Lunar Micro-Rover Group Update

Communications Subsystems

LMR Mission

To develop and deploy a Lunar Microrover to the moon by 2012 assembled from modular commercial off the shelf technology capable of supporting NASA scientific and technical objectives.*

**Note: JPL defines Microrover as a small rover weighing less than 10Kg.*

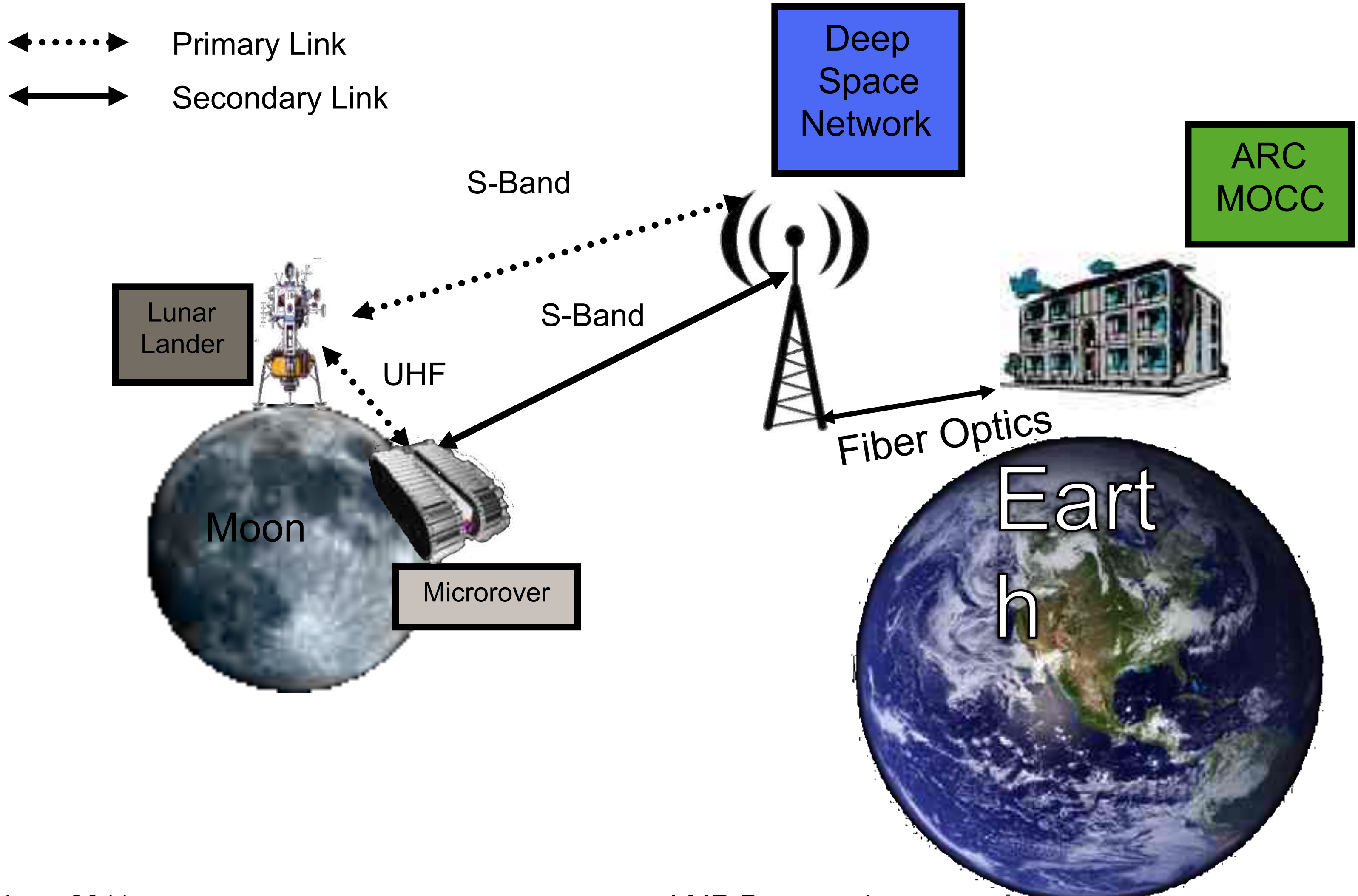
1.0 Requirements Analysis

This consists of the components of the communication process such as the antenna, radio hardware, the receiving ground station, analysis, and testing. From the analysis and testing processes, the communication systems must be able to overcome atmospheric interference, doppler effect, power constraints, orbital limitations, frequency limitations, pass spectrum analysis, and meet desired wave propagation times.

2.0 Design Options Considered

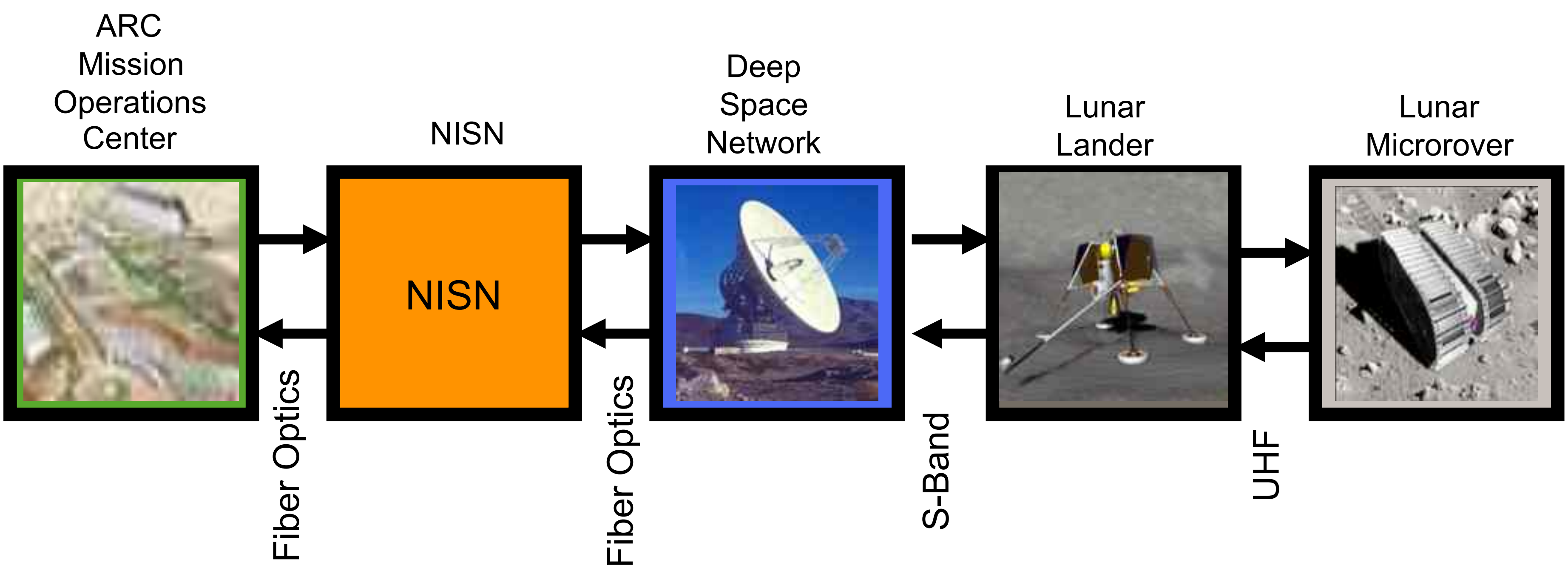
Redundant communication capability was designed placing an additional S-Band antennae on the LMR. This option would increase cost by $200K, increase weight by .5 Kgm and increase power consumption by 30 Watts. For these reasons it was removed from the design in 2007.

