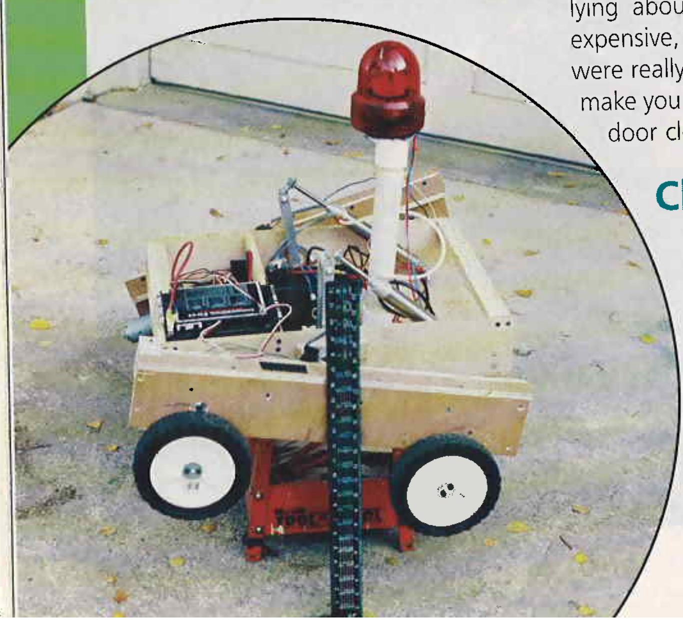
Build Your Own Planetary Rover Bogey Suspension Platform

by Alan Federman

Both the Mars Pathfinder and MER rovers used a rocker bogey suspension system of six wheels. The rocker bogey is an amazingly simple design that has proven its effectiveness. It is passive — no computer is required to control it. The goal of the system is to keep as many wheels in contact with the ground as possible over uneven terrain. I wanted an easy-to-build, inexpensive platform for students to use to simulate planetary rover operations.

My requirements were the platform had to be able to carry a payload of up to 10 kg, the entire robot could be lifted by one person, and that it could fit in the average car trunk. My target price for the platform would be $200-500, depending on how good a scrounger or recycler I turned out to be.

I've seen lots of student projects where someone has put a camera on a RC car, and called it a rover, but I don't feel that teaches kids anything about robotics. Most commercial kits are only suitable for use on smooth level surfaces indoors. Now, where's the fun in that? If I am going to build a rover, I want one that can get its wheels dirty! I call my robot the PMMP = Pneumatically Mediated Mobile Platform. I am going to show you how I built it.



Complete view of the rover showing the freedom of motion and the legs at opposing angles.

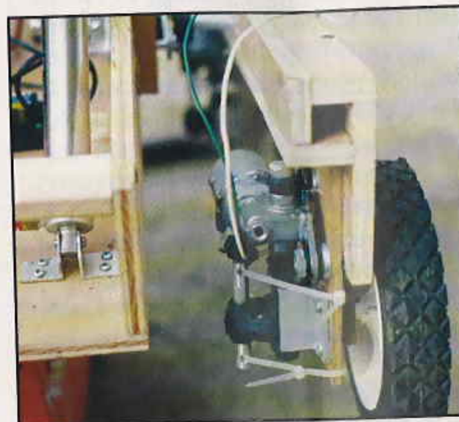
Why Go Bogey?

Just think about it. Suppose you had a four wheel vehicle with no suspension. If one wheel hit a rock or a curb and tried to climb it, you'd soon have two wheels up in the air, and only 50% of your traction. If your suspension could automatically adjust to the terrain, you'd always have at least three wheels on the ground and 75% or more of your traction. A rule of thumb is a round wheel can't climb a curb generally greater than 1/3 of its diameter. A four wheel system with a bogey suspension can usually get by at a 1/2 to 2/3. Add a rocker to the bogey, and you can usually climb an obstacle 1 to 1.5 diameters. Another advantage of a bogey suspension is the platform tends to stay level with the ground. So a flush mounted camera is always aligned with the local horizon.

There are several ways to make a bogey. NASA's rovers use differential gears. You could also use simple tie rods, like the control rods used by RC modelers. For my bogey, I chose pneumatic cylinders, because I could get away with being a sloppy machinist, and I happened to have a couple of extra ones lying about. New cylinders are kind-of expensive, but used ones aren't. If you were really strapped, you probably could make your own by using a pair of screen door closers or bicycle pumps.

