

TIGER – Terrain Investigator and Geological Experimentation Rover

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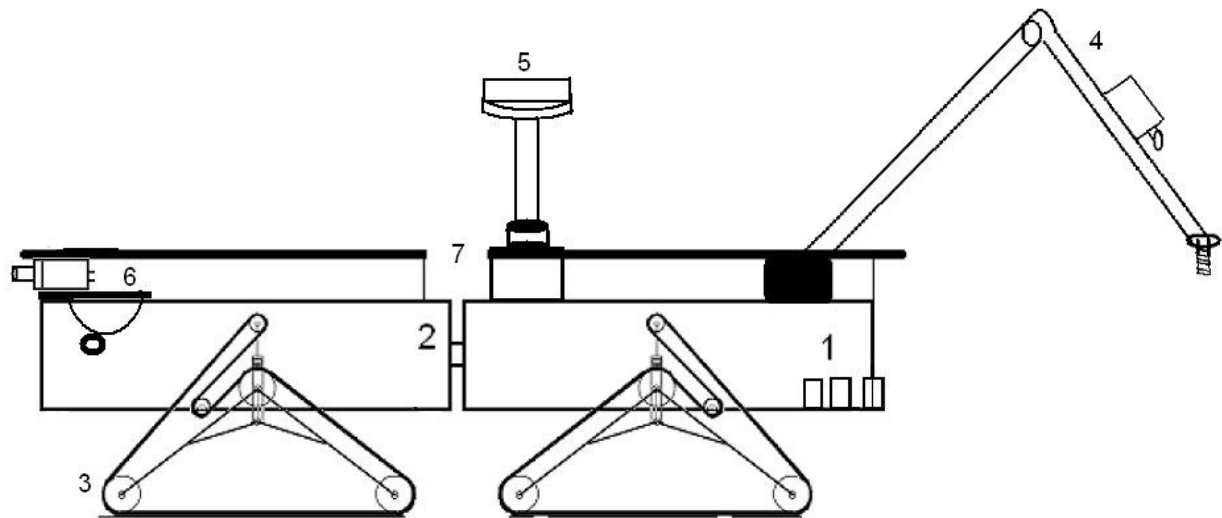
INTRODUCTION

The human mission for finding a suitable place to build a long term human base on moon will be supported by TIGER. The rover as the name suggests is used for mapping the lunar surface and subterranean features. It is also used to drill out samples from the ground. The sample is then brought back to the human base (Lunar station) for further tests to be conducted by humans. It uses a Ground Penetrating RADAR to scan the subterranean features. After scanning a certain area it deploys a radio relay to repeat the signal and goes on with the scanning process. Thereby the rover can cover a huge area within the period of operation. The Rover also houses a Drilling arm with a portable digital Gas chromatograph. The rover is to be deployed in the Peak of eternal light which receives sunlight for almost all part of the year. As the light source is continuous the batteries of the rover can be recharged by using solar panels. This caters the energy needs of the rover. Therefore it is possible to operate the rover for more than 180 earth days. The whole rover system is placed under the belly of the lunar lander. This enables the rover to be compatible with the human mission.

DESCRIPTION

TIGER – Terrain Investigator and Geological Experimentation Rover is a semi-autonomous rover. i.e. it needs no human intervention for its motion and to perform its basic functions but it needs human control to perform complex tasks like drilling a surface and collecting the sample. The outside dimensions of the rover is 90cm X 60cm X 45 ~ 50cm. The rover is modular in design. This split apart design is useful in climbing steep slopes. The modules are of the dimensions 45cm X 60cm X 45~50cm Module1 contains the Ground Penetrating RADAR (GPR) and the main camera. Module2 has a drilling arm/Gas Chromatograph combo and panoramic camera with 360° view which is used for mapping the lunar surface. The drilling arm has got its own camera to assist humans in the drilling process. The rover uses an unique and a hybrid suspension system called Radically Adjustable Track System RATS. The area of contact between the track system and the ground can be altered by realigning the rollers. This is achieved by a pneumatic system. When the rollers are realigned the track may flap. This is prevented by using two free rollers. This system helps in realigning the centre of mass of the rover and helps in increasing the traction. It also helps to change the ground clearance of the rover, which is used to position the GPR antenna either near the surface for scanning or above the ground to protect it from the uneven terrain.