LMR Communications System: General Concept

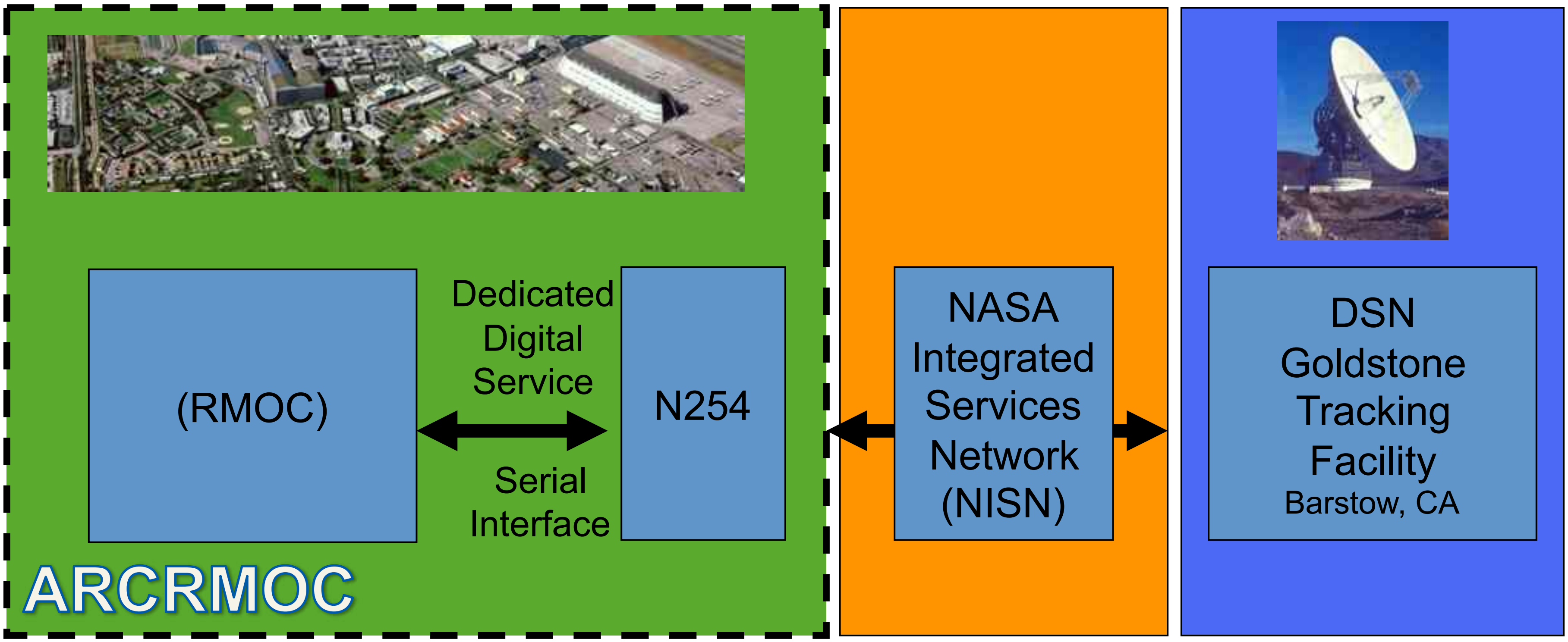


LMR Communications System: General Concept

Primary Communication Configuration utilizes the landers S-Band Radio to communicate with Earth

