ROBOTIC TECHNOLOGIES FOR SURVEYING HABITATS AND SEEKING EVIDENCE OF LIFE: RESULTS FROM THE 2004 FIELD EXPERIMENTS OF THE "LIFE IN THE ATACAMA" PROJECT.

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The Chilean Atacama Desert is the most arid region on Earth and in several ways analogous to Mars. Evidence suggests that the interior of the Atacama is lifeless, yet where the desert meets the Pacific coastal range dessication-tolerant micro-organisms are known to exist. The gradient of biodiversity and habitats in the Atacama's subregions remain unexplored and are the focus of the Life in the Atacama project.

Our field investigation attempts to bring further scientific understanding of the Atacama as a habitat for life through the creation of robotic astrobiology. This involves capabilities for autonomously traversing hundreds of kilometers while deploying sensors to survey the varying geologic and biologic properties of the environment, Fig. 1. Our goal is to make genuine discoveries about the limits of life on Earth and to generate knowledge about life in extreme environments that can be applied to future planetary missions. Through these experiments we also hope to develop and practice the methods by which a rover might best be employed to survey desert terrain in search of the habitats in which life can survive, or may have in the past.

Over three years will use a rover to make controlled transects in the Atacama with instruments to detect life and to characterize habitats. The first 2003 field investigation and experiments *validated components* and methods, 2004 tested the *functional integration* of the system with the necessary capabilities for exploration, and in the 2005 season we will conduct a fully *operational science* mission.

Our objectives are summarized below—ultimately hope to contribute to the understanding of the limits of life on Earth utilizing robotic technologies in a manner that is relevant to future planetary science.

Objective	Significance
Seek life	Establish if the hyper arid region of the Atacama represents an absolute limit to life and understand the gradient of biodiversity and environments
Understand Habitat	Understand the strategies used by life to survive in arid environment following climate changes
Relevant Science	Design a payload capable of identifying environments for life and test science exploration strategies enabling the positive identification of life
Over-the-Horizon Navigation	Exhibit productivity of traverse achieving 1km per command cycle
Efficient Resource Utilization	Enable science rovers to reason about resources and make on-the-fly decisions to optimize performance
Autonomy and Self-awareness	Engage science rovers in telescience, managing with minimal communication, while fully aware of themselves and their surroundings

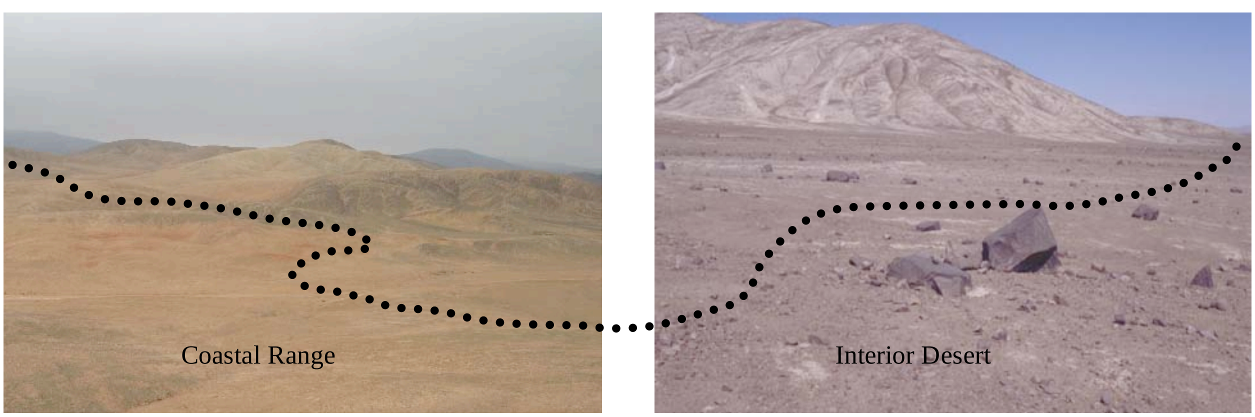


Fig. 1. The biodiversity and distribution of habitats in the arid Atacama Desert of Chile are not measured or fully understood. *Where does life survive and where does it not? What factors govern its distribution?* The Life in the Atacama investigation is conducting robotics transects of the desert to sample and map the distribution of life.

