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# A12.3

# Instrument Landing System and Electromagnetic Fields from MetroLink at Dublin Airport

COMPLIANCE
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| | |
|---|---|
| EM | Electromagnetic |
| EMF | Electromagnetic fields |
| EMR | Electromagnetic Radiation |
| EMI | Electromagnetic Interference |
| DC | Direct Current |
| AC | Alternating current |
| RF | Radiofrequency |

## 1.0 Introduction

As part of stakeholder consultations, and with the intention of informing the EIAR for MetroLink, CEI liaised with the Irish Aviation Authority in relation to the Instrument Landing System at Dublin Airport and sought to address their questions concerning the potential for EMI from the development on the operation of this safety critical system.

A system description, operational features and locations of the antenna arrays were obtained from the IAA and the principle of operation was also outlined.

The IAA requested that they be presented with a document that outlines the proposed electrical and communication systems expected to be installed as part of the MetroLink. Complimenting this the operational frequencies of these systems as well as the predicted electromagnetic profile for the system will also be outlined.

An important note regarding the details below is that some of the systems listed are based on reference designs as the detailed design study in relation to RF comms systems will be carried out at a later stage in the project but the principles and conclusions will still apply regardless of the final solution adopted.

## 2.0 The Instrumnent Landing Systems (ILS)

The following systems were discussed with the IAA:

1. IRVR – utilised for measuring visibility
2. Landing DME – utilised to measure the distance to the runway (111.2 MHz)
3. LLZ (Horizontal Guidance Localizer) – radio beam utilised for guiding the aircraft horizontally (108.9 MHz – 111.5 MHz)
4. Glide Path - radio beam utilised for guiding the aircraft vertically (329.3 MHz – 332.9 MHz)
5. FFM, MM and OM signals (75 MHz)

The main concern for the IAA centred around the guide beams (items 3 and 4) which are used by aircraft to align with the runway when landing.

The carrier frequency in each case is AM modulated with 90 Hz and 150 Hz. The aircraft detects which modulation is more prevalent to determine how far above or below the Glide Path (GP) it is and can adjust accordingly. Similarly, for the horizontal guidance system.

The guidance signals are bounced off of the ground in front of the antenna array (at a distance of up to 300 m away) such that any changes to the baseline environment that would affect the calibration of these signals needs to be accounted for. The most obvious modification would be the construction of a new building in this path but unwanted RF emissions in the carrier frequency range could cause interference also.

The locations of these systems were provided by the IAA and are illustrated in **Error! Reference source not found.** along with an indicative overlay of the proposed MetroLink route.

