

ROBOT COMMUNICATIONS

24) Communications / Tele-Robotic Operations

a) Mining Robot Wireless Systems Requirements

- i. Each team is required to command and monitor their mining robot over the NASA provided network infrastructure shown in Figure 1.
- ii. This configuration must be used for teams to communicate with their robot.
- iii. The "Mars Lander" camera is staged in the Caterpillar Mining Arena, and Mars Lander Control Joystick and camera display will be located with the team in the Mission Control Center (MCC).
- iv. The MCC will have an official timing display, which includes a real-time display of BP-1 collected during the match.
- v. Handheld radios will be provided to each team to link their Mission Control Center team members with their corresponding team members in the Caterpillar Mining Arena during setup.

b) Each team will provide the wireless link (access point, bridge, or wireless device) to their mining robot, which means that each team will bring their own Wi-Fi equipment/router and any required power conversion devices. Teams must set their own network IP addresses to enable communication between their mining robot and their control computers, through their own wireless link hosted in the Caterpillar Mining Arena.

- i. In the Caterpillar Mining Arena, NASA will provide an elevated network drop (male RJ-45 Ethernet plug) that extends to the Mission Control Center, where NASA will provide a network switch for the teams to plug in their laptops.
- ii. The network drop in the Caterpillar Mining Arena will be elevated high enough above the edge of the regolith bed wall to provide adequate radio frequency visibility of the Caterpillar Mining Arena.
- iii. A shelf will be set up next to the network drop at a height 0 to 2 feet above the walls of the Arena, and will be placed in a corner area on the same side as the collection bin. During robot system operations during the competition, there may be some dust accumulation in this area. This shelf is where teams will place their Wireless Access Point (WAP) to communicate with their mining robot.
- iv. Teams are **STRONGLY** encouraged to develop a dust protection cover for their wireless access point (WAP) that does not interfere with the radiofrequency signal performance.
- v. The WAP shelves for side A and side B of the Caterpillar Mining Arena will be at least 25 feet apart to prevent electromagnetic interference (EMI) between the units.

c) Power Interfaces

- i. NASA will provide a standard US National Electrical Manufacturers Association (NEMA) 5-15 type, 110 VAC, 60 Hz electrical jack by the network drop. This will be no more than 5 feet from the shelf.
- ii. NASA will provide standard US NEMA 5-15 type, 110 VAC, 60 Hz electrical connections in the Mission Control Center for each team.
- iii. The team must provide any conversion devices needed to interface team access points or Mission Control Center computers or devices with the provided power sources.

d) During the setup phase, the teams will set up their access point and verify communication with their mining robot from the Mission Control Center.

e) The teams must use the USA IEEE 802.11b, 802.11g, or 802.11n standards for their wireless connection (WAP and rover client).

- i. Teams cannot use multiple channels for data transmission, meeting this rule will require a spectral mask or “maximum spectral bandwidth setting” of 20MHz for all 2.4 GHz transmission equipment.
 - ii. Encryption is not required, but it is highly encouraged to prevent unexpected problems with team links.
 - iii. During a match, one team will operate on channel 1 and the other team will operate on channel 11. See Figure 2. These channels will be monitored during the competition by NASA to assure there are no other teams transmitting on the assigned team frequency.
- f) Teams must be able to use and switch between channel 1 and channel 11 for the competition.
- g) Each team will be assigned an SSID that they must use for the wireless equipment for channel 1 and channel 11.
 - i. SSID will be “Team_##.”
 - ii. Teams are required to broadcast their SSID.
- h) The use of specific low power Bluetooth transmission equipment in the 2.4 GHz range is allowed for sensors and other robot communications. Bluetooth is allowed only at power levels of Classes 2 3, and are limited to a maximum transmit power of 2.5 mW EIRP. Class 1 Bluetooth devices are not allowed.
- i) The use of 2.4 GHz ZigBee technology is prohibited because of the possibility of interference with the competition wireless transmissions.
- j) Technology that uses other ISM non-licensed radio frequencies outside of the 2.4 GHz range, such as 900 MHz and 5 GHz, are ALLOWED to be used for any robot or sensor systems, but these frequencies will NOT be monitored during the competition. Interference avoidance will be the responsibility of the Team and will not be grounds for protest by any team.
- k) Radio Frequency Power:
 - i. All Team provided wireless equipment shall operate legally within the power requirements power levels set by the FCC for Unlicensed Wireless equipment operating in the ISM radio band. The FCC Federal Regulations are specified in the Electronic Code of Federal Regulations, Title 47, Telecommunication, Part 15, and must be followed if any commercial equipment is modified. All unmodified commercial off the shelf access point equipment and computers already meet this requirement.
 - ii. If a team inserts any type of power amplification device into the wireless transmission system, this will likely create a violation of FCC rules and is NOT allowed in the competition.
 - iii. This radio frequency power requirement applies to all wireless transmission devices at any ISM frequency.
- l) Data Utilization Bandwidth Constraints
 - i. Use of the NASA provided situational awareness camera in the control room will add 200 kb/s of data use for each camera. If the team elects to turn on the camera during the match, they will be charged for the full 200 kb/s of data use.
 - ii. The communications link is required to have an average data utilization bandwidth of no more than 5,000 kb/s. There will not be a peak data utilization bandwidth limit.

m) Radio Frequencies and Communications Approval

- i. Each team must demonstrate to the communication judges that their mining robot and access point are operating only on their assigned channel. Each team will have approximately 15 minutes at the communication judges' station.
- ii. To successfully pass the communication judges' station, a team must drive their mining robot by commanding it from their mining robot driving/control laptop through their wireless access point. The judges will verify the course of travel and verify that the team is operating only on their assigned channel.
- iii. The teams must identify and show to the judges all the wireless emission equipment on the robot, including amplifiers and antennas. If the team has added an amplifier, written documentation shall be submitted to the judges demonstrating that the limits as designated in these rules for power transmission levels are not being exceeded.
- iv. If the team robot is transmitting low power Bluetooth, or is using any non-2.4 GHz frequency equipment, the following information must be provided to the judges during the communications checkout. Printed documentation from the manufacture with part numbers of all wireless transmission equipment. This printout must be from the manufacturer's data sheet or manual, and will designate the technology, frequency, and power levels in use by this type of equipment.
- v. If a team cannot demonstrate the above tasks in the allotted time, the team will be disqualified from the competition.
- vi. On Monday of the competition week, on a first-come, first-serve basis, the teams will be able to show the communication judges their compliance with the rules.
- vii. The NASA communications technical experts will be available to help teams make sure that they are ready for the communication judges' station on Monday and Tuesday of the competition week.
- viii. Once the team arrives at the communication judges' station, the team can no longer receive assistance from the NASA communications technical experts.
- ix. If a team is on the wrong channel during their competition attempts, the team will be disqualified and required to power down.

n) Wireless Device Operation in the RoboPits

- i. Teams will not be allowed to power up their transmitters on any frequency in the Pits during the practice matches or competition attempts. All teams must have a hardwired connection for testing in the RoboPits.
- ii. Teams will have designated times to power up their transmitters when no matches are underway.