GUIDE TO MUNIN SPACECRAFT

Brower Propulsion Laboratory

BPL DOCUMENT 003092010001

THE MUNIN SPACECRAFT

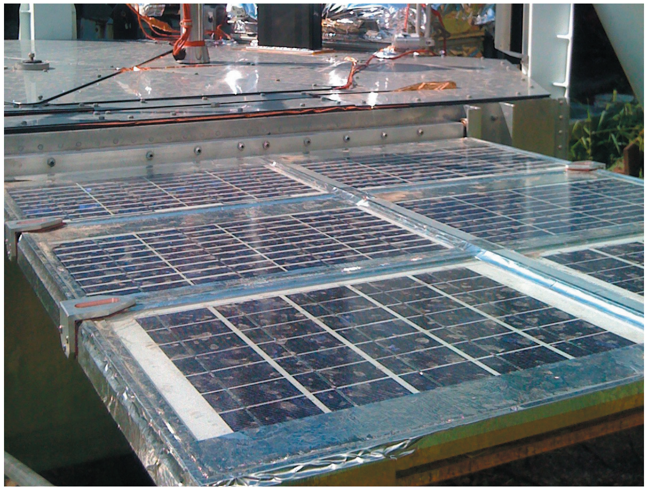
The basic design of the MUNIN (Module for Unmanned Novel Investigation and Notation) vehicle (including its arbitrarily Norse name) is the Viking Lander, constructed by Lockheed Martin for NASA in the 1970's. The Viking mission consisted of two Landers and two Orbiters which were used to study Mars in detail and search for life. BPL's Research and Envelopment team spent several years studying the Viking mission and traveling around the United States to examine extant hardware at NASA centers and museums.

BPL's version of the Mars Lander, while inspired by the Viking Lander, differs in significant ways from the original vehicle. The Mission Requirements are very different. BPL's lack of funds and equipment also curtail our ability to faithfully reproduce flight hardware. Our educational background in painting pictures also tends to extend our learning curve when it comes to scientific and technical goals. Finally, BPL's entire staff and administration being centrally located in one person makes for a very different kind of bureaucracy from those that carry out space missions generally.

STRUCTURE

The body of the lander is constructed of welded and riveted aluminum panels and structural members. Its geometrical arrangement is that of a triangular box with the points cut off, creating a hexagonal prism. On the short sides of this hexagon are mounted posts which form the top mounting positions of a triangular arrangement for three legs. The body is used to house equipment and to provide stability for the system. The interior of the body is accessible through panels screwed to the top surface.

The legs are composed of three sets of spring loaded aluminum tubes and pairs of aluminum outriggers that join together at three foot pads. The foot pads are made of aluminum honeycomb material sandwiched between two outer layers of graphite impregnated epoxy. The leg system distributes the load from the foot pad to the lower corners of the body and to a point above the body at the top of the mounting post. This system allows the lander to remain stable under any surface conditions.



POWER

The original Viking Landers contained two Radioisotope Thermoelectric Generators which created all the power for the system. Being skittish about radioactive materials, BPL Engineers opted to prePurpose some solar panels 'left over' from a job, to charge battery banks on the vehicle. MUNIN's main solar array is capable of generating 50 watts of power. Several supplemental panels constitute separate systems.

