National Aeronautics and Space Administration

NASA**facts**

Space Technology
Game Changing Development
The Ocean Worlds Technology

The Ocean Worlds Technology projects will advance critical technologies for the exploration of Europa and other Ocean Worlds. Three projects—Intelligent Landing System, Ultra-Low Temperature Batteries, and Ultra-Low Temperature Electronics—target applications in the first potential landed mission currently being formulated by NASA's Jet Propulsion Laboratory in Pasadena, Calif. A fourth project—Mobility and Sensing Technology—would enable advanced surface exploration capabilities for follow-on missions to the Ocean Worlds.

The **Intelligent Landing System (ILS)** project will mature two technologies, Terrain Relative Navigation (TRN) and Hazard Detection (HD) which are critical for precise and safe landing on the surface of Europa. TRN technology developed for the application of precise landing on Mars will be extended in this project for application in the Europan environment. New challenges that will arise from that environment include hundreds of meters of icy terrain with relief (cliffs) of hundreds of meters that can result in shading, shadows, and terrain relief warping. This project will address these challenges with high fidelity map models, camera models, and inertial measurement unit models, all integrated into a high fidelity simulation environment. These tools will be available to simulate the icy moon images and analyze the effect of terrain relief on position estimation performance.

The HD system will require a lidar sensor. The critical challenge is a lack of detectors for the lidar that can simultaneously provide high throughput and be robust resistant to radiation damage and noise in the Europan environment. The project seeks to meet this challenge by engaging vendors to perform analysis and testing on detectors that have been screened for potential to meet the required performance. The results of these efforts will be test-derived knowledge to guide future detector selection and development.

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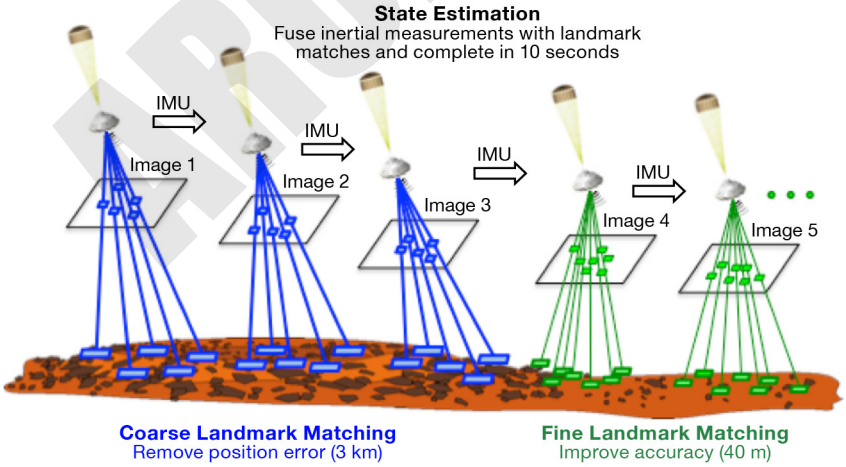
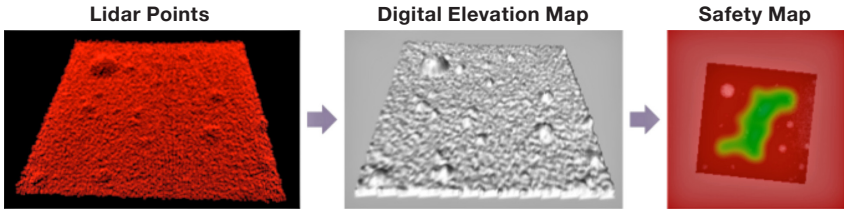
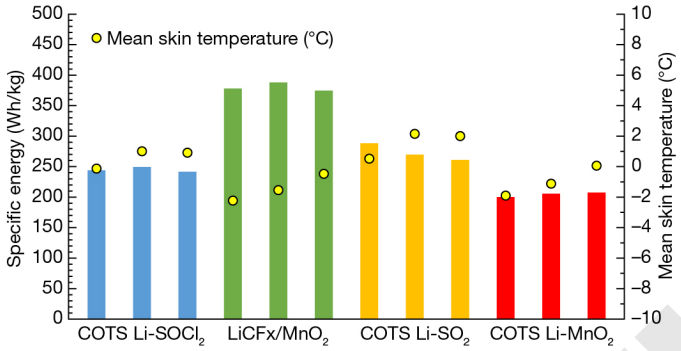


Terrain relative navigation for precision landing.