Overview of the Proposed Rover Design

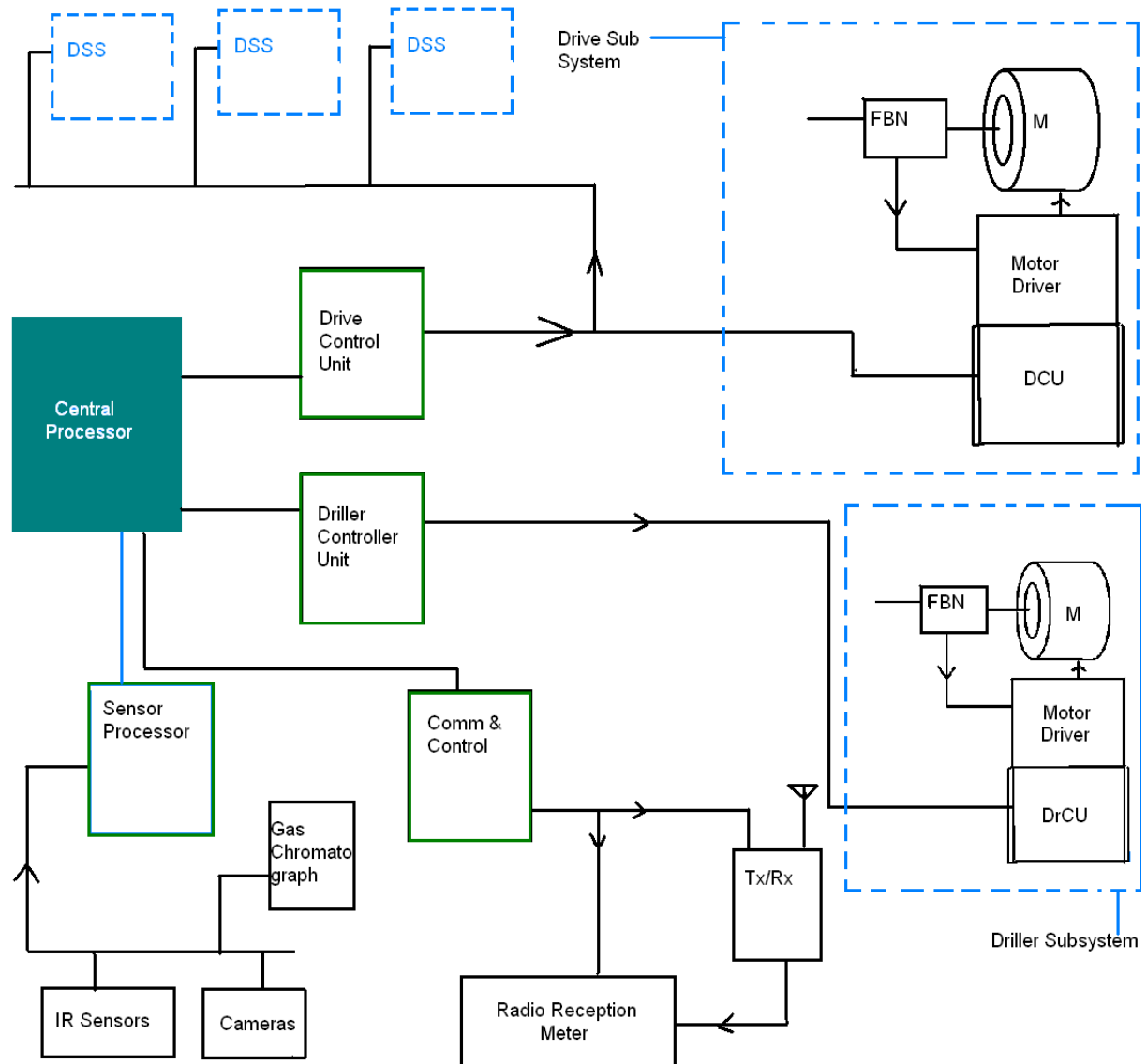


- 1 – Radio Relay System*
- 2 – GPR Chamber*
- 3 – Tracked wheel*
- 4 – Drilling arm with Gas chromatograph and Camera.*
- 5 – Panoramic camera*
- 6 – Main Camera.*
- 7 – Solar panels*

