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#### **Executive Summary**

This report examines the potential for interference to social alarm systems from Long Term Evolution (LTE) user equipment (UE) operating in the 800 MHz band. The study tests the performance of an example social alarm in the real-life environment of a residential flat in a sheltered housing complex.

In June 2011 Ofcom published a report by ERA Technology Ltd and Aegis Systems Ltd considering the potential for interference from LTE UE into a wide range of Short Range Devices (SRDs) operating in the 863 – 870 MHz band [3].

In that earlier study, measurements were undertaken under controlled laboratory conditions using a simulated 800 MHz UE interferer. In addition, emissions were recorded directly from a UE emulator developed by a leading equipment vendor. The tests were designed to derive Carrier-to-Interference (C/I) protection ratios, which in turn were used to generate estimates for the protection distances required to avoid interference from LTE 800 MHz UE devices to SRD equipment. Using somewhat worst-case assumptions about UE operation and wanted SRD signal level, the results suggested that there is a potential risk of interference to certain types of SRD.

This report builds on the earlier work and considers the potential for interference into a social alarm installed as part of a Telecare system in a social housing complex in the London Borough of Lambeth. Interference to Telecare systems is of particular concern since they provide a mix of facilities for infirm and disabled people including self and/or automatically triggered alarms.

The alarm unit was subjected to discontinuous (time varying) LTE 800 MHz UE emissions captured from an emulator developed by a leading LTE equipment vendor. These were the same recordings as used for the measurements in the previous study [3]. The UE emulator was configured for 20 Mbits/s and 10 Mbits/s data throughput, with out-of-band (OOB) spectral emissions adjusted to match, as closely as practicable, with the OOB requirements for FDD terminal stations defined in ECC/DEC/(09)03 [6].

The tests were then repeated with the UE OOB emissions adjusted to be 5 dB and 10 dB better than the ECC requirement. Although these values are somewhat arbitrary, they do represent the possibly more realistic scenario of a UE handset designed to have better performance than the ECC minimum requirement.

The results show that, under worst case assumptions, with the LTE UE located 2m from the social alarm hub unit and operating at the maximum permitted EIRP of 23 dBm, there is the potential for interference to the social alarm unit. However, when the OOB emissions were reduced to 10 dB below the ECC requirement, as may be considered more representative of



a real device, the alarm was successfully triggered from all locations inside the flat, and all locations except the very furthest point in the complex's communal garden; this location was found to be close to the limit of the tested systems' operating range without the LTE interferer transmitting.

When the LTE UE was placed at other locations in the flat and garden, with OOB emissions 10 dB below the ECC requirement, the alarm was successfully triggered from all locations. This is most likely due to a combination of the lower OOB emissions and reduced interfering signal strength received at the social alarm hub unit.



#### Contents

			Page No.
1.	Intr	oduction	9
2.	Test	t Location	10
3.	Test	t Setup	12
	3.1	Wanted signal	12
	3.2	Interfering Signal	13
	3.3	Interference Criterion	16
	3.4	Test Method	16
4.	Res	ults	18
5.	Con	clusions	29
6.	Refe	erences	30
Арр	Appendix A RF propagation characteristics		31
Арр	endix	B Results of blocking measurements	39

Appendix C Comparison of minimum sensitivity between different social alarms 48



#### **Tables List**

Table 1: Social alarm device tested in this study	12
Table 2: Out-of-band requirements for FDD terminal stations	13
Table 3: Body attenuation loss at 869.215 MHz with different postures	33
Table 4: Received Pendant Signal Strength	34
Table 5: Measured signal strength for different pendant orientations	36
Table 6: Signal strength from different trigger units	37
Table 7: Measured penetration losses         Table 0: Distance from measurement location to cooled clarms hub with	37
Table 8: Distance from measurement location to social alarm hub unit	38
Table 9. Comparison of minimum sensitivity between unrefent social dialitis	49

## **Figures List**

#### Page No.

Figure 1: 800 MHz band plan	9
Figure 2: Plan view of test flat with measurement locations (units in cm)	0
Figure 3: View of test flat from communal garden 1	1
Figure 4: Trigger pulse from social alarm pendent (shown in time domain)	3
Figure 5: Generation of LTE UE interferer 1	4
Figure 6: Spectral emissions of LTE UE Profile 1, 2 and 3: 20 Mbits/s (100 kHz RBW) 1	5
Figure 7: Spectral emissions of LTE UE Profile 4: 10 Mbits/s 1	6
Figure 8: LTE UE at location 2, pendant triggered from standing position	9
Figure 9: LTE UE at location 2, pendant triggered from kneeling position	0
Figure 10: LTE UE at location 11, pendant triggered from standing position	1



Figure 11: LTE UE at location 11, pendant triggered from kneeling position 22
Figure 12: LTE UE at location 6, pendant triggered from standing position
Figure 13: LTE UE in vestibule, pendant triggered from standing position 24
Figure 14: LTE UE at location 7, pendant triggered from standing position
Figure 15: LTE UE at location 8, pendant triggered from standing position
Figure 16: LTE UE at location 9, pendant triggered from standing position
Figure 17: LTE UE at location 12, pendant triggered from standing position
Figure 18: Received Social alarm pendant signal levels
Figure 19: Body loss (Subject A) effects at different locations
Figure 20: Social Alarm / LTE measured ratios 40



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# 1. Introduction

In March 2011 Ofcom published a consultation document setting out proposals for the award of spectrum in the 800 MHz and 2.6 GHz frequency bands [1]. The 800 MHz band is part of the digital dividend; the spectrum freed up as a result of the switchover from analogue to digital TV. Ofcom envisions this spectrum will be used to deliver the next generation of mobile broadband services using technologies such as LTE and WiMAX.

