Suspension and stabilisation system design for an UGV demonstrator

Jorge Perez Garcia, s2062380
j.perezgarcia@student.utwente.nl

ABSTRACT

The topic of this project was the creation of a suspension system based around the use of compliant mechanisms and the creation of an integrated stabilisation system. Said systems had to be integrated onto a small UGV. To create the suspension, research was conducted on the basics of suspension system design and on the application of compliant mechanisms. A prototype of the overall system had to be built however, due to cost overruns it could not be built. Instead, the simulations and analysis used to design the systems had to be used to evaluate the concept. This evaluation found that the suspension achieved a poor performance due to the inability to deform and absorb enough load. This was thought to be due to the insufficient length of the flexures and the poor performance of the material selected. On the other and, according to the available analysis the leveling and the overall system meet all the imposed requirements.

INTRODUCTION

This project was conducted in the context of a graduation assignment for the fulfilment of a bachelors of Industrial Design Engineering. The objective of this project was to research on the usability of compliant mechanisms as suspension elements and implement the possible findings on the design of a suspension. Said suspension would in addition to a stabilisation system be implemented onto a small UGV demonstrator. The stabilisation system had the porpoise of controlling the position of the vehicle to allow its interaction with other automated systems.

DESIGN PROCESS

The design process was characterized by the division of the development into two independent subsystems, the suspension and the stabilisation subsystems. These subsystems were to be developed separately and integrated at a later stage to form a fully defined overall system. To validate the design a prototype was planned, however this was later canceled due to budget constraints and the system would have to be conceptually evaluated based on the simulations used to design it.

SUSPENSION SUBSYSTEM

The suspension is divided into bogies which support a pair of wheels. The suspension consists of a central piece, which supports one end of the flexures. At the other end is a piece which supports the wheel axle. A damper connects the wheel to the rest of the frame through the aforementioned piece. The movement of the suspension is achieved mainly by the deflection of the flexures, however since it was found that this deflection was insufficient an additional feature was implemented. This feature allows the rotation of the bogie, coupling the flexures of each wheel together. This has the effect of distributing the load between the flexures allowing more travel.

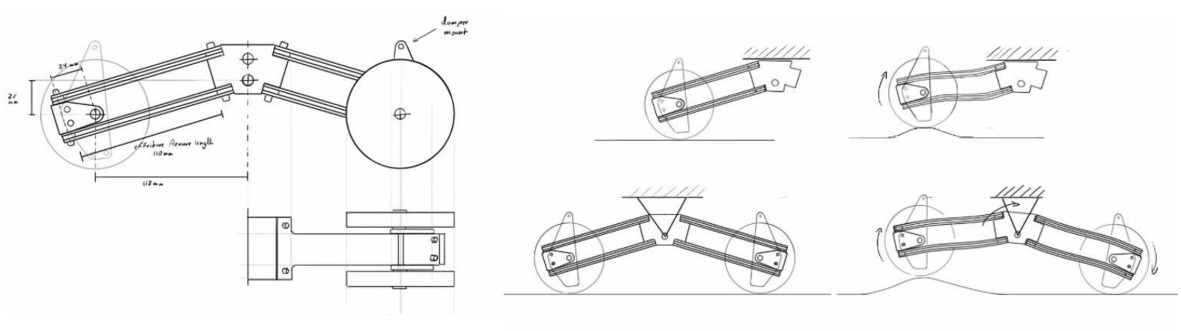

Figure 1. Left: Suspension system layout. Right: Storyboard suspension action.

LEVELING SUBSYSTEM

The suspension is mounted onto a linear guidance system, which thanks to an actuator is capable of lifting each corner of the vehicle. This systems offers three degrees of freedom and allows to control the pitch, roll and height of the vehicle. The leveling system achieves a correction of 10 degrees for pitch and roll and 72mm of height adjustment. It is also fully enclosed within the frame of the vehicle.