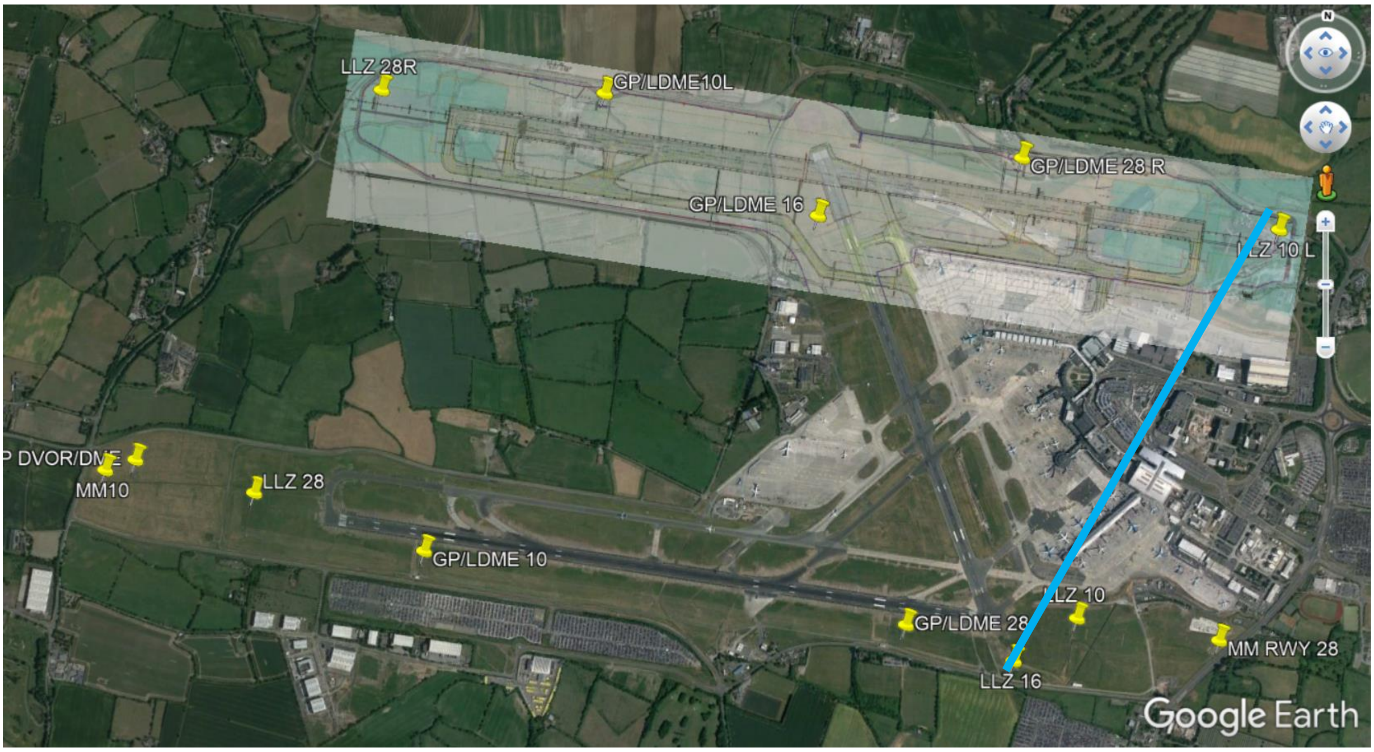


Figure 1: ILS locations at Dublin Airport and the proposed MetroLink route

# 3.0 The MetroLink Systems

The proposed systems to be installed as part of the MetroLink project can be broken into 3 categories. The electrical supply and traction systems, control and communications systems and signalling systems.

## 3.1 Power Supply and Traction Systems

All power lines will be run within the tunnel which is to be at a depth of approximately 16 m in the vicinity of Dublin Airport from the brow to surface level. Therefore, the services within will be at a minimum of 16 m from the surface. Within the tunnel will be two main medium voltage systems.

1. 20 kV AC Medium Voltage ring used to bring power along the route to support all the ancillary systems. At each station this is transformed to three phase 400 V and singe 230 V for equipment such as ticketing and information systems, signalling systems, ventilation systems etc. Any electromagnetic fields relating to the supplies will be at 50 Hz. The Medium voltage cables will be routed through the tunnel in conduit in a trefoil arrangement providing large cancellation of the related electromagnetic fields.
2. Traction supply. The proposed development will have two substations where high voltage connections will be supplied by the ESB. At these substations (not located within Dublin Airport) the supplied voltage will be rectified to 1,500 Vdc which will be the drive voltage for the trains. The characteristic of this rectified signal is such that it will have a DC component predominantly as well as a 50 Hz component due the nature of its AC origin along with harmonics of this fundamental 50 Hz frequency at frequencies such as 100 Hz, 150 Hz, 200 Hz etc.

Below are illustrations of these harmonics of the fundamental frequency obtained from another 1,500 Vdc rail system in Dublin (the DART), which were measured at approximately 8 m away underneath the line. Figure 2 Figure 3 depict the Magnetic fields from DC up to 1 kHz, while Figure 4Figure 3: depicts the Electric Fields. Note that in relation to the Magnetic Fields the 50 Hz component is larger than any of its harmonics. The E-Fields produced as a result of the traction system will be shielded by the earth regardless but it is important to point out that Magnetic Field Strength diminishes at a rate proportional to the distance cubed such that the harmonics will be reduced to background levels at surface level with the exception of the DC component which could still be detectable at surface level.