ARCHITECTURE & ORGANISATION

The rover features a radically efficient and fail-over architecture, which makes the system all but fail-proof. Instead of relying on a central control unit (microprocessor/controller) for all the operational decisions and controls, the rover houses several sub - control units in various sub-systems. It emulates the autonomous neural conduction of a biological organism. Hence the name **Brain and Body System(BBS)**. All the subsystems have a dedicated control unit which has full authority over it and receives a constant feedback status signals from all components concerned. This level of distributed processing eliminates the risk of computational failure leading to complete shut-down. **All critical elements of the system is backed up with a simple Nv-net based backup system(which enables the system to return to the base for repairs) ensuring the survival of the Rover. The key element in the design is the Nv-Neural network working in tandem with the RISC system.** The Nv-Net technology used for the design is based on the works of Mark Tilden. This unique architecture gives limited autonomy and decision making ability for the individual elements such as the adjustment of the RPM of a particular motor or the RADAR sweep frequency to suit the mission parameters without the explicit authority/command from the central processor.

Architectural Block Diagram



FBN – Feedback Network
DSS – Drive Sub System

DCU – Drive Control Unit
DrCU – Driller Control Unit

The Nv-net RISC integrated process elements utilises the best of both analog and digital computing. In short, the each sub-system controls and has limited capability for correcting and communicating with the adjoining unit, even in the event of communication failure and or central processor failure. In this scenario, all this sub-systems ensures that the rover survives and possibly returns to the base.

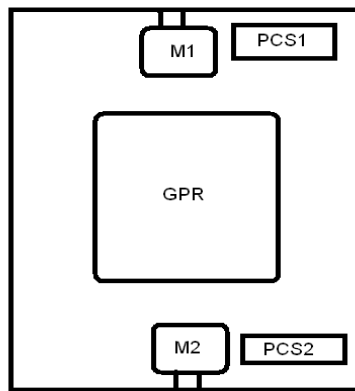
PHYSICAL ORGANIZATION

The Rover is designed to maximise the utilisation of space and weight. So the Rover is segmented into two modules and they are in turn made up of two decks. The first one houses the Heavy parts like Power-pack, battery and GPR. While the top compartment houses the sophisticated circuitry

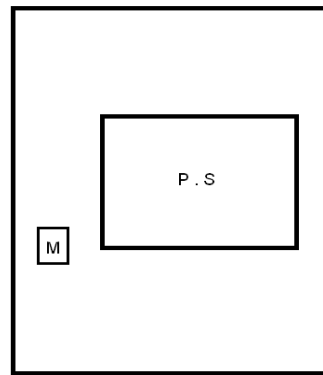
and sensitive sensors. The Solar panels can be expanded by means of pneumatic piston, powered by the same system which powers the Track suspension.

Module 1

The module is double decked. The (lower) deck 1 contains the motors (M1 &M2) and the pneumatic control systems (PCS 1&2) for the track system. The separate pneumatic systems facilitate better control over the tracks. This enables independent movement of the tracks thereby increasing stability and mobility of the rover. The (upper) deck 2 contains the battery for power storage (P.S). This is used by the on-board GPR. Further it contains the control system for the main camera. (M)