The harmonised frequency arrangements for the 800 MHz band are set out in ECC Decision 2010/267/EU [2], based on Frequency Division Duplex operation with the downlink located in the lower part of the band, from 791 – 821 MHz, an 11 MHz duplex gap between 821 – 832 MHz and then the uplink located from 832 – 862 MHz. The band plan is illustrated in the figure below.



Figure 1: 800 MHz band plan

In June 2011 Ofcom published a report from ERA Technology and Aegis Systems on the potential for interference from 800 MHz LTE UE equipment transmitting in the 832 – 862 MHz band into SRDs operating in the adjacent 863 – 870 MHz band [3]. The results of that study indicated that, under certain assumptions about UE operation and wanted SRD signal level, there is the potential for interference into some types of SRD equipment if the UE is placed within a certain minimum distance of the receiving unit.

SRD devices operate in unlicensed spectrum and therefore have no right of protection from interference. However, the potential for interference into one category of SRD, known as social alarms, does raise cause for concern because these devices are typically used by infirm and disabled people to summon assistance in the event of a fall or other incident.

ERA Technology was therefore commissioned to undertake further testing on a social alarm installed as part of a Telecare system in the London Borough of Lambeth. ERA worked with Ofcom's engineers to evaluate whether the installed alarm could be triggered from various locations in the test flat and communal garden while being subjected to a series of different LTE UE emission parameters.



# 2. Test Location

The measurements were undertaken in a ground floor flat and communal garden that forms part of a social housing complex in the London Borough of Lambeth. The layout of the flat and the test locations are shown in the following figure. The distance between each location and the social alarm hub unit is included in Appendix A.6.



Figure 2: Plan view of test flat with measurement locations (units in cm)



The flat is of standard construction, with brick walls and double glazed windows looking out onto the communal garden. The front door is accessed from a communal corridor and opens into a vestibule which connects the living room, the kitchen, a small study, the bedroom and the toilet/bathroom. There are two small storerooms located next to the kitchen and the study. Ceiling height is 2.26m.

There is a mature garden at the rear of the flat, with some small bushes and trees between locations 12 and 13 and the living room. A view from the corner of the garden (location 17 in Figure 2) looking back at the test flat is shown in Figure 3.



Figure 3: View of test flat from communal garden

The social alarm hub unit (base station) was installed in the living room (marked as SRD in Figure 2) next to a wall. The unit was connected to the Lambeth Telecare centre using a standard telephone connection.



# 3. Test Setup

# 3.1 Wanted Signal

Social alarm systems provide a mix of facilities for infirm and disabled people including self and/or automatically triggered alarms. Alarms can be triggered by sensors around a dwelling (to detect an overflowing bath for example) or on the person (to detect a fall for example). Such alarm signals are received by the hub unit which then communicates with a remote monitoring centre where appropriate action can be initiated.

The technical parameters of the social alarm assessed in this study are shown in Table 1.

Device	Frequency Band (MHz)	Typical Receiver Category
Social alarm	869.215	1

Table 1: Social alarm device tested in this study

The receiver category in the table above is defined in ETSI EN 300 220-1 [4] and is specified by the device manufacturer. Receiver category 1 is defined as *Highly reliable SRD communication media; e.g. serving human life inherent systems (may result in a physical risk to a person).* 

The majority of measurements were made with a body-worn pendent device used to trigger the alarm. This is attached to a lanyard and worn around the neck with the pendant in a vertical position. A limit set of measurements were also made using a flood detector as the trigger device. A receiving antenna was located in the vertical plane at a distance of 45cm from the hub unit to measure both the wanted and interfering signal strength.

The trigger signal is shown in Figure 4, captured in the time domain. The signal comprises three pulses, each pulse is about 0.3 second wide with a delay of 0.1 seconds between pulses. However it should be noted that according to the alarm manufacturer, each of the three pulses repeat the same information and only one pulse needs to be received to trigger the alarm.





Figure 4: Trigger pulse from social alarm pendent (shown in time domain)

# 3.2 Interfering Signal

Commission Decision ECC/DEC/(09)03 [6] sets out the technical parameters that apply to the use of the 800 MHz band by networks other than high-power broadcasting networks. The technical licence conditions that Ofcom proposes to adopt for the 800 MHz band are set out in a consultation document published in June 2011 [7] and are fully consistent with the ECC/DEC/(09)03 parameters. The out-of-band requirements for FDD terminal stations defined in ECC/DEC/(09)03 are shown in Table 2 below.

Frequency offset from FDD (lower/upper) block edge	Maximum mean out-of- band power	Measurement bandwidth
822 MHz to -5 MHz from FDD uplink lower channel edge	-6 dBm	5 MHz
-5 to 0 MHz from FDD uplink lower channel edge	1.6 dBm	5 MHz
0 to +5 MHz from FDD uplink upper channel edge	1.6 dBm	5 MHz
+5 MHz from FDD uplink upper channel edge to 862 MHz	-6 dBm	5 MHz

Table 2: Out-of-band r	equirements for	r FDD terminal	stations
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LTE 800 MHz technology is in the early stages of roll-out and at the time of this study there were no "real" UE handsets available for testing. In order to investigate the impacts of discontinuous (time varying) LTE emissions into social alarms we have used emissions



captured from an emulator (approximately the size of a netbook computer) developed by a leading LTE equipment vendor. The UE emulator was configured for 20 Mbits/s and 10 Mbits/s data throughput. In each case the resource block allocation and sub-frame usages were adjusted automatically according to the vendor's UE scheduler.