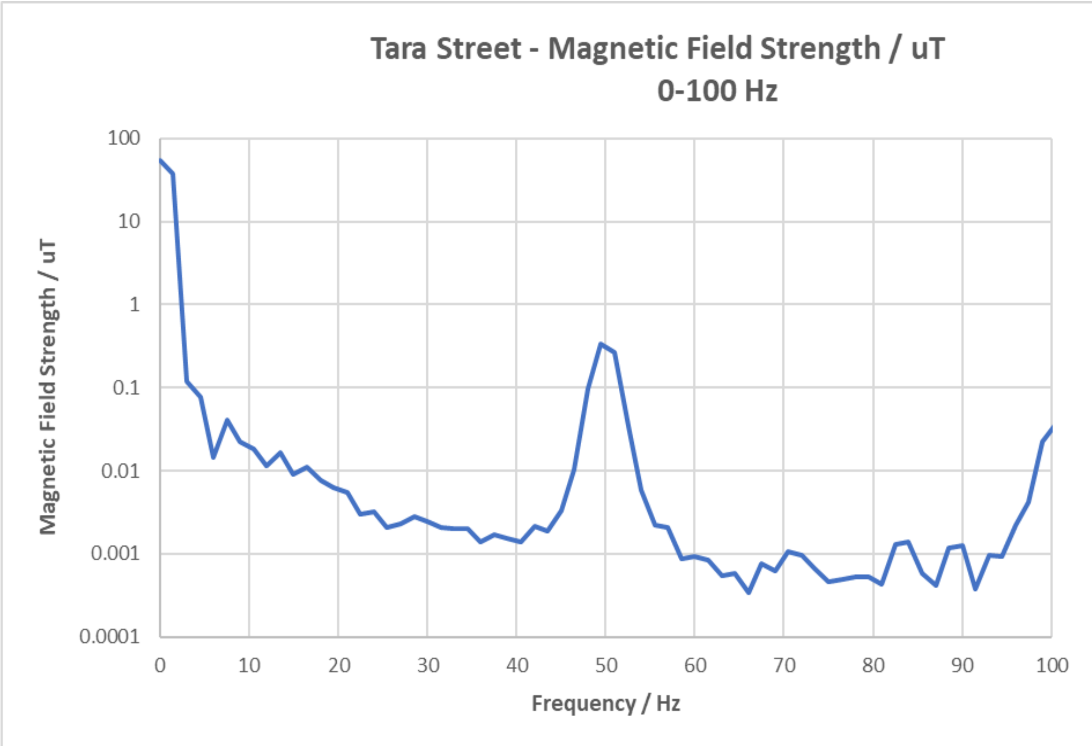


Figure 2: AC Magnetic Fields measured from the DART (DC – 100 Hz)

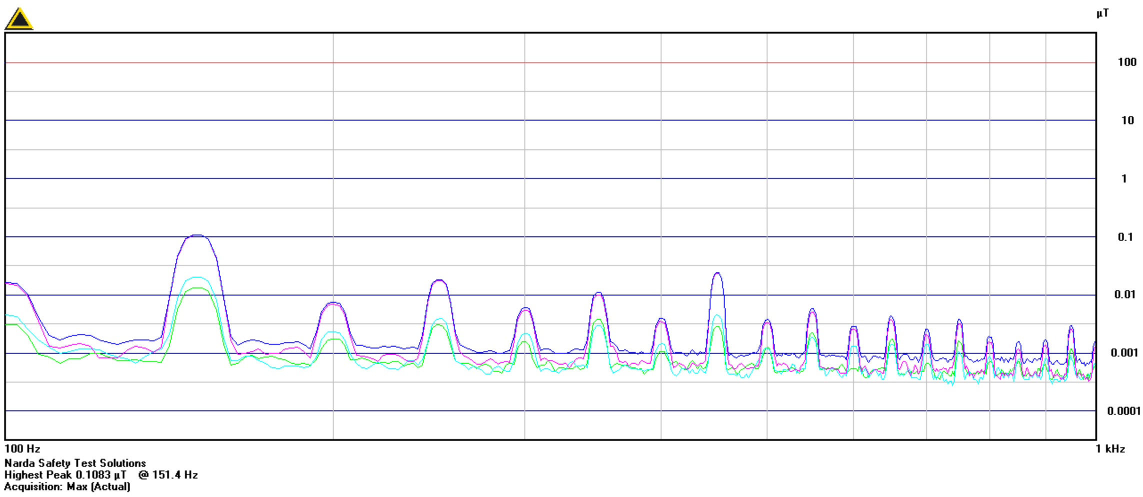


Figure 3: AC Magnetic Fields measured from the DART (100 Hz – 1 kHz)