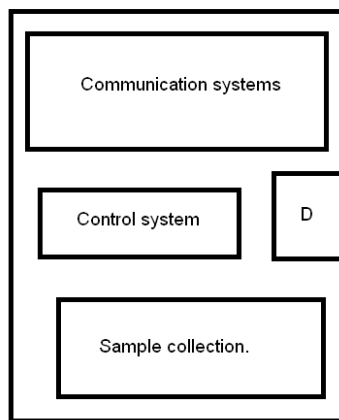


DECK 1

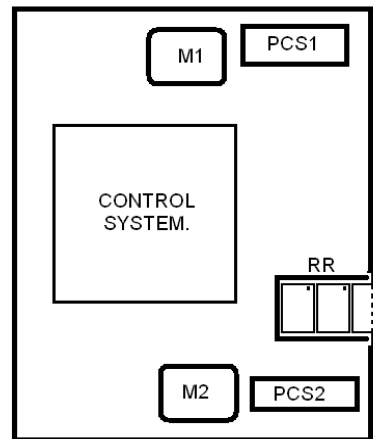


DECK 2

Module 1



DECK 2



DECK 1

Module 2

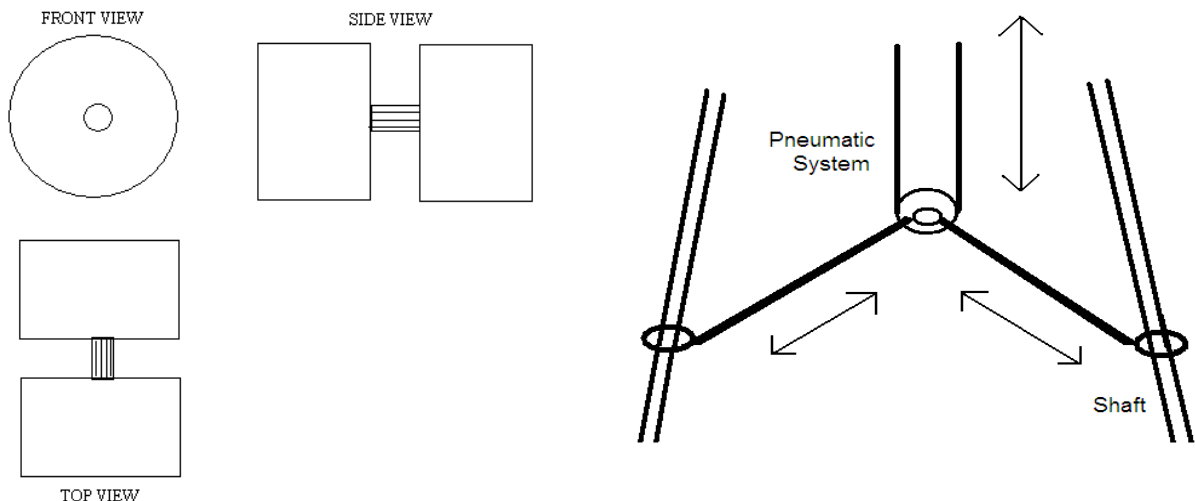
Module 2

Like the module 1, the module 2 is also double decked. The deck 1 of the module 2 contains motors control systems etc. Apart from this it also contains the radio relays which are deployed to repeat the signals for increasing the range of the rover. The deck 2 contains the base and controls of the drilling arm. Further, it contains a small chamber for collecting the samples by the drilling arm. It also contains the communication systems and the base of the panoramic camera. The panoramic camera can be raised up and brought down by the control system.

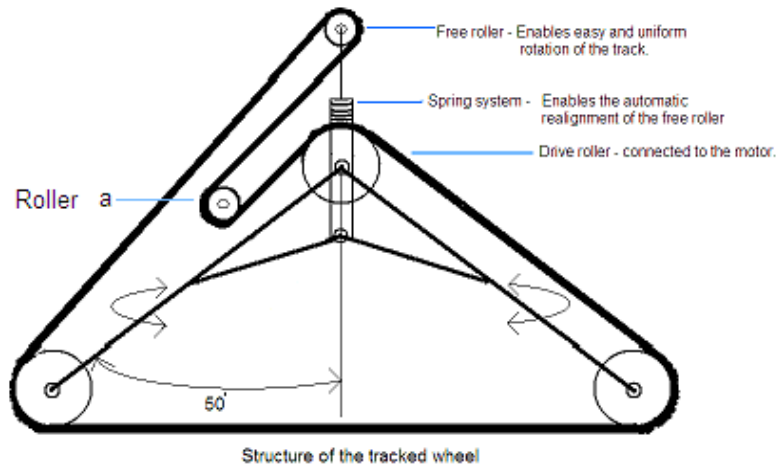
SUB-SYSTEMS

RATS1 - Radically Adjustable Track System1:

