ARAMMIS: Autonomous Robots for Area Mapping, Monitoring and In-situ gas Sensing, focused on Lunar exploration and Earth Science applications

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Abstract

The ARAMMIS project is a collaborative research effort between INFICON and ETH Zurich's Robotic Systems Lab (RSL) to develop and deploy autonomous robots enabled with gas sensing capabilities to provide 3D gas concentration mapping, monitoring, and in-situ sampling of varied environments, especially focused on Earth Science geochemical applications and Lunar analog demonstration for future Space exploration missions.

A commercially available, compact quadrupole mass spectrometer-based system has been mechanically and electrically integrated into a legged robot. The overall system, named **ARAMMIS** (**A**utonomous **R**obot for **A**rea **M**apping, **M**onitoring and **I**n-situ gas **S**ensing), is designed for deployment in diverse environments such as chemical plants, oil installations, semiconductor factories, as well as open fields, geological sites, caves, volcanoes, and even emergency scenarios. Its purpose is to map gas concentrations across the area or locate gas sources where concentrations exceed the background levels. The MS operating commands and data retrieval are carried out fully autonomously through the robot's main computer.

The first volcano deployment of the ARAMMIS system using the Transpector MPH quadrupole mass spectrometer, integrated into RSL's modified ANYmal D legged robot, was performed in June 2025 at Mt Etna volcano´s Cratere del Laghetto (an established ESA and NASA Lunar analog site), in collaboration with INGV Rome, Palermo, and Catania groups, the University of Costa Rica, University of Pisa, and University of Catania.

The mission objective was to test the autonomous capabilities of the ARAMMIS robot by walking at the rim of an active crater to characterize the emitted gases, enabling in-situ real-time analysis together with other robotic platforms and gas sensing instruments. These experiments support geochemical Earth sciences by contributing to volcano gas emission studies aimed at establishing eruption precursors, while also demonstrating capabilities relevant to future lunar exploration in terrains with similar characteristics.

Biography - James Fox

Dr. James Fox is a Staff Research Scientist at INFICON with more than 12 yrs experience in mass spectrometer design, testing , integration and applications. He earned his bachelor's degree in chemistry at Sam Houston State University in Huntsville, TX. From there, he attended the University of North Texas, earning a doctorate in analytical chemistry with a research background in mass spectrometry theory, design and applications. In 2013, he joined INFICON Inc. in East Syracuse, NY where he is part of the Emerging Technologies and New Markets research application group.

Keywords

Robotic Platforms, Earth Science, Lunar Analog, Exploration, Volcano gas detection and monitoring