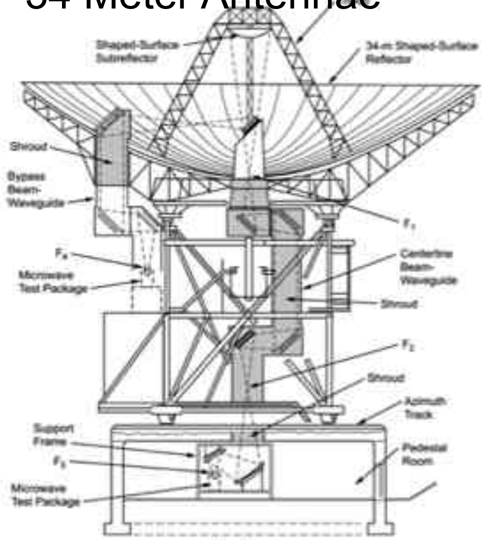


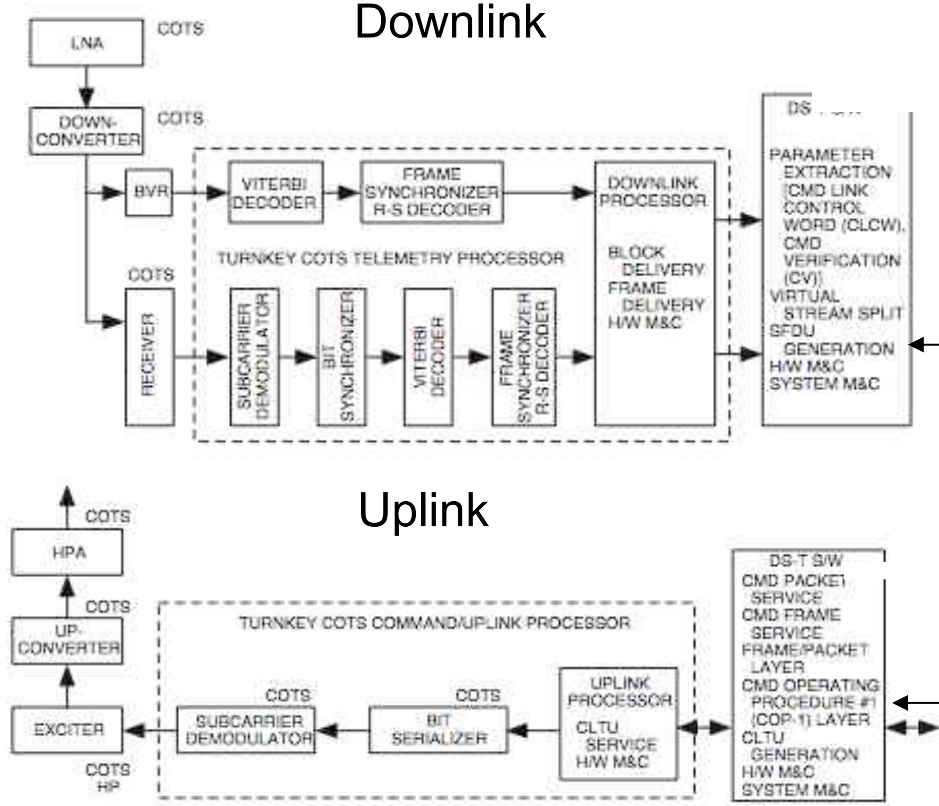
LMR Communication System: RMOC/NISN/DSN



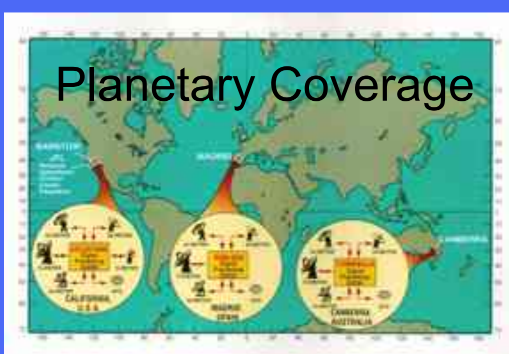
LMR Communication System: Deep Space Network (DSN) 34M