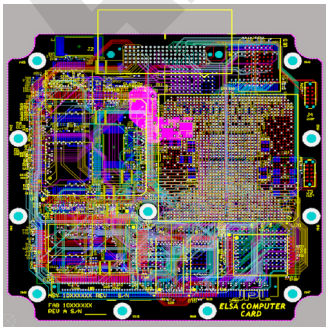
More than 3 million cycles were achieved at less than –100 °C with dry lubricated hybrid gearbox.

The **Ultra-Low Temperature Battery (ULTB)** project seeks to improve the specific energy of batteries operating at sub-zero Celsius due to the 100 K ambient temperature, in a high radiation environment with strict planetary protection requirements. The project goal is to gain at least a one hundred percent increase in specific energy over existing battery technology operating in such extreme environments. The key challenge is in identifying a chemistry composition for cells with specific energy storage across extreme temperatures, with cell chemistry reacting slower with lower temperatures. Meeting the aforementioned goal will double the overall lifetime of the proposed lander mission, over the lifetime achievable with batteries based on existing NASA developed technology. The key output of the current project will be demonstrated improved battery cell technology in a relevant environment.



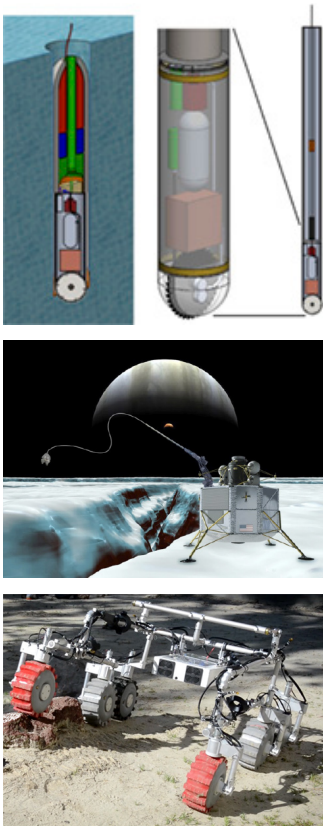
Candidate cell chemistry performance, 50 mA discharge at 0 Celsius.

The **Ultra-Low Temperature Electronics (ULTE)** project seeks to reduce volume by a factor of ten, mass by a factor of three, and power by factor of two, over the existing avionics suite in the baseline design of the Europa lander Concept. The key challenge is in adapting commercial parts and practices for packaging and fabrication for extreme environments and planetary protection requirements. Meeting the goals outlined above will offer improved science performance of the mission by making available volume, mass and power resources that can be used for increased science instrumentation and/or operations. At the end of the project, key avionics boards—primary computer and motor controller boards—will be tested and validated in a relevant environment to demonstrate that the volume, mass, and power gains are possible across the entire avionics suite, with equivalent or improved functionality over existing state-of-the-art.



Compact computer board.

The **Mobility and Sensing Technology** project is developing concepts for robotics systems to operate on the surface and subsurface of Ocean Worlds. Mission scenarios being considered include lander proximity science, long-range mobility and deep subsurface access. In the current study phase of this effort, concepts are being developed and evaluated with respect to science goals and environmental and mission constraints. A trade study is being performed to select the best approaches to implement for laboratory and field demonstrations. A key challenge is developing mobility technology for the range of science exploration scenarios in these Ocean Worlds. The output of the current phase will be the results of the trade study, the mobility and sensing robotics concepts and their respective development plans, with selection and priority informed by science figures-of-merit for the Ocean Worlds.



Concepts under development in the mobility and sensing task.

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

The GCD Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/

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