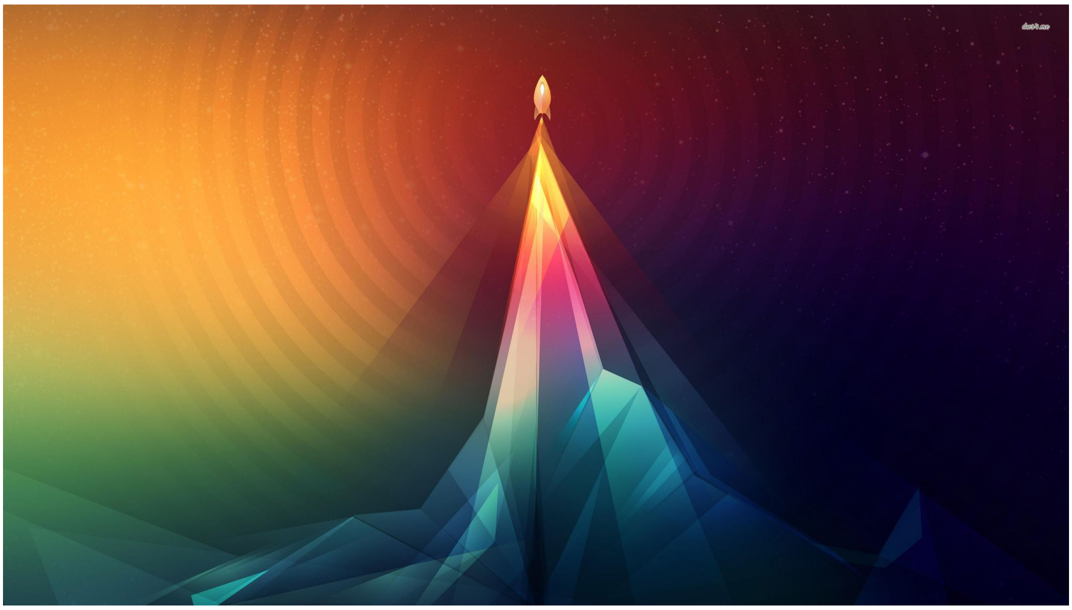
Rocket Navigation System



Project Report

Group CE6-633

Aalborg University
Electronic Engineering and IT

This report is compiled in LaTeX.

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Abstract:

Preface

This report is composed by group CE6-633 during the 6th semester of Electronic Engineering and IT at Aalborg University, 2017. The study of wireless power transfer and drone tracking described in this report is part of the theme *Control Engineering*.

For citation the report employs IEEE style referencing. If citations are not present by figures or tables, these have been made by the authors of the report. Units are indicated according to the SI system.

The natural logarithm is denominated by ln and $\log_{10}$ is the base 10 logarithm.

A period is used as a decimal mark. Half a space is used as a 100 0 separator.

Aalborg University, February 14, 2017

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Part I

Pre-analysis & requirements

Chapter 1

Introduction

Start with an explanation of why space exploration and orbitting technology is an advantage. Transition into how to put stuff in orbit or leave earth's gravity (rockets). Talk about issues with having basically a stick with thrusters beneath. It can tip over and variances in air currents have a large influence on the direction of the rocket. End with saying a control system that can make sure it's going straight is an advantage. Now we have a reason for making the control system we want.

Chapter 2

Initial Problem Statement

In order to design and implement a controller that can ensure a stable launch and flight of a rocket the following questions needs answering:

How is it possible to counteract the instability that occurs during launch and flight of a rocket, and how can rocket instability be defined. Should Be Changed - Mathias

- Which factors contribute to an unstable rocket during launch and flight?
- Can the rocket be modelled based on another system with similar instability problems?

Chapter 3

Preliminary Analysis of a Rocket

The following chapter describes the functionality and structure behind a rocket. The goal is to determine which factors that leads to instability in flight and launch of a rocket.

The full scale rocket model that will be described consist of,

- a payload system.
- a guidance system.
- a propulsion system.
- a structural system.

