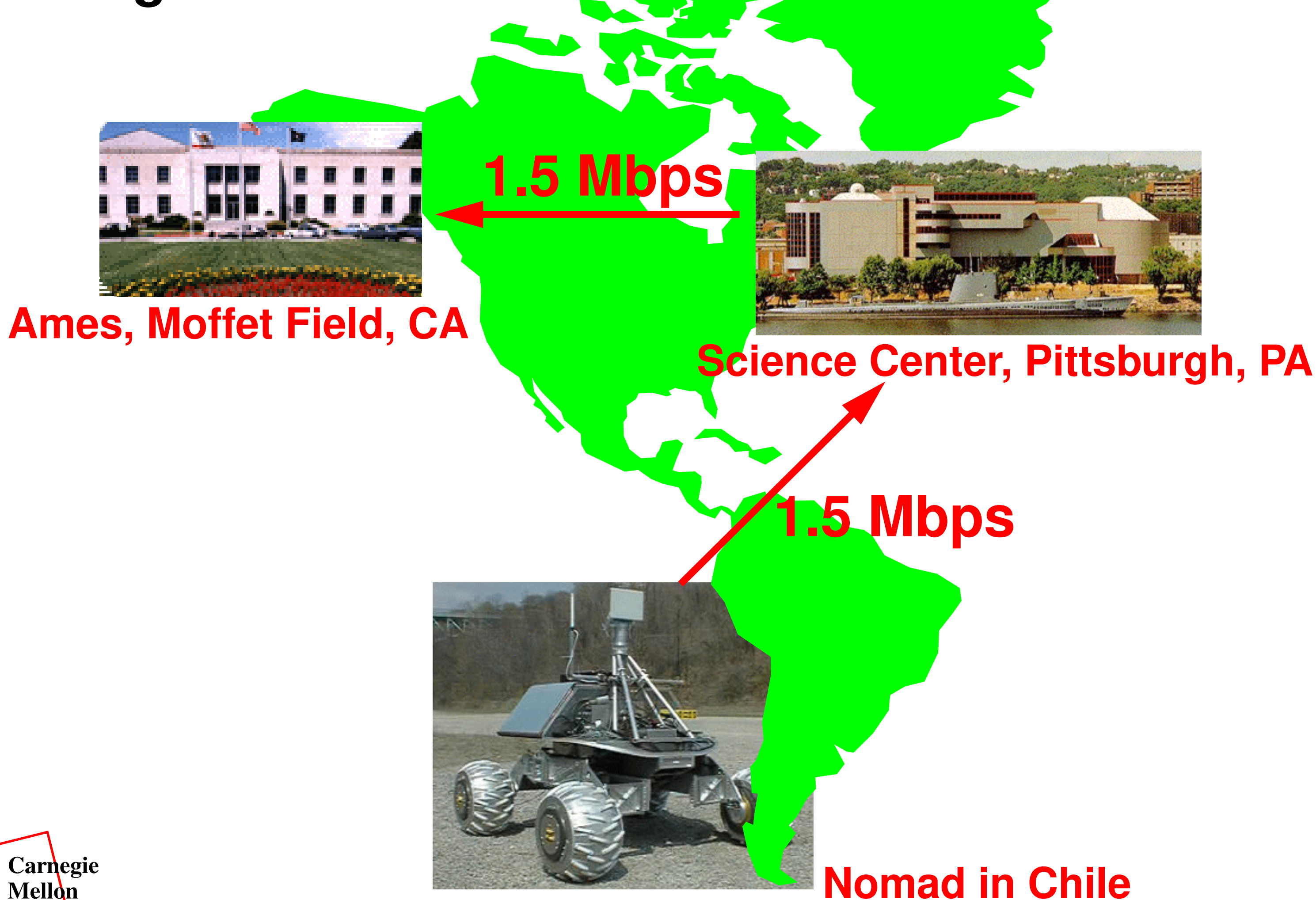
Nomad- Communication System

Deepak Bapna

Bottom Line/ Status

1.5 Mbps from Nomad moving in Atacama terrain to