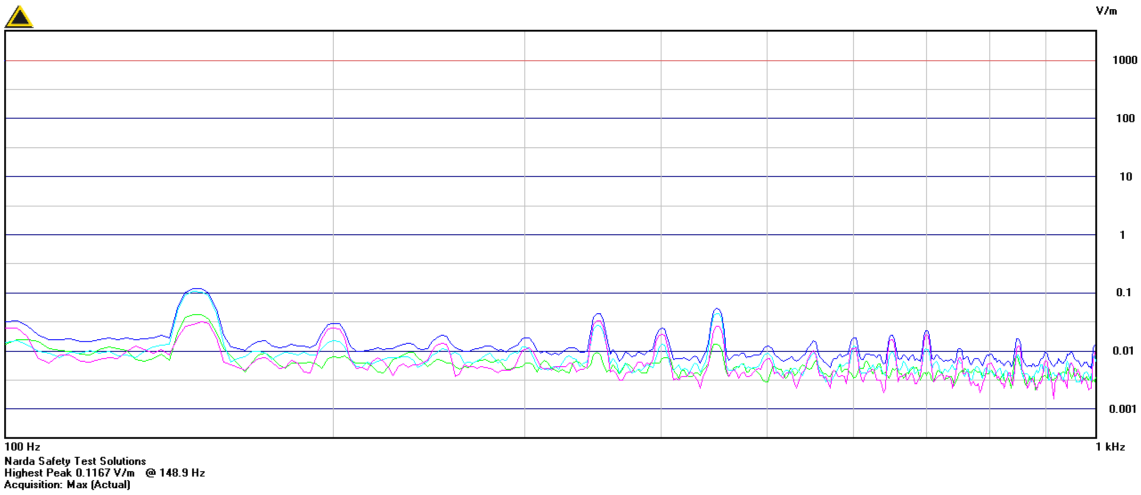


Figure 4: AC Electric Fields measured from the DART (100 Hz – 1 kHz)

The ILS would be required to withstand 3 A/m (equivalent to 3.7 µT) at 50 Hz as part of its own regulatory EMC requirements. It would not contain any magnetically susceptible components in the AC frequency ranges discussed above. The Horizontal and vertical guidance beams would also have no susceptibility to the DC component of the traction supply. Therefore the power supply and traction systems pose no risk to the ILS.

### 3.2 Control and Telecommunication Systems

While the signalling and telecommunication systems have not been finalised and will not be until the detailed design phase is entered, all systems installed will need to meet the EMC and Radio Directives. Radiated emissions will be limited to a maximum of those permitted by the Railway EMC standard series EN 50121. Any licenced transmissions such as WiFi will need to meet both the EMC standards and respective radio standards.

Figure 5 illustrates these emissions limit lines from EN 50121 across the frequency range 9 kHz to 1 GHz when measured at a distance of 10 m from the centre line of the railway. So, at distances of greater than 10 m the levels will be even lower again. Note: Line B is the limit line for 1.5 kVdc systems.

Although both electric and magnetic fields co-exist across all frequencies in the range 9 – 30 MHz the H Field (Magnetic field) is what is specified and therefore measured while from 30 MHz to 1 GHz it is the E-Field that is measured.

The frequency range we are interested in here in relation to the ILS is 75 – 335 MHz where the emissions limit varies from 95 dBµV (-12 dBm*) at 30 MHz down to 70 dBµV (-37 dBm*) at 1 GHz.