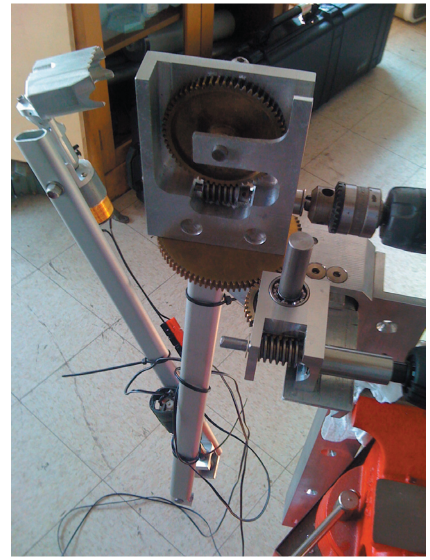
COMPUTER CONTROL

MUNIN has two Main Computers on board, running independently. A decrepit but reliable Panasonic CF-28 controls the Mast Mounted Camera and its connection to the internet. A Macintosh Powerbook G4 suffering from intermittent bouts of something called 'kernel panic' is in charge of internet connection, two cameras, and microcontroller interface with experiments. There are several microcontrollers located on the spacecraft for low - level operations such as motor control, serial export of sensor data, and for helping to make things overly complicated. All the computers are remotely accessed by BPL engineers from the Provisional Administrative Mission Production Equipment Resource Unit (PAMPERU).

TELEOPERATED MANIPULATOR

The Munin Arm And Manipulator (MAAM) is connected to the +Z face of the vehicle body. It includes motors and gear trains, a sample collector and a camera. The arm has what BPL calls 3.5 degrees of freedom of movement, as one of the degrees is kind of limited. The base (waist) of the arm can rotate in a horizontal plane 5 degrees before it runs into something. At the same location, another degree of freedom (shoulder) allows the arm to rotate 300 degrees in a plane vertical to the lander. At the midpoint of the total length of the arm is another rotation point (elbow), which is capable of 350 degrees of rotation. Finally at the end of the arm (wrist) is another point of rotation which is connected to the collector head. This aluminum scoop can be rotated 360 degrees and has the ability to flex in the vertical plane approximately 12 degrees in case it tries to pick up something it shouldn't. The arm has undergone several redevelopments, mostly due to the trial and error (mostly error) method used for selecting motors. Being the only aerospace company to be broke most of the time, BPL Systems (BS) developers chose the smallest and crappiest motors they could find to build the MAAM. We quickly saw that these units would not stand up to the rigors of the Yellowstone Other Space Environment (YOSE). Our documents reflect an agonizing journey over the rough terrain which exists just next to the well paved road of precedent in this area. Others have created exquisite pieces of equipment that are designed explicitly for their tasks, and that perform their duties nearly perfectly in multi - year cycles. Our MAAM works ok. It has a personality. Our solution to the motor problem was to put down the Maxxon catalogue and forget the motors NASA uses for its Mars missions. We went to a local 'home center' and found a pile of 'electric screwdrivers' for eight bucks a piece (including batteries!), which we then took apart and adapted for Other Space use. We should mention here something about the influence of China on BPL's products. BPL recognizes the security and quality issues that can arise when using the cheapest possible goods in ways that contradict their intended

function. However, we feel that this use of the Global Marketplace for manufacturing Aerospacey goods will keep us at the forefront of High Impoverished Technology (HIT) development. Please see BPL Document BPL-002 Experimental Outsourcing Mission To China for more information on our policies in this regard. Our final configuration has the hacked up screwdriver's planetary gearboxes connected to our own custom worm drives developed and machined at BPL's Chipmaking Facility (no cute acronym). The motors are controlled by an Arduino microcontroller with serial output to one of the MUNIN Main Computers. The routines that run the motors are customized to BPL's 'Spineless Backbone (SB)' wireless network. This balky system causes numerous hazards for teleoperation of the MAAM, aside from the Other Space ones encountered during normal mission operations. The codes for moving the arm have built - in hesitation and 'indecision algorithms', which cause it to double check before performing an operation, and then to hem and haw about it while the imagery from the cameras catches up and the Mission Controller can see what's going on. In a convenient parallel, this is not unlike the form (but not the content) of the process that NASA uses to operate its robotic vehicles on Mars. The signals can take several minutes to traverse the space between Earth and Mars, so one operation must follow only after the results of the previous operation are known. NASA's robots are smarter and can make more of their own decisions without having to constantly ask permission. At BPL we scoff at this lack of discipline and force our robots to wait for commands. If they perform them though, we give them treats.



COMMUNICATIONS

MUNIN's connection across the Other Space environment is achieved through a microwave antenna that can slew to maintain contact with Mission Execution Repeater Elements (MERE), or with a convenient Starbucks. This

is the main interface between the spacecraft and the Spineless Backbone (SB) communications network.