The captured signal was played back through a signal generator and amplified by an overdriven amplifier to create spectral re-growth. The signal was then filtered such that the resultant spectral emission mask conformed as closely as possible to the out-of-band requirements for FDD terminal stations defined in Table 2. The transmit power was controlled using a variable attenuator to step the entire mask up or down, thus maintaining the same Adjacent Channel Leakage Ratio throughout the testing. The equipment setup is shown in Figure 5 below.



Figure 5: Generation of LTE UE interferer

The methodology used to generate the interfering signals is the same as that used in the report 'Investigation on the receiver characteristics of SRD equipment in the 863 – 870 MHz band' [3].

Four LTE UE emission profiles have been considered in the testing:

- Profile 1: 20 Mbits/s data throughput, 23 dBm/10 MHz in-band power, OOB emission mask tuned to match the ECC/DEC/(09)03 requirement;
- Profile 2: 20 Mbits/s data throughput, 23 dBm/10 MHz in-band power, OOB emission mask tuned to be 5 dB below the ECC/DEC/(09)03 requirement;
- Profile 3: 20 Mbits/s data throughput, 23 dBm/10 MHz in-band power, OOB emission mask tuned to 10 dB below the ECC/DEC/(09)03 requirement;



• Profile 4: 10 Mbits/s data throughput, 10 dBm/10 MHz in-band power, amplifier and filter settings preserved from Profile 1<sup>1</sup>.

Profile 1 represents a somewhat worst-case scenario which is considered unlikely to arise in practice. However, it does reflect the potential situation of a UE device operating at maximum permitted power, using full resource block allocation and engineered to just meet the minimum OOB requirement of ECC/DEC/(09)03.

Profiles 2 and 3 are better than the ECC requirement. Although these values are somewhat arbitrary, they do represent the more realistic scenario of a UE handset designed to have better performance than the ECC minimum requirement, as evidenced by measurements of real emissions from UMTS UE handsets [8].

The spectral emissions of these profiles are shown in Figure 6 and Figure 7 below, along with the mask of ECC/DEC/(09)03.



#### LTE UE emulator spectrum emissions

Figure 6: Spectral emissions of LTE UE Profile 1, 2 and 3: 20 Mbits/s (100 kHz RBW)

<sup>&</sup>lt;sup>1</sup> The in-band power for 10 Mbits/s data throughput (profile 4) is lower due to the configuration of the LTE vendor's emulator and the lower number of resource blocks in use.

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#### LTE UE emulator spectrum emissions



#### 3.3 Interference Criterion

The key receiver characteristic of interest to this study is blocking / desensitisation. This is usually defined as "a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unmodulated input signal at any frequency within a defined distance".

Blocking / desensitisation performance for social alarms is defined in BS EN 50134 -3:2001 [5] as "inhibiting reception of alarm triggering signal".

#### 3.4 Test Method

In order to determine if the wanted social alarm signal was blocked by interference from LTE UE emissions the alarm was triggered by a body-worn pendant being activated from a number of different test locations in the flat and communal garden. At each test location different LTE emission profiles described above were applied and the pendant was triggered from two positions:

• Standing position: the test subject triggered the pendant in the front of the chest, facing away from the social alarm hub unit.



• Kneeling position: the test subject triggered the pendant from a kneeling position, facing away from the social alarm hub unit. This position is suggested by the social alarm vendor as the more common trigger position, representing a fall.

In both positions additional signal loss occurs due to "body-loss" effects, i.e. shielding of the wanted signal by the human body. The results of body-loss from different test subjects are included in Appendix A.2. Note, all testing was carried out by the same person.

The results were repeated with the LTE UE transmissions positioned at locations inside the flat and in the garden:

- In the living room, 2m from the social alarm hub unit (location 2);
- In the communal garden, near to the living room wall (location 11).

Limited testing was also undertaken with the LTE UE at a variety of other locations including the kitchen, vestibule, study, bedroom and bathroom.

For each test location both the wanted social alarm trigger signal and interfering LTE UE signal strength were recorded at the hub unit.



# 4. Results

The receiver blocking results are shown in Figure 8 to Figure 17 below. The four LTE UE profiles are represented by different symbols, which are then colour coded to represent the following results:

- Pass: The alarm was successfully triggered;
- Fail, pass when retest: marginal result the alarm failed to trigger at the first attempt but was successfully triggered when re-tested;
- Fail: The alarm failed to trigger.

Figure 8 and Figure 9 show the results for the UE in the living room, 2m from the social alarm hub unit (location 2), and the alarm triggered from either a standing or kneeling position at a number of different locations. The results show that when the UE was operating at 20 Mbits/s, with out-of-band emissions close to the ECC/DEC/(09)03 requirement, there were two locations inside the flat where the alarm failed to trigger (locations 6 and 9). The alarm also failed to trigger from the corridor and any location in the garden.

When the UE OOB emissions were reduced to 10 dB below the ECC requirement the alarm was successfully triggered from all locations inside the flat and corridor. Similarly for the garden, when the UE OOB emissions were assumed to be 10 dB below the ECC requirement then the alarm was successfully triggered from all locations except the very furthest point in the garden (location 19) when kneeling.

Figure 10 shows that when the LTE UE was moved to the garden, near to the living room wall (representing an LTE user outside the premises), the alarm was triggered from all locations inside the flat regardless of the level of the OOB emissions. However, the alarm failed to trigger from 50% of locations in the garden unless the OOB emissions were reduced to be 10 dB below the ECC requirement.

Figure 12 through to Figure 17 show that when the LTE UE was placed at other locations in the flat and garden (representing an LTE user in neighbouring rooms or premises), with 20 Mbits/s data throughput and OOB emissions 10 dB below the ECC requirement, the alarm was successfully triggered from all locations.





