INTEGRATED ANTENNA SYSTEM FOR BLOCKAGE AND INTERFERENCE MITIGATION FOR SATELLITE-ON-THE-MOVE (SOTM) COMMUNICATIONS

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ABSTRACT

A satellite-on-the-move (SOTM) communications system is required for Future Combat Systems (FCS) battlefield environment. However, because of non-planar terrain, foliage, buildings and natural obstacles, communications can be interrupted and complete or partial blockage occurs. The signal can also degrade due to interference and multipath effects. In the case of unavoidable blockages, a-priori knowledge or estimate of the propagation conditions allows an alternative means to be put into action until the terminal is able to reacquire the satellite link. This paper addresses mitigation of unavoidable blockage scenarios by the use of an integrated antenna system, which consists of a main-link antenna and a number of cross-link antennas.

1. INTRODUCTION

A SOTM communication system in a battlefield environment needs to be adaptable to various transmission medium conditions as it may encounter many obstacles along the communication path, such as foliage, buildings, hills, mountains, etc. These obstacles along with multipath and interference effects can severely degrade or in some cases completely block the communications link. These degradations are related to the propagation characteristics of the medium and the speed of the vehicle as well as the satellite orbit. Unless precautions are taken, the continuation of the communication is done by reacquiring the signal after the causes for degradation disappear. This could take seconds while the terminal is moving. In the case of unavoidable blockages, a-priori knowledge or estimate of the propagation conditions allows an alternative means to be put into action until the terminal is able to reacquire the satellite link.

An integrated antenna system that will allow the terminals to adapt to unfavorable propagation conditions is discussed in this paper. The antenna system, which consists of a main-link antenna and a number of cross-link antennas, is designed so that it can be mounted on a HMMWV or equivalent vehicles. The main-link antenna is part of the direct communication link between the satellite and the vehicle. As the vehicle moves in regions that are completely blocked, cross-link antennas enable an uninterrupted link by relaying data from/to the blocked vehicle to/from the cross-link antenna of a vehicle in complete line-of-sight of the satellite. The second vehicle communicates with the satellite through its own main-link antenna. The concept of the integrated antenna system and its functionality is demonstrated in Figure 1.

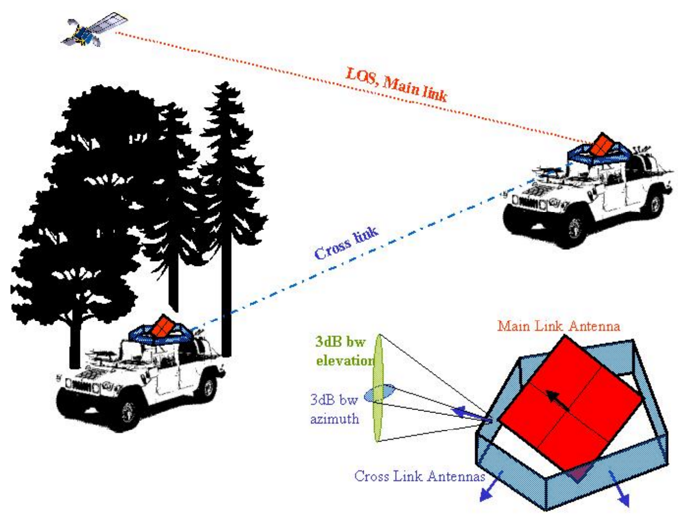

Figure 1. Integrated antenna system concept for blockage mitigation.

2. INTEGRATED ANTENNA SYSTEM

The integrated antenna system is positioned on a platform that rotates in azimuth for satellite acquisition and tracking. The main-link antenna is a flat plate structure that has elevation control for a second axis satellite acquisition and tracking. The flat antenna is constructed as a multilayer structure of printed circuits, which enable a lightweight and cost effective design. The antenna is sized to produce the gain, gain-to-noise ratio (G/T) and effective isotropic radiated power (EIRP) required to close the link for the data rate under consideration (Kilic et al., 2001). Figure 2 shows the multiplayer structure of the antenna.

The flat plate antenna has heritage in several applications for low-cost satellite terminals (Zaghloul, et al., 2001).