* 50 Ω system impedance used in conversion

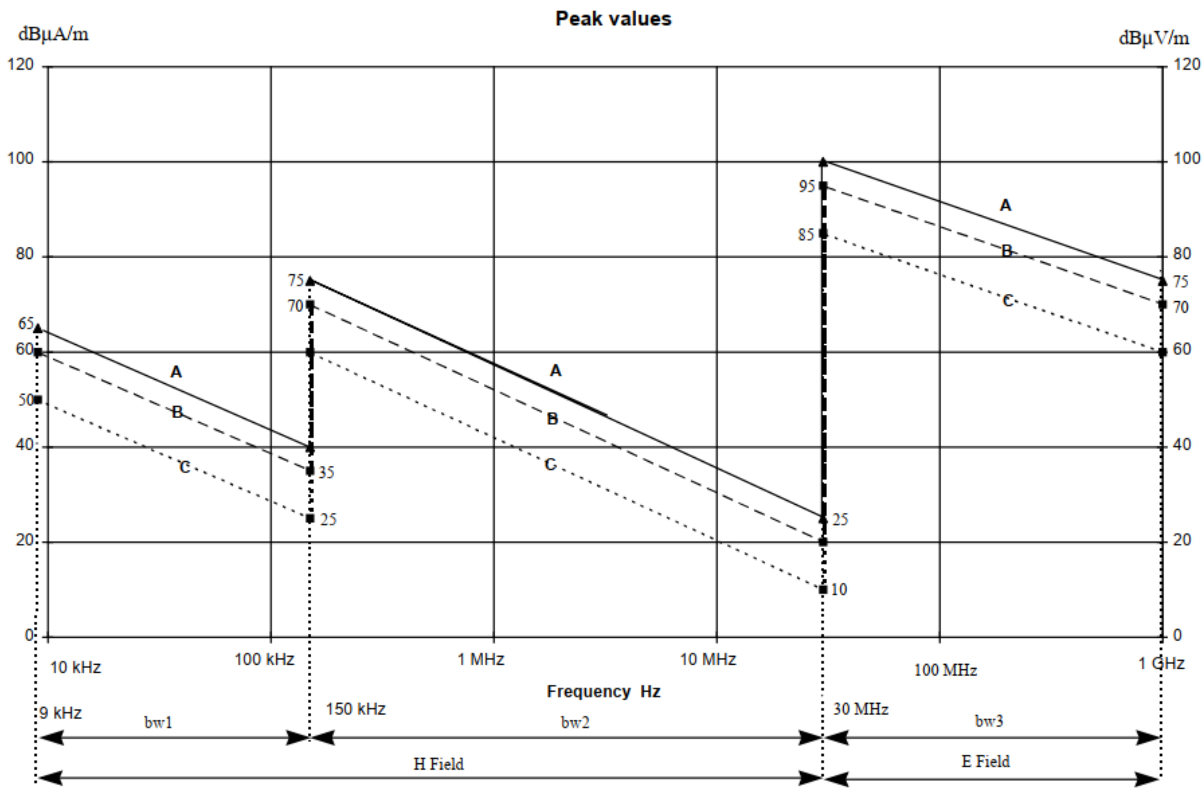


Figure 5: Emission limits for electrified railway in the frequency range 9 kHz – 1 GHz

Any E-Fields emanating from the system at surface level in the frequency range relating to the ILS operational range will have travelled a distance of 16 m from the brow of the tunnel through earth and so will more than likely be immeasurable on the ground directly above the proposed tunnel.

As requested however a list of the proposed systems (central command and control systems) is given below:

- Passenger information systems
- Access control and intrusion systems
- CCTV
- Multiservice communications network
- Administrative network
- Comms system for passengers (WiFi)

- Central Clock system
- TETRA radiocommunication system
- SCADA
- Public Address and voice alarm

One system of note here would be the TETRA system with an operational frequency of typically around 390 MHz. If utilised it could be fed via a leaky feeder cable run throughout the tunnel. The rationale for using a leaky feeder throughout the tunnel is due to the high radiated losses within the tunnel for such a signal. If TETRA is not utilised GSM-R may be with operational frequencies in the 800 – 900 MHz range.

SCADA can have multiple operating frequencies in the MHz range, but links will be hard wired and therefore E-Field emissions in its eventual operational frequency range minimised. The SCADA system may implement some wireless protocols which are again yet to be decided but they would through the use of pre-approved modules and thus compliant with EMC requirements.