The model is seen cf. figure 3.1.

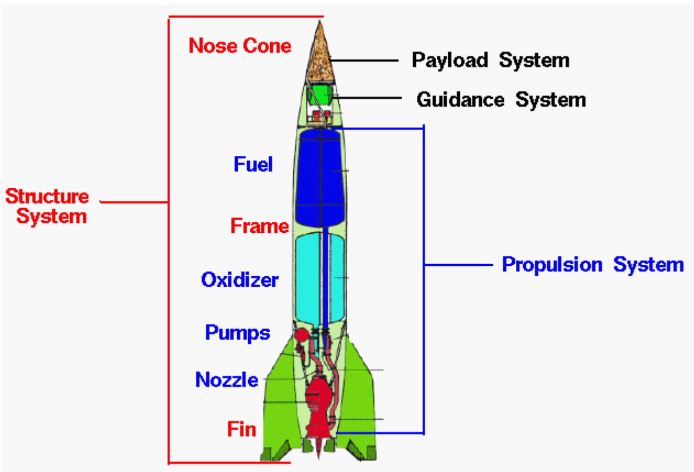

Figure 3.1: Structure of a full scale rocket[2].

Payload System
Most rockets has some form of a payload system. The goal of the payload system is to carry different objects to its wanted destination. The payload can be everything from satellites and astronauts to fireworks depending on the purpose of the rocket. The payload should be considered when looking at the stability of the rocket, because incorrect weight distribution in the rocket, could lead to aerodynamic and structural instability.

Guidance System
All rockets that has the goal to be directed or controlled includes a guidance system. The guidance system consist of a processors, sensors, radars, and a form of wireless communication. Its purpose is to control the stability, direction and rotation of the rocket during launch and in flight. The guidance system is developed based on the understanding of forces acting rocket and its motion. The guidance system in moderne rockets often actuate on the propulsion and nozzle system to correct rotation and direction of the rocket.

Propulsion System
The propulsion system of a rocket is the part which thrust the rocket. Thrust is the the main force that makes the rocket launch and fly. All propulsion systems is based on Newton's third law. This means that a propulsion system should be able make a combustion which produces a downwards force high enough to launch the structural system of the rocket.

The propulsion system can either be a liquid rocket engine or a solid rocket engine. A liquid rocket engine is based on a combustion of fuel and a oxidizer which is mixed an burned. The resulting gas of the burn, is directed trough a nozzle which accelerates it. A solid rocket engine has premixed oxidizer and fuel which becomes the propellant. This propellant is compressed into a cylinder with an hole in it that functions as a combustion chamber. Which means that after ignition the propellants surface functions as the combustion chamber. The gas is therefore also forced trough a nozzle that accelerates it. Which applies i force to the engine that gives a launch of the rocket.

Structural System
Close to all full scale rockets consist of a structural system. The system consist of the cylindrical body/frame, a nose cone with the payload system and the fins that ensures a stable aerodynamic profile. Though most newer full scales rocket does not rely only on aerodynamics to ensure stability.[2]

Write something about instability based on the introduction.

The correct combination of the system modules should ensure a stable flight.

3.1 Stability of a Rocket

A rocket in order to fly in a controlled manner has to be stable [1]. Figure 3.2 gives a good example of chaotic trajectory due to unstable design.

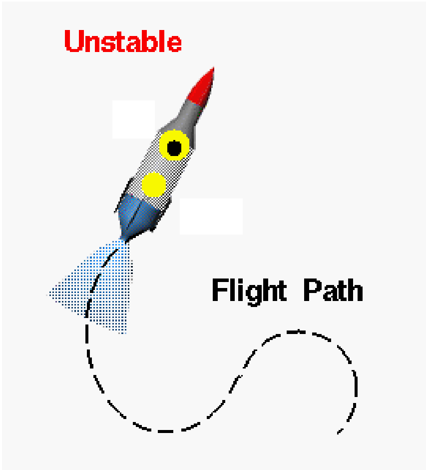

Figure 3.2: Example of trajectory for an unstable rocket [1].

