Effective Rover Suspension: Exploring and evaluating the benefits and shortcomings between modern Rocker Bogie and traditional double wishbone suspension systems

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Abstract

The suspension system of a vehicle is responsible for maintaining contact between the wheels of a vehicle and the ground and protecting onboard instrumentation, equipment, and supplies. The suspension system and chassis are the principal components in any rover design, providing the foundation for all subassemblies to build upon. Saddleback College's Rover Team evaluated two different suspension systems on their ability to perform under the four rigorous competition missions. The rocker-bogie, initially developed for use on NASA's Sojourner (1997), remains a staple of space exploration systems with continued use on NASA's 2020 rover, *Perserverance*. On the other side of the spectrum, the double wishbone suspension system is used in the automotive sector and is noted for its use in sport, racing, and off-road vehicles . After a comparative study of the different systems and review of past rover systems in the space exploration industry and of our own, the team adopted the double-wishbone suspension system as the basis for the Saddleback College 2020 University Rover Challenge (URC) rover entry, *Odin*.

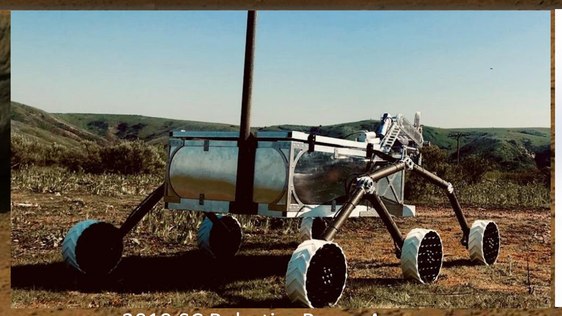
Introduction

A suspension system is a linkage that permits relative motion between the frame and the wheels of a vehicle. For the 2020 University Rover Challenge, the implemented suspension system for the rover must endure the extreme terrain at the Mars Desert Research Station (MDRS) and protect expensive and sensitive instrumentation on-board. An analysis of the two popular suspension systems utilized by finalists in the competition was conducted to determine this year's design.

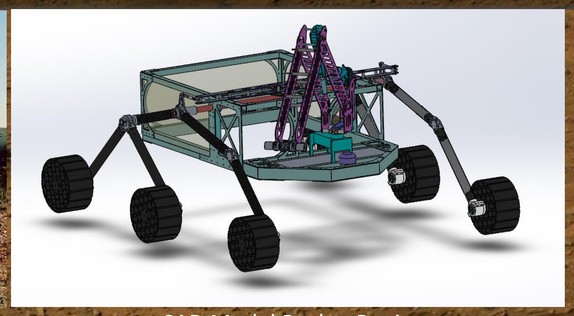
Rocker-Bogie

Originally designed by JPL for traversal over the uncharted Martian terrain, the rocker-bogie suspension system has proven to be dependable in the field of space exploration rover suspension systems. It offers security of internal equipment and most notably its capability of enduring high mileage over persistently rocky surfaces. This suspension system offers a rigid platform that implements a self balancing mechanism, allowing greater stability while traversing rocky outcroppings. A custom differential locks two rocker arms of the rover forcing them to act in opposite fashion relative to on another. This occurs as one rocker arm is moved up, the differential pivots causing the other side to move down. A bogie is pinned via hinge to each rocker arm and pivots to any position in order to maintain ground contact through the attached wheels.

For the first SC rover, the rocker bogie was the top choice for three reasons. (1) The suspension did not need extra hardware to maintain ground contact because it relied on gravity to push the wheels to the ground. (2) It is able to evenly distribute heavy loads while maintaining structural balance due to the nature of the suspension system.



2019 SC Robotics Rover *Aurora*



CAD Model Rocker Bogie

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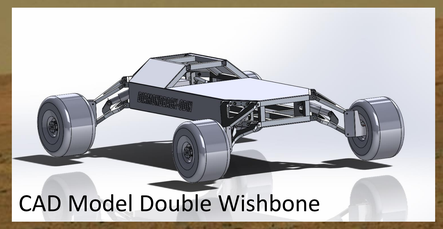

CAD Model Double Wishbone

QR Code link to SC Robotics 2020 SAR

2020 SC Robotics Rover *Odin*

(3) It was the standard space exploration suspension system. Although ideal for space exploration, the rocker-bogie system implemented in last years rover lacked two key features stemming from our funding and competition parameters. For a rocker-bogie suspension to be successful, it must have a wheel assembly robust enough to sustain stress from rocky terrain and the ability to absorb shock from drops.

Double wishbone

The double wishbone is the de facto standard system in the automotive industry. It is capable of absorbing falling impacts, maintaining stability through rough terrain and has uses in high speed applications. This assembly features two components able to absorb impacts, both the pneumatic shock and tires aid in dissipating mechanical stress from a fall or tumble. In off-roading applications, a double wishbone suspension system offers better stability as it can have high spring travel for stability on irregular terrain. Due to this, it is the ideal design for a rover that will maneuver through rocky terrains at above average speeds. Additionally, the system's modularity allows slight modifications to fit various suspenders or shocks without requiring entire redesigns of the whole assembly.

Unlike the rocker-bogie suspension system, the faults in the double wishbone result from a dependency on its integrated hardware. The shocks absorption capabilities are dependent on the combined payload and vehicle weight, the spring travel is proportional to overall load and dampened when it is too high. The hardware responsible for facilitating motion in a wishbone assembly requires regular maintenance. Optimal double wishbone systems utilize durable materials with long maintenance interval components. The team designed a double wishbone suspension system for this year's rover due to its abilities in offroad applications, ease of manufacturing, and shock reduction from falls and rough terrains.

Conclusion

After thorough examination of the two systems, the team decided to implement the double wishbone suspension system to this year's model. This came as a result of an observational investigatory study of the limitations of each design assembly and comparing the benefits of both systems. Integrating adjustable suspension geometry with long arm travel allows the rover to clear obstructions to prevent collisions. Real-time applications exemplified the superiority of the double wishbone over the rocker-bogie in the competition missions. This year's rover was tested in two heavily stressful settings, traversal over rocky terrain and a 20-step cement stair climb. In both scenarios, the double wishbone was able to perform beyond the specifications we designed.

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