Carnegie Science Center and Ames research Center



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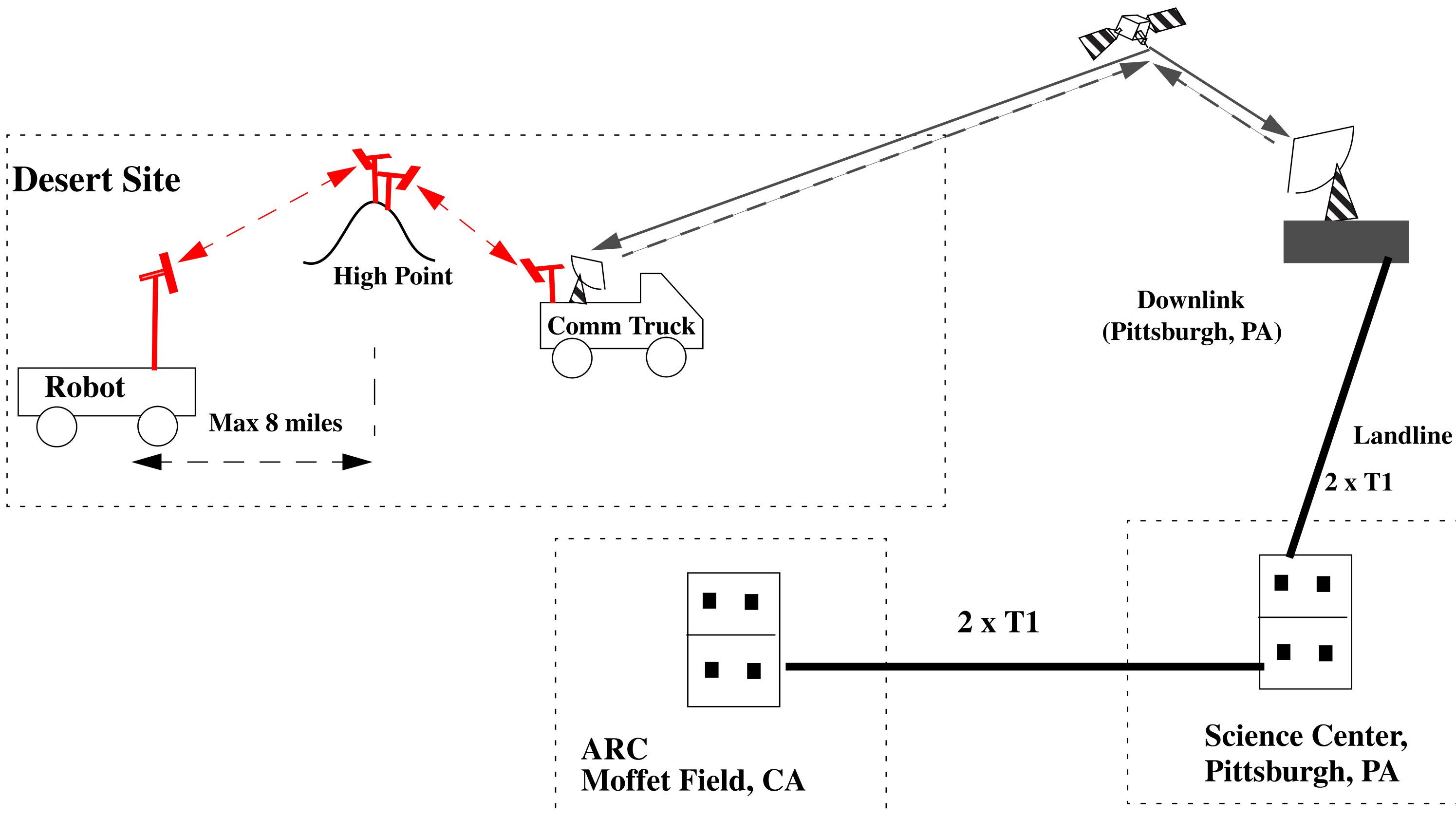
Overview



