Communication System

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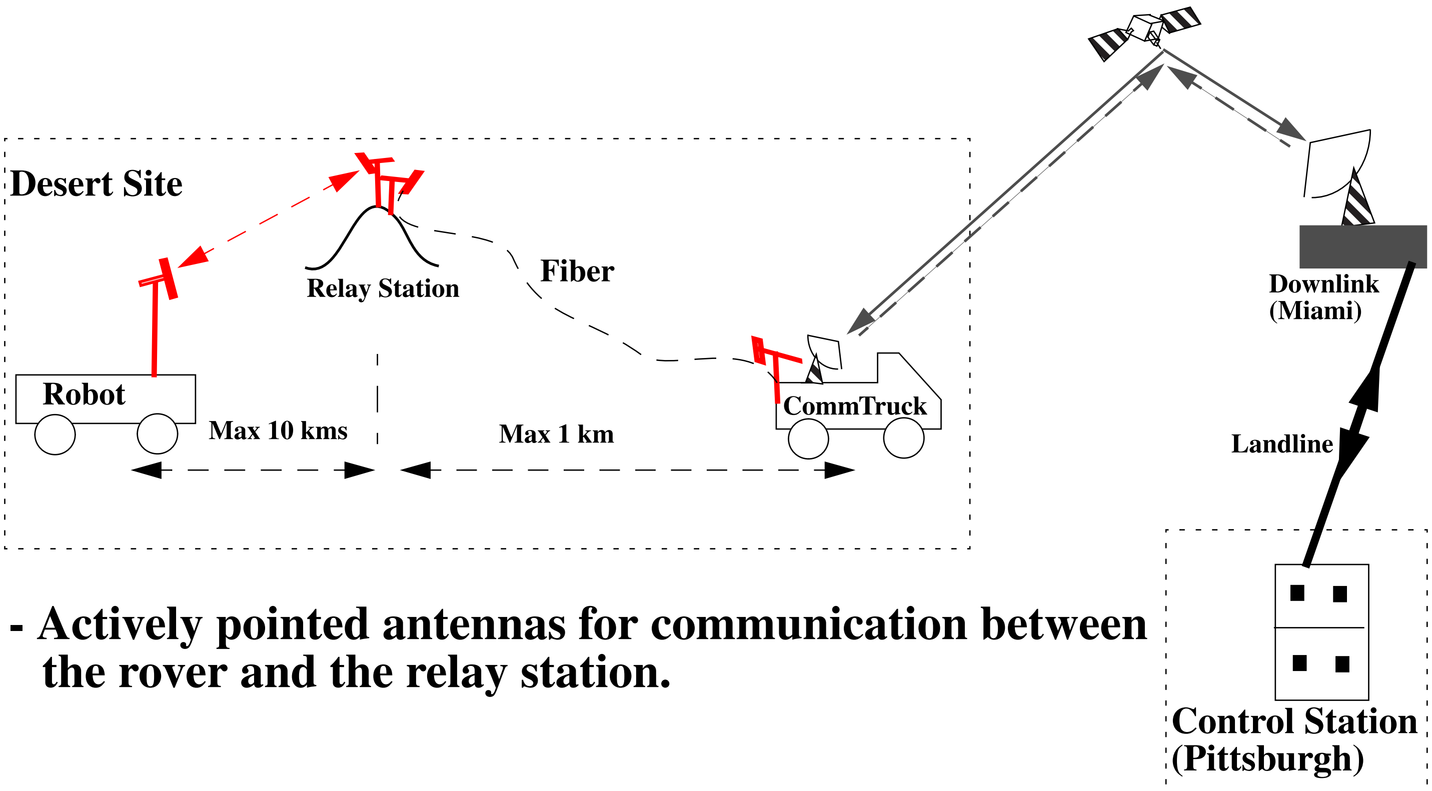
Requirements

- Control from remote site (non line-of-sight).
- Uninterrupted command and control.
- 2.5 Mbps from the rover to the control station during times the rover is operational.
- 500 Kbps from control station(s) to the rover during times the rover is operational.
- Communication range up to 10 Kms between the rover and the relay station.

