

# EXPERIMENTAL VALIDATION OF SIMULATED 3D FIELD DISTRIBUTION WITHIN A VEHICLE CABIN

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## Abstract

Large resonant cavities such as a vehicle cabin present a challenging measurement environment for both field emissions and exposure limits testing. A model vehicle cabin which includes interior details such as steering wheel, seats and dashboard was constructed to validate field levels predicted by FEKO and CST Microwave Studio. Individual effects of these furnishings to internal fields were included in the study. The simulated field levels were compared with measurements made using a 3D automated low-disturbance probe positioning system and it was found that the predicted values were within 3.4 dB of measured field levels.

## 1 Introduction

Wireless networks are gaining popularity and an increasing number of transmitting antennas are being mounted within the cabin of the vehicle to support such networks. Optimising the installation of such transmitting antennas can be a highly challenging task as the vehicle cabin and the furnishings may present a difficult environment for wireless networks [1]. The vehicle cabin itself is a resonant cavity and can be highly reflective causing spatial field variations and disruption to wireless transmissions [2]. Field levels outside the vehicle cabin were measured in [2] but not within the cabin. In addition, field exposure issues associated with these wireless devices generate considerable concern among many sectors of the general public. Optimising the performance of transmitters and at the same time ensuring compliance to radiation safety standards usually requires understanding of fields within and outside the vehicle [3].

However, to ensure minimum disturbances to fields, optical probes and other equipments required for such measurements can be expensive and the process time consuming. Furthermore for internal field measurements in the vehicle cabin, a probe positioner will be required and the fittings may inevitably cause intrusion to the interior trims and metal work of the vehicle.

As increased computing power becomes more affordable and CAD data more readily available from major vehicle manufactures, large scale vehicle simulations become viable. This provides a solution to

the problem described above and in some cases allows investigation into areas inaccessible to field probes. However, before computer modelling can be used, a certain level of confidence in the model needs to be established. This is more important in the case when the model is a large resonant cavity and convergence in simulation data may present a problem. In this paper, CST Microwave Studio (CST MWS) which implements a Time-domain method and FEKO which implements a frequency domain method were used to evaluate fields within a simple rectangular model of a vehicle cabin. The simulated results are compared with measured data and the difference can be used in conjunction (e.g. as an error bound) for the validation method described in [2].

## 2 Measurement and simulation setup

A simple rectangular box which includes interior cabin details such as steering wheel, seats, dashboard and apertures shown in Fig. 1 was constructed to represent the interior cabin of a vehicle with open windows. Vehicle CAD data was not used in this case to keep the measurement setup identical to the simulation model.

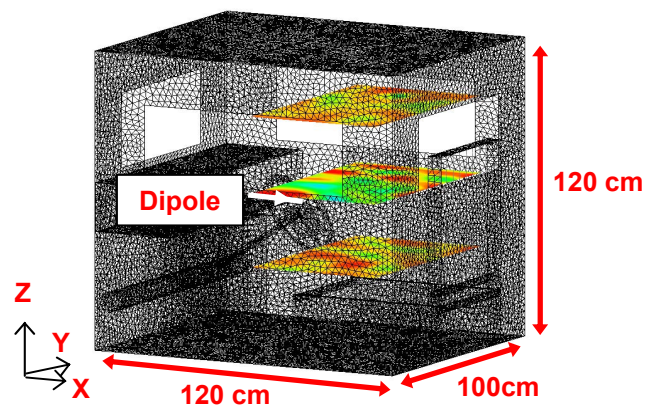


Fig. 1: Simple cavity representing vehicle cabin.

A dipole fed by a 15 dBm source is inserted 10cm into the cavity via the left aperture to represent an on-board transmitter. 3D field measurements are then taken within the cavity using an isotropic free-field probe (IndexSAR – IXP60) at 870 MHz by a low disturbance automated probe positioner mounted on the roof of the cavity. The positioner is very similar to a simple XY scanner with an additional vertical arm to move the free-field probe in the Z direction. The cavity was placed in an anechoic chamber. For clarity, Fig.1 shows only three 2D planes instead of the entire 3D data. These

planes are selected such that they are useful for evaluating fields in the head, body and legs of a human seated within a vehicle. A convergence study using uniform mesh for the entire geometry has been conducted using both simulators.  $\lambda/12$  mesh was used for FEKO and  $\lambda/20$  mesh was used for CST MWS.