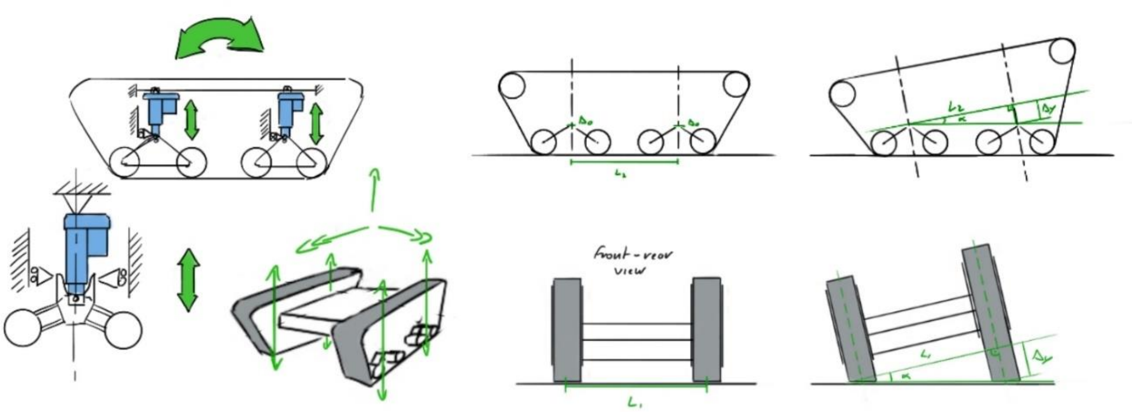

Figure 4. Leveling system concept sketches.

SIMULATIONS

The simulations were conducted using Spacar, a finite element analysis (FEA) program. An iterative process using this program was undertaken to find the optimal flexure layout. It was additionally used to test the performance of the final flexure layout in terms of stress and deflection, as shown in the figure below.

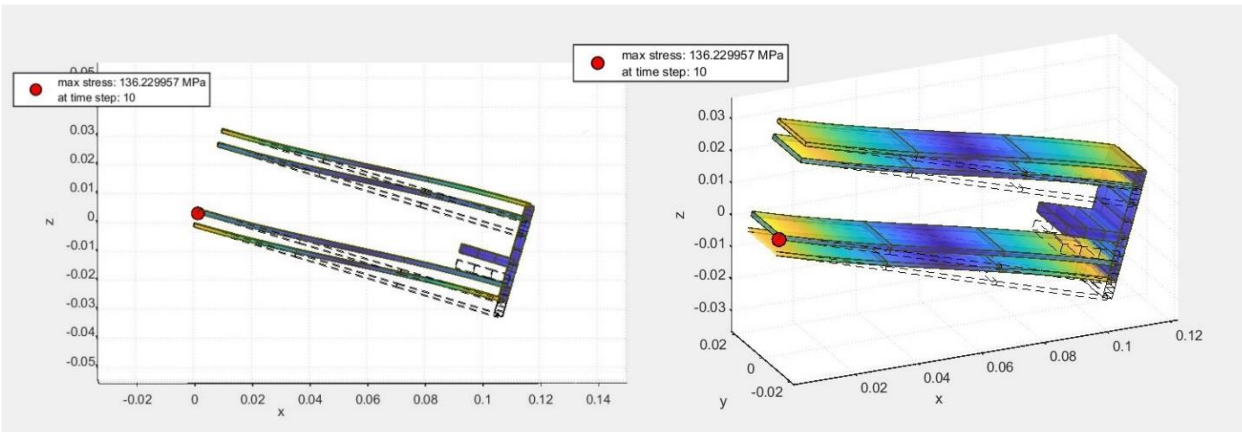

Figure 2. Spacar simulation.

The results from spacar were then used to create a model of the suspension to analyse on the frequency domain. This analysis would show the system behaviour to impacts and its performance while driving. It was thanks to this analysis that the poor performance of the suspension was noticed. The system failed to meet the travel requirements which in turn made the system to stiff and negatively impacted its vibration absorption characteristics.

