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NEXT-GEN TECHNOLOGIES FOR MARS EXPLORATION: AI, MOBILITY, AND IN-SITU RESOURCE UTILIZATION

Abstract

Mars is now a priority mission for space agencies and private industry worldwide. As future human missions are in the planning stages and future robotic missions are in development, new technological innovation and scientific breakthroughs keep refining our knowledge of the Red Planet. Robotic landers, rovers, and orbiters still provide precious data regarding Mars' geology, climate, and habitability. However, difficulties in the form of extreme environmental conditions, communication time-lags, and resource constraints necessitate creative solutions to success in upcoming missions. The article describes the scientific goals, cutting-edge instruments, and new technologies that will be the backbone of Mars exploration in the years to come. The article says that artificial intelligence-driven autonomous systems, novel mobility systems, and miniaturized science instruments are making missions more efficient. The paper also talks about in-situ resource utilization (ISRU), or the capacity to create oxygen, water, and fuel from Martian resources themselves, which lessens the amount of supplies that must be shipped from Earth.

One of the essential aspects of this study is the creation of the next generation of scientific instruments that will be utilized to search for evidence of life, past or present, on Mars.

Among the tools that are extending the frontiers of the ability to investigate Mars' surface and subsurface environments are high-resolution spectrometers, subsurface radar, and bio-signature analyzers. The article reports on recent discoveries from NASA's Perseverance Rover, ESA's ExoMars Mission, and China's Tianwen-1 and what they imply for planetary science. Furthermore, the paper discusses Mars mission next-generation mobility solutions, including autonomous rovers, drone capability (such as the Ingenuity helicopter), and next-generation human exploration vehicles. These are all intended to enhance the range, efficiency, and flexibility of Mars missions in the unforgiving Martian environment. The findings point out that scientific breakthroughs, cutting-edge instrumentation, and new exploration approaches are a mix that future Mars missions will require. As indicated in the report, cooperation between space agencies, universities, and private enterprise is leading the way for new possibilities for Mars exploration in the far future and for human settlement concepts.

The missions to come, helped by sophisticated instruments, artificial intelligence, and in-situ resource utilization, will open the door to further scientific discoveries and ultimately to human presence on Mars. This paper forms part of the discussion as to how new technologies can enhance the success and sustainability of Mars exploration.