Unmanned Ground Vehicles - Design considerations for man-portable/packable vehicles

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A UGV is “a ground based mechanical device that can sense and interact with its environment.” (Carlson, How)

A Field Robot is expected to work outdoors, though generally not in rain or snow, including rough terrain, dirt and dust. (Carlson, Reliability)

A Man-portable robot weighs less than 40 pounds, or is capable of being broken down into subassemblies for two soldiers weighing less than 40 pounds each. (Bruch)

A Man-Packable robot can safely be carried by one person. (Carlson, Follow-up)

Cost is generally under forty thousand USD. Vehicles used for Urban Search and Rescue (USAR) should be inexpensive, preferably under five hundred USD, so they can be used without concern for losing the robot. (Mathew)

Size can vary between models. According to Lundberg, Police vehicles can mitigate size and weight problems because they can generally be driven to a deployment site, but size and weight can be a problem for Military Operations in Urban Terrain, where foot-travel is used.

Between Lundberg and Nguyen, many uses were mentioned:

- USAR (Urban Search and Rescue
- MOUT (Military Operations in Urban Terrain)
- EOD (Explosive Ordnance Disposal)
- CBRN (Chemical, Biological, Radiological, Nuclear) tasks
- Mobile Surveillance
- Hostage negotiation
- Transport items to and from a barricaded suspect
- Retreive a weapon if a suspect surrenders
- Recon in storm drains and tunnels
- Hilltop repeater
- Site security
- Zone defence
- Valve manipulation

Nguyen lists several obstacles and terrain issues that must be dealt with like:

- curbs
- dirt
- high grass
- mud
- snow
- stairs
- loose rugs
- newspapers
- crawl spaces
- airplane or bus aisles

Each of these issues can require different design features.

Several payload options are mentioned by Lundberg and Nguyen. Among these are:

- distraction sirens
- Less lethal weapons (beanbag rounds, pepper spray, nets, TASER, pulse lighting)
- Tire deflating strips
- CBRN sensors
- GPS
- Laser range finder
- Window punch
- Breaching tools

Nguyen places less importance on robot mounted weapons and more emphasis on sensors and effectors.

Operating temperature varies widely with location. Antarctic vehicles will need to operate in sub-zero temperatures. Vehicles used in the desert could see temperatures about 130F.

Barnes mentions several possible configurations. These include:

2 wheeled cylinder

- can self-right
- ability to negotiate terrain and small obstacles extremely limited
- has a tendency to yaw back and forth while moving which seriously degrades video

6 wheeled skid steer brick

- rectangle with 3 wheels on two sides
- paddle stored on top can turn vehicle back over and can help it climb obstacles as tall as its wheelbase

4 wheeled brick

- similar to 6 wheeled brick

Inflating weight shifting ball

- compact
- inflates after being thrown
- limited mobility
- inflatable skin vulnerable to sharp objects
- sensitive to wind

Spiny ball

- softball size
- very portable
- complex design
- expensive to build
- hard to maintain

Rebound with flippers

- 4 wheeled vehicle
- two external flippers mounted on rear

At least one camera is needed to provide visual intelligence. Barnes states the need for low-light/night-light capability, a wide field of view, ability to zoom in on an item, pan/tilt capability, and the ability to look into bright areas without picture washout. Bruch mentions the need for two front cameras to spot obstacles, a rear facing camera for backing up, and the ability for the camera output to be inverted if the vehicle flips. According to Check-Sanchez, a 10 hour recording time should be provided with an auto-focus and auto-iris that have manual override capability, a 20x optical and 100x digital manual zoom, the ability to raise from vehicle height to at least 36", and also pan/tilt capability. The ability to distinguish between black and brown wires is needed for EOD operation. A camera that is mounted too low has difficulty seeing obstacles at long distances, while a camera mounted too high could miss obstacles directly in front of the wheels/tracks. The ability to raise and lower the camera, pan from side to side, and tilt the camera to different angles, is preferred.

Live video is helpful to get an accurate picture of what is happening at a scene. A few issues are mentioned by Bruch:

- analog video transmitters have too much multi-path break-up and signal degredation
- digital video systems need an update rate of at least 10 frames per second
- mechanical jitter is a problem during movement
- a high-resolution camera with tilt and zoom is necessary.

Weather conditions can cause problems with camera operation. Going from a low temperature to a high temperature or vice versa can cause condensation to form on the camera lens. Ice can hinder pan/tilt operation. Mud or blowing snow can collect on lenses and block the picture.

The ability to have two-way communication becomes a necessary feature if dealing with a barricaded suspect, or finding someone trapped in a collapsed building.

If a vehicle is to be controlled by a human operator or needs to transmit video back to a viewing station, the signal strength must be taken into account. Barnes states that 40m in an open area or 2 cinder-block walls is sufficient for many missions. Bruch mentions the need for 200m inside tunnels.

Batteries pose a problem for unmanned vehicle operation. Vehicle-based operations, where the unmanned vehicle is carried to the site by a passenger vehicle, are limited by the size of the vehicle. A larger vehicle can carry more batteries for the UGV, and also provide charging capability. Foot operation is where problems arise. Enough batteries must be carried to provide operation, but individual sustainment must also be carried. A few considerations were mentioned by Bruch and Lundberg:

- One battery (dirty power) for motors and lights
- A different battery (clean power) for electronics
- Different battery boxes should be different colors
- Different batteries should have different pin configurations
- Batteries need to be standard, readily-available packs
- Multiple packs should be interchangeable, if possible
- Need to be able to charge from a wall outlet or a vehicle outlet
- Batteries should be able to be charged while they are still mounted in the vehicle

Two hours is listed as an adequate run-time for a vehicle. The ability to accept standard alkaline batteries allows for operation while other batteries are charging.

No matter how well constructed the UGV may be, eventually something may break. According to Carlson, in “Follow-up analysis...”, field repairable is defined as the ability to be repaired under favorable environmental conditions with equipment that normally accompanies the robot. A common problem for UGVs with tracks, is “throwing a track” or the track coming loose from the vehicle. Tracked vehicles can collect debris, mud, or snow in the tracks, which causes problems. Vehicles with pneumatic tires can develop flat tires if operated around sharp objects. Electrical connections can become dislodged during operation. Wires or metal parts subject to continual bending become weak and can break. After prolonged operation or operation in dusty or wet environments, wheel bearings or differential grease may need to be changed.

These are just a few things to keep in mind when designing an Unmanned Ground Vehicle.

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