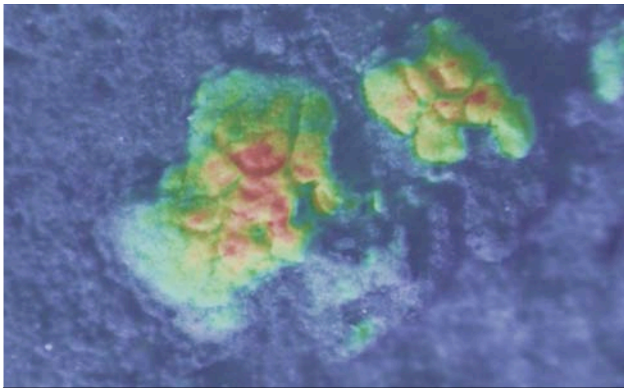


Fig. 2. Microscopic fluorescence image of an Atacama sample. False color shaded from low (blue) to high (red) intensity of fluorescence due to chlorophyll (620nm) overlayed on visual image of sample. Image FOV approximately 1 cm.

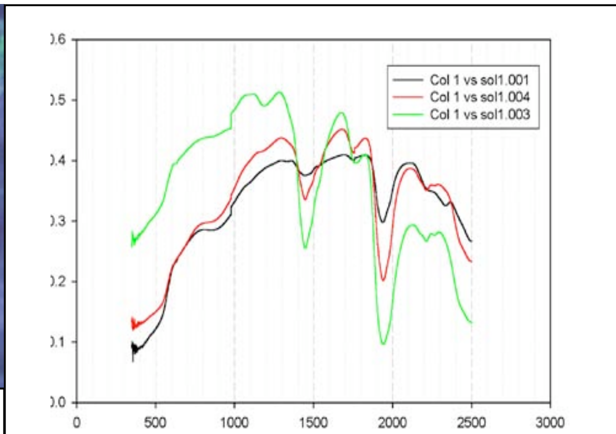


Fig. 3. Spectra from three samples selected remotely, each shows the steep rise in reflectance beginning at 500nm that is characteristic of chlorophyll.

Fig. 4. Zoë robot in the Atacama conducting long-distance traverse with full instrument payload to characterize geology and biology of site (2004).

The technical experiments conducted in the 2003 and 2004 field seasons focused on necessary *in situ* validation of individual components, instruments (Figs. 2 & 3), algorithms, and models and on the functional integration of the payload package with a terrain capable rover (Fig. 4). Operational tests with the rover were conducted to investigate issues including perception, localization, power, and mobility. Tests were conducted with scientific instruments to understand their methods of use and technical properties important to field deployment by a rover.

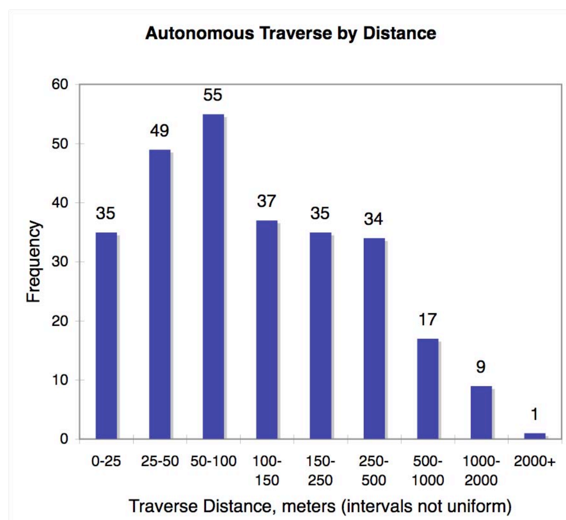
In conjunction with the science investigation (see related abstracts in this LPSC), the technical function of the field season was to pose and answer key questions that must be resolved to proceed to design of the robotic astrobiology system and to achieve three-year goal to robotically detect and map the distribution of life in the Atacama.

Significant findings include:

Validation of high-resolution imaging, Vis/NIR spectrometer, and fluorescence macroscope in the field and issues for integration with a rover platform.Importance of not only near-field obstacle avoidance but also far-field terrain evaluation to determine feasible traverse autonomously.

Efficacy of odometry-based localization (3-5% accuracy) in rough terrain when augmented with inertial sensing and correction for sensor drift.

Demonstration of long distance autonomous traverse. In over 270 experiments of single command autonomous, more than half exceeded 100m, and ten exceeded 1km.



At this point, we conclude that we have developed an instrument payload capable of detecting microorganisms and a rover able to autonomously conduct survey traverse in the Atacama.

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