```

Bemerkung: Ersetzt man den Positionierungsparameter `h` durch `H`, so wird das Gleiten der Abbildung verhindert.

## 2.6 Mathematische Formeln

Einfache mathematische Formeln werden mit der `equation`-Umgebung erzeugt:

$$p_{meof}(T_e, \omega_e) = k_1(T_e) \cdot (k_2 + k_3 S^2 \omega_e^2) \cdot \Pi_{max} \cdot \sqrt{\frac{k_4}{B}}. \quad (2.1)$$

Der Code dazu lautet:

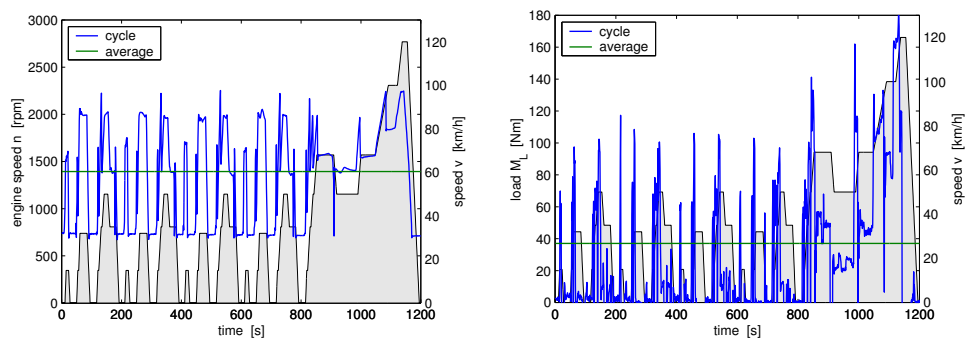


Figure 2.2: Zwei Bilder nebeneinander.

```
\begin{equation}
p_{\text{me0f}}(T_e, \omega_e) \setminus = \setminus k_1(T_e) \setminus \cdot (k_2 + k_3 S^2
\omega_e^2) \setminus \cdot \Pi_{\text{max}} \setminus \cdot \sqrt{\frac{k_4}{B}} \setminus , .
\end{equation}
```

Mathematische Ausdrücke im Text werden mit `$formel$` erzeugt (zB:  $a^2 + b^2 = c^2$ ).

## 2.7 Weitere nützliche Befehle

Hervorhebungen im Text sehen so aus: *hervorgehoben*. Erzeugt werden sie mit dem `\epmh{.}` Befehl.



## Chapter 3

# Finding a Hardware and Software Solution



## Chapter 4

# The different Control Modes



## Chapter 5

# Realization of the HMI as a whole and for each Control Mode



## Chapter 6

# Trajectory Planning

For the two most advanced modes, i. e. the Half-Automatic and the Full-Automatic Mode, trajectories had to be generated. In this chapter the best trajectories for skye are elaborated.

### 6.1 Introduction

#### 6.1.1 Definition

What is a trajectory...(notation, parameter, time...) How do we intend to realize our idea...

#### 6.1.2 Our Approach

From the GUI it was given that the goal trajectory would be a multipoint-interpolating trajectory. The user is able to define waypoints on a map which afterwards should be connected with a reasonable and realizable trajectory. Beside interpolating trajectories there exist also approximating trajectories but they were not taken into consideration, since usually the user wants skye fly directly through a waypoint. In another Bsc Thesis elaborated in this project a controller for waypoint following was designed. So it was convenient in the scope of this Thesis to use this controller instead of a specialized trajectory controller.

### 6.2 Vorschlag: Geometric Parameterized Paths

BLA: Everything considering generating splines, boundary conditions, order, and comparison and evaluation (skye independent)

### 6.3 Vorschlag: Time Parameterized Trajectories

BLA: System constraints, time parametrization

### 6.4 Vorschlag: Trajectory Controller

BLA: Feeding the trajectories into skye, controller approach, evaluation (comparison trajectory and trace)

UNSCH"ON: Hier muss alles was oben theoretisch beschrieben wird repetiert werden (BC, Order, Constraints?, different time parametrization)

## 6.5 System Constraints for Trajectory

### 6.5.1 Maximum Velocities and Accelerations

In order to plan a feasible trajectory one has to know the capabilities of the system. Here just a basic derivation for the velocities and accelerations is given, for more details refer to (!!!!Bsc Thesis Joe, Bsc Thesis Andy)

The maximum feasible acceleration in any direction is calculated to be:

$$|a_{max}| = \frac{|F_{res,w}|}{m_{tot}} = 0.96m/s^2 \quad (6.1)$$

Whereas the  $F_{res,w}$  is the force resulting from all four thrusters operated under full load in the worst direction and  $m_{tot}$  is the sum of the masses of the helium, the virtual mass and the mass of the system itself.

The maximum feasible velocity in any direction is calculated to be:

$$|v_{max}| = \sqrt{\frac{|F_{res,w}|}{\frac{1}{2}c_d\rho\pi r^2}} = 4.7m/s \quad (6.2)$$

which is nothing but  $|F_{res,min}| = |F_{drag}|$ .

For trajectories for position and orientation the maximal feasible angular acceleration is also important. It is calculated to be:

$$|\Psi_{max}| = \frac{|M_{res,w}|}{|\lambda_{max,J_B}|} = 2.82rad/s^2 \quad (6.3)$$

which is quite conservative because it is assumed that worst axis for turning is also the principle axis of the inertia tensor with the highest inertia.

Since the system is almost undamped for rotations, the rotational velocities will never be the limiting factor.

### 6.5.2 Continuity



# Appendix A

## Irgendwas

Bla bla ...



## Appendix B

# Nochmals irgendwas

Bla bla ...



# Bibliography

- [1] R. MAHONY, T. HAMEL, J.-M. PFLIMLIN: *Complementary filter design on the special orthogonal group  $SO(3)$* . In 45th Conference on Decision and Control CDC'05, Seville, Spain, 2005.