HEDGE
Hypersonic ReEntry Deployable Glider Experiment

INTELLIGENT SYSTEMS IN MARS EXPLORATION

An Executive Summary
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Executive Summary of Technical and STS Projects

Technical Project: Hypersonic ReEntry Deployable Glider Experiment (HEDGE)

Objective: Demonstrate the feasibility of using CubeSats for low-cost, sustainable hypersonic flight.

Background: Hypersonic technology has been designated as a top modernization priority by the Department of Defense, and holds significant potential for both military and civilian applications. The technology's capability for traveling at speeds exceeding five times the speed of sound brings strategic advantages and challenges, including issues related to aerothermal heating, material integrity, and control at high velocities. The Hypersonic ReEntry Deployable Glider Experiment (HEDGE) undertaken by undergraduate students at the University of Virginia responds to these challenges. It explores the innovative use of CubeSats, small satellite platforms traditionally utilized for space research due to their cost efficiency and modularity, to conduct hypersonic flight experiments. The choice of CubeSats reflects a strategic move towards more economical and accessible research methods in aerospace engineering, aiming to democratize high-speed flight testing and encourage hands-on learning in an educational setting.

Methodology: The HEDGE project, designed by aerospace and mechanical engineering students, sought to demonstrate that hypersonic experiments could be conducted at a fraction of the cost associated with traditional methods. The project focused on designing a deployable glider that could sustain hypersonic flight conditions. Key challenges included ensuring communication during the high-speed reentry, developing adequate thermal protection to withstand extreme heating, and maintaining structural integrity under the stresses of launch and hypersonic flight.

Results: The HEDGE project achieved its primary objectives by demonstrating that a CubeSat could be effectively used for hypersonic flight experiments. The project not only proved the technical feasibility of the CubeSat platform for challenging flight regimes but also provided students with invaluable hands-on experience and direct exposure to industry and government practices in aerospace.

Conclusion: The successful completion of the HEDGE project marks a significant advancement in hypersonic research, proving that low-cost, student-led projects using CubeSats are feasible and offer substantial benefits. This initiative paves the way for future explorations and could fundamentally transform how educational institutions engage in cutting-edge aerospace research. The implications of this success extend beyond academia into the broader aerospace industry, suggesting that similar approaches could revolutionize other areas of high-cost technological research. As educational institutions continue to foster such innovative projects, we can expect a new generation of engineers equipped with practical, cost-effective problem-solving skills that could lead to significant advancements in aerospace technology and methodologies.

STS Project: Intelligent Systems in Mars Exploration

Objective: Examine the socio-technical implications of integrating intelligent systems into Mars exploration missions, especially in overcoming significant communication delays and enhancing autonomy.

Background: The concept of manned Mars missions has shifted from science fiction to a near-term possibility, highlighting the need for advanced technological solutions to overcome the unique challenges posed by such missions. Among these challenges, the significant communication delay between Earth and Mars, which can extend up to 22 minutes one way, creates a critical need for autonomy in robotic and manned missions. Intelligent systems, encompassing advanced robotics, artificial intelligence, and autonomous decision-making technologies, have emerged as essential components in addressing these challenges. This research project explores how these technologies can be effectively integrated into the Mars mission architecture, aiming to enhance operational independence and reduce reliance on real-time Earth-based decision-making. Through the lens of the Actor Network Theory framework, this study investigates how these intelligent systems are not only technical solutions but also agents of change influencing societal perspectives, policy-making, and the strategic direction of space exploration.

Methodology: This research employed the ANT and Discourse framework to analyze the adaptation and integration of intelligent systems within Mars missions. It drew on diverse sources, including peer-reviewed articles, case studies, NASA reports, and expert interviews, providing a better understanding of the technological and societal dynamics shaping Mars exploration.

Results: The findings indicated that intelligent systems are catalyzing significant shifts in operational strategies for Mars missions. These systems enhance mission autonomy and efficiency while also influencing broader social dynamics, including policy decisions and public perceptions of space exploration.

Conclusion: The integration of intelligent systems into Mars exploration signifies not just a technological shift but a profound evolution in operational paradigms and social interactions related to space exploration. This research underscores the complexity and necessity of integrating technological advancements with thoughtful policy and public engagement to ensure the sustainable and ethical use of intelligent systems in space. The successful deployment of such technologies on Mars could serve as a blueprint for future explorations of other celestial bodies, potentially leading to an era where interplanetary travel and habitation become as integrated into our society as space travel has in the past century. As we stand on the brink of this new frontier, the implications for policy, societal values, and future technological developments are vast and deeply intertwined with the continued success of interplanetary exploration.

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