Chassis

I am a big fan of using plywood box beams for structural elements. Plywood is cheap, easy to work with, and almost everyone can get access to a table saw. I started by making two 30 inch box beams to hold the motors. I used four 12 volt seat positioning motors. These use a two stage worm gear reduction for a top speed of about 75 RPM. I used lawnmower wheels mounted directly to the output shaft by a pin and endcap tapped into the shaft end.



This photo shows the end of the box beam, made of three 1.5 inch wide pieces of 1/2 inch birch plywood, glued and screwed to one piece of six inch wide plywood. The motors are bolted to the wider piece of plywood. Two assemblies — one for each side — are made.

The Central chassis is just an open plywood box. A few pieces of lumber are used to stiffen the box and act as support struts for the battery and warning light.

Both wheel assemblies are attached to the central chassis box by ball bearing races and 8" aluminum shafts. The shafts are either drilled through and bolted, or drilled and tapped to attach additional structural elements.

Before attaching the pneumatic cylinders, it is important to check the balance and freedom of motion of the wheel assemblies. The cylinder attachment brackets are made from some L channel, some C channel, and some 1/2: aluminum rod. The assemblies are either bolted directly to the plywood box or drilled, tapped and bolted together. I used a small piece of plumber's steel

PARTS LIST

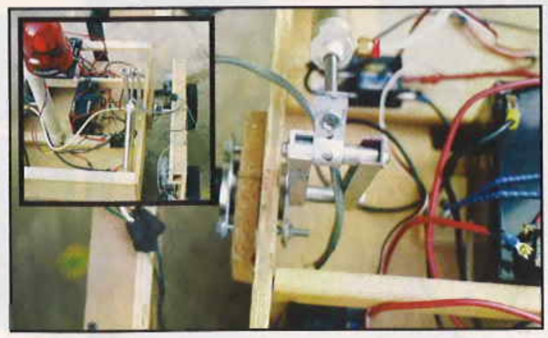
- 1 4' by 4' sheet of 1/2" birch plywood
- 36" long 1/2" diameter aluminum shaft
- 2' of 3/4" aluminum C channel
- 1' of 2" aluminum L channel
- 1 box 1" drywall screws
- 1 bottle carpenters glue
- 12" of Plumber's steel mounting tape
- Two pneumatic cylinders, with tubing and fittings
- 2 1/2" inside diameter self-locking ball bearings, with mounting flange.
- Four 6" diameter lawnmower wheels
- Four matched low speed 12 volt automotive motors (seat positioning or similar)
- One 12 volt rechargeable battery (sealed lead acid is best)
- Small fuse panel and fuses
- Two PWM ESCs
- Wires and crimp connectors
- RC or other controller

Tools

- Table saw
- Good cordless electric drill with screw driver attachments
- Hacksaw
- Files and sandpaper
- Drills, including a good sharp 1/2" bit
- Crimp tool, wire cutter/stripper

Optional Tools

- Drill press
- Small tap set
- Dremmel
- Soldering iron



Detail of bearing and cylinder attachment.

mounting tape to attach the end of the cylinder to the top of the axle lever assembly.

Final Assembly

Hook-up the two cylinders straight across (top to top, bottom to bottom). Check to see that the operation is what you expect. When one side tilts up, the other should tilt down. I suspect that using pneumatics instead of a differential may have some advantages, especially if you are driving a little more quickly than is prudent by NASA standards. The mechanism is sloppy and works like shock absorbers for sharp bumps. I am using a 12 volt battery (15 amp hour capacity) typically sold in electronic stores and used in small uninterruptable power supplies. I am using two older Innovation First Victor 800 series PWM speed controllers, but this is probably overkill. A pair of smaller hobby shop ESCs should work just fine.

I have run this platform with both an older Innovation First FRC controller and a RadioShack VEX.

Future Plans

Now that I have my platform, I intend to try some enhancements, including different autonomous controllers, a solar panel battery charger, and maybe a stereo camera system. So now I have my very own planetary rover, and I am all set to explore my back yard. You can have your very own, as well. I hope my design will inspire your creativity. I say a computer on every desk and a robot in every garage! **SV**