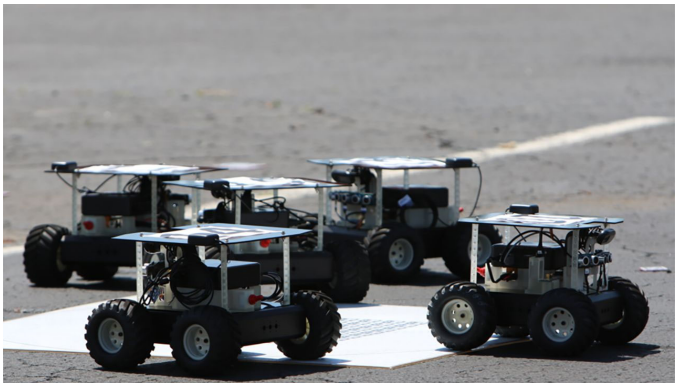
Leverage the Power of Swarming Robotics to help NASA Locate Resources, Excavate, and Build on the Moon.



Swarmie Robots developed NMSU and the NASA Kennedy Space Center Swamp Works lab

Name of Technology: Coordination and Control of Swarms of Space Vehicles

Participating NASA Centers: Jet Propulsion Laboratory (lead) Langley Research Center

Technological Area: TA4- Robotics, Telerobotics and Autonomous Systems

Vision for the Technology: NASA plans to deploy different robots to the surface of the moon to complete different tasks such as observation, prospecting, excavating, transporting, and building. These robots will include both planetary rovers and flyers, which will work collaboratively to maximize efficiency.

Challenges: Swarming robotics requires a high level of accuracy as it relates to location and synchronizing activities. The swarms will also have to operate autonomously, and in some cases without communication amongst the different robots.

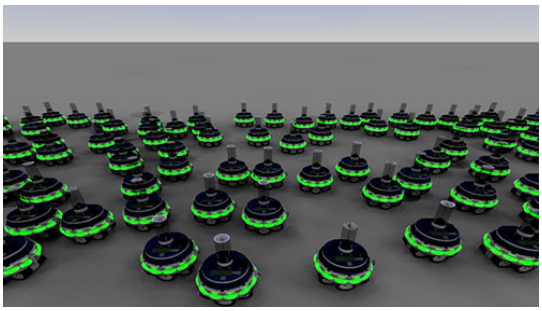
Overview of Student Project: NASA seeks innovative ideas from students in the form of theoretical frameworks, algorithms, software simulations and demonstrations of feasibility. If students are able to demonstrate capabilities on hardware platforms this is also of significant interest but not required.

Ultimately, NASA Seeks to Develop Arrays that Meet the Following Specs

- High precision relative localization and time synchronization in orbit and on planet surface.
- Coordinated task planning, operation, and execution with realistic communication limitations.
- Fast, real-time, coordinated motion planning in areas densely crowded by other agents and obstacles.
- Operations concepts and tools that provide situational awareness and commanding capability for a team of spacecraft or swarm of robots on another planet.
- Communication-less coordination by observing and estimating the actions of other agents in the multi-agent system.
- Cooperative manipulation and in-space construction
- Cooperative information gathering and estimation for exploration and inspection of a target object (large space structure or small asteroid).

Innovative Areas Student Projects Can Address

- Operation of small homogeneous swarms of robots demonstrated via algorithms and software simulations.
- Operation of small homogeneous swarms of robots demonstrated via actual hardware.
- Operation of small heterogeneous swarms of robots (example rovers and flyers) via algorithms and software simulations.
- Operation of small homogeneous swarms of robots demonstrated via actual hardware.



A swarm of robots being tested at the NASA Jet Propulsion Laboratory

Research Funded by NASA on this Topic:

Proposal Number - 19 -1 T4.03-5760
IN-PASS: Intelligent Navigation, Planning, and Autonomy for Swarm Systems

Proposal Number - 19 -1 - T4.03-3131
Mars/Interplanetary Swarm Design and Evaluation Framework (MISDEF)Orbit Logic, Inc.

Proposal Number - 19 -1 T4.03-3451
Provably Convergent Game-Theoretic Coordination for Space Vehicle Swarms

Proposal Number - 18 -1 T4.03-6342
Smallsat Swarm Sparse Aperture SAR for Recon and Surveillance (SSSASAfRaS)

Proposal Number - 18 -1 T4.03-2132
Coordination of Heterogeneous Robot Swarms for Planetary Logistics Operations

Proposal Number - 17 -1 T4.03-9857
Reinforcement Learning For Coordination And Control of Swarming Satellites

Proposal Number - 17 -1 T4.03-9829
DISCUS: Distributed Intelligent Swarm Control & Utilization System

Proposal Number - 16 -1 T4.03-9796
Satellite Swarm Localization and Control via Random Finite Set Statistics

Proposal Number - 16 -1 T4.03-9758
Spacecraft Swarm Coordination and Planning ToolAurora Flight Sciences Corporation

Proposal Number – 15 - A2.02-9727
A Modular Swarm Optimization Framework Enabling Multi-Vehicle Coordinated Path Planning

References:

"PUFFER: JPL's Pop-Up Exploring Robot; This little robot can go where other robots fear to roll,“

"Precision Formation Flying,”

"Mars Helicopter to Fly on NASA’s Next Red Planet Rover Mission,"

"The A-Train: How Formation Flying is Transforming Remote Sensing,"

"Achieving Science with CubeSats: Thinking Inside the Box," National Academies of Sciences, Engineering, and Medicine, 2016.