Figure 8: LTE UE at location 2, pendant triggered from standing position





Figure 9: LTE UE at location 2, pendant triggered from kneeling position





Figure 10: LTE UE at location 11, pendant triggered from standing position





Figure 11: LTE UE at location 11, pendant triggered from kneeling position





Figure 12: LTE UE at location 6, pendant triggered from standing position





Figure 13: LTE UE in vestibule, pendant triggered from standing position





Figure 14: LTE UE at location 7, pendant triggered from standing position





Figure 15: LTE UE at location 8, pendant triggered from standing position





Figure 16: LTE UE at location 9, pendant triggered from standing position





Figure 17: LTE UE at location 12, pendant triggered from standing position



# 5. Conclusions

Interference measurements have been undertaken on a social alarm installed as part of a Telecare system operated by the London Borough of Lambeth. The alarm unit was subjected to discontinuous (time varying) LTE 800 MHz UE emissions captured from an emulator developed by a leading LTE equipment vendor. The UE emulator was configured for 20 Mbits/s and 10 Mbits/s data throughput, with out-of-band spectral emissions adjusted to match, as closely as practicable, with the out-of-band requirements for FDD terminal stations defined in ECC/DEC/(09)03. The tests were then repeated with the UE OOB emissions adjusted to be 5 dB and 10 dB better than the ECC requirement. Although these values are somewhat arbitrary, they do represent the more realistic scenario of a UE handset designed to have better performance than the ECC minimum requirement.

The social alarm unit was triggered by a body-worn pendant from a number of different locations inside the test flat and from the communal garden. The tests were repeated for the LTE UE also positioned in different locations with respect to the social alarm hub (base) unit.

The results show that, under somewhat worst case assumptions, with the LTE UE located 2m from the social alarm hub unit, operating at the maximum permitted EIRP of 23 dBm and with out-of-band emissions close to the ECC/DEC/(09)03 minimum requirement, there is the potential for interference to the social alarm unit; the alarm failed to trigger from two locations inside the flat and from any location in the communal garden or corridor. As would be expected in this situation the LTE UE interferer, in effect, reduces the range of the social alarm pendant.

When the UE OOB emissions were reduced to 10 dB below the ECC requirement, as may be considered more representative of a real device, the alarm was successfully triggered from all locations inside the flat, and all locations except the very furthest point in the garden; this location was found to be close to the limit of the tested systems' operating range without the LTE interferer transmitting.

When the LTE UE was placed at other locations in the flat and garden, with OOB emissions 10 dB below the ECC requirement, the alarm was successfully triggered from all locations. This is most likely due to a combination of the lower OOB emissions and reduced interfering signal strength received at the social alarm hub unit due to increased separation.



#### 6. References

- [1] Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, Ofcom consultation, 22<sup>nd</sup> March 2011 (<u>http://stakeholders.ofcom.org.uk/consultations/combined-award/</u>)
- [2] European Commission Decision of 6 May 2010 on harmonised technical conditions of use in the 790 – 862 MHz frequency band for terrestrial systems capable of providing electronic communications services in the European Union (2010/267/EU) <u>http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010D0267:EN:NOT</u>
- [3] Investigation on the receiver characteristics of SRD equipment in the 863 870 MHz band, ERA Technology Ltd and Aegis Systems Ltd, June 2011. Available from: http://stakeholders.ofcom.org.uk/consultations/technical-licence-conditions/
- [4] ETSI EN 300 220-1: Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods.
- [5] BS EN 50134-3:2001 Alarm systems Social alarm systems Part 3: Local unit and controller.
- [6] European Commission Decision of 30 October 2009 on harmonised conditions for mobile/fixed communications networks (MFCN) operating in the band 790 - 862 MHz (ECC/DEC/(09)03).
   (http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCDEC0903.PDF)
- [7] Consultation and information on technical licence conditions for 800 MHz and 2.6 GHz spectrum and related matters, Ofcom consultation, 2<sup>nd</sup> June 2011 (<u>http://stakeholders.ofcom.org.uk/consultations/technical-licence-conditions/</u>)
- [8] ERA report 2008-0234 for Ofcom, Measurements of UTRA FDD user Equipment characteristics in the 2.1 GHz band, 2008.



Appendix A RF propagation characteristics



#### A.1. Variation in Received Signal Level

The received social alarm pendant signal level from the locations around the flat is shown in Figure 18. The square mark represents the average received signals (from standing positions) at the location, and the vertical line represents the range of the received signal level.



Figure 18: Received Social alarm pendant signal levels

It can be seen that the signal level varies by around 10 dB. This could be due to a combination of the following factors:

- The orientation of the pendant; the effects of polarisation orientation can introduce 15 dB difference, as detailed in section A.3
- The body attenuation losses, as detailed in section A.2
- The receiving antenna was not co-located with the antenna of the social alarm hub unit; a 45cm distance was maintained between the two antennas to reduce the effects of any coupling loss. Although this may change the overall signal level, it would not be expected to significantly affect the variation in signal level.



#### A.2. Body Loss Effects

Indicative measurements of body-loss were obtained for three different test subjects with the pendant triggered in the following postures:

- Posture 1: standing up, facing away from the social alarm hub unit, pendant at chest height;
- Posture 2: laying on the floor over the pedant, facing away from the hub unit;
- Posture 3: kneeling down and leaning over the pendant, facing away from the hub unit.

The results, measured at 869.215 MHz and location 2, are summarised in the table below. It can be seen that, in general, the highest loss was observed when the test subject was laying on the floor over the pendant. Posture 3 is more typical of how the pendant is likely to be used in practice. Generally posture 3 is expected to provide an increase in body loss when compared to posture 1. However, this is not seen in the results of Table 3. It is likely that choice of location2 (within the same room as the social alarm hub) is subject to several forms of reflection within the room and that when kneeling, the pendant is closer to the floor and therefore a different reflected path with lower propagation loss has become dominant. This is borne out by the received signal strength values presented in Table 4.