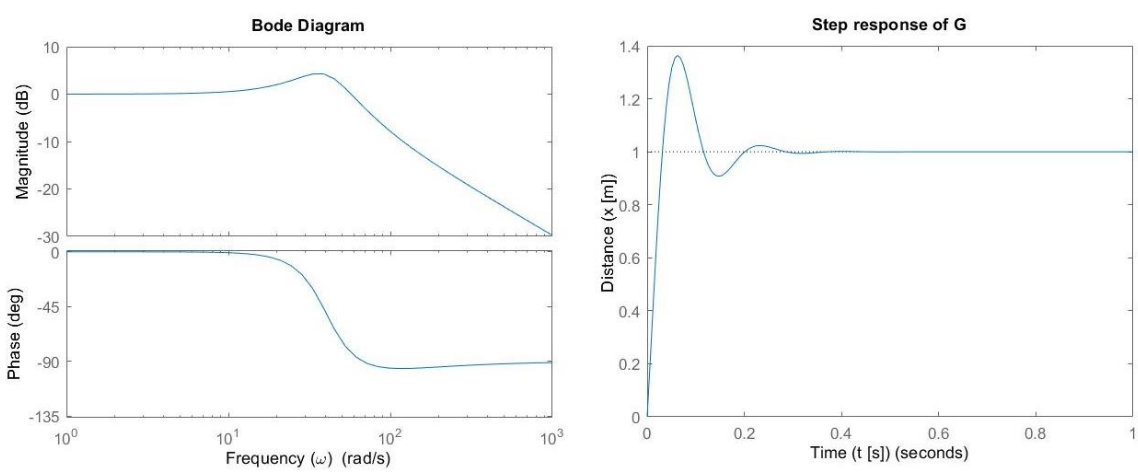

Figure 3. Left: Bode plot of the dampened system. Right: step response of the system.

OVERALL SYSTEM

Initially these systems were to be implemented into an UGV platform developed by fellow students, however due to the complexity of the subsystems, the integration required so many modifications that it was ultimately decided to create a new platform. The new platform is made out of mostly sheet metal and was designed with modularity and optimised manufacturing in mind. The controls and electronics of the original were however preserved.

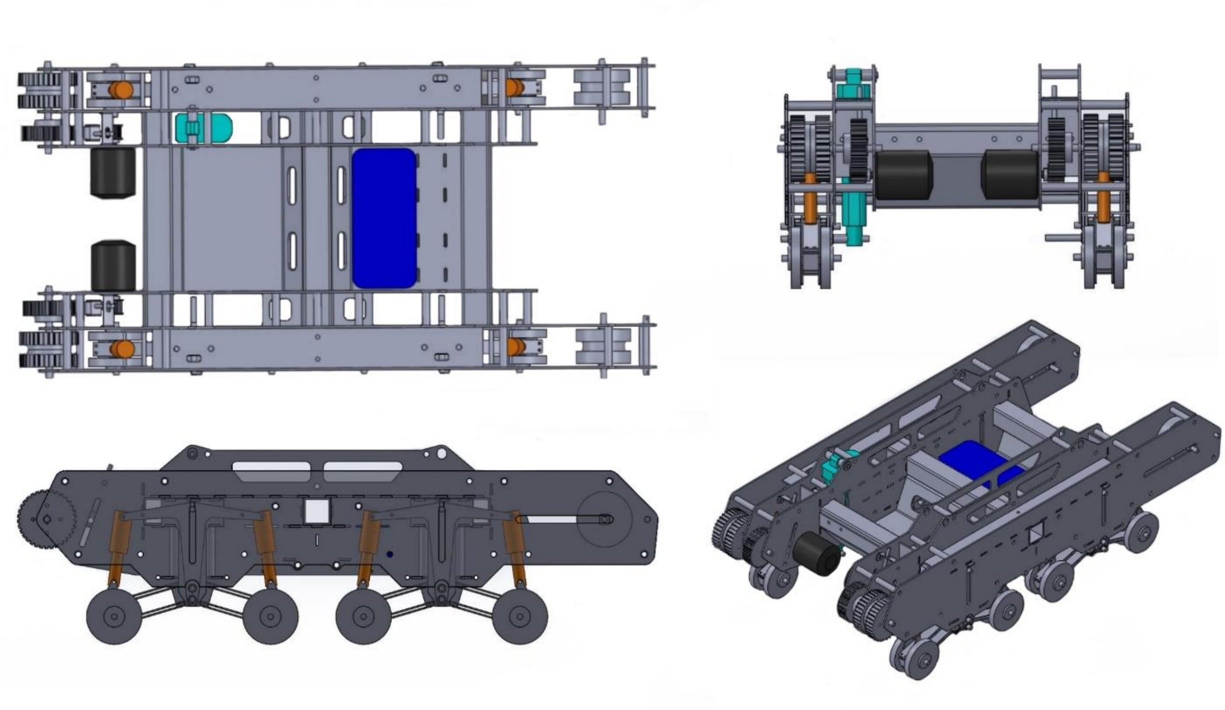

Figure 5. Multiple views of the Solidworks model.

CONCLUSION

The leveling and the platform were successful, according to the conceptual analysis they meet all the requirements imposed that could be tested without a prototype. On the other hand the suspension fell short of its performance requirements. The FEA simulations showed that the system could not achieved the desired deflection without risking major failure, which in turn meant that the system could not meet the required performance for vibration absorption and driving characteristics. The issues causing the bad suspension performance were identified to be poor material performance and insufficient flexure length given the layout used.