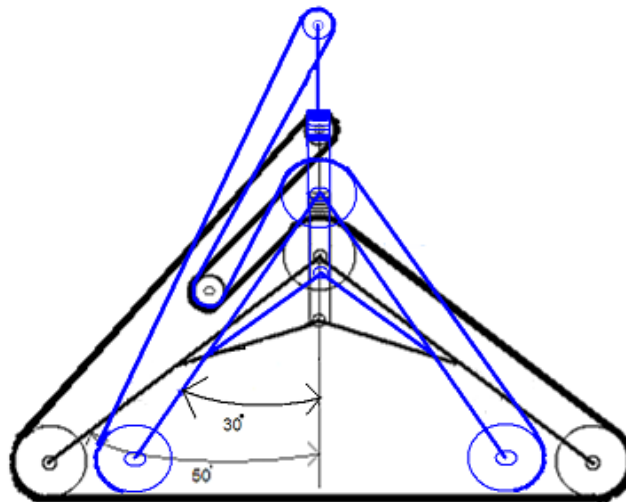
The suspension system is a unique and a hybrid system. It uses four tracked wheels, each of which contains three drive (power) rollers and two free rollers. The central roller is directly connected to the gear box, whereas the other two rollers are mechanically coupled with the motor by a shaft. The shaft translates the rotatory motion along the X axis into rotatory motion along Y axis. By using another set of gears it is again changed into rotatory motion along the X axis. The contact area between the track and the ground can be changed adjusting the inter-axial distance between the rollers. This is controlled by a separate pneumatic system. The change in the inter-axial distance between the rollers changes the perimeter of the track frame, which causes flapping. In order to avoid the flapping of the track, the track is run through two free rollers. A spring system adjusts the height of the free roller according to the change in the inter-axial distance between the rollers. The spring system enables an automatic change in the height of the free roller, which gives a smooth transformation of the track size. The change in the inter-axial distance between the rollers bring about a change in the height of the tracked wheel. As each tracked wheel is separately controlled by a pneumatic system, the area of contact between the ground and the tracked wheel and its height can be effectively altered. This gives the advantages of an Actively Articulated Suspension System. i.e. the rover can change its centre of mass and can also traverse in challenging terrains with ease. All the power rollers are of same size, 50mm in diameter. Each roller is a combination of two half rollers as shown. This enables easy coupling of the rollers.



The free rollers are made half its size, in order to reduce the frictional losses. These are simple rollers which are positioned as shown in the fig. The roller 'a' is fixed in the chassis and immovable. The other free roller is automatically positioned as per the necessity by the stored energy in the spring. The shaft angle is adjusted by the central rod which consists of two bracket ended rods. This translates the motion of the piston in Y direction into motion of the rods in X axis as shown in fig. The control rods also acts as rigid supports for the rollers, so that the rollers does not goes out of position. The tracked wheel is as shown in the fig.



