# Predictive Path-Planning for Robotic Vehicles

A NEW CO-DEVELOPMENT OPPORTUNITY

**Reference No:** NNJ14ZBH023L

**Potential Commercial Applications:** automotive industry, Department of Defense (DoD), emergency operations (police, rescue, first responders, etc.), disaster recovery operations, remote or hazardous operations, drones and others

**Keywords:** autonomous robotic vehicle, electric vehicles, robots, robotic perception, sensing of the environment, user-centered interface

**Purpose:**
NASA JSC seeks parties interested in co-developing technology associated with its current robotic vehicle capabilities.

NASA intends to address the areas of overall performance, controls modeling and safety, in addition to robotic perception and intelligence. NASA JSC has multiple mobile robot prototypes for planetary exploration. Each of these vehicles is capable of autonomous driving and has sensor packages that provide large streams of environmental data. While these robots are intended for use during human spaceflight missions, NASA JSC desires to employ the robots as explorers during periods of unmanned activity. Earth-based human supervised autonomy is the expected mode of operation for these robotic explorers. The data time delay can range from 2 seconds to 1.5 minutes from vehicle to earth and back to the vehicle (round-trip). Due to these expected and variable data and command latencies, NASA JSC plans to provide predictive models of robot behavior to earth-based human operations supervisors.

Technology associated with Predictive Path-Planning for Robotic Vehicles will be of interest to any entity that desires a navigation system for a completely autonomous vehicle.

**Technology:**
Primary challenges include robust sensing of the environment, bandwidth management of data and user-centered interface development.

The main mobile robots developed at NASA JSC are the Space Exploration Vehicle (SEV) and the Centaur 2 rovers. The SEV is a large electric rover that can function as a manned vehicle or as an autonomous robotic vehicle. The SEV consists of a chassis with six wheel modules capable of 360° of motion, enabling it to drive in any direction and to point-turn the entire vehicle, and a cabin for human-use and which also serves as a mounting location for robotic sensors. The SEV chassis without the cabin can carry a variety of payloads. The current SEV can cover very rugged terrain, maneuver steep inclines and perform straight-line driving at a top speed of 12 MPH using its Six Degrees of Freedom (6-DOF) chassis. The Centaur 2 rover has 4 wheel modules, and like the SEV, can point-turn and drive in any direction. Centaur 2 can carry science-payloads, geologic tools or even a Robonaut 2.

Space Exploration Vehicle (SEV)

Centaur 2

Path planning for these rovers will consist of avoiding large objects on a surface (e.g., rocks or human habitats), avoiding craters, driving through permanently dark areas and potentially driving through lava tubes. The human operators supervising the robots must easily model path planning for use.

**R&D Status:**
The NASA JSC rovers currently use a predictive and interactive graphical interface (PIGI) for unmanned operations over time delays. PIGI provides telemetry from the robot to a human operations supervisor through a visualization of the robot's environment. PIGI has proven useful for varying communication latencies, minimal bandwidths and variable network speeds. Current path planning for use in PIGI allows the SEV and Centaur 2 rovers to avoid obstacles. JSC desires to produce path-planning models for the robots that will allow them to operate in varying planetary situations, as noted earlier.

**Intellectual Property:**
Multiple individual technologies associated with robotics are currently available for co-development and licensing. Visit Robonaut 2 web page and click on Licensing Opportunities.

This co-development project may produce new IP that could be jointly owned by NASA and the partner or may become the property of the partner.