IMAGING
For the -003 Moranic Mission to Montana, the spacecraft is equipped with three camera systems. The main camera is mounted to a mast extending from panel three on the deck of the vehicle. It is capable of 350 degrees of horizontal movement and 200 degrees of vertical movement. The CCD camera element is extended on a short boom which also houses the Laser Imaging And Rotation System (LIARS). Camera motors are controlled by an ancient 'Basic Stamp' microcontroller and a php script running through the main computer. Remote viewers of the mission can operate this camera when it feels like working via interweb controls. A second camera is mounted just above the Collector Head on the MAAM, and can be used to assess samples or to get close up views of the vehicle or elevated views of the sky and landscape. It is used to conduct several imaging experiments and is also very shiny. The third camera has a fixed mount on the +Z end of the deck, and is angled downward 50 degrees. This camera takes detailed photos of the landing area and observes collection of soil samples. Because its geometry is fixed, it can be used to determine range and size of sample elements and might not be as prone to breaking.

ENVIRONMENTAL SENSORS
MUNIN is equipped with a weather station which operates on power supplied by solar panels and sends its data to Mission Control independently of the vehicle's main computers. The spacecraft is fitted with a number of redundant systems like this one so that complete mission failure can only take place if numerous unlikely catastrophic events occur simultaneously, and everyone knows that never happens. The wind speed and direction, rain, temperature, barometric pressure

and relative humidity sensors report to an Argent Data Systems controller, which converts the data to packets of information that are sent by a dinky Yaesu VX-1R radio to Other Space repeater locations. From these the information is sent through a series of tubes to an interweb site called APRS.fi, and from there to the BPL Mission 003 interweb site. The weather station operates on a frequency of 144.390 megacycles, and locally is using by kind permission the repeater of K7YD. The Station ID is KC2SQU-2.