34 Meter Antennae



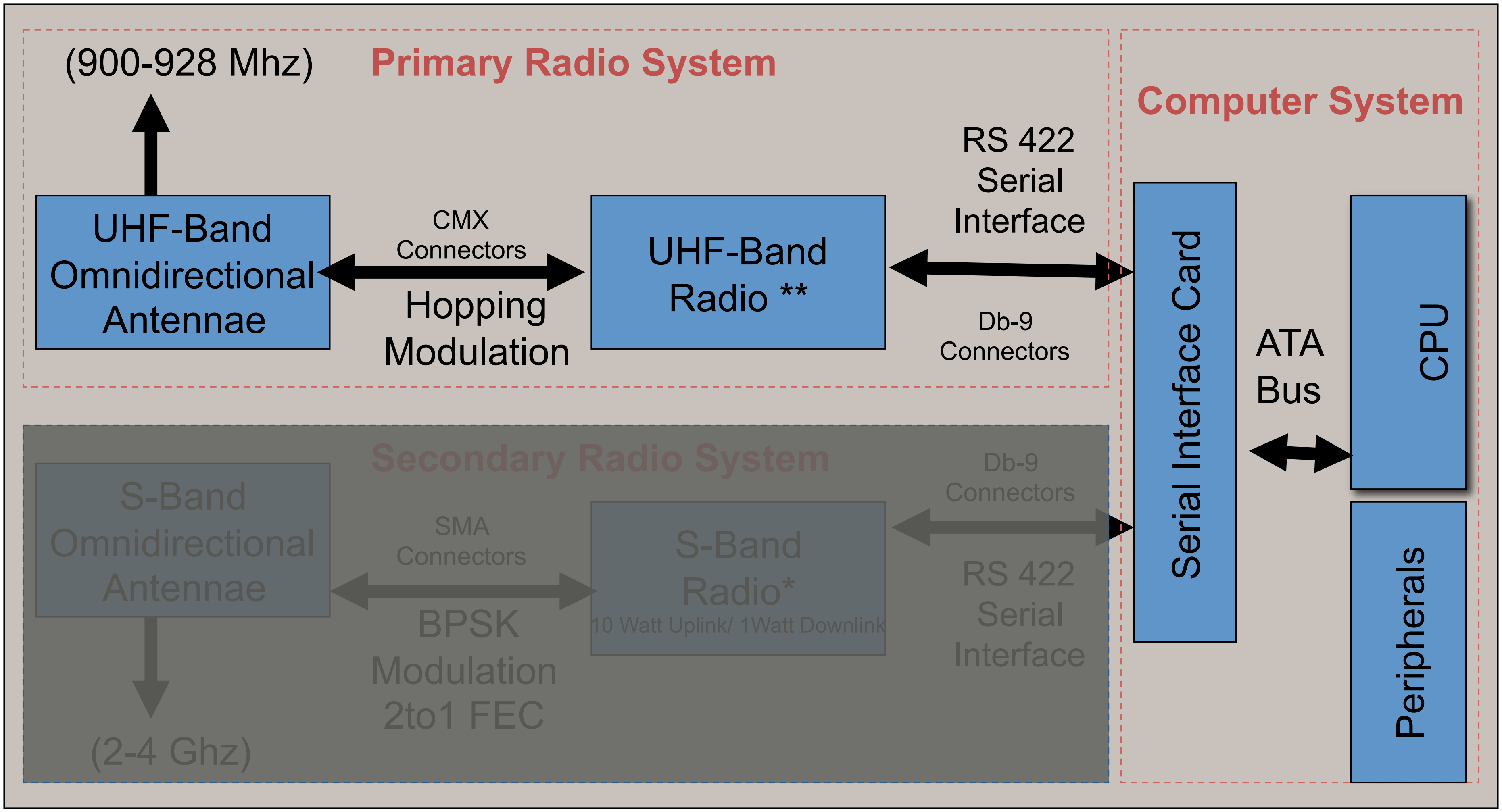


Planetary Coverage

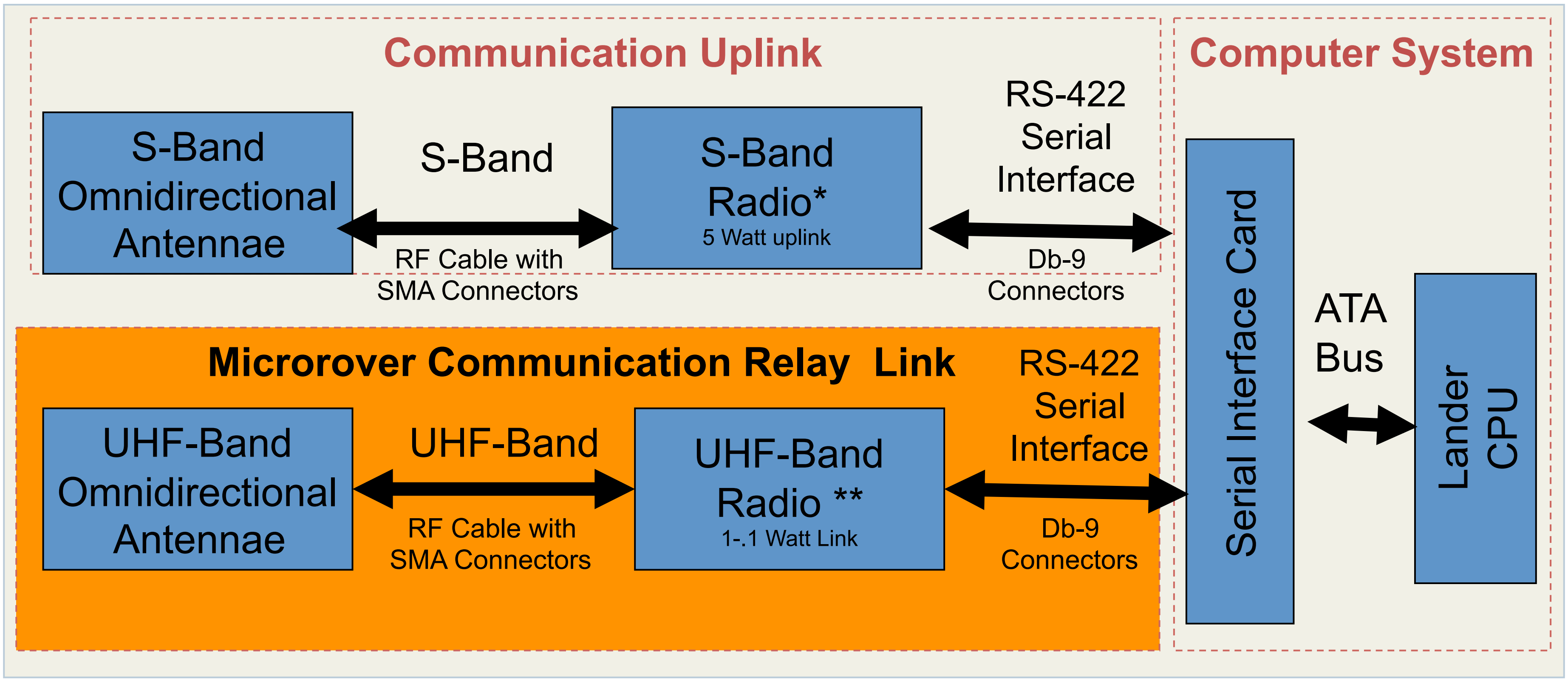


Fiber Optics to ARC MOCC

LMR Communication System: Primary Communication Configuration



LMR Communication System: Primary Communication Configuration



Required Modification to Lander to support MicroRover Communication Relay

* Specifications currently met by Aeroastro product

** Specifications currently met by Microhard product

LMR Communication System: Primary Communication Configuration

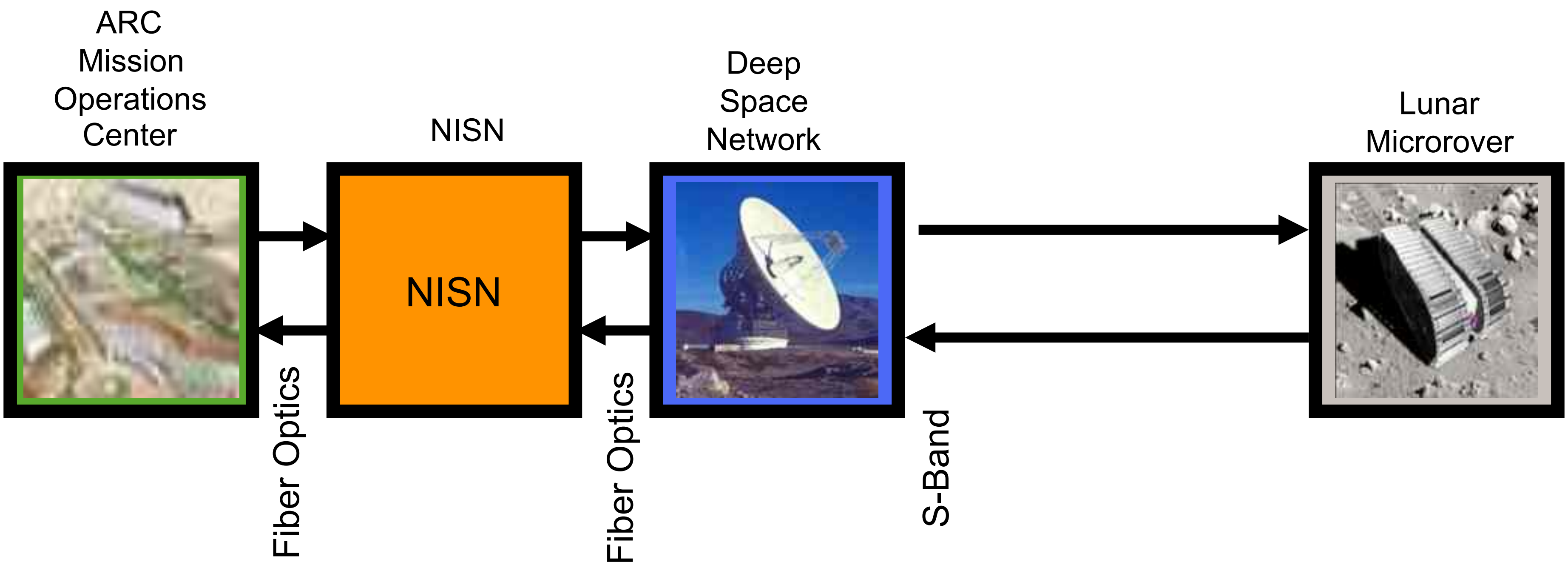
Power & mass required to Implement Primary Config.

Description Required	Weight		Power	
•Utilization of existing S-Band Radio	0	grams	32	Watts
•Microhard UHF Modem	420	grams	2.0	Watts
•Additional Wiring Harness	20	grams	0.1	Watt
•Omnidirectional UHF Antennae	50	grams	0.0	Watt
•Evolved S-band Antennae*	5	grams	0.0	Watt
•Modem Mounting	10	grams	0.1	Watt
•RS-422 Com port to CPU	5	grams	0.1	Watt
TOTAL	510	grams	34.3	Watts