### 3.3 Signalling Systems

In relation to the signalling the MetroLink will contain systems such as -

- Automatic Train Protection (ATP) system. Typically operates in the 10s-100s of Hz range
- Automatic Warning system
- Axle counters
- SSI Interlocking system
- Lights

These systems are expected to be predominantly hardwired and therefore radiated electromagnetic emissions from the signalling will be localised to the rails and again any E-Field emissions will be attenuated by both the walls of the tunnel and the earth above such that no signals should be detectable at ground level with the added protection that emissions must again meet the limits of EN 50121.

## 4.0 Conclusions

Figure 6 and Figure 7 below show baseline plots from Dublin Airport obtained in 2018 in the relevant frequency range. Overlaid (the yellow line) is the EN 50121 limit for DC railway (750 Vdc limit line in this case).

At this site the strongest emissions were caused by Analog radio broadcasts (80 – 110 MHz), Digital Radio (147-223 MHz), Maritime Communications (160 MHz), Tetra Radio (390 MHz), Personal Mobile Radio (450 MHz), Digital Television Broadcasting (470 – 790 MHz), WiFi (2.4 GHz, 5 GHz), RADAR (5.6 GHz) and FWALA (10.4 GHz) . In terms of mobile technology, the following signals were present, mobile broadband, LTE (791-821 MHz and 925-960 MHz), GSM 900 and 1800 (900 MHz and 1.8 GHz) and 3G (2.1 GHz).

The electromagnetic spectrum around 75-335 MHz can already be seen to be quite populated by licensed transmissions. The health of the spectrum particularly in these frequency ranges are strictly monitored by the communications regulator (Com Reg) to ensure adherence to the assigned bandwidths and prevent no cross interference. If TETRA turns out to be the chosen radio communications method for the MetroLink it's signal strength at ground level will be dwarfed by the current TETRA signals (currently used by the emergency services) at the airport which was measured to have an E-Field strength of 108 dBµV/m at our measurement location.

