Abstract—This paper presents a characterization of the signal fading caused by moving vehicles near the receiver on digital terrestrial television (DTV). The results shown are based on a measurement campaign carried out in the cities of Madrid and Bilbao (Spain), in order to explore the channel behaviour. These results would help when planning DVB-T portable reception.

Index: DTV, DVB-T, COFDM, Signal Fading, Portable Wireless services.

I. INTRODUCTION

The new digital terrestrial TV standards [1],[2] are already on air in several countries around the world. In Europe, this introduction has been successfully achieved in countries like United Kingdom, Sweden and Spain. In order to make the new systems more appealing to the customers, new services, which include HDTV and both mobile and portable reception, are now being tested for future implementation.

This paper focuses on Class A portable reception [3] and its main goal is to characterize the time variation of a COFDM 8 MHz signal in urban environments by means of a field measurement campaign. This characterization is a part of a wider study that is being carried out to test some DVB-T receivers under different reception conditions.

During the last decade, studies to characterize wireless mobile and portable reception have included channel statistics analysis and have been mainly focused on mobile telephony systems[4]. The signal bandwidth involved on such networks is much narrower than the DVB-T one, so new measurements and channel modeling have to be made in order to prepare for the introduction of portable reception.

The contents of this paper can be summarized as follows. First, a brief description of the DVB-T network will be given. After that, the measurement system and techniques will be described. Further on, the results will be presented in tables and graphs. Finally some conclusions will be outlined.

II. MEASUREMENT CAMPAIGN

A. Single Frequency Network

The measurement campaign was carried out inside the coverage area of a nation wide single frequency network [5][6] in Spain, which nowadays enables access to DVB-T fixed reception services for more than 80% of the Spanish population using the upper channels of the UHF band. Measurements were taken in two cities. Some of the data was captured in Bilbao, where signals from three different transmitters can be received. Another set of data was taken in Madrid which is also served by three transmitters. In both cases transmitters are located inside a 30 square kilometers area. The COFDM signal used for these tests has a 7.61 MHz bandwidth and is allocated to a 8 MHz TV channel. The center frequency of the signal used in these measurements is 850 MHz (UHF Channel 68).

B. Measurement System

The measurement system was installed on a mobile measurement unit and was designed to take field measurements in order to characterize the mobile and portable reception of DVB-T signals under a variety of conditions. The receiving system is based on an omnidirectional antenna designed for UHF television signals with horizontal polarization. This antenna is located on top of the vehicle by means of a special mount. The overall antenna height is 2.30 meters above ground level.

A vector signal analyzer was used to measure the received power level. This equipment measures the received DVB-T signal power by integrating the spectral power density all over the useful COFDM signal bandwidth (7.61 MHz). The measurement speed was checked by laboratory tests and the mean value is 26 power measurements per second. It has been assumed that moving vehicles around the receiver do not create a Doppler frequency higher than 26 Hz. The measurement process is controlled by a PC with specially designed software which remotely configures and controls the vector signal analyzer.

C. Measurement Methodology and Data Preprocessing

The whole set of data consists of measurements taken at 144 points downtown and in the suburbs of the cities of Madrid (93 points) and Bilbao (51 points). Those points had been...
previously planned in order to characterize the portable reception in the different environments that can be found in a big city, which can vary from suburban locations with two story buildings to dense urban areas where most of the buildings have more than four stories. The criteria used to select the measurement locations are described in Report 567-4 from the ITU-R and it was formerly also used to test the reception of digital audio broadcasting (DAB) signals. It basically consists of a nine level classification of possible reception environments that vary from open rural locations to dense urban ones.

At each of the 144 measurement locations the received power level was logged during a 3 minute time period. Those values were stored by the PC for further processing. At each location, some annotations were also made in order to describe the measurement location and environment type, which in some cases differed from those expected during the measurement planning stages. As environment classification is in some cases a matter of subjective appreciation, several photographs of the measurement point were also taken as ancillary data for further assessment.

Two parameters have been used to describe the time variation of the received power level at each location. The first one is the standard deviation ($\sigma$) of the received power over the measurement period (3 minutes). The second one is the fading which is not exceeded more than 1% of the time. These fading occurrences were measured taking the median received power over the measurement period as the reference value (median power = 0 dB fading). This fade margin was calculated as the difference between the 1st and the 50th percentiles of the received power at each location.