Data Rate Requirements

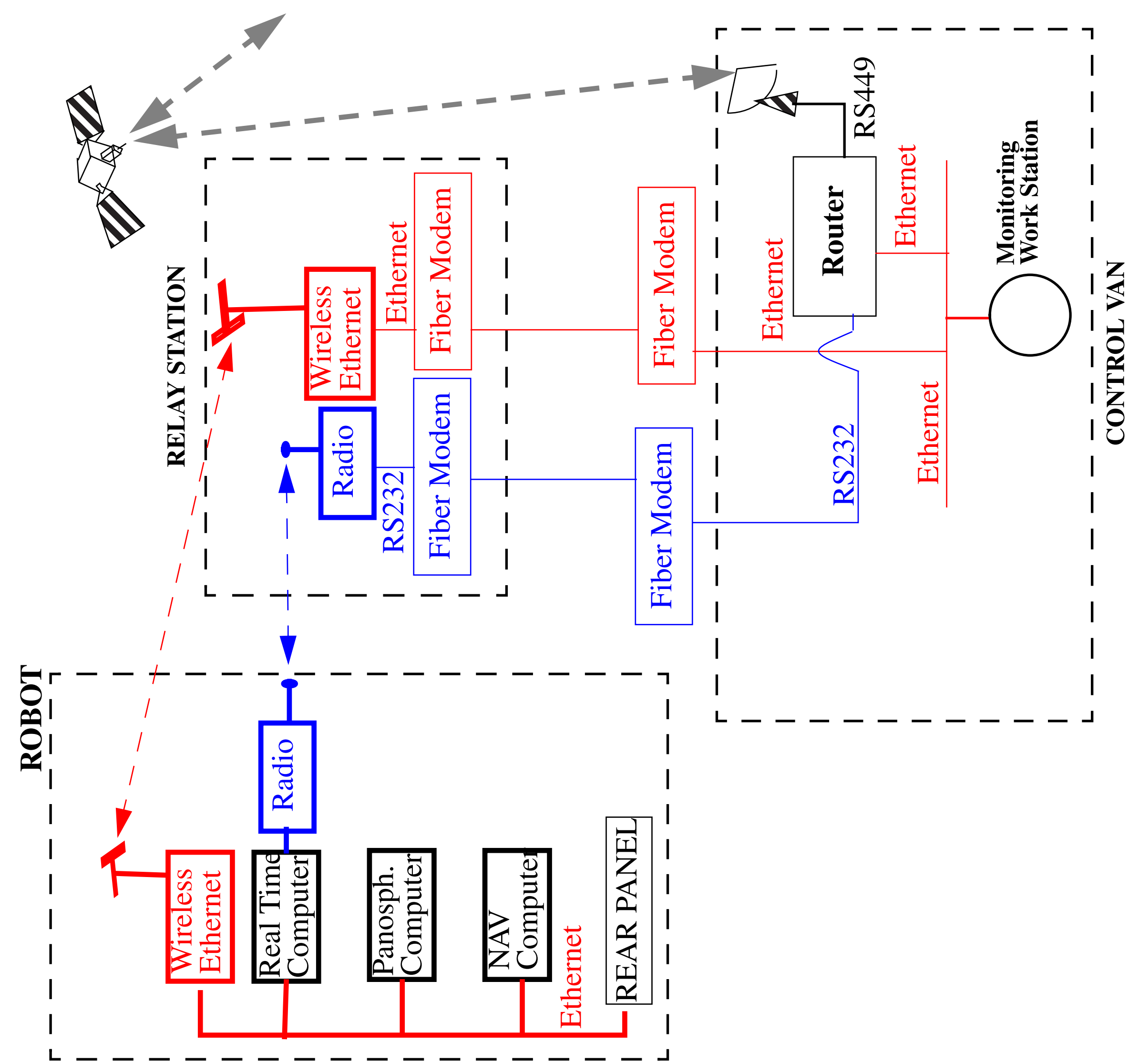
Item	Data rate	Data rate with Compression	Comments	Total
Uplink				
Rover Status	20 int at 4 Hz	1280 bps	Continuous	2.5 Mbps (with protocol overheads)
Panospheric Camera	2k x 2k @10 bit, 6-8 Hz = 32 Mbps	1.88 Mbps (170:1 compression)	Continuous	
Front Camera	1k X 1k @ 8 bit		Occasionally	
Back Camera	1k X 1k @ 8 bit		Occasionally	
Stereo Cameras			For Debugging only	
Downlink				
Command & Control	20 int + 20 floats at 4 Hz.	3840 bps	Continuous	500 Kbps available
Camera Control			Which camera, Compression Ratio, FOV	
Downloading code	-	-	Occasional	

