MARS CALL EARTH:
A NOVEL ARRAY ANTENNA DESIGN FOR FUTURE PLANETARY MISSIONS

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The author would like to thank the organizers for inviting him to present an invited talk in this special session dedicated to advanced array antennas. The presentation is based on the work detailed in our cover page paper [1] and the author would like to acknowledge his collaborators from UCLA and JPL for their significant contributions. With the recent deployment of larger rovers such as Curiosity, high-performance DTE (Direct to Earth) communication links are now considered a viable link for upcoming Mars missions. Designing novel antennas with higher gain and power handling would enable greater flexibility and higher data rates.

The transmit and receive frequency bands allocated to the Mars 2020 mission are utilized as the required frequency of operation bands for the concepts summarized in this presentation. Circular polarization (CP) was considered for interoperability with DSN Earth stations. Some specific design parameters were: (a) Right-hand circularly polarized, (b) Boresight gain above 30dBic at the Tx band (8.425GHz), (c) Operational frequency bands considered were a 70 MHz bandwidth centered at 8.425GHz (Tx) for downlink (Mars to Earth) and a 47 MHz bandwidth centered at 7.1675GHz (Rx) for uplink (Earth to Mars). The challenges were to utilize an antenna concept that adheres to the above specifications with as simplified antenna fabrication architecture as possible and with reduced development cost.

Among variety of antenna concepts evaluated for this design, a novel multi-tile array architecture was proposed for future Mars Rover Missions [1]. The concept could also be considered for other planetary missions requiring DTE. In this presentation, we will revisit the construction of the CP Half E-shaped patch antenna for operating at both Tx/Rx X-bands. The dual-band capability (impedance match and axial ratio) of the CP Half E-shaped patch element will be the main focus of our novel design. This element utilizes the CP Half E-shaped element's compact size, approximately 50% size reduction from its full E-shaped element counterpart [2]. The CP Half E-shaped patch element allows the application of a single-feed and single-layer by considerably reducing the fabrication complexity in the X-band. In the subarray design, a stripline feed network is used to avoid spurious and unwanted radiation. Additionally we will discuss how each of the individual components are integrated, simulated, fabricated, and measured. It will be demonstrated that the desirable axial ratio (AR)-impedance matching (S11) bandwidths, good broadside radiation, and high directivity are achieved. Utilization of the array tile and its integration into a larger array will also be highlighted.

[1] J. M. Kovitz , J. P. Santos , Y. Rahmat-Samii, N.F. Chamberlain and R.E. Hodges, "Enhancing Communications for Future Mars Rovers: Using high-performance circularly polarized patch subarrays for a dual-band direct-to-Earth link," *IEEE Antennas and Propagation Magazine*, vol. 59, no. 4, pp. 50-61, August 2017.
[2] F. Yang, X. Zhang, X. Ye and Y. Rahmat-Samii, "Wideband E-shaped Patch Antennas for Wireless Communications," IEEE Transactions on Antenna and Propagation, vol. 49, no. 7, pp. 1094-1100, July 2001.