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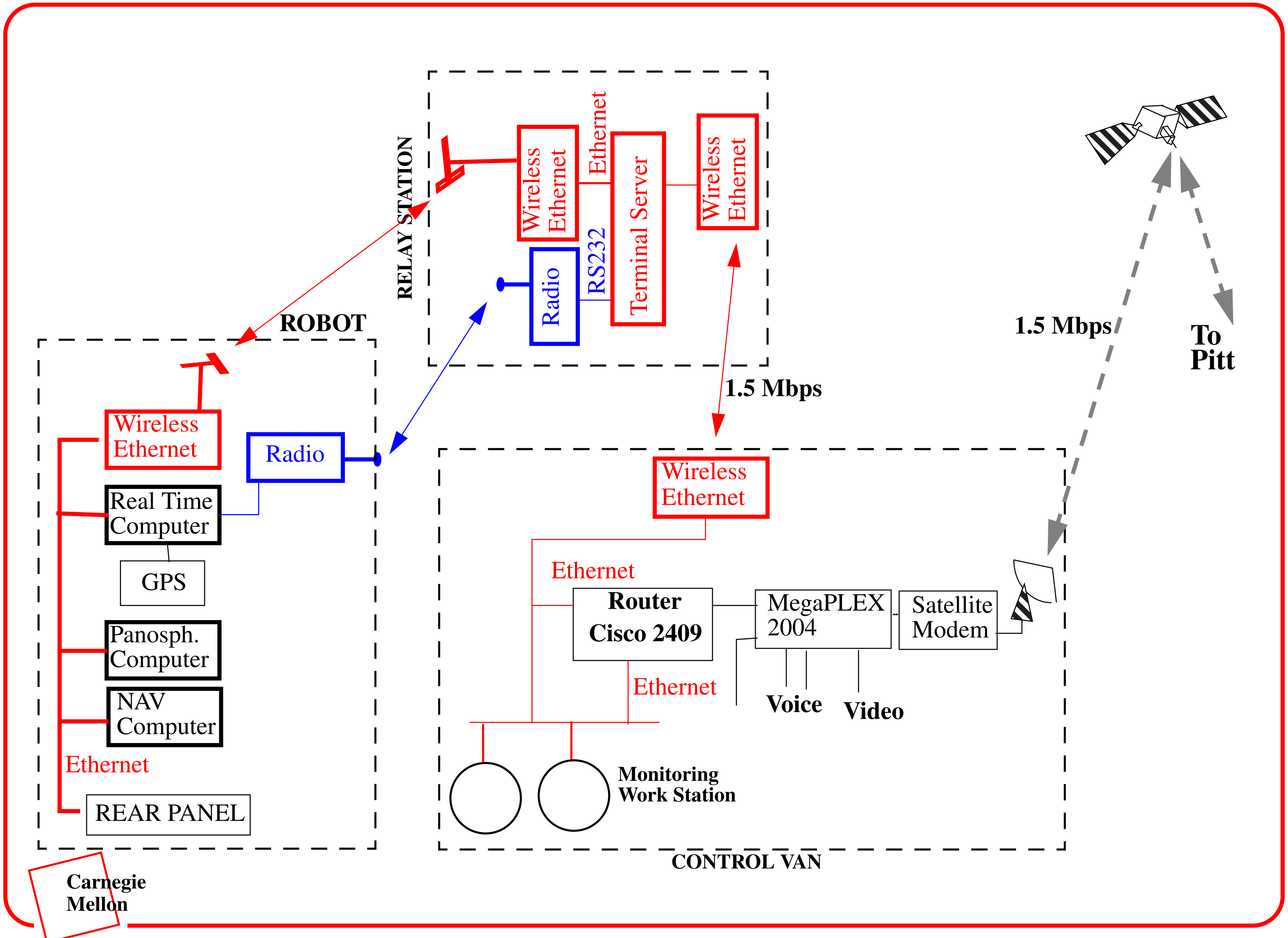
