

# INNOVATIVE SOFTWARE FOR SAMPLE RETRIEVAL MISSIONS IN SPACE

**CHALLENGE:** NASA needed a spacecraft operations system that could assess situational uncertainties when undertaking complex sample collection tasks and respond quickly with the best course of action based on pre-programmed scenarios.

**MISSION DIRECTORATE**  
Science

**SBIR FUNDING**

Revenue derived from software licensing and support – Approximately \$1.4 Million

**SNAPSHOT**

Deep space missions for retrieving samples from planetary bodies, comets, asteroids, or moons look to sophisticated software to make operational decisions without human intervention.

**SOLUTION:** An autonomous operations system based on Virtual Machine Language (VML) enables a spacecraft to perform guidance, navigation, control, and instrument activities without ground control personnel oversight back on Earth.

NASA's relationship with Blue Sun Enterprises, an engineering consulting firm based in Boulder, Colorado, has evolved over a decade with a series of Small Business Innovation Research (SBIR) awards which is pushing the boundaries of VML for space exploration. VML is an advanced procedural sequencing language for computers. Sequencing makes automated commanding on-board the spacecraft possible, which is needed when light speed delays prevent direct commanding from the ground.

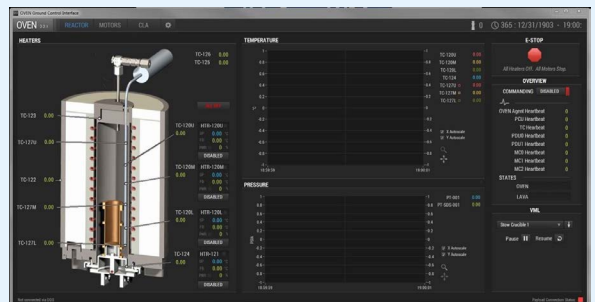
Blue Sun Enterprises developed the autonomous ability made possible by VML using pre-programmed scenarios based on rules. The rules are used to monitor conditions and respond appropriately during missions. This allows for a wide range of complex activities and safety-related responses to be inexpensively implemented without complex procedural programming.

VML is an adaptable technology that is easily integrated with other computer programs to help run equipment. The scripted software is designed to be easily updated without making modifications to the software code which serves as instructions. The code enables flight software to be adapted for use on almost any mission, then updated in flight by replacing scripts which control software applications.

NASA and Blue Sun Enterprises have further collaborated on VML3 for an instrument package called Water Analysis and Volatile Extraction, or WAVE (formerly RESOLVE).

RESOLVE's payload consisted of several co-operating instruments atop a rover that work together to obtain and analyze Moon samples. In 2015, NASA conducted a successful test of RESOLVE to control instruments from four NASA space centers and the Canadian Space Agency. The replacement, WAVE, is being proposed for flight on commercial landers to the lunar poles.

To date, evolving versions of VML have been used on 14 missions. Blue Sun Enterprises hopes to make an impact on Mars exploration using VML3 by developing scripts to sequence the successful entry, descent, and landing of the Mars Phoenix Mission. Blue Sun Enterprises maintains the intellectual property ownership of VML3 and has provided NASA with both a license and flight source code, along with operations scripts interpreted by the software. NASA Space Centers utilize the code on missions with engineering support provided by Blue Sun Enterprises.



The OVEN instrument which heats sample, with telemetry and VML OVEN control on the lower right.