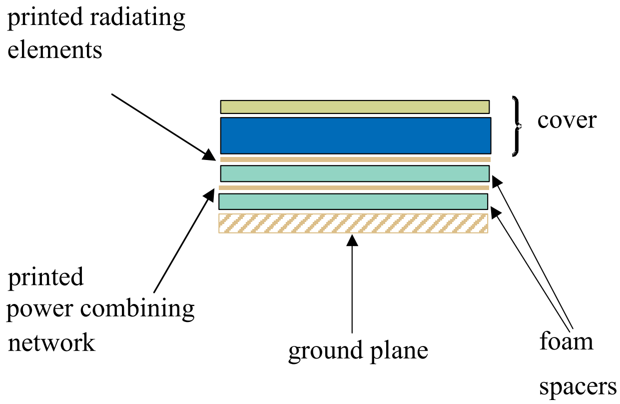

Figure 2. Multiple layer antenna structure.

The cross-link antennas form a cylindrical structure composed of planar panels that surround the main-link antenna. In situations where blockage or deep fade occur in the link to the main-link antenna, the signal is re-routed through the cross-link antennas to another vehicle in the vicinity that has a clear line of sight to the satellite. The re-routing algorithm is integrated with the acquisition and tracking algorithm that is built in the two-dimensional control of the main-link antenna. The cross-link panels have broad beam in elevation and cover limited sectors in azimuth. The panels use printed circuit designs and are proportionally small to close the link between the vehicles for the same data rate. Both main and cross-link antennas may have aperture control to reduce or cancel interference.

2.1 Flat Antenna Design Issues

The flat plate antenna uses printed circuit elements to construct an array fed with stripline network in a multilayer structure. The elements can be fed to have uniform phase and amplitude aperture distribution, or can have tapered aperture to produce certain sidelobe pattern for interference control. In the case of large aperture sizes, excessive feed circuit losses can be reduced by using multiple panels in the design of the flat plate antenna. This increases the antenna efficiency by introducing the ability to replace parts of the stripline circuit with waveguide sections, which significantly reduces the overall loss of the antenna.

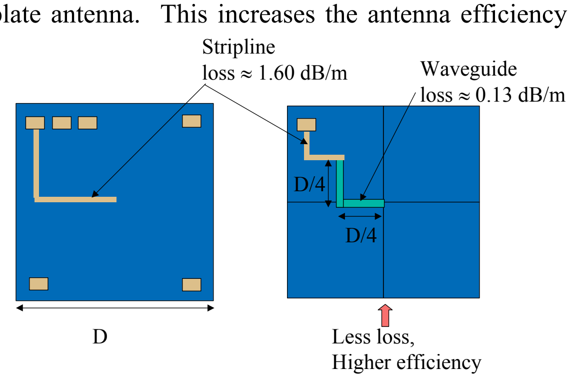

Figure 3. Multiple panel construction of the flat antenna showing circuit losses at 12.2 GHz.

A parametric plot of the antenna gain as a function of the aperture size for various number of panels is shown in Figure 4. Link analyses for the satellite-to-vehicle and vehicle-to-vehicle communications will determine the required size for both main-link and cross-link antennas for the system data rate and other signal parameters.

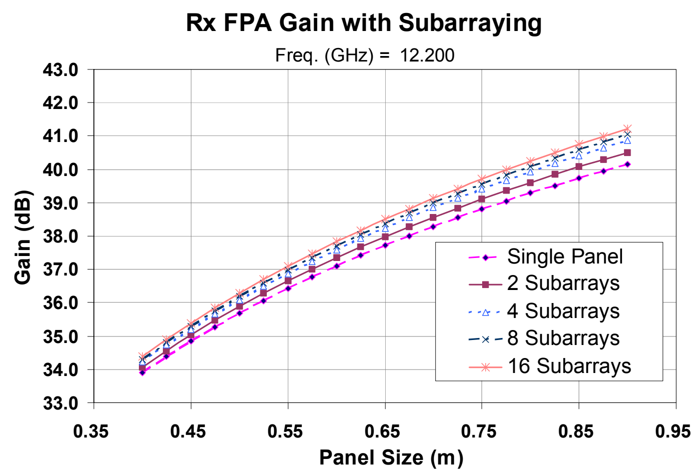

Figure 4. Effect of multiple panels on antenna efficiency as a function of size.

3. CONCLUSION

Uninterrupted communication between the vehicle in the battlefield and the satellite in a SOTM system can be achieved using an integrated antenna system that provides satellite-to-vehicle and vehicle-to-vehicle connections. The system uses a main-link antenna and a number of cross-link antennas on every vehicle, all constructed in a low-cost multilayer printed antenna structures that use a proven technology. The blockage to the satellite is mitigated by re-routing the communication between vehicles using a-priori information on the battle terrain and reflection and interference environments. The same data rate is kept throughout the switching and routing process.

4. REFERENCES

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