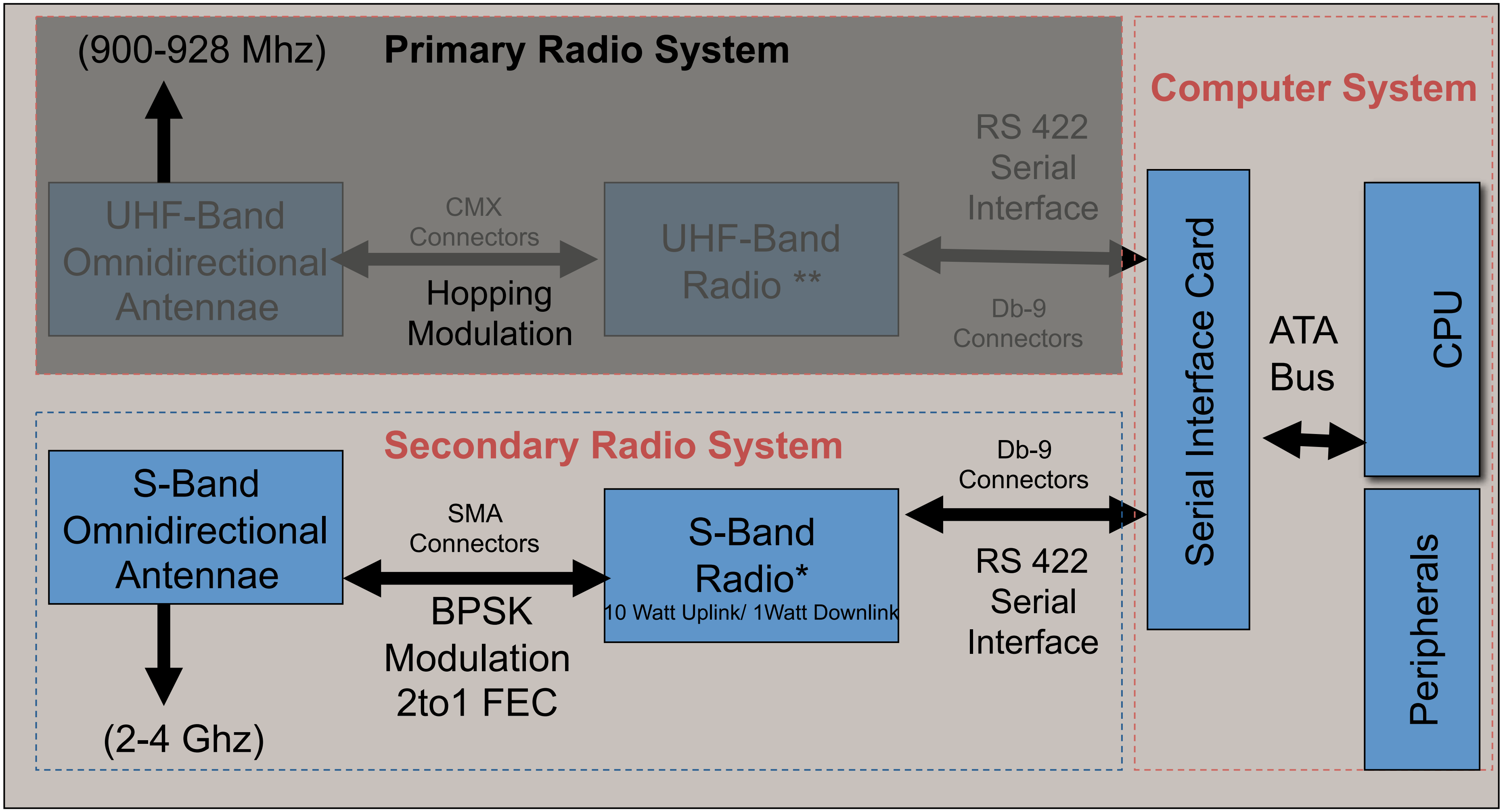
•Replaces omnidirectional Antennae

** Burden Presumes and existing 5 Watt radio on board Lander

LMR Communication System: Secondary Communication Configuration



LMR Communication System: Secondary Communication Configuration

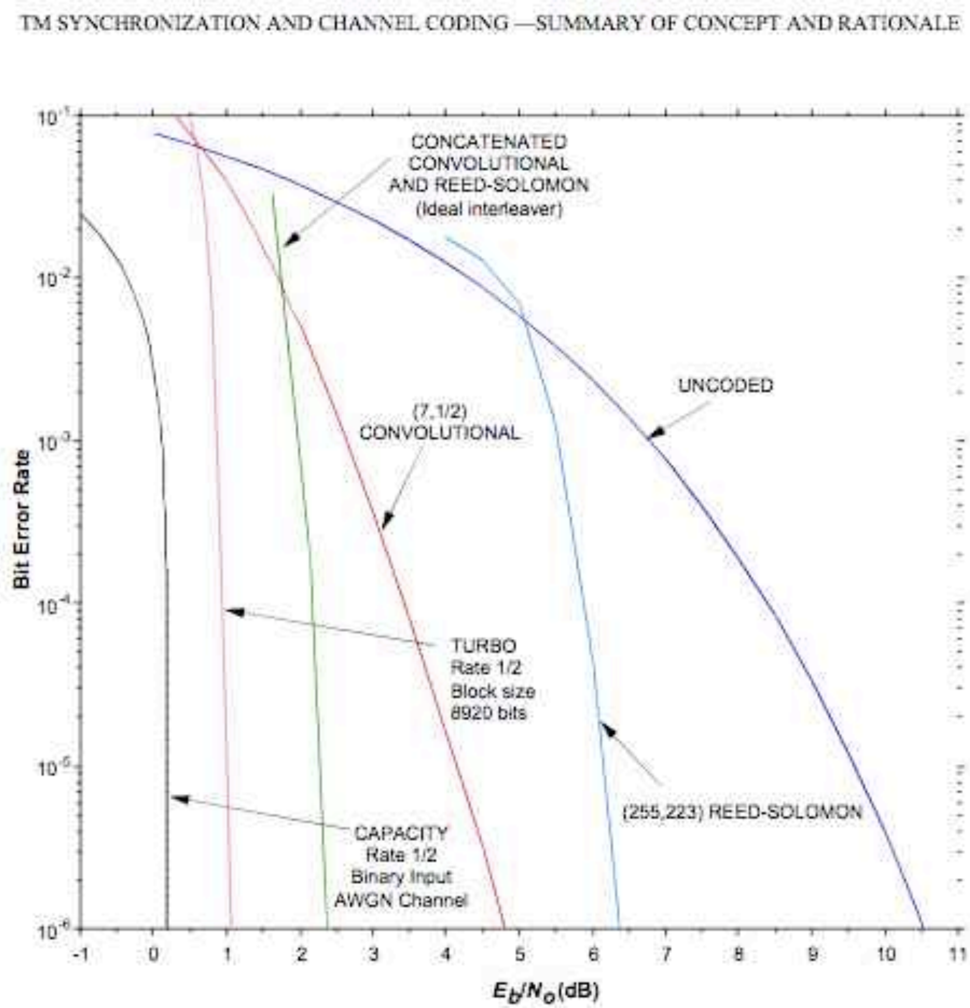


LMR Communication System: S-Band DownLink Calculations

LMR S-BandDownLink Calculations	
Link Segment Description	#
Transmitter Power (w)	5
Transmitter Power (dBw)	6.99
Passive Loss (dB)	1.7
Freq. (MHz) [FMHZ]	2300
Antenna gain (dB)	0.00
Pointing loss (dB)	0
EIRP (dBW)	5.29
Coding para., Convo rate	0.500
Range (km)	384000
Space loss (dB)	211.02
Atmospheric Att (dB)	0.50
Scintillation Loss (dB)	0.20
Rain atten (dB) [Lrain]	0.00
Polarization loss (dB)	0.10
Pointing loss (dB)	0.10
Multipath loss (dB)	0.00
Intermediate sum	-206.64
Rcvd power den (dBW/m2)	-178.29
Rcvd PFD over 4 KHz, peak	-196.08
DSN antenna size (m)	34

