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# STRUCTURAL DESIGN AND SIMULATION ANALYSIS OF ALTER: A HIGH-MOBILITY ROVER FOR MULTI-TERRAIN LOCOMOTION AND MISSION SUPPORT

**Abstract**

Search and Rescue (SAR) operations in extreme and uneven terrains need advanced mobility robotic systems for easy locomotion. However, the traditional wheel and track-based robots encounter some problems with uneven, rocky, and sandy landscapes, reflecting their effective locomotion systems in disaster response and exploration missions. In this research, we analyzed ALTER (Autonomous Locomotion Technology for Emergency Rescue), a modular rover engineered for efficient mobility, structural strength, and adaptability in extreme and uneven terrains. We are also highlighting its mechanical subsystem, payload capacity, stability, and maneuverability for search and rescue missions across different environmental conditions and gravitational forces. ALTER features a four-flipper mobility system and a crash-protected structure, designed for enhanced durability and adaptability in extreme environments. The rover's dimensions are 1.1 x 0.6 x 1.4 meters with an overall weight of 50 kg whereas the arm is 8 kg. The body weight with flippers is 42 kg, and without, it is 25 kg. To evaluate structural integrity, stress distribution, and deformation resistance under different scenarios such as static loads, dynamic loads, compression, and tension loads, Finite Element Analysis (FEA) was conducted. Kinematic and dynamic simulations modeled the terrain compatibility, stability, and efficiency of the structure in uneven, sandy, and sloped terrains. Different kinds of load tests were performed on the Alter to study the impact of frame weight and payload on the overall load capacity, as well as on the structural reliability. ALTER's durability and multi-terrain capabilities, coupled with autonomously adjustable features, is what makes it suitable for search and rescue operations as well as planetary exploration. The final results, such as the ability to withstand impact, great traction and stability, and high payload capabilities with low distortion prove this claim. Overall, this paper focuses on the verification and validation of ALTER's structural integrity, mechanical performance, payload capacity, dynamic simulations, load testing, and reliability through FEA. This research helps to develop robust mechanical designs for high-mobility rovers, which can be used in planetary exploration and disaster response missions.