Subject (body mass)	Posture 1 (dB)	Posture 2 (dB)	Posture 3 (dB)
A (68 Kg)	9.5	17.9	8.6
B (72 kg)	16.5	29.0	9.3
C (115 kg)	16.6	26.8	10.6

Table 3: Body attenuation loss at 869.215 MHz with different postures

Table 4 shows that in general all locations show a reduced signal strength of up to 4dB (assessed as increased body loss) for all locations with the exception of locations 1 - 3 and 9 in the living room and toilet/bathroom respectively.



Location	Received Power	Received Power
	Posture 1 (dBm)	Posture 3 (dBm)
1 (Living room)	-77.7	-73.1
2 (Living room)	-70.1	-69.1
3 (Living room)	-76.9	-76.9
4 (Vestibule)	-76.8	-73.4
5 (Vestibule)	-83.7	-86.3
6 (Kitchen)	-78.2	-80.7
7 (Study)	-83.3	-85.5
8 (Bedroom)	-84.6	-88.9
9 (Toilet/bathroom)	-91.9	-88.9
10 (Corridor)	-93.2	-95
11 (Garden)	-81.9	-92.6
12 (Garden)	-88	-92.8
13 (Garden)	-91.8	-92.8
14 (Garden)	-89.6	-93.4
15 (Garden)	-92.9	-94.8
16 (Garden)	-94.9	-97.0 <sup>2</sup>
17 (Garden)	-90.6	-90.8
18 (Garden)	-89.6	-92.0

#### Table 4: Received Pendant Signal Strength

 $^{\rm 2}$  -97.0 dBm was within 0.5 dB of the measured noise floor in the environment



	19 (Garden)	-87.8	-92.6 <sup>3</sup>
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Subject A in Table 3 was used for all other testing in this report and Figure 19 below shows how the body loss varied at different measurement locations (Note: no measurements were made at location 10 or 14).

In all cases the body loss was calculated from the delta between received signal strength at the social alarm hub with the test subject facing towards the hub and then facing away from the hub. This assumed the dominant propagation path was the direct path between the test location and the hub. The large range in values for body loss at different locations indicates that this was not the case and that other reflected or diffracted paths may have been the most significant.



Figure 19: Body loss (Subject A) effects at different locations

<sup>&</sup>lt;sup>3</sup> Re-tested results are provided as Posture 3 at location 19 failed on the first attempt at -100.3dBm but passed when re-tested



#### A.3. Effects of Social Alarm Pendant Polarisation Orientation

The table below provides a summary of the effects of different pendant orientations on the received signal strength. The tests were conducted with the pendant at arm's length from the body, with no body blocking. A plastic button extension was used to reduce the effect of the subject's hand on the measurements. All tests were conducted at location 2 in the living room.

The results show that the orientation of the pendant when triggered can result in a variation in received signal strength of up to 20 dB. This is predominantly due to the effects of the propagation path and the pattern of the antenna within the pendant.

	Signal Strength
Pendant position	(dBm)
Away (Button facing away from the receiver)	-60.9
Towards (Button facing towards the receiver.)	-63.9
Away 90 degrees (lanyard to the side)	-65.4
Towards 90 degrees (lanyard to the side)	-69.5
Button facing down, lanyard towards receiver	-81.0
Button facing up, lanyard towards receiver	-70.0
Button facing up, lanyard away from receiver	-64.4
Button facing down, lanyard away from receiver	-75.3

#### Table 5: Measured signal strength for different pendant orientations

# A.4. Signal Strength of different Trigger Units

The table below shows the measured signal strength at the social alarm hub unit of different types of trigger unit installed at different locations around the flat. It should be noted that the pendant in the nearest equivalent location for the flood alarm (location 2 and location 9) and the smoke detector (location 4) has lower received signal strength by approximately 10dB, 10dB and 20dB respectively with reference to Figure 18 than the devices in the table below. The bogus call button has a similar received signal level to the pendant in location 4.



Devices	Device Locations	Signal level (dBm)
Flood alarm	living room location 2	-63.5
Flood alarm	Floor of toilet	-76.3
Smoke alarm	Ceiling of Vestibule (height: 2.26m)	-51.3
Bogus call button	Front door (height: 1.5m)	-73.2

#### Table 6: Signal strength from different trigger units

#### A.5. Penetration Losses of different Obstacles

The measured penetration losses through different obstacles in and around the flat, measured at 857 MHz, are shown in the table below.

Obstacle	Penetration loss (dB) at 857MHz
Vegetation (2m high 2m wide perennial bush with dense leaves) [see Figure 3]	7.6
Internal wall	1.3
External wall	16.2
Window glass	7.8

#### Table 7: Measured penetration losses



#### A.6. Distance from Measurement Locations to Hub Unit

The distance between each test location, and the obstacles on the path, are shown in the table below. It should be noted that the dominant method of propagation may not necessarily have been through the obstacles shown.