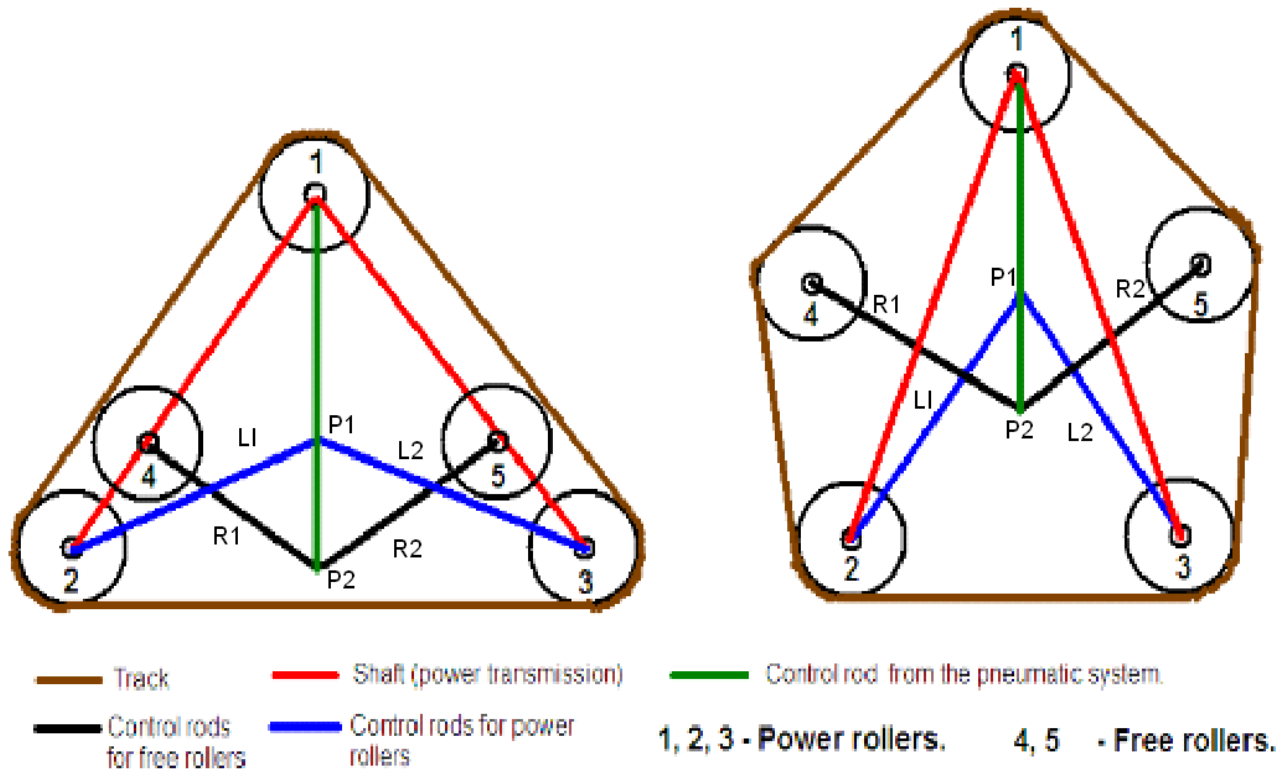
The positions of the rollers under different conditions are shown in the same fig.



RATS2 :

The adjustable tracks can also be controlled by a less complex system as shown in the following fig. In this system the free rollers, themselves are movable and hence maintains the perimeter of the track frame. The free rollers are connected to the pneumatic system which alters the shaft angle. So,

that the free rollers are repositioned automatically when the inter-axial distance between the power rollers is changed. This makes the control system simple. In the following fig. The rollers A, B, C are power rollers and D, E are free rollers. P1 is the point from which the control rods for the power rollers are connected and P2 is the point from which the control rods for the free rollers are connected and R1 & R2 are their lengths between the point and the rollers. Now when the pneumatic system pulls the central control rod upwards, P1 & P2 are moved up. This reduces the shaft angle between the power rollers and simultaneously increases the angle between the free rollers. This keeps the perimeter of the track frame constant and prevents the track from flapping. RATS2 is a simple solution and uses the counter-moving of the control rods to achieve the change in the wheel size and hence the area of contact between the ground and the wheel. This also helps in increasing or decreasing the height of the rover. The following figure will give a clear about the RATS2.



Using the RATS (1 or 2) will increase the stability and rough terrain mobility of the rover. A detailed view about the mobility and maneuverability of the rover is given at a later stage.