### 3 Comparison of 2D field data

Using three cut-planes of height 35, 65 and 95 cm from above the ground of an empty cavity, Table 1 provides an illustration of the maximum difference in field levels found in each plane between the two simulators and the measurements. It is found that FEKO consistently gives higher maximum field predictions for a source power of 15 dBm as compared to measurements for all field points. The maximum difference between FEKO and measurements was 3.4 dB. Predictions by CST MWS may fall below the measured values for some points as illustrated in the field magnitude on the 35 cm cut-plane. The field profile obtained in an empty cavity by FEKO is compared with measurements in Fig. 2 and Fig. 3 and similarly for CST and measurements in Fig. 4 and Fig. 5. It can be seen that measured and simulated results are very similar.

	FEKO	CST MWS	Measured
Plane-95cm	23.5 dBV/m	22.6 dBV/m	20.4 dBV/m
Plane-65cm	23.6 dBV/m	20.1 dBV/m	20.2 dBV/m
Plane-35cm	23.8 dBV/m	20.3 dBV/m	21.6 dBV/m

Table 1: Comparison of maximum field levels.

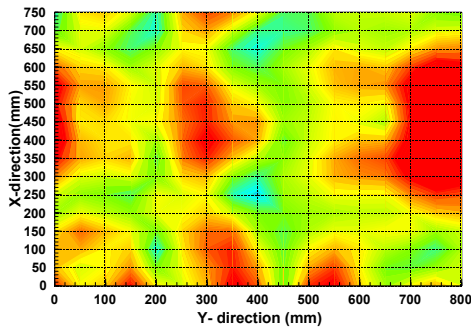


Fig. 2: Measured Field (95 cm above cavity ground)

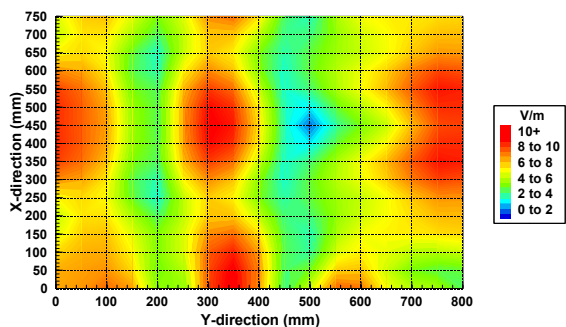


Fig. 3: Simulated Field using FEKO (95 cm above cavity ground)

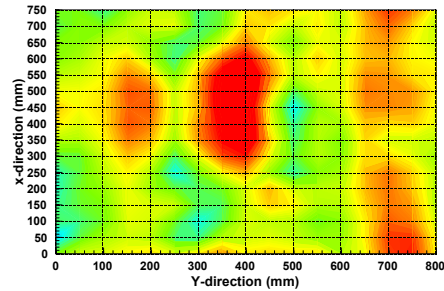


Fig. 4: Measured Fields (35 cm above cavity ground)

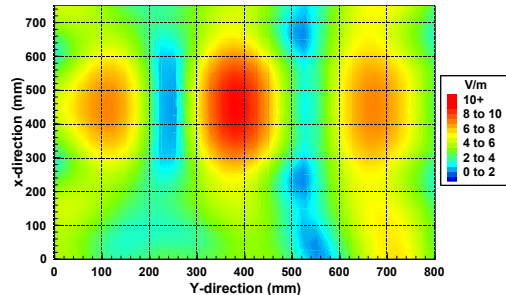


Fig 5: Simulated Field using CST MWS (35 cm above cavity ground)

### 4 Conclusion

It is shown that computer modelling can be used for prediction of field strength within a large resonant cavity. Both the time domain (CST MWS) and frequency domain (FEKO) solvers accurately predicted areas of high field regions and the peak amplitude to an accuracy of approximately 3.4 dB when compared to measurements. Vehicle furnishing changes the field profile and must be included in the model. This has already been verified in an on-going study but not shown in this paper. These results are applicable not only to automotive EMC and antenna designers but will also be of interest to aerospace and construction industries where resonant cavities are encountered.

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