Antenna efficiency (%)	55
Antenna surf. tol. loss (dB)	0.28
Antenna gain (dB)	55.05
Power Received (dBw)	-151.59
Power Received (dBm)	-121.59
Ant to LNA Passive Loss (dB)	0.30
LNA gain (dB)	55
Power into Dn Conv (dBm)	-66.89
System temp (deg K)	71.10
System temp (dB-K)	18.52
System G/T (dB/K)	36.23
C/No (dB Hz)	58.19
Data rate (bps)	107422
Physical Link data rate (bps)	125000
Coded Bandwidth (dB Hz)	53.91
Noise Power in data BW(dBw)	-159.77
Implementation loss (dB)	0.5
Avail Eb/No (dB)	7.38
Es/No at bit synch (dB)	4.37
Eb/No required (dB)	4.2
Sig/Noise margin (dB)	3.18
Acquisition Margin (dB)	13.41

LMR Communication System: S/N & Data rate Calculations



LMR Communication System: Communications Coding and Modulating

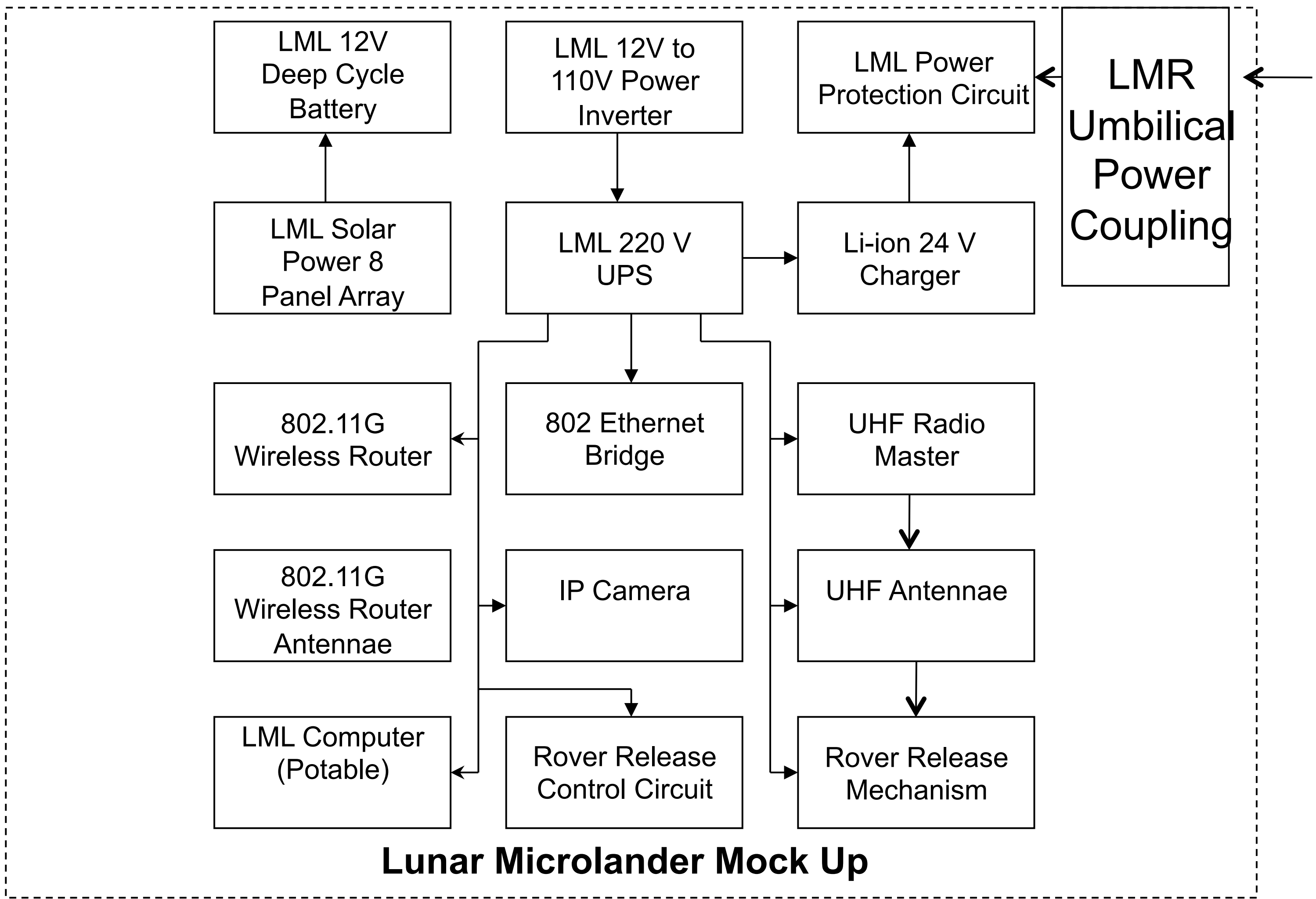
- S-Band radio data framing structure
  - CCSDS AOS at top level
  - 6 byte header
  - packet structure
- Encoding
  - (executed in software)
  - rate ½ convolutional code (CC) with Reed Solomon (RS)
- Decoding
  - (executed at ground station)
  - For rates under 20Mbps it may be possible to use a computer real time
- Modulation
  - BPSK (modulated directly onto the carrier)
  - If necessary QPSK is also possible but is a second choice (See System Testing with TDRSS)

