PAN-1 EMC Analysis

Introduction:
This exhibit provides an assessment of potential for interference from the PAN-1 mission mRobotics SiK radios. The mission comprises two spacecraft, PAN-1A and PAN-1B, launched together. The maximum separation distance they are expected to operate is 1 km. The two spacecraft communicate with one another via the SiK radios, a low power, low gain link, with the following characteristics:

Center Frequency: 50 channels, from 915 MHz to 928 MHz.
Bandwidth: 250 kHz per Channel
Radio Power: 0.025 W, equal to -16.02 dBW
Antenna Maximum Net Gain: -4 dBi
Modulation: GFSK
Altitude: 500 km

Summary of Findings:
This study calculates the power spectral density at Earth surface, at the nadir point directly under the spacecraft as it orbits. This value, 1.27e-19 W/m^2-Hz or -189 dBW/m^2-Hz, appears to be below the threshold of concern for interference, and to be below the noise floor for receivers in this frequency range. It is expected that no Earth based receiver will be configured to receive a signal of this weak power. Therefore, no interference is expected.

Consideration of Spread Spectrum Transmission:
The SiK radio uses spread spectrum frequency hopping, over the frequency range given. The channel changes every 0.4 seconds, hopping among the 50 channels in a pseudorandom sequence. This means that a given channel is only in use for 0.4 seconds, once every 20 seconds. For a 5 minute pass, this would mean a total exposure on a given channel, of 6 seconds, for 0.4 seconds at a time, during the 5 minute pass.

Earth Surface Maximum Power Density and Power Spectral Density:
Power density is calculated using the formula

Power Density = $(P + G)/(4 * Pi * D^2)$, where

P = Output Power
G = Gain
D = Distance

From the values given in the Introduction, the formula yields the following for maximum power density at Earth surface:

Power Density = 3.18 e-14 W/m^2, or -135 dBW.

Bandwidth is 250 kHz, so spectral power density at the transmitter is 0.025/250000 = 1e-7 W/Hz. With a gain of -4 dBi, and at a distance of 500km,

Power Spectral Density at Earth Surface = 1.27e-19 W/m^2-Hz or -189 dBW/m^2-Hz.

Based on this, we believe that the emissions of the PAN inter satellite radios are below the noise floor of any ground systems operating on this frequency.