Both parameters have a direct relationship with the coverage definitions made on internationally agreed recommendations for digital terrestrial television frequency planning. The fading characterization for 1% of the time is specially meaningful because the coverage is described in terms of minimum received levels during 99% of the time.

D. Results

Table I shows the results obtained on the whole set of measurement locations in Bilbao and Madrid (144 measurement points).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean(dB)</th>
<th>Max.(dB)</th>
<th>Min.(dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>0.87</td>
<td>1.81</td>
<td>0.53</td>
</tr>
<tr>
<td>Fade Margin</td>
<td>2.37</td>
<td>7.37</td>
<td>1.24</td>
</tr>
</tbody>
</table>

More detailed information can be obtained from the histogram shown in Fig. 1. This graph represents the fading margin not exceeded 1% of the time obtained at the 144 data points. It can be observed that most of the locations (80%) show a fading margin which is less than 3 dB. Nevertheless, 20% of the measurement set shows higher values, ranging from 4 dB up to the maximum which is near to 8 dB.

In order to characterize those variations as a function of the environment type, the measurement data were first classified according to the ITU Report 567-4. The results offered by this classification show no significant differences between the different environments that can be found in a city.

Fig. 1. Fading not exceeded more than 1% of the time, taking the median value as the 0 dB reference. Histogram of the whole measurement campaign values.

The second factor analyzed was the vehicle density moving near the mobile unit at each location. As the antenna is omnidirectional and located not far above ground level, such moving vehicles near the mobile unit can cause fast variations on the receiver power level. In order to quantify the influence of the traffic, a second classification of the measurement locations was made according to the traffic density. In this way, measurement locations were divided into two categories:

- Dense-Very Dense traffic locations
- Low- Null traffic locations

The “Dense-Very Dense traffic” condition was assigned to points where vehicles pass almost continuously near the measurement mobile unit, and “Low-Null traffic” was assigned to locations with no traffic at all or where vehicles appear sporadically. Table II and Table III show the results for both location categories.

<table>
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<tr>
<td>$\sigma$</td>
<td>0.97</td>
<td>1.81</td>
<td>0.65</td>
</tr>
<tr>
<td>Fade Margin</td>
<td>2.72</td>
<td>7.37</td>
<td>1.49</td>
</tr>
</tbody>
</table>
TABLE III
RESULTS AT "LOW-NULL TRAFFIC" LOCATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean(dB)</th>
<th>Max.(dB)</th>
<th>Min.(dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>0.74</td>
<td>1.13</td>
<td>0.53</td>
</tr>
<tr>
<td>Fade Margin</td>
<td>1.85</td>
<td>3.58</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Results on Table II and Table III show that the time variations are lower at points belonging to the “Low-Null traffic” category. This effect can be observed for both parameters, but it is significantly higher on the fading not exceeded more than 1% of the time.

![Low - Null Traffic Locations](image)

At approximately 90% of the locations where traffic is low, the value obtained is less than 3 dB whereas, at dense traffic locations, the same percentage leads to signal fading occurrences of up to 5 dB. Just as before when considering the whole set of data, those effects can be better observed on the histograms of Fig. 2 and Fig. 3.

### III. CONCLUSION

The results shown in this paper have a direct application on DTV network planning for portable receivers in urban environments, where the effect of moving vehicles near the receiver causes signal fading of up to 8 dB from the median received level. This fading would eventually make the demodulation and decoding process fail, specially on locations near to the coverage threshold. It should be also taken into account that such deep and fast fading can make the synchronization algorithms fail in conventional receivers which have not been designed to work in fast varying radio channels [10]. Further studies following this work should be done on investigating the speed of variation of the channel.

![Dense-Very Dense Traffic Locations](image)

Fig. 3. Fading not exceeded more than 1% of the time, taking the median value as the 0 dB reference. Histogram of the “Dense-Very Dense traffic” locations.

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### REFERENCES


All Authors are with the TSR Research Group (Signal Processing and Radiocommunications Group). This group belongs to the Department of Electronics and Telecommunications at the Bilbao Engineering College (University of the Basque Country) and focuses its main interests on digital broadcasting systems planning.