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### **ANTS 2 Project Description**

Our project will be to contribute to NASA's Goddard Space Flight Center Autonomous Nano Technology Swarm project. Autonomous Nano Technology Swarm (ANTS) is a project being explored by the NASA Goddard Space Flight Center (Curtis et al., 2000). The goal of the ANTS project is to explore one of the final frontiers of the solar system: the asteroid belt located between the planets Mars and Jupiter. The exploration of this region should offer great insights as to how our solar system originated and evolved. The goal of the ANTS project is to scientifically categorize all asteroids greater than one kilometer in diameter. Another goal of the ANTS project is to perform an initial prospecting expedition for resources becoming depleted on Earth and that are of use in space exploration and development. These are formidable goals considering the fact that there are thousands of asteroids in the asteroid belt with diameters greater than one kilometer. Since the asteroid belt is so far away from Earth, the spacecraft that are sent there must possess an extremely high autonomy, which depend minimally on communications with Earth, and have few consumables. The ANTS project will hopefully overcome these obstacles by providing a totally autonomous solution for the exploration of the asteroid belt.

NASA intends to send a swarm of 1000 picospacecraft each with a mass of less than one kilogram from Earth's orbit to the asteroid belt using solar sails (Curtis et al., 2000). The swarm would utilize a social insect type of artificial intelligence to coordinate the exploration of the asteroid belt. The project would implement three main

types of picospacecraft: rulers, messengers, and workers. Rulers would act as swarm heuristic operations planners. Some of the jobs of a ruler would be to assign tasks to workers, maintain swarm statistics, manage overall mission objectives, resolve conflicts, and coordinate collision avoidance. Messengers would be structurally similar to rulers and would transport information between rulers and workers. Messengers would thus be equipped with more communication and propulsion equipment and less scientific instrumentation. Workers would function as heuristic operations planners and be responsible for acquiring, processing, sharing, and delivering data. Each swarm worker would have specialized instruments such as magnetometers, x-ray sensors, or gamma-ray sensors to evaluate the resource potential of each asteroid. Thus, a general mission for ANTS would consist of a specific set of workers gathering data about a particular asteroid. The data gathered by these workers would be given to messengers, which would transfer the worker's data to the rulers. The rulers would be responsible for coordinating the overall mission and making mission decisions based on the data received.

Since these spacecrafts will be located far away from earth, the architecture for the ANTS system must be developed so that it is as autonomous as possible (Curtis et al., 2000). Thus, there is great importance for the ANTS project to develop artificial intelligence software to enable the spacecrafts to work together on their own. The layers and methods of artificial intelligence, relationships between spacecraft, and layers of social structure will together determine how the satellites will achieve autonomous planning and execution. It is in this area that our project is focused. Our project will focus on the artificial intelligence aspect of the ANTS project. It is the goal of our

project to make a meaningful contribution to the ANTS project in the area of spacecraft interaction and artificial intelligence.

In order to accomplish this goal, our team will need to identify and explore the various areas of artificial intelligence and determine how they can be applied to the ANTS project. To do this we will need to gather reference material on artificial intelligence. In addition, we will need to form contacts with as many people as possible in the fields of artificial intelligence to further our knowledge.

Specific things that we need to learn to better our understanding of this project are agents, agent communication languages, and swarm technologies. Specific areas of artificial intelligence that should be examined are fuzzy logic, neural networks, distributed artificial intelligence, genetic algorithms, and heuristic methods.

## **Bibliography**

Curtis, S., Mica, J., Nuth, J., & Marr, G. (2000). ANTS (Autonomous Nano Technology Swarm): An Artificial Intelligence Approach to Asteroid Belt Resource Exploration. 51<sup>st</sup> International Astronautical Congress: Brazil.