

# Space Technology Mission Directorate Game Changing Development

## MRV - Modular Robotic Vehicle

The Modular Robotic Vehicle, or MRV, completed in 2013, was developed at the Johnson Space Center in order to advance technologies which have applications for future vehicles both in space and on Earth. With seating for two people, MRV is a fully electric vehicle modeled as a “city car”, suited for busy urban environments.



Modular Robotic Vehicle (MRV)

Just as NASA helped pioneer fly-by-wire technology in aircraft in the 70s, MRV is an attempt to bring that technology to the ground in modern automobiles. With no mechanical linkages to the propulsion, steering, or brake actuators, the driver of MRV relies completely on these control inputs being converted to electrical signals, and transmitted by wires to the motors within the vehicle. A turn of the steering wheel for instance is recorded by sensors and sent to computers at the rear of the vehicle. These computers interpret that signal and instruct motors at one or all four of the wheels to move at the appropriate rate causing the vehicle to turn as commanded. Due to a force feedback system in the steering wheel, the driver feels the same

resistance and sensations as a typical automobile.

Not having a mechanical linkage between the driver and the steering wheel introduces new risks not seen on conventional automobiles. A failed computer, or cut wire, could cause a loss of steering and the driver to lose control. Because of this, a fully redundant, fail-operational, architecture had to be developed for MRV. Should the steering motor fail, the computer system responds immediately by sending signals to a second, redundant motor. Should that computer fail, a second computer is ready to take over vehicle control. This redundancy is paramount to the safe operations of a by-wire system.

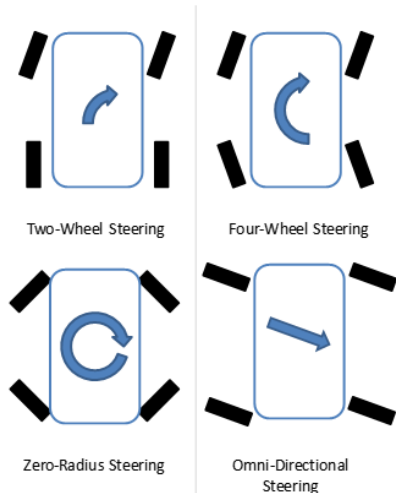


Close-up of MRV e-corner

MRV is driven by four independent wheel modules, called e-corners. Each e-corner consists of a redundant steering actuator, a passive trailing arm suspension, an in-wheel propulsion motor, and a motor driven friction braking system.

Each e-corner can be controlled independently and rotated +/- 180 degrees about its axis. This allows for a suite of driving modes allowing MRV to maneuver unlike any traditional vehicle on the road. In addition to conventional front two wheel steering, the back wheels can also articulate allowing for turning radiuses as tight as zero. The driving mode can be switched so that all four wheels point and move in the same direction achieving an omni-directional crab-like motion. This makes a maneuver such as parallel parking as easy as driving next to the spot and strafing directly in between two cars.

#### MRV Steering Modes



#### MRV Driving Modes

The driver controls MRV with a conventional looking steering wheel and accelerator/brake pedal assembly. Both of these interfaces were specially designed to mimic the feel of the mechanical/hydraulic systems that people are used to feeling in their own cars. Each device includes its own redundancy to protect for electrical failures within the systems. In addition a multi-axis joystick is available to allow additional control in some of the more advance drive modes.

A configurable display allows for changing of drive modes and gives the user critical vehicle information and health and status indicators.



MRV Steering Wheel, Joystick, and Dashboard Controls

Each of the propulsion motors is located inside of the wheel and capable of producing 190 ft-lbs of torque. An active thermal control loop maintains temperatures of each of these high powered motors. A separate thermal loop cools the avionics including custom lithium-ion battery packs.

The technologies developed in MRV have direct application in future manned vehicles undertaking missions on the surface of the moon, mars, or asteroids. In addition MRV provides a platform to learn lessons which could drive the next generation of automobiles. This includes the safety of drive-by wire systems as well as the advanced vehicle dynamics that MRV's systems allow for.