Locations	Straight line	Obstacles along the straight line between
	distance (m)	measurement locations and Rx
1 (Living room)	1	Line of sight
2 (Living room)	2	Line of sight
3 (Living room)	3	Line of sight
4 (Vestibule)	2	2 internal walls
5 (Vestibule)	4.7	2 internal walls and 1 door
6 (Kitchen)	3.4	1 internal wall
7 (Study)	3.9	2 internal walls
8 (Bedroom)	7.4	3 internal walls
9 (Toilet/bathroom)	6.9	6 internal walls
10 (Corridor)	8.3	5 internal walls and 2 doors
11 (Garden)	5.0	1 external wall
12 (Garden)	11.5	1 external wall and vegetation
13 (Garden)	11.2	1 external wall and vegetation
14 (Garden)	12.1	1 internal wall, 1 window and vegetation
15 (Garden)	14.0	2 internal walls, 1 window and vegetation
16 (Garden)	16.3	2 internal walls, 1 external wall and vegetation
17 (Garden)	15.3	1 external wall and vegetation
18 (Garden)	17.0	1 internal wall, 1 window and vegetation
19 (Garden)	23.5	2 internal walls, 1 external wall and vegetation

#### Table 8: Distance from measurement location to social alarm hub unit



Appendix B Results of Blocking Measurements



The wanted (C) and interfering (I) signal strengths measured at the social alarm hub unit are summarised in the following tables. The wanted signal is from the pendant, measured in a 10 kHz resolution bandwidth centred on 869.215 MHz; the interfering signal is from the LTE UE in block power, measured in a 10 MHz resolution bandwidth centred on 857.0 MHz.

The red colour represents a "fail" of the social alarm system, i.e. the alarm failed to trigger; yellow represents the "marginal" condition where the alarm failed to trigger at the first attempt but was successfully triggered when reset. The ratio of C/I is also shown, for information only; this should not be confused with the C/I protection ratio required to protect the social alarm from interference as no testing was undertaken to determine the exact failure point.

Figure 20 shows the measured social alarm versus LTE signal level ratios for all profiles as detailed in the following subsections. It can be seen that there is some overlap between pass and fail, indicating that it is not entirely blocking caused by the presence of the LTE signal that prevents the social alarm from triggering and that the impact of the LTE modulation and time varying signals may also have some effect.



#### Figure 20: Social Alarm / LTE measured ratios



Pendant	I (dBm) at	C (dBm), standing	Ratio	C (dBm), kneeling	Ratio
		standing	standing	Kneening	Kiteening
1	-18.1*	-63.3	-45.2	-67.6	-49.5
2	N/A	N/A	N/A	N/A	N/A
3	-17.00*	-70.1	-53.1	-74.0	-57.0
4	-16.2	-72.7	-56.5	-78.8	-62.6
5	-16.2	-83.4	-67.2	-86.4	-70.2
6	-16.6	-73.7	-57.1	-85.3	-68.7
7	-16.8	-70.7	-53.9	-86.1	-69.3
8	-16.5	-84.3	-67.8	-87.2	-70.7
9	-16.9	-86.4	-69.5	-82.1	-65.2
10	-16.4	-92.5	-76.1	-87.1	-70.7
11	-16.2	-78.4	-62.2	-85.7	-69.5
12	-16.1	-89.3	-73.2	-90.0	-73.9
13	-15.8	-89.0	-73.2	-87.6	-71.8
14	-17.1	-90.7	-73.6	-88.0	-70.9
15	-15.7	-92.0	-76.3	-90.3	-74.6
16	-16.0	-94.5	-78.5	-90.7	-74.7
17	-15.8	-89.6	-73.8	-89.5	-73.7
18	-16.2	-91.4	-75.2	-88.9	-72.7
19	-16.3	-91.6	-75.3	-88.9	-72.6

#### B.1. Blocking Observations with LTE UE Profile 1

\* Note the received power from the LTE is slightly affected by the presence of the test engineer within the room for positions 1 and 3.



Pendant	I (dBm) at	C (dBm),	Ratio standing
location	location 11	standing	
1	-34.6	-69.0	-34.4
2	-35.0	-74.9	-39.9
3	-35.1	-68.6	-33.5
4	-29.8	-74.8	-45.0
5	-29.6	-78.5	-48.9
6	-29.9	-81.9	-52.0
7	-29.6	-79.6	-50.0
8	-30.6	-84.3	-53.7
9	-31.2	-86.4	-55.2
10	-29.1	-92.5	-63.4
11	-28.3	-74.8	-46.5
12	-27.8	-89.3	-61.5
13	-28.6	-89.0	-60.4
14	-29.5	-90.7	-61.2
15	-28.3	-92.0	-63.7
16	-27.0	-94.5	-67.5
17	-27.0	-89.6	-62.6
18	-27.1	-91.4	-64.3
19	-27.0	-91.6	-64.6

# B.2. Blocking Observations with LTE UE Profile 2

Pendant location	I (dBm) at location 2	C (dBm), standing	Ratio standing	C (dBm), kneeling	Ratio kneeling
1	-17.0	-71.8	-54.8	-68.4	-51.4
2	N/A	N/A	N/A	N/A	N/A
3	-14.1	-74.8	-60.7	-73.2	-59.1
4	-16.8	-70.3	-53.5	-70.3	-53.5
5	-16.3	-78.2	-61.9	-77.1	-60.8
6	-16.5	-75.6	-59.1	-85.3	-68.8
7	-16.6	-76.0	-59.4	-86.1	-69.5
8	-16.3	-84.3	-68.0	-87.2	-70.9
9	-16.5	-86.4	-69.9	-82.1	-65.6
10	-16.1	-92.5	-76.4	-87.1	-71.0
11	-16.2	-78.4	-62.2	-85.7	-69.5



Pendant location	I (dBm) at location 2	C (dBm), standing	Ratio standing	C (dBm), kneelina	Ratio kneeling
			3		j
12	-17.2	-89.3	-72.1	-90.0	-72.8
13	-17.2	-89.0	-71.8	-87.6	-70.4
14	-17.0	-90.7	-73.7	-88.0	-71.0
15	-16.5	-92.0	-75.5	-90.3	-73.8
16	-16.0	-94.5	-78.5	-90.7	-74.7
17	-16.8	-89.6	-72.8	-89.5	-72.7
18	-16.8	-91.4	-74.6	-88.9	-72.1
19	-17.0	-91.6	-74.6	-88.9	-71.9

