DXing on Mars

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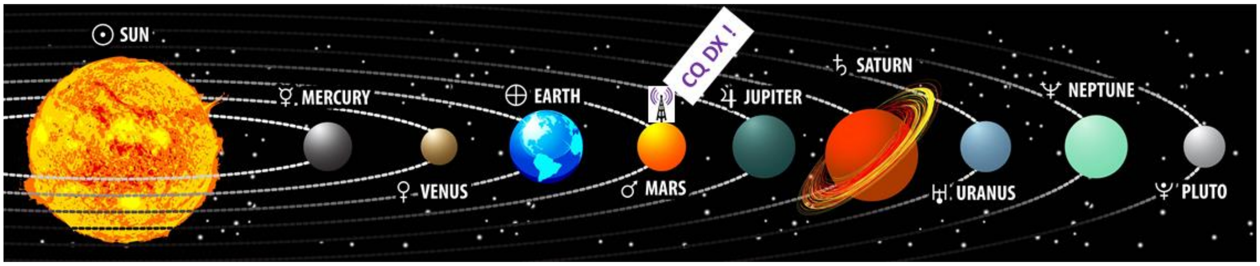


One of these days humans will go to Mars. At first it will be for scientific reasons, but eventually we'll likely colonize Mars with permanent settlements. More than likely there will be Amateur Radio operators participating in the colonization. How will DXing be on Mars?

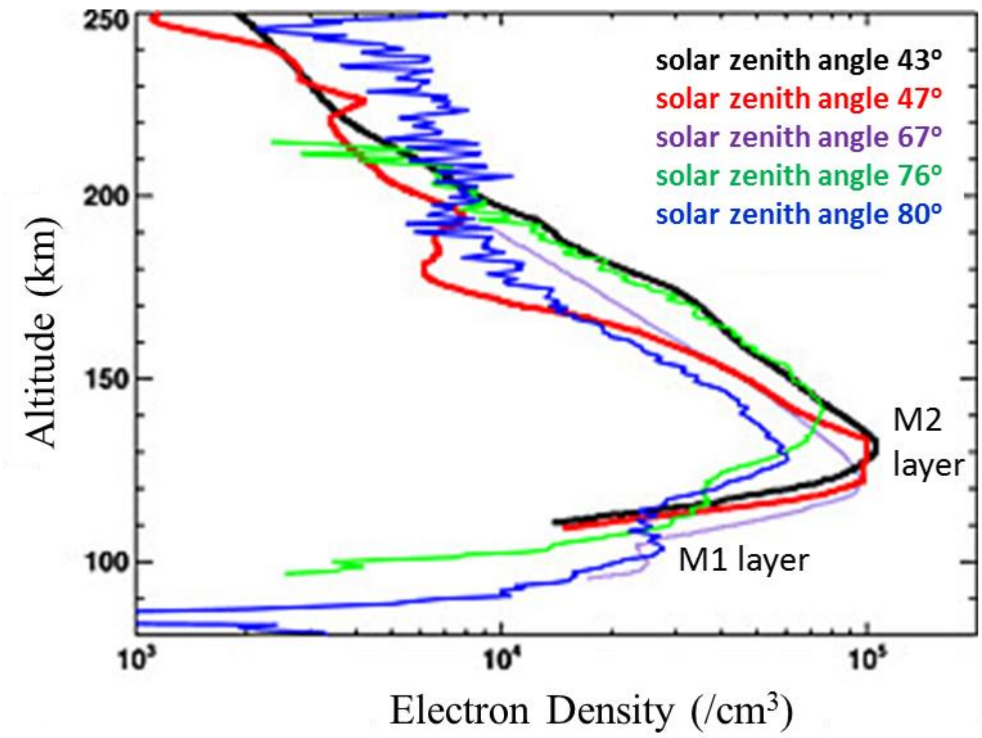
Let's start with some comments about noise. Initially the man-made noise environment will be quiet since there won't be that many humans on Mars. But if there's a population explosion on Mars, we'll have man-made noise levels similar to Earth. I don't think we'll have atmospheric noise (QRN) problems as I'm not aware of any thunderstorms on Mars. But perhaps dust storms could create QRN.

Now let's look at HF propagation. To do this we need to know what the ionosphere of Mars looks like. I guess the first question is "does Mars have an ionosphere?" The answer to that is "Yes". And we've already sent enough probes to Mars to have a decent idea what the atmosphere and the ionosphere of Mars look like.