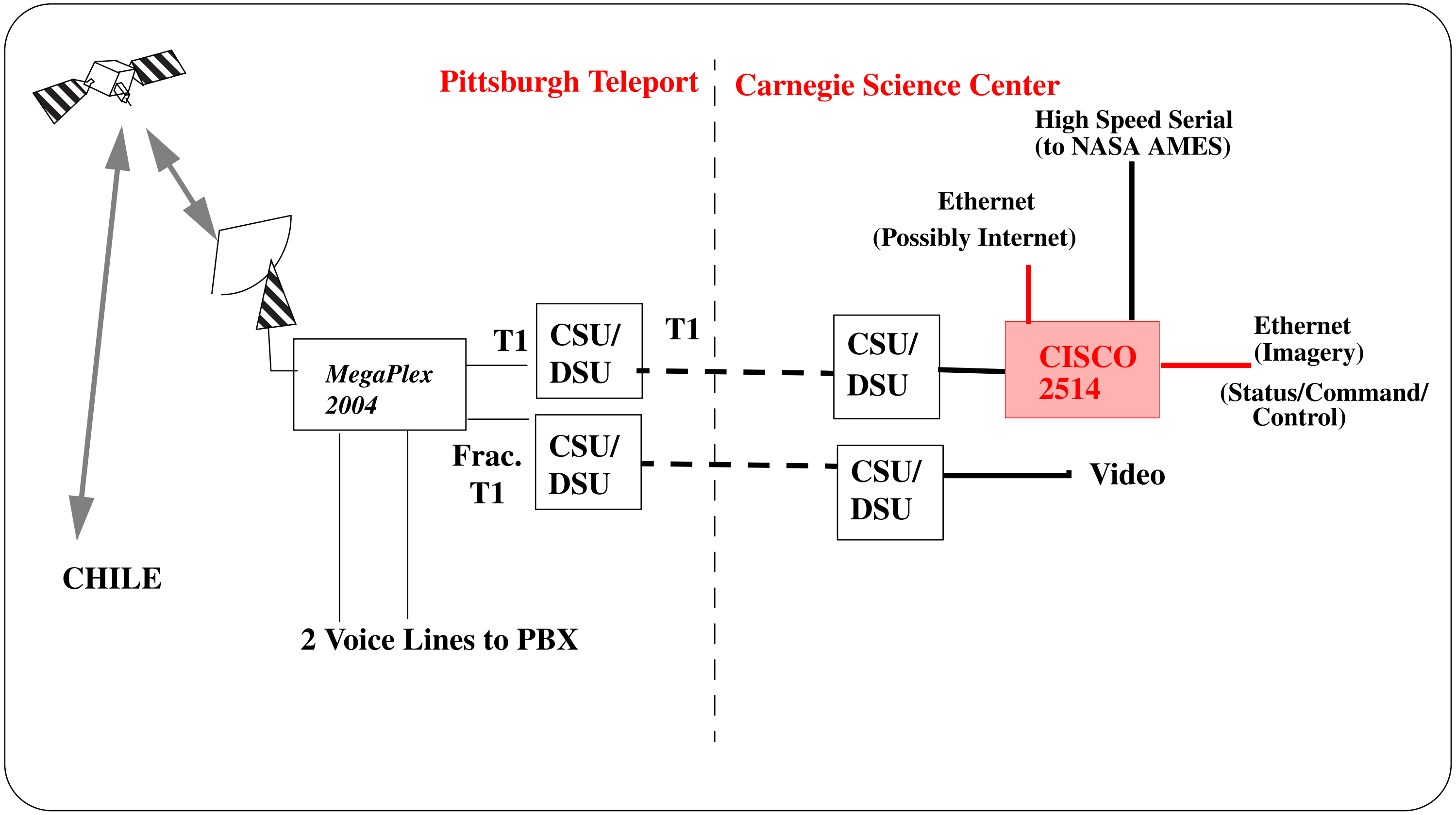
Some Details...(Chile)