Pendant	I (dBm) at	C (dBm),	Ratio	C (dBm),	Ratio
location	location 11	standing	standing	kneeling	kneeling
1	-30.0	-70.9	-40.9	-65.1	-35.1
2	-30.0	-73.2	-43.2	-78.4	-48.4
3	-30.0	-74.2	-44.2	-74.4	-44.4
4	-30.0	-76.8	-46.8	-80.9	-50.9
5	-30.0	-82.8	-52.8	-88.7	-58.7
6	-30.0	-78.4	-48.4	-85.0	-55.0
7	-30.0	-80.6	-50.6	-87.9	-57.9
8	-30.0	-84.8	-54.8	-87.9	-57.9
9	-30.0	-89.1	-59.1	-81.2	-51.2
10	-30.0	-89.6	-59.6	-87.3	-57.3
11	-30.0	-75.1	-45.1	-85.5	-55.5
12	-30.0	-89.6	-59.6	-90.0	-60.0
13	-30.0	-89.8	-59.8	-87.6	-57.6
14	-30.0	-90.7	-60.7	-88.0	-58.0
15	-30.0	-88.9	-58.9	-90.3	-60.3
16	-30.0	-90.1	-60.1	-90.7	-60.7
17	-30.0	-86.1	-56.1	-89.5	-59.5
18	-30.0	-87.6	-57.6	-88.9	-58.9
19	-30.0	-87.2	-57.2	-88.9	-58.9

Note that in the above table the interference power (I) was only measured in one location due to time constraints.



Pendant location	I (dBm) at location 2	C (dBm), standing	Ratio standing	C (dBm), kneeling	Ratio kneeling
1	-18.0	-67.9	-49.9	-70.1	-52.1
2	N/A	N/A	N/A	N/A	N/A
3	-18.0	-70.4	-52.4	-73.5	-55.5
4	-18.0	-84.1	-66.1	-76.6	-58.6
5	-18.0	-79.6	-61.6	-84.1	-66.1
6	-18.0	-78.9	-60.9	-85.5	-67.5
7	-18.0	-83.8	-65.8	-84.2	-66.2
8	-18.0	-87.2	-69.2	-86.5	-68.5
9	-18.0	-85.9	-67.9	-82.9	-64.9
10	-18.0	-87.4	-69.4	-86.8	-68.8
11	-18.0	-87.5	-69.5	-85.9	-67.9
12	-18.0	-85.3	-67.3	-88.0	-70.0
13	-18.0	-87.4	-69.4	-88.1	-70.1
14	-18.0	-84.7	-66.7	-89.0	-71.0
15	-18.0	-85.6	-67.6	-89.0	-71.0
16	-18.0	-89.0	-71.0	-88.6	-70.6
17	-18.0	-85.2	-67.2	-89.0	-71.0
18	-18.0	-86.0	-68.0	-87.2	-69.2
19	-18.0	-87.3	-69.3	-88.9	-70.9

## B.3. Blocking Observations with LTE UE Profile 3

Note that in the above table the interference power (I) was only measured in one location due to time constraints.

Pendant	I (dBm) at	C (dBm),	Ratio	I (dBm) at	C (dBm),	Ratio
location	location 6	standing	standing	location 7	standing	standing
1	-35.0	-68.1	-33.1	-28.3	-64.4	-36.1
2	-37.0	-79.3	-42.3	-28.0	-82.5	-54.5
3	-35.8	-71.5	-35.7	-28.2	-76.4	-48.2
4	-34.4	-75.0	-40.6	-27.1	-74.2	-47.1
5	-35.1	-86.8	-51.7	-27.7	-84.1	-56.4
6	-43.3	-80.2	-36.9	-28.1	-80.1	-52.0
7	-33.0	-79.9	-46.9	-36.6	-80.0	-43.4
8	-32.9	-87.8	-54.9	-28.1	-86.1	-58.0



Pendant location	I (dBm) at location 6	C (dBm), standing	Ratio standing	I (dBm) at location 7	C (dBm), standing	Ratio standing
9	-32.4	-89.9	-57.5	-28.5	-81.2	-52.7
10	-33.3	-95.0	-61.7	-27.5	-89.9	-62.4
11	-33.1	-75.8	-42.7	-27.6	-74.3	-46.7
12	-33.5	-87.1	-53.6	-28.1	-93.8	-65.7
13	-33.0	-89.6	-56.6	-28.6	-89.9	-61.3
14	-33.1	-92.0	-58.9	-27.7	-92.6	-64.9
15	-33.6	-93.5	-59.9	-27.8	-92.4	-64.6
16	-33.8	-95.6	-61.8	-28.8	-96.3	-67.5
17	-33.8	-88.3	-54.5	-27.5	-87.0	-59.5
18	-33.9	-91.7	-57.8	-27.7	-89.5	-61.8
19	-34.3	-95.6	-61.3	-28.7	-89.1	-60.4