The following table compares the neutral species (non-ionized atmospheric constituents) in the atmosphere of Mars to the neutral species in the atmosphere of Earth.

Mars	Earth
Carbon dioxide 95.32%	Nitrogen 78.1%
Nitrogen 2.7%	Oxygen 20.9%
Argon 1.6%	Other 1.0%
Oxygen 0.13%	
Other 0.25%	

With CO_2 leading the pack on Mars, the Mars ionosphere is formed by photoionization of carbon dioxide (CO_2) by solar flux at EUV wavelengths. The resulting electron density profile features a main peak that is typically located around 120-130 km altitude. This main peak is analogous to the F1 layer on Earth and is frequently called the M2 layer. There appears to be an intermittent underlying layer, called the M1 layer, at around 100 km, with a density about one fourth as much. The following plot (reference 1) shows typical electron densities on Mars versus the solar zenith angle.



Remember that a solar zenith angle of 0 degrees means the Sun is overhead. A solar zenith angle of 90 degrees means the Sun is on the horizon.

From the electron density plot above, the largest M2 layer peak density is around 1 x 10^5 electrons per cubic centimeter, which translates to 1 x 10^{11} electrons per cubic meter. This gives an M2 layer critical frequency of 2.8 MHz. Applying spherical geometry to this scenario gives a maximum useable frequency (MUF) of around 14 MHz for low elevation angles with an M2 peak height of 120-130 km. In a similar manner, the MUF for the M1 layer at low elevation angles is around 7.6 MHz.

Thus there should be some good 20-Meter openings – if the frequency allocations on Mars parallel those on Earth. On the downside, the M1 layer (if present – note that it's not seen at all solar zenith angles) could block low elevation angles from getting to the greater electron density (higher MUF) of the M2 layer. As for hop distances, the 120-130 peak height of the M2 region should give us 2500 km hops – not as far as the 4000 km or so F2 region hops on Earth, but we'll have to take what we get.

The data in the plot is from September 2015, which had a smoothed sunspot number of 40 (this is in terms of the "old" sunspot numbers, not the "new" sunspot numbers – remember the April 2016 Monthly Feature?). This results in pretty low solar activity and suggests that the electron density of the ionosphere of Mars could be much greater at the peak of a solar cycle. So 17-Meters and higher could be viable for DXing efforts.

What about nighttime DXing? The above electron density plot only goes to a solar zenith angle of 80°, which says the Sun is still above the horizon. Note that the peak electron density decreases as the solar zenith angle increases. After sunset, photoionization essentially stops, and it is believed that the electron density will decrease significantly because Mars does not have a magnetic field as does Earth. On Earth at night, residual F2 region electrons are trapped in the magnetic field, and do not escape into space.

It is believed that early in its life Mars had a magnetic field similar to Earth. But it switched off long ago when the molten core cooled and solidified. All that's left are patches of remnant magnetism spread across the surface – these are called crustal fields (reference 2). At best, the nighttime ionosphere of Mars may be patchy thanks to Mars crustal fields.

Might there be something similar to Earth's sporadic E? With Mars crustal fields influencing the ionosphere, the dayside ionosphere may also be patchy. This could be thought of as sporadic M2 or sporadic M1.

What about auroral issues similar to Earth's auroral issues? Interestingly, large portions of the southern hemisphere of Mars (and to a lesser degree in the northern hemisphere) remain magnetized to some degree. These crustal fields appear to be strong enough to drive features in the upper atmosphere of Mars akin to auroral displays seen on Earth. So maybe VHFers will enjoy Mars, too.

In summary, HF propagation on Mars is certainly possible for DXing endeavors. Our understanding of the ionosphere of Mars is fundamental at best, so what was presented here is rudimentary. The only way we'll get a deeper understanding of our neighbor's ionosphere is to do in situ measurements (for example, with ionosondes when we colonize Mars).

Two final thoughts: I hope there won't be any HOAs (Home Owner Associations) to restrict antennas in the colonies on Mars and I wonder what the call sign structure will be for Amateur Radio operators on Mars. ☺

References:

1. Marissa F. Vogt, et al; MAVEN Observations of Dayside Peak Electron Densities in the Ionosphere of Mars; Journal of Geophysical Research – Space Physics; 2016; doi 10.1002/2016JA023473

2. http://sci.esa.int/mars-express/58554-mars-ionosphere-shaped-by-crustal-magnetic-fields/