LMR Communication System: S-Band Radio Testing

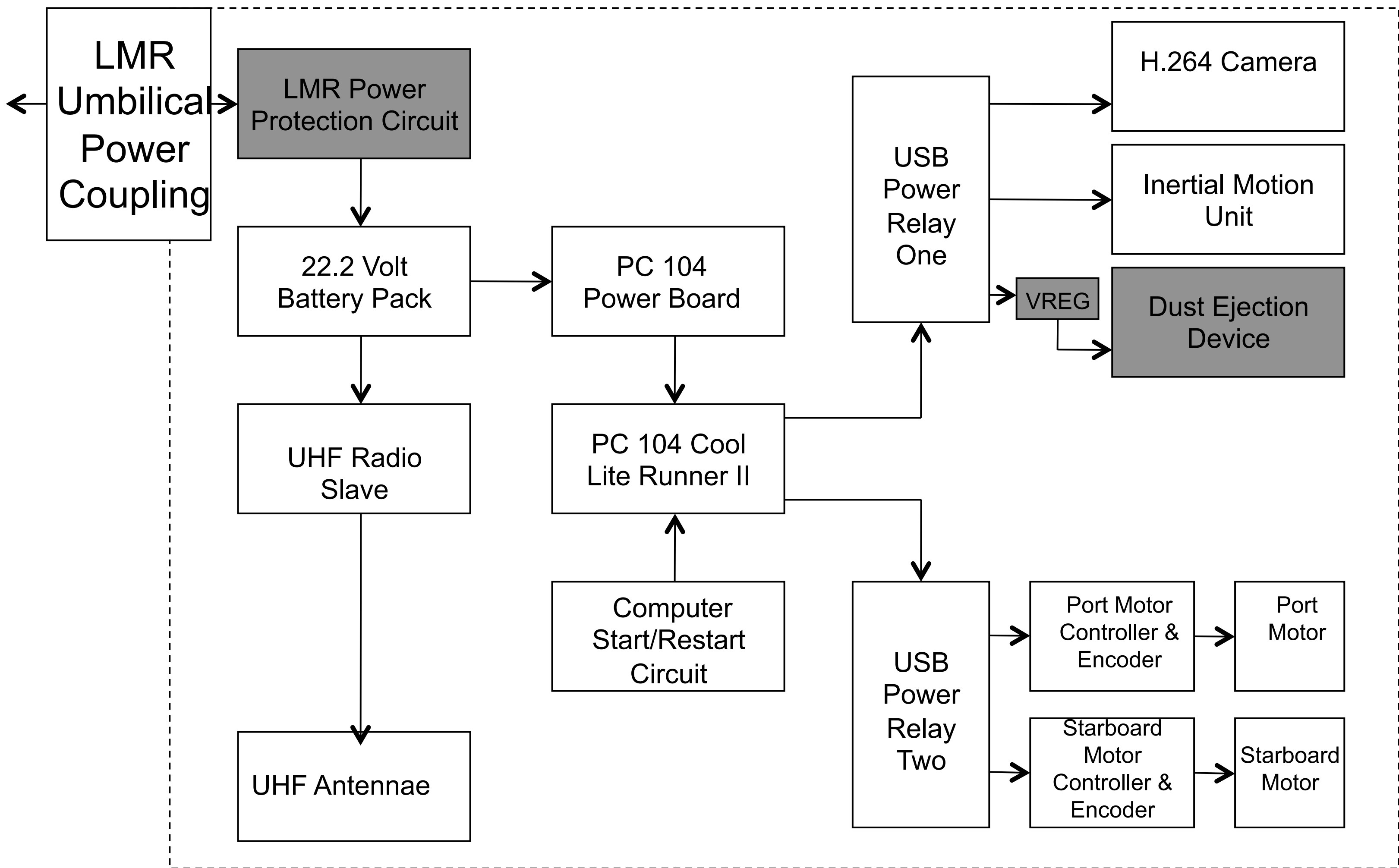
- **Series A Test** (Radio Standalone TDRSS Test)
  - Generate End to End Simulation of Rover loaded on to a PC.
  - Travel to S-Band Manufacturing site and connect to radio over RS-232 to simulation and uplink to TDRSS.
    - Calculate data rates using uplink with a 5-watt radio
    - Test omni directional antennae
    - Test Evolved Antennae

- **Series B Test** (Integrated Rover TDRSS Test)
  - Test radio on low look angle using TDRSS
    1. Obtain location on CONUS which will force us to use TDRSS from a low look angel much like we will from the moon to DSN
    2. Travel to location and test radio by transmitting from a low look angle to TDRSS.(This will produce similar dynamics with the antenna performance)
    3. Compare and contract evolved antennae and Omni-directional antenna

LMR Communication System: Communications Power Relay



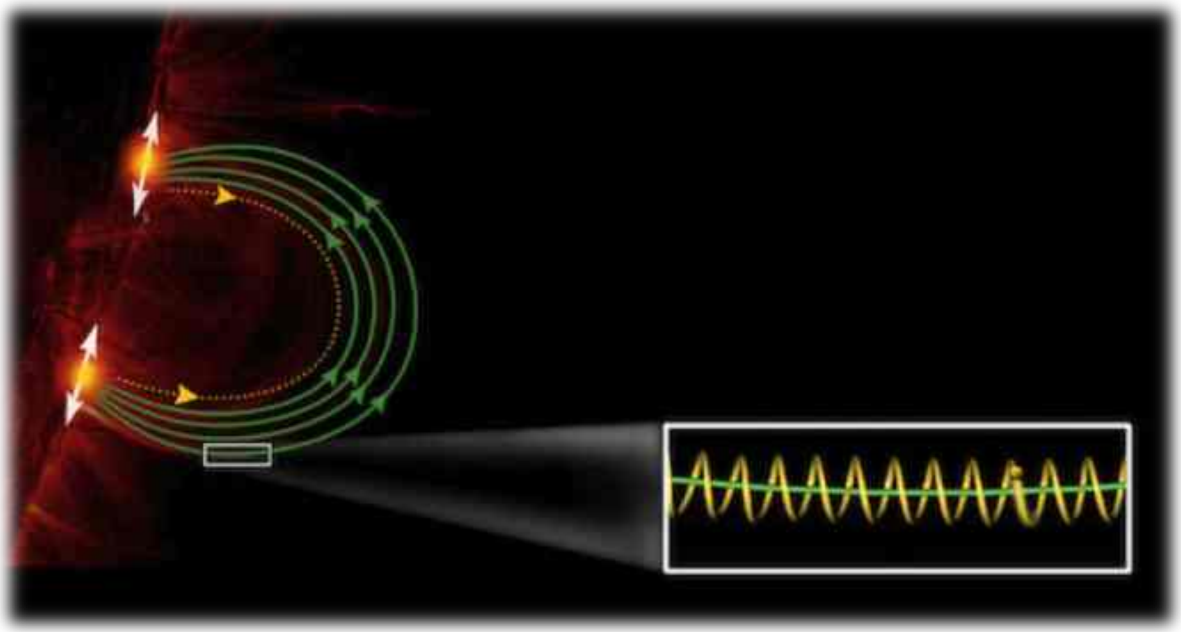
LMR Communication System: 6B Subsystem Block Diagram



LMR Communication System: Failsafe Mechanisms

Multiple times a day, the sun can release mass amounts of energy/charged particles.