More Details... (Pittsburgh)



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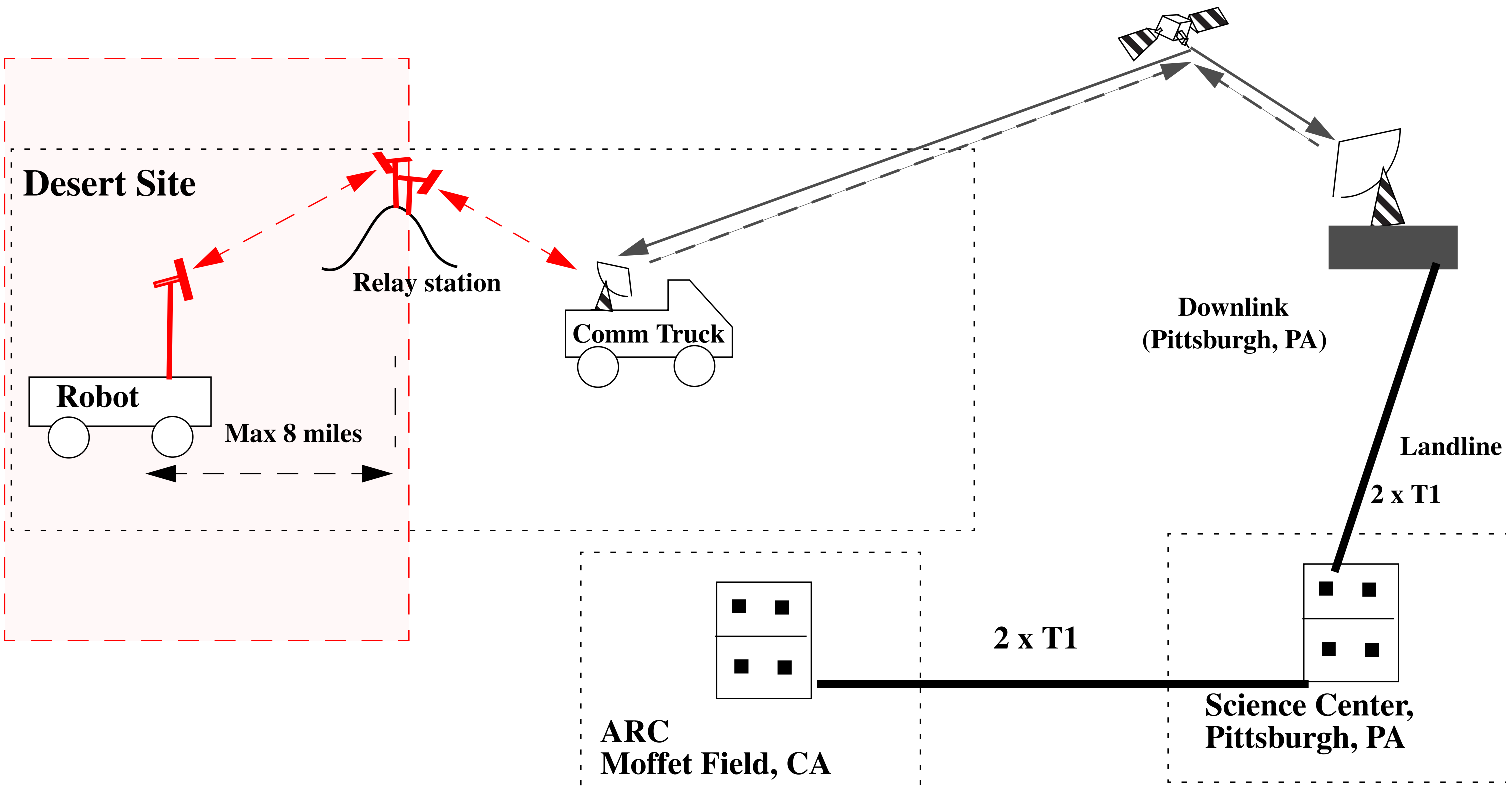
So Whats the Big Deal...

Well, nothing really,

except that...

Rover to Relay station communication is a bottleneck.



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Why is it difficult?

High datarate communication from a moving robot to a distant receiver (> 3 miles) is bottleneck

- Cannot be achieved using omnidirectional antennas, high gain directional antennas are required.
- Directional antenna (on the rover) must be actively pointed while the robot is moving.
- Off-the-shelf pointing devices couldn't meet the specifications (RF losses, pointing slew rates, mass, power)

High gain antenna, actively pointed using a CMU developed mechanism is being used to achieve high bandwidth communication between the Nomad and a relay station.

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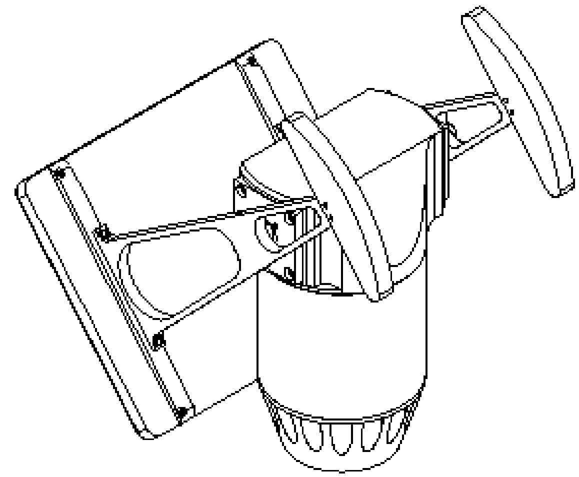
Antenna Pointing Mechanism- Features