Pendant	I (dBm) at	C (dBm),	Ratio	I (dBm) at	C (dBm),	Ratio
location	location 8	standing	standing	vestibule	standing	standing
1	-35.4	-72.3	-36.9	-30.9	-64.4	-33.5
2	-36.7	-73.3	-36.6	-33.2	-70.8	-37.6
3	-37.7	-75.2	-37.5	-31.6	-82.4	-50.8
4	-35.7	-73.5	-37.8	-29.2	-75.1	-45.9
5	-37.2	-85.6	-48.4	-30.9	-79.6	-48.7
6	-34.8	-80.4	-45.6	-31.3	-85.9	-54.6
7	-35.4	-75.9	-40.5	-32.8	-77.8	-45.0
8	-35.8	-84.4	-48.6	-30.5	-81.6	-51.1
9	-35.4	-87.6	-52.2	-30.5	-90.6	-60.1
10	-35.5	-95.5	-60.0	-31.0	-97.0	-66.0
11	-35.4	-80.4	-45.0	-29.6	-77.6	-48.0
12	-35.6	-95.8	-60.2	-29.8	-90.3	-60.5
13	-35.1	-94.9	-59.8	-31.4	-87.1	-55.7
14	-36.0	-90.2	-54.2	-32.5	-91.0	-58.5
15	-35.2	-93.3	-58.1	-33.2	-95.0	-61.8
16	-35.9	-98.0	-62.1	-33.1	-96.3	-63.2
17	-35.7	-89.0	-53.3	-33.0	-89.1	-56.1
18	-35.8	-95.4	-59.6	-32.3	-87.8	-55.5
19	-35.9	-92.0	-56.1	-33.2	-89.5	-56.3



Pendant	I (dBm) at	C (dBm),	Ratio	I (dBm) at	C (dBm),	Ratio
location	location 9	standing	standing	location 11	standing	standing
1	-40.3	-67.8	-27.5	-34.2	-64.5	-30.3
2	-41.6	-82.0	-40.4	-35.5	-74.8	-39.3
3	-41.2	-75.0	-33.8	-32.5	-72.7	-40.2
4	-39.7	-73.3	-33.6	-30.6	-73.9	-43.3
5	-38.7	-83.0	-44.3	-29.7	-87.5	-57.8
6	-37.7	-83.6	-45.9	-29.9	-79.5	-49.6
7	-37.0	-74.9	-37.9	-29.9	-79.2	-49.3
8	-38.7	-78.4	-39.7	-30.5	-82.9	-52.4
9	-44.0	-86.6	-42.6	-29.6	-82.1	-52.5
10	-38.6	-94.5	-55.9	-29.1	-93.6	-64.5
11	-38.5	-76.3	-37.8	-30.5	-74.6	-44.1
12	-38.7	-90.3	-51.6	-29.1	-87.6	-58.5
13	-38.1	-88.0	-49.9	-29.2	-87.1	-57.9
14	-38.4	-92.1	-53.7	-29.2	-90.5	-61.3
15	-38.4	-93.8	-55.4	-30.1	-92.9	-62.8
16	-38.2	-98.0	-59.8	-29.1	-96.1	-67
17	-38.0	-96.0	-58	-29.1	-90.6	-61.5
18	-38.0	-95.5	-57.5	-29.2	-89.3	-60.1
19	-38.4	-92.1	-53.7	-29.1	-91.7	-62.6

Pendant location	I (dBm) at location 12	C (dBm), standing	Ratio standing
1	-38.0	-72.3	-34.3
2	-37.7	-77.4	-39.7
3	-39.2	-72.2	-33.0
4	-38.6	-75.0	-36.4
5	-38.3	-84.0	-45.7
6	-39.6	-93.4	-53.8
7	-39.6	-79.4	-39.8
8	-38.3	-88.4	-50.1
9	-39.3	-82.8	-43.5
10	-39.2	-92.6	-53.4
11	-38.3	-74.6	-36.3



Pendant	I (dBm) at	C (dBm),	Ratio standing
location	location 12	standing	
12	-38.3	-83.9	-45.6
13	-38.1	-88.3	-50.2
14	-38.4	-89.8	-51.4
15	-38.5	-93.2	-54.7
16	-37.7	-96.0	-58.3
17	-38.1	-92.7	-54.6
18	-38.4	-93.4	-55.0
19	-37.9	-96.0	-58.1

# B.4. Blocking Observations with LTE UE Profile 4

Pendant location	I (dBm) at location 2	C (dBm), standing	Ratio standing
1	-33.2	-66.5	-33.3
2	-38.1	-69.8	-31.7
3	-35.6	-75.8	-40.2
4	-35.8	-79.6	-43.8
5	-35.7	-78.0	-42.3
6	-35.1	-86.3	-51.2
7	-36.6	-81.7	-45.1
8	-38.6	-90.1	-51.5
9	-38.3	-89.9	-51.6
10	-36.0	-87.7	-51.7
11	-36.3	-87.0	-50.7
12	-37.8	-90.7	-52.9
13	-37.0	-91.7	-54.7
14	-36.8	-91.8	-55.0
15	-36.6	-91.4	-54.8
16	-37.3	-88.6	-51.3
17	-35.5	-95.5	-60.0
18	-36.3	-95.6	-59.3
19	-33.2	-66.5	-33.3



# Appendix C Comparison of Minimum Sensitivity between different Social Alarms



#### C.1. Minimum Sensitivity

Following completion of the test programme in the social housing unit in Lambeth, Ofcom requested some additional lab measurements to determine the minimum receiver sensitivity for a social alarm from two alternative manufacturers. The table below shows how the results compare with the alarm used in the Lambeth testing.

	Table 9: Com	parison of minimum	sensitivity between	different social alarms
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Social Alarm	Minimum receiver sensitivity (dBm)
A (used in Lambeth testing)	-107.9
В	-103.9
С	-109.4

The results show that all three alarm systems have a similar minimum sensitivity, which suggests that Alarm B and C will have similar performance to the device tested in Lambeth (although this has not been verified through testing). It should be noted that one device tested utilised a 2 way system that allows the user to know that the alarm has been activated via the pendant as well as the hub.