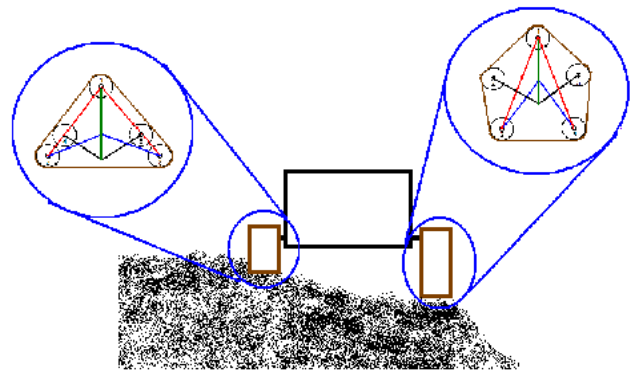
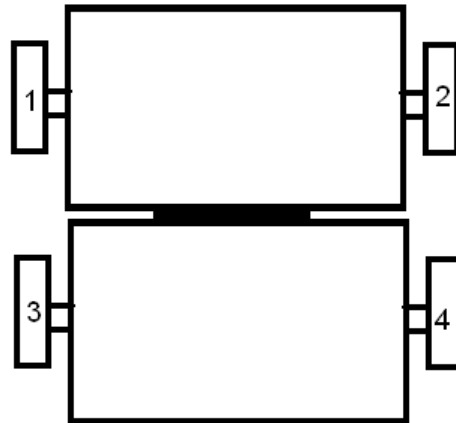
**Operation:
Changing of the directions**

To change the direction of the rover wheels are engaged in pairs. This gives a good maneuverability to the rover. To turn the rover to its right, wheels 1 & 3 are engaged whereas the wheels 2 & 4 are disengaged. This gives the extra torque to the left of the rover making it to turn to its right. Similarly to turn to its left 2 & 4 are engaged while 1 & 3 remains disengaged. For a closer right turn wheels 1 & 3 are engaged but 2 & 4 are braked. For a closer left turn 2 & 4 are engaged and 1 & 3

are braked. For more abrupt turns 1 & 3 are engaged in forward whereas 2 & 4 are reversed. Again for a more abrupt left turn 2 & 4 are engaged while 1 & 3 are reversed. This can also be used to rotate the rover at the same place. This will be much useful to evade an obstacle or to turn inside a narrow path way. Further this will be very useful while maneuvering the rover while drilling and while lifting a sample with the robotic arm.

Advantages of the RATS.

- Increases rough terrain mobility by changing the wheel height as per necessity.
- Repositions the centre of mass.
- Increases the traction by increasing the area of contact between the track and the ground.
- The GPR antenna can be repositioned simply by changing the track height i.e. It can be made to touch the ground when scanning and can be positioned above the ground so as to protect it from damage.
- The stability of the rover can be dramatically increased by maneuvering the track height/width, this comes in handy during drilling operations when the rover loses its initial centre of gravity after commencing drilling.



Disadvantages of RATS.

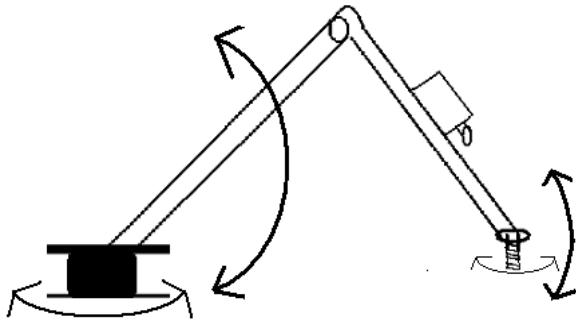
- Makes the suspension system complex.
- Increases the number of rollers per wheel and hence mass.

GROUND PENETRATING RADAR

The GPR uses RADAR pulses to scan subsurface. It can be used in rocks, soil, ice, water etc. It can detect objects, changes in material, and voids and cracks. This property is exploited to find the density changes (i.e. Change in the constituents) in the lunar surface, presence of water or ice, presence of any caves or any voids that are large enough to build a permanent human base. The GPR uses an ultra wide band carrier to be able to penetrate and sense a variety of surfaces. The GPR scan can be transferred to the home base in real-time for further study and to the Earth if needed.