EXPERIMENTS

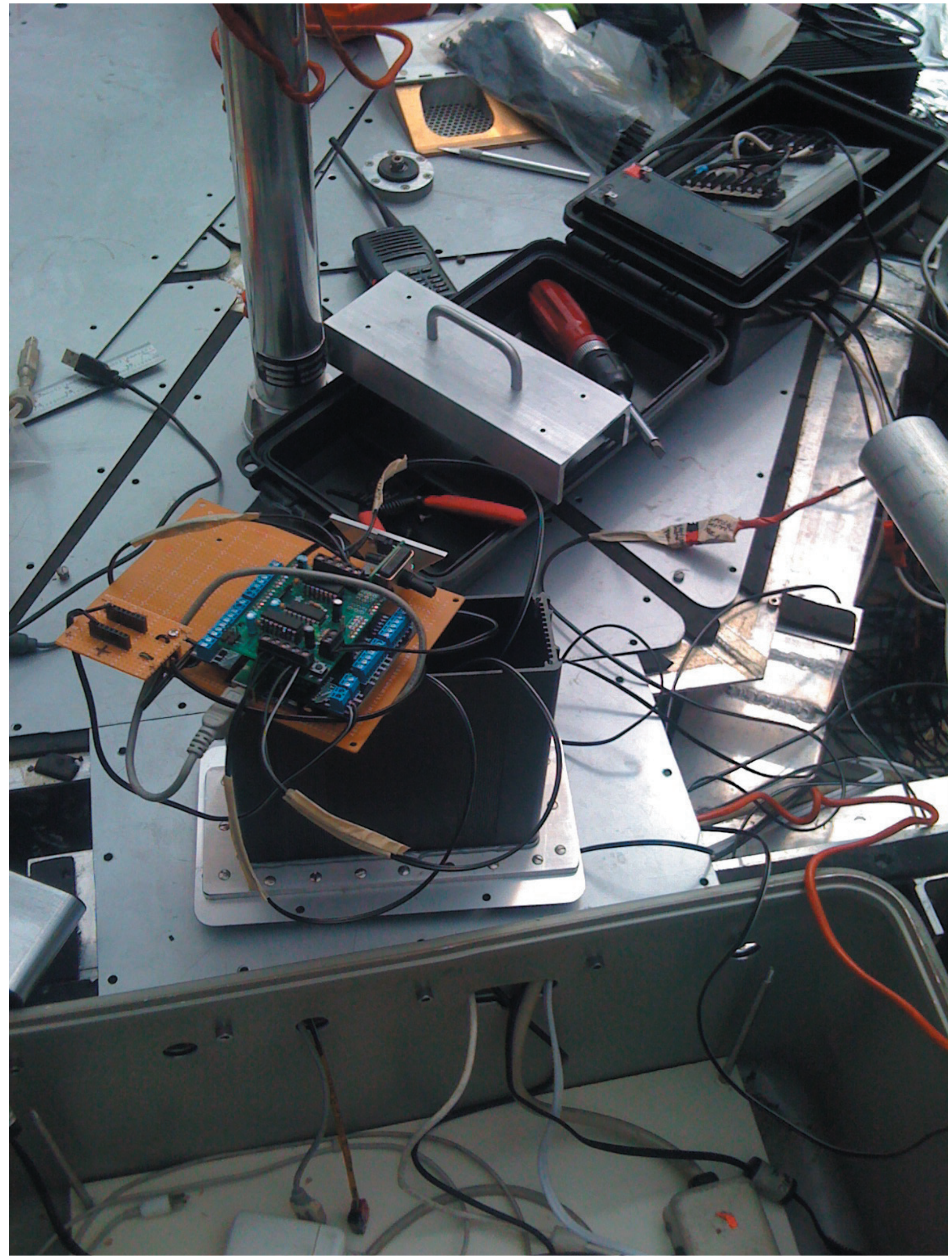
The MUNIN weather station is calibrated to report conditions local to the vehicle itself. Thus, the temperature and humidity refers to the internal temperature and humidity of the vehicle. Also reported by this unit is the voltage level of the vehicle's power system. This data is analyzed by BPL to determine the "mood" of the spacecraft, rather than the "weather" at the landing site, which can be reliably determined by looking at today's paper. The MUNIN spacecraft is a unique and delicate instrument and it requires sensitivity and compassion to be able to carry out its tasks. If it feels too hot, or if the humidity is very high, it doesn't perform as well as it might. In such cases, Mission Controllers can prescribe vehicle systems to undertake less taxing duties until it feels better. The amount of sunlight the solar panels receive has a direct effect on the power level of the vehicle. At different times of day, MUNIN may report 'elation', 'anxiety', 'depression', 'hunger', or 'slight bloating', depending on the weather and its energy level. The imagery reported by the cameras on board is also determined by light levels, so the BPL Algorithm Section Experiment (BASE) was established to determine how much MUNIN 'likes' certain pictures. MUNIN uses Thomas Moran paintings as an ideal image base from which to compare its Photographic Products (PP). Combined with its mood, MUNIN forms

