Introduction: A new modelling method suited to the dual circular polarised (MIMO) channel applicable to land mobile satellite (LMS) communications in line of sight cases is presented. In this scenario, it is necessary to apply correlated fading to the co-polarised and cross-polarised channels separately in order to model the evident polarization multiplexing in such channels found from measurement data. Comparisons between model and measured data for satellite elevations of 30° are presented for validation. Influence of the vehicle interior on the channel model is also analysed.

Background Channel Model: The LMS MIMO channel is illustrated in the vehicular case in figure 1. The satellite will use directional dual circular polarised antennas while the two mobile antennas are omni-directional and circular polarised. It is also possible that omni directional antennas on a mobile television handset could be used inside the vehicle, such that the measurements included in this paper consider the channel model for both on top of the vehicle and inside the vehicle, which would be applicable to using MIMO for digital video broadcasting standards, DVB-SH (satellite to handset) and DVB-NGH (next generation handheld) [1].

More detail of the model construction will be presented in the full paper but the basic routine applied to the model to generate the small scale fading is outlined as follows:

1. Create four independent identically distributed (i.i.d) Ricean fading channels based on suitable rice factors taken from measurement data.
2. Apply correlated fading to the co-polar elements, $h_{RR}$ and $h_{LL}$.
3. Apply correlated fading to the cross-polar elements, $h_{RL}$ and $h_{LR}$.
4. Apply the appropriate mean values to the co-polar and cross-polar components based on the cross polarization ratio.

The channel matrix is therefore a multiplicative noise component by the input bit stream vector $x(t)$ so that the output bit stream at the mobile, $y(t)$ has the following relation with additive white Gaussian noise, $n(t)$:

$$y(t) = H(t)x(t) + n(t)$$  \hspace{1cm} (2)
5. Combine the co-polar and cross-polar components together to create a newly formed channel matrix $H$.

It should be noted that the full model would include Markov chain based shadowing, though the scope of this paper is only interested in the small scale fading.

Measurement Setup: To validate the model, a measurement campaign was carried out in a suburban area of Guildford, UK as illustrated in figure 2. Two directional transmitting antennas (right hand and left hand circular polarised) were placed on top of a tower block to act as an artificial satellite platform which could then transmit a 2.5GHz wideband impulse pseudo random sequence to a vehicle receiver.

![Fig.2: Ariel view of the measurement run using a tower block as the artificial platform](image)

At the mobile were two omni-directional antennas on the roof of the vehicle, while in the interior, two meandered quadrifilar antennas were used as shown in figure 3. In both cases, there was a left hand and right hand circularly polarised antenna. The distance from the tower to the vehicle meant that the elevation angle was comparable to that of 30°, which is therefore reflecting a typical LMS scenario.

![Fig.3: Antennas used at the mobile for the measurement campaign.](image)

Measurement Results: To validate the model, it is most appropriate to compare the eigenvalue cumulative distributions, which are related to the channel as follows [6]:

$$\mathbf{H} \mathbf{H}^H = \mathbf{V} \mathbf{S} \mathbf{V}^H$$

Where $\mathbf{V}$ is the eigenvector matrix and $\mathbf{S}$ is a diagonal 2x2 matrix in this case containing the two eigenvalues. It is useful to analyse the distributions of the eigenvalues in figures 4 and 5 because they are close together and in parallel, which indicates a strong polarization multiplex rich environment. This is not typically seen in conventional terrestrial mobile systems, requiring the need for a new model which is in good agreement with measured data both for in-vehicle and out of vehicle cases.

![Fig.4: Comparison of eigenvalues for measured and modelled data outside the vehicle.](image)

![Fig.5: Comparison of eigenvalues for measured and modelled data inside the vehicle.](image)

REFERENCES