- Azimuth/Elevation configuration

- less coupling

- Slip ring for elevation actuator

- continuous rotation unlike cable-wrap.
- reduces complexity (management of cables is easier)

- RF rotary joint

- to send RF signal from the transmitter to the antenna
- located co-axial with the slip ring
- RF characteristics remains constant unlike that for flexible RF cable
- Less losses (0.5 dB) compared to flexible RF cable (1.2 dB)

- *Harmonic drive and brushed motor*

- minimize backlash

- *Balanced system*

- minimizes disturbance torques

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APM- Specifications

Item	*Value*
RF Losses	~ 1.5 dB
Elevation range	$-40°$ to $+60°$
Azimuth range	$360°$
Elevation Rate	$60°$/s
Azimuth Rate	$30°$/s
Elevation Acceleration	$190° / s^2$
Azimuth Acceleration	$190° / s^2$
Pointing Accuracy	$2.5°$ openloop
Pay Load Capability	4 kg
Payload Size	27.3 x 34 x 2 cm
Mass	~ 12 kg
Peak Power	< 25 W

APM- State Estimation

Differential GPS

- position of the robot and the relay station in the inertial frame.

Digital Gyro Compass

- magnetic azimuth of the vehicle.

Inclinometers

- roll and pitch of the vehicle.

Encoders

- positions of azimuth and elevation motors.
- optical switches to generate absolute pulse.

IMU

- rotational rates
- fused with compass data to get better bandwidth on azimuth.

APM- Future Work

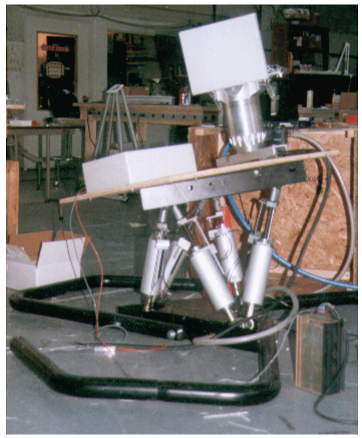
- Develop metric(s) to
  - evaluate pointing performance.

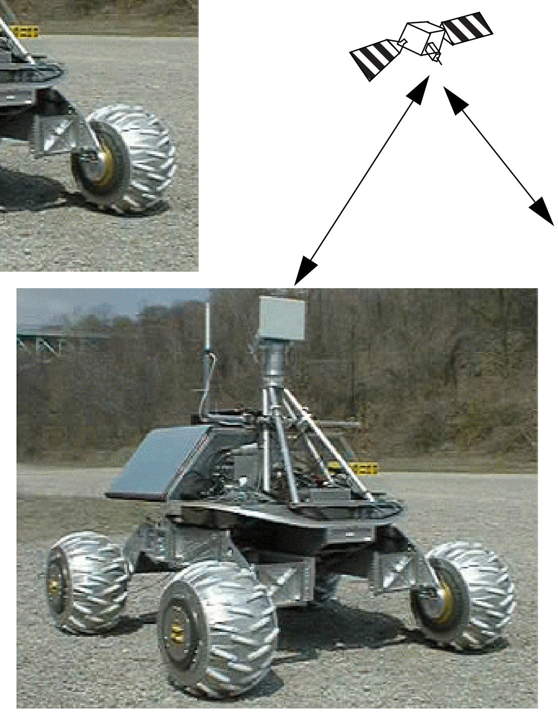
- Perform experiments to
  - characterize the mechanism
  - test and compare different control strategies
  - verify the effects of various parameters (like locomotion configuration, sensing, planning, and velocity) on the pointing performance.

- Validate/Tune the APM model and simulations using the experimental data.

- Validate the approach (integrated control/design).

Dream...





Direct high bandwidth communication between a robot and a satellite.

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Features

- The high gain planar antennas are light weight and have wide beamwidth suitable for the application.
- Antenna pointing is required, but the accuracy needed is not low due to wide beamwidth.
- 1.5 Mbps continuously between the Nomad and a relay station using an Antenna Pointing Mechanism.
- Low loss APM (< 1.5 dB).
- Range of 6-8 miles can be achieved.
- Command and control is communicated via a lower bandwidth, higher reliability (non-LOS problems to a lesser extent) serial modem.
- Private subnet keeps the internet traffic away.
- Monitoring from CMU and Ames possible.