- Can easily knock out or wreak havoc with all electrical systems, especially communications
- Our solution is to implement a remote reset system
  so we can easily restart the rover in the event of a system failure



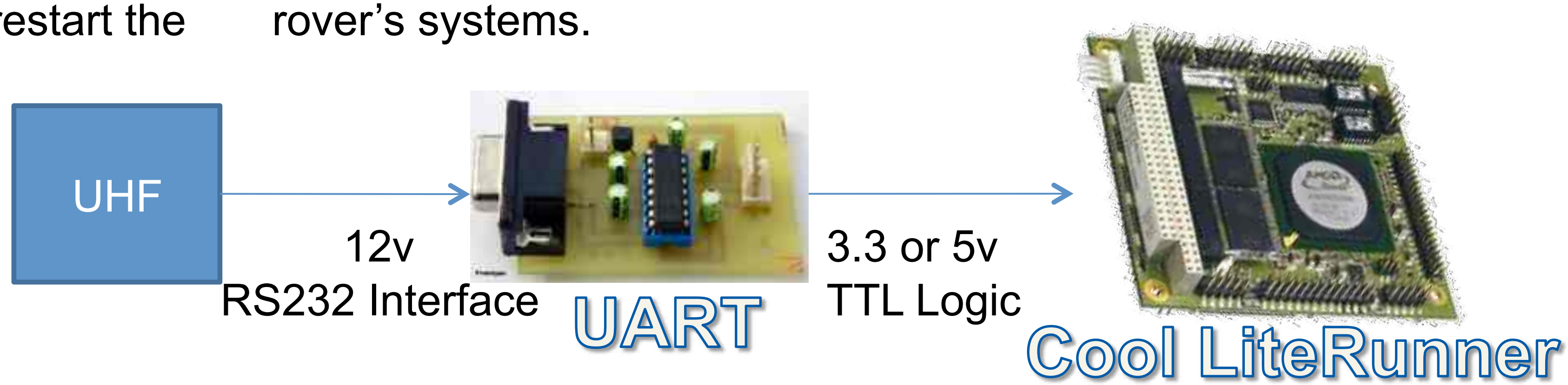
LMR Communication System: Failsafe Mechanisms

This system will be implemented similar to how an actual computer is reset.

- When the reset button is pressed on a computer, it completes a contact closure mechanism which sends a signal of a certain voltage to the motherboard (in this case the Cool LiteRunner) which causes the computer to power cycle.
- However in this case, the signal to restart will need to be sent remotely.

The UHF forwards a serial port to the rover

- Will be able to output signals through that port to a UART system
- Signals turn into TTL logic gates (+/- 3.3 or 5 volts) which will be used to restart the rover's systems.

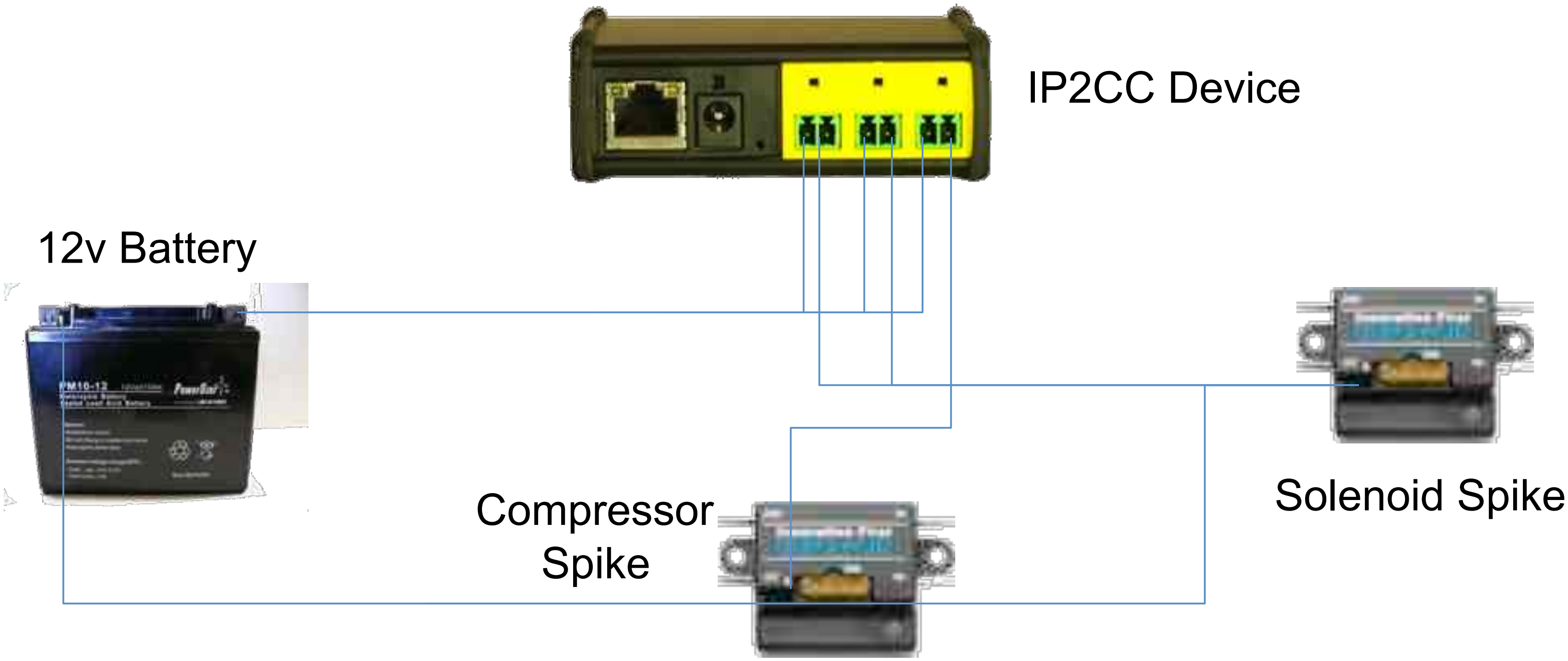


LML Communication System: Remote Release System

A remote release system built onto the lander for deploying the rover has been implemented.

- This replaces the previous method of releasing the rover, which required the user to stand next to the lander to activate the buttons.
- These buttons have been replaced by a wireless router and contact closure modules activated by IP (Internet Protocol) so the lander can be controlled from a computer.
- A signal is sent from the computer through a dedicated comm port on the router to give the IPCC device instructions to complete one of three relay circuits.

LML Communication System: Remote Release System



- These circuits are powered by a 12v line which in turn sends a 12v signal to the spike relay for the compressor or to activate the solenoid.
- The solenoid is connected in a way such that it may be activated in either direction using the same spike relay, therefore reducing the amount of connections needed.
- When the solenoid is activated, it powers actuators using a pneumatics (air powered) system.

LML Communication System: Remote Release System

In space this method of application is not viable, and will soon be replaced with an electrical linear actuator system, which will further simplify the electronics by eliminating the need for the compressor, both spike relays, solenoids, and pneumatics tubing.