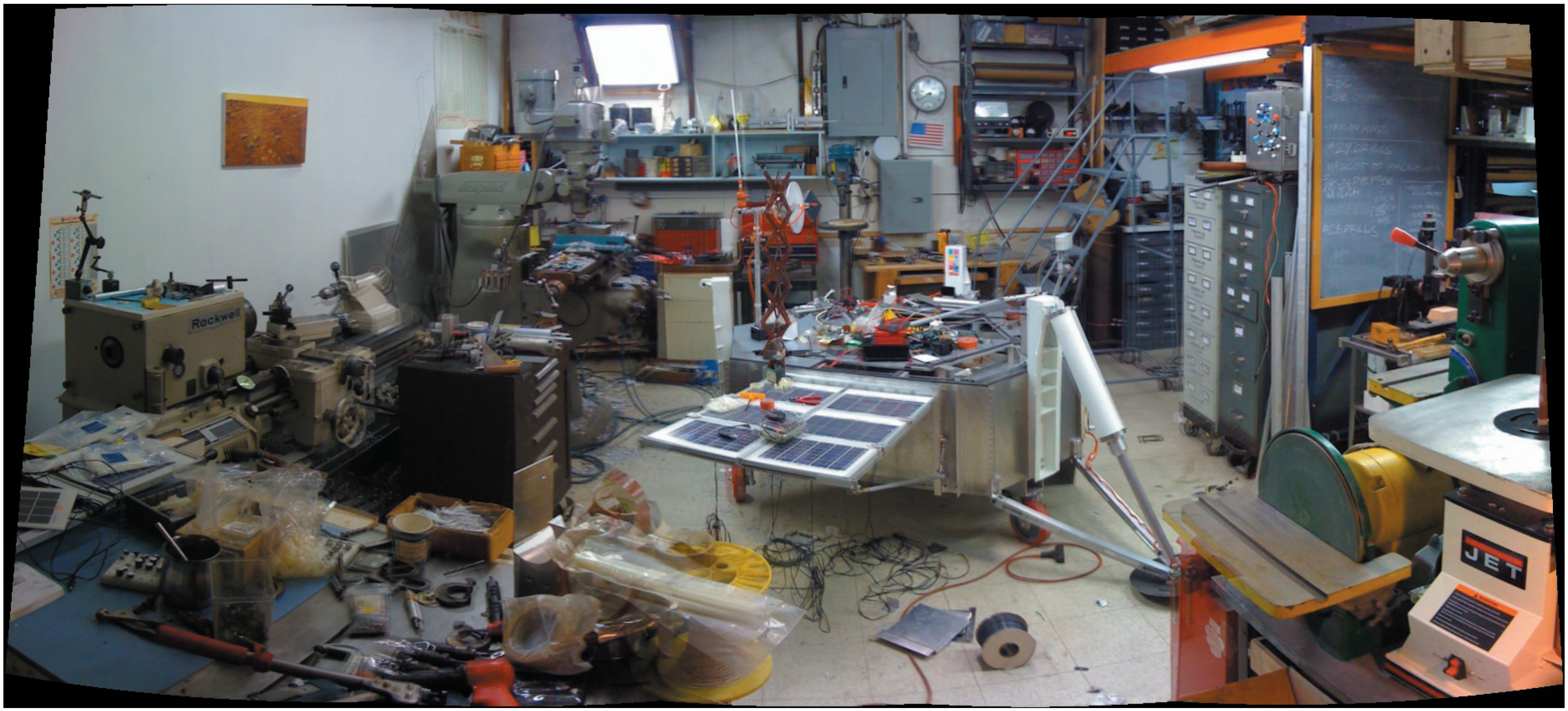
opinions about its environment and helps Mission Planners to determine ineffable qualities of the landscape that 'everyone knows but can't explain'. It is thought that these qualities play a role in the mythologizing of places and inspire exploration and debate.

The Search For Life On Earth (SFLOE) is an ongoing BPL Experimental program. Data acquired by BPL missions is compiled and analyzed in an effort to understand the parameters implied by such a squiggly term as 'life'. In addition to the imaging and mood experiments outlined above, there is also a chemistry experiment. The Methane ANd ALcohol Yen for Society In Samples (MANALYSIS) experiment takes two expression factors for "MAN" (Methane-Alcohol Number) and attempts to extract them from samples at the landing site. If evidence of MAN can be produced at MUNIN's location, then perhaps life is not far off. BPL has obtained data that imply that MAN might be found in abundance in the Yellowstone Region.

The LIARS experiment is a method developed at BPL for 'cheap - ass night vision'. Two lasers are fitted with collimiters and fixed to the camera boom so as to create crosshairs projected onto any surface the camera is pointed at. When a programmed routine is run, the camera is rotated a small amount and a picture taken. This process is repeated a number of times, and if the routine runs at night, the lasers create an image of the contours of the objects they encounter. All of the photos in the series are combined to form a map of the area. This map can later be compared to daylight images of the site to eliminate 'atmosphere' as a factor in determining the suitability of the image for appreciation or framing.

Other Experiments Pending...

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