INTRODUCTION

Tycho is a modern training vehicle designed and built to meet the needs of 21st century human exploration of the Moon and Mars.

The original Grover (Geologic Rover), built by the USGS in the mid-1960s, supported Apollo astronaut training for lunar EVAs and was borrowed by NASA Centers for modern training exercises. Since the USGS declared Grover a historic object, it has been retired to museum status.

Tycho is a rugged, more technically advanced successor of Grover, intended to serve as a flexible and robust training test bed. In the future, Arizona State University students and faculty will use Tycho to test exploration concepts. It is also available for loan to NASA Centers, relevant NASA collaborators, and international partners.

VEHICLE DESCRIPTION

Tycho consists of an aluminum frame to which various components are attached. Each wheel is independently driven and steered through 180º range of motion.

Tycho is controlled by a single joystick, similar to what was used in the Lunar Roving Vehicle, with multiple added driving modes accessible via pre-mapped buttons. Rover status information is shown to the driver on a direct-Sun-viewable monitor mounted between the seats.

GOALS & OBJECTIVES

The primary goal of the Tycho project is to build an advanced successor to the Apollo-era Grover that can be used for astronaut training and lunar surface operation simulation.

The design and construction of Tycho employs a three-phase strategy. In phase I, Tycho is driven by an onboard operator. Phase II will see Tycho operated remotely. Ultimately, phase III will add autonomous driving capability.

FLEXIBLE RECONFIGURATION

The modular design allows for rapid payload reconfiguration in the field and multiple surface operation scenarios to be tested in a single test session. In particular we are interested in the concept of astronauts rapidly reconfiguring a rover for autonomous operations during a sleep period, and then switching back to crewed operations the next “day”.

REQUIREMENTS

Tycho is battery powered and capable of carrying two crew members across terrain with slopes and at speeds equal to, or greater than, those achievable by the historic USGS Grover. The minimal requirements for Tycho are:

- Attain a speed of 15 km/hr on flat surfaces.
- Negotiate a maximum 15º terrain slope from rest.
- Operate continuously for two hours on flat terrain.
- Drive sideways and turn around in place.

A single motor controller manages both the drive and steering motors at each wheel and synchronizes the motors to accurately regulate wheel position. These controllers (RoboteQ XDC2460) have two high-power, built-in power drivers, one for each motor, and support 150 amps on each channel.

A Raspberry Pi 3+ running the Raspbian operating system with ROS (Robot Operating System) and two Arduinos control the rover. ROS facilitates communication with the Arduinos and ultimately the various sensors, controllers, relays, etc.

The drive components are the same for each corner of the vehicle and consist of a motor, axle shaft, wheel flange, locking hub, chain and gear set to connect the motor to the axle shaft.

The steering components are the same for each corner of the vehicle and consist of a motor, steering shaft, and thrust bearings. The steering and drive motors are the same model, and are attached to the steering shaft and thrust bearing assembly.

Power for the computers, eight motors, controllers, and other electronics is supplied by four 6-Volt, deep-cycle, flooded/wet lead-acid batteries connected in series providing 24 volts. Circuitry is protected with appropriately sized circuit breakers and fuses.

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