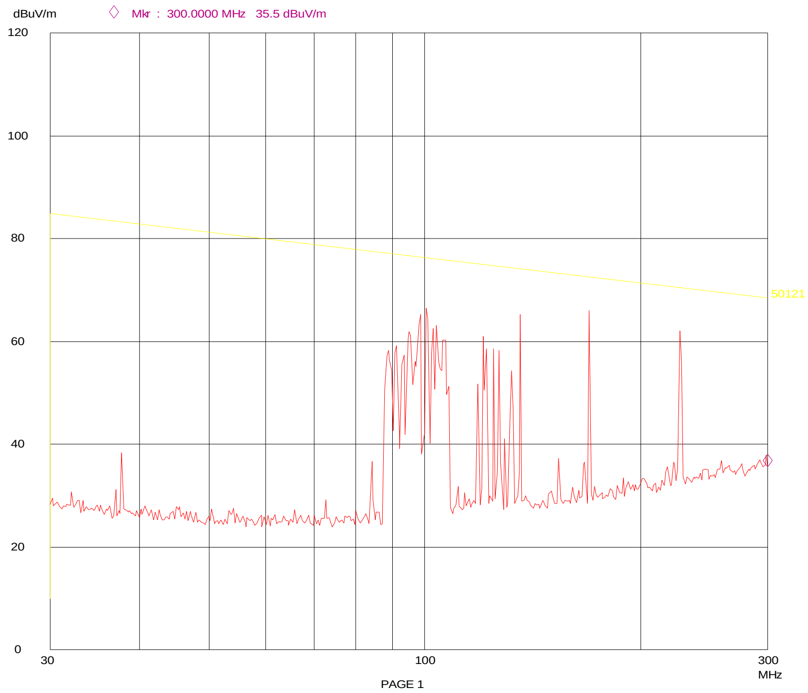


Figure 6: Dublin Airport - 30 MHz to 300 MHz

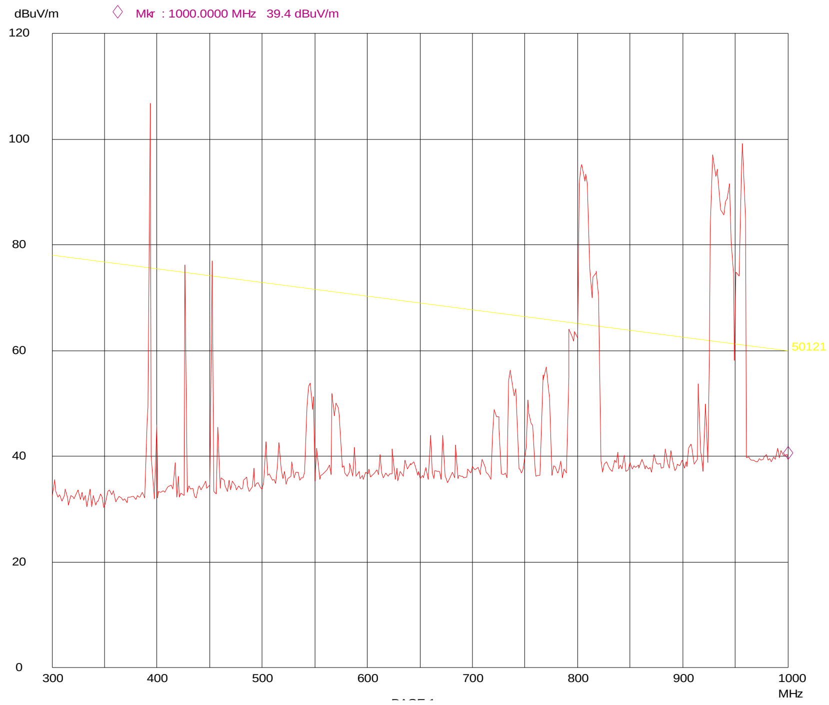


Figure 7: Dublin Airport – 300 MHz - 1 GHz

The IAA also requested details of transmit powers if they were available. Discussions with the design team in relation to obtaining further details on the radio systems to be adopted for the MetroLink and the respective transmit powers yielded the following response: "*The radio system used will be determined by the most suitable/licenced system available at the time as technology changes quickly in this area, therefore our design only looks at performance and functionality. As an example, the Luas TETRA is licenced for a maximum of a 10W Base station and it is unlikely that ComReg would allow for anything more than that.*" In summary the specific details will be decided at much later stage in the project, however the same regulations in relation to emissions will still be in force then.

Discussion of the Luas in the paragraph above brings up the final point and reference for this report. Figure 8 and Figure 9 below are measurements taken within 10 m of the Luas Cross City line outside the Rotunda Hospital after it became operational in 2017. Although a smaller system its electromagnetic profile in the VHF and UHF range is comparable to that of the proposed development. The main signals/transmissions present are quite similar to those already at Dublin Airport with no unwanted emissions at the operational frequencies of the ILS above the EN 50121 limit line.