To see how a stable rocket has to be designed an analysis of the force applying to the rocket needs to be done. Figure 3.3 on the next page shows the different situations a rocket encounters during its flight and describes the forces applied in these cases.

In figure 3.3 on the following page two points can be seen on the rockets. The first one CP Center of Pressure is where the lift and the drag force apply [1]. The second one is CG Center of Gravity, it is the point where the rocket rotate [1]. Due to this characteristics the torque applied by the lift and the drag is dependent of the relative positioning between the CG and the CP. Since a rocket tilts due to a torque applied by external forces such as the wind, the lift and the drag has to be oriented so it counters these forces. In order to do so the CP has to be above the CG [1]. This means depending of the position of the CP compared to the CG the rocket flight will be either stable or unstable.

However there might be case where the construction can only be unstable such as actual. In this case a control system has to be designed, in order to counter the torques applied by the external forces reinforced by the drag and the lift.

3.2 Mechanical System of a Rocket

Input/output relation of a rocket.

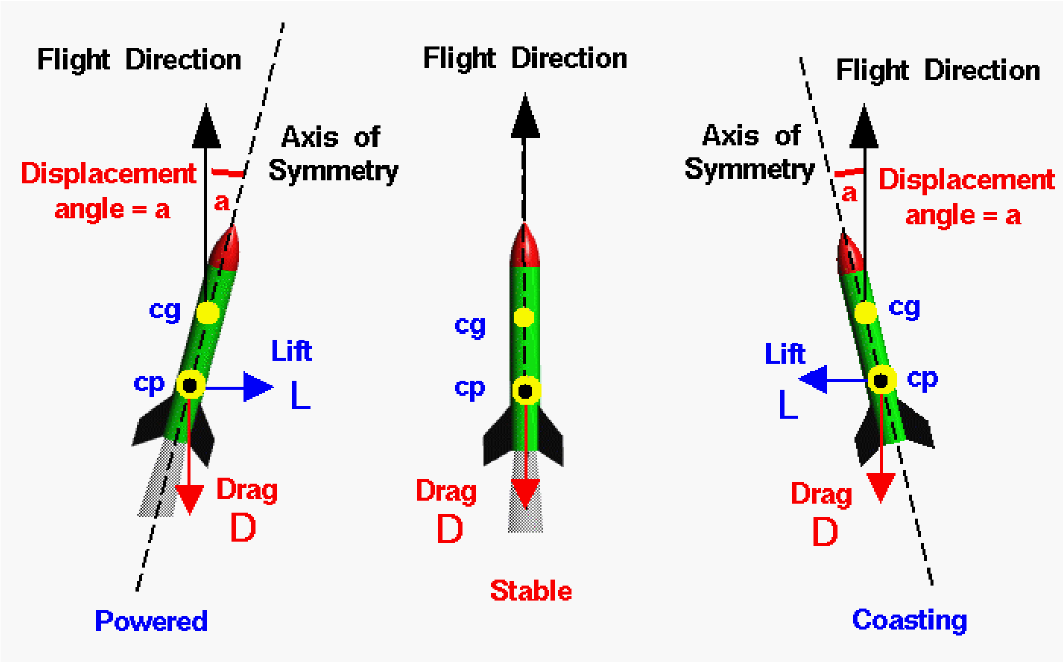

Figure 3.3: Summary of forces applied to a rocket during its flight [1].

3.3 The Inverse Pendulum

relate the rocket model to a Inverse Pendulum

Part II

Design

Part III

Test & conclusion

Bibliography

[1] Benson, T., 2014. *rocket*. (Last update: 22 October 2015). Available at: <https://spaceflightsystems.grc.nasa.gov/education/rocket/rktstabc.html>. [Accessed 14 February 2017].

[2] NASA, 2015. *Rocket Structure*. (Last update: 5 Ocotober 2005). Available at: <https://spaceflightsystems.grc.nasa.gov/education/rocket/rockpart.html>. [Accessed 20 December 2016].