Current Configuration



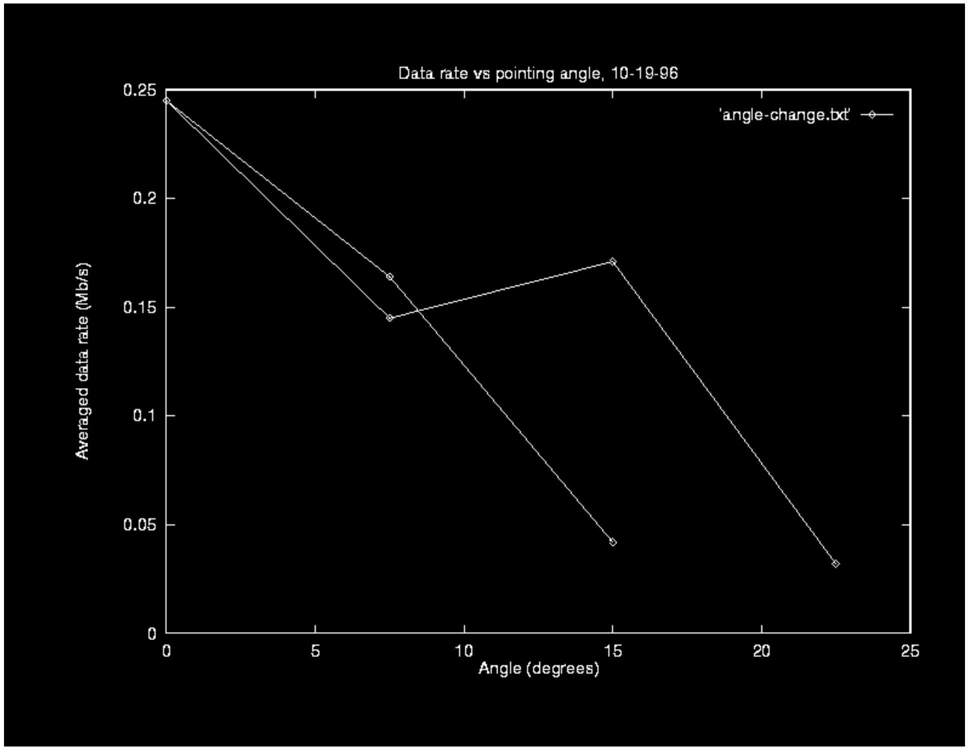
- Actively pointed antennas for communication between the rover and the relay station.

Block Diagram



Antenna Pointing- Why?

- 8-10 Kms range at high data rate cannot be achieved with omnidirectional antennas.



- The data rate drops rapidly with the pointing offset.

Antenna Pointing- Requirements

Item	*Value*	*Comments*
Elevation range	-60 to + 60 deg	
Azimuth range	360 deg	Continuous
Elevation Rate	60 deg/sec	
Azimuth Rate	30 deg/sec	
Elevation Acceleration	190 deg/sec^2	
Azimuth Acceleration	190 deg/sec^2	
Pointing Accuracy	2.5 deg	Aggregate
Pay Load Mass	2 kg	
Payload Size	27.3 x 34.0 x 2 cm	
Target Mass	Approx. 6 kg	Flexible
Target Power	Approx. 25 W	Flexible
Environmental		

Antenna Pointing- Configuration

Configuration:

- Azimuth/Elevation Configuration
- Slip ring for elevation actuator
- RF rotary joint to send RF signal from the transmitter to the antenna.

Sensing:

- Differential GPS
- Incremental Encoders
- Gyro Compass
- Inclinometer
- Inertial Measurement Unit

Satellite Link

- 2.5 Mbps to Pittsburgh/ 0.5 Mbps to the Rover
- 3.4 m C-band dish mounted on a truck
- Duplicate for each component (except the dish)
- Modem capacity- 8 Mbps
- Flexibility in link time/duration
- Downlink in Miami
- Landline to Pittsburgh (satellite vendor responsible for the landline)

Status

- Tested high gain planar antenna (8dB gain) for long range. We were able to achieve 3.5 miles LOS communication with these antennas.
- Higher gain planar antennas and New bridge arrived yesterday.
- Satellite vendor have been identified and the formal contract would be signed soon.
- The design of the pointing mechanism is being finalized.
- The sensors needed for pointing are identified and some of the sensors (gyrostabilized compass, IMU) are acquired and being tested.
- The simulation of the pointing system are in progress and would be completed in next 2 weeks.

Features

- Expected Data rate 2 Mbps continuous.
- Range of 8-10 kms between the rover and the relay station is expected to be achieved.
- Command and control is communicated via a lower bandwidth, higher reliability (non-LOS problems to a lesser extent) serial modem.
- Same configuration as Ratler.
- The high gain planar antennas are light weight and have wide beamwidth suitable for the application.
- Antenna pointing is required, but the accuracy requirements are generous.

Issues

- Non-LOS is a big issue
  - Couldn't identify a radio which would give non-LOS transmission over 8-10 miles range.
  - "Freewave radio" needs to be tested for longer range and non-LOS.
  - Worst case- use repeaters and/or choose the terrain accordingly.
- Antenna Pointing Mechanism development needs to speed up.
- Closing the feedback loop for antenna pointing is important, but we don't have a proven/tested solution.

Future Work

- Test “freewave radio” for 8-10 miles LOS and non-LOS. If freewave doesn’t work, “Pacific Crest” which is a lower frequency radio might be better. What are the other options?
- Test the “BR2040-EE” wireless ethernet bridge over longer range and various pointing offsets with the new antennas.
- Speed up the development on the Antenna Pointing Mechanism.

Communication- Block Diagram