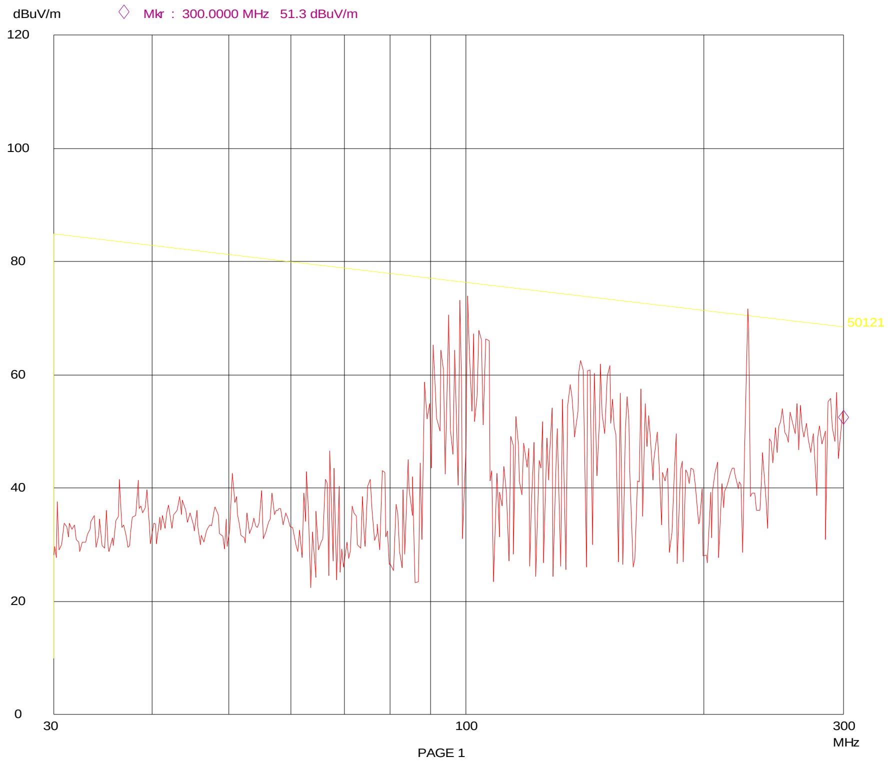


Figure 8: Site 4, Rotunda Hospital, 30 MHz to 300 MHz

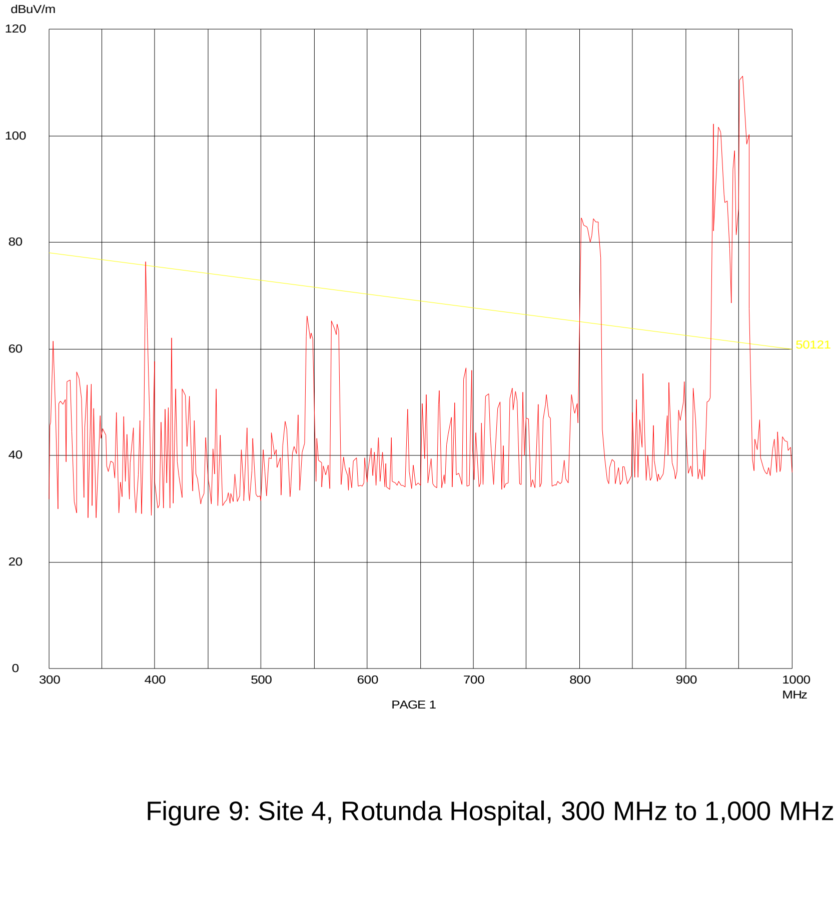


Figure 9: Site 4, Rotunda Hospital, 300 MHz to 1,000 MHz

The three mains sources of electromagnetic emissions from the proposed development have been discussed above. With the exception of licenced transmissions at specific frequencies the limits of EN 50121 will not be exceeded at 10 m distance from the rails and certainly not at ground level due to the earth acting as a natural attenuator to the Electric Fields that may exist in the frequency range of the ILS (75 – 335 MHz).