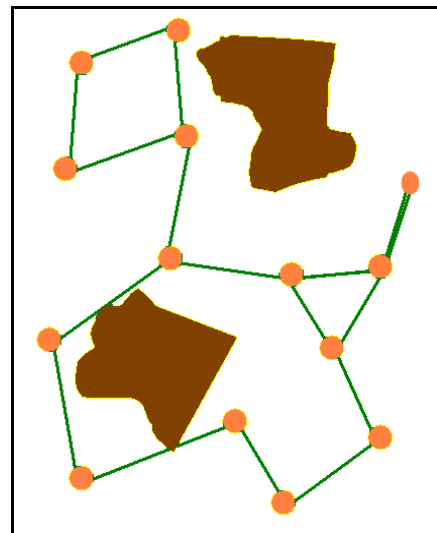
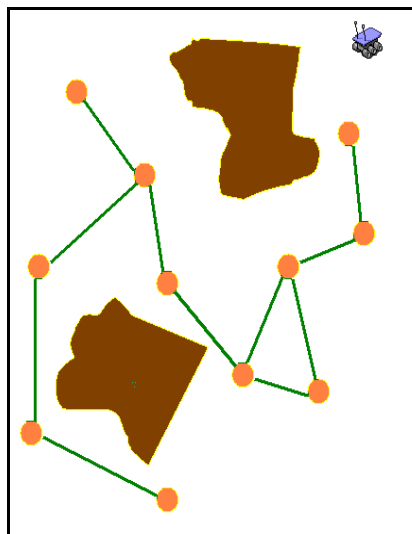
DRILLING ARM & GAS CHROMOTAGRAPH

The drilling arm is three jointed and it contains a camera to assist humans during drilling. The base of the drilling arm itself is rotatable. This enables the arm to cover the area all around the rover. The first joint can be used either to elevate or to bring down the drilling arm. The second joint can be used to change the gives The arm is used to drill the rocks and craters to find the ground strength which is important in building a permanent habitat. The driller is also used to collect samples for further investigation by humans. While the driller is engaged, the DGC can be switched on remotely to further study the composition of the formation drilled. The results of the same can also be transferred online to the home base.



RADIO RELAY SYSTEM

The radio relay system is actually a collection of a number of self-reliant(Solar powered) radio beacons and a radio network. This network is used for both command-control and information transmission. The system actually deploys a Radio beacon in the event of the signal gain from the base station goes below a certain threshold. This in turn increases the range of the Rover. As the Radio beacons are themselves a self-reliant system based on solar power and can operate for extended period of time, **this system of beacons can even be used for deep-exploration of the lunar surface by Lunar Explorers. Allowing them to camp beyond the range of the base transmitters yet stay in contact with the base.**



a) The path taken by the rover limited by the geographic features and b) established network.

This Radio Relay System operates on a simple logic implemented in **HARDWARE** via Nv-Net system. The logic is presented below.

Robot Loop

```
If no beacon within radio range
    deploy beacon
Else
    if predefined course exists,
        follow
Else
    move in direction suggested by nearest beacon
```

Beacon Loop

```
Emit least recently visited Beacon ID
```

UNIQUENESS OF TIGER :

1. Each subsystem has an individual power system.
2. The RATS enables the Rover to navigate steep angles and deep crevasses.
3. The unique BBS control topology enables the rover to salvage itself from most of the Electronic failures.
4. The sensory data are saved locally and transmitted to the home-base too.
5. The RRS enables the Rover to stay well out of Radio range of the base, this system of radio relay networks can also be used to service camping Explorers and link them to the base.

CONCLUSION :

The fusion of this very radical and efficient technologies working in tandem with the superior computer yet known, the Human brain will surely mark a new step in the ladder of success in the long history of manned exploration.

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