



JOINT OPERATORS TECHNICAL SPECIFICATION OF GSM, UMTS & LTE INDOOR CELLULAR SYSTEM

SCOPE

This document defines the requirements of indoor cellular system for GSM, UMTS and LTE operation. It covers the design and test requirements, and the characteristics of the elements used in the system where the network performance is affected.

It also defines the scope of work and the expected deliveries from the contractor during the different phases of a project.

It is expected that the contractor will be responsible for the maintenance of the indoor cellular system, therefore a high level service level agreement is described.

PURPOSE

This document will be used by the neutral host contractor (NHC) for the design and implementation of indoor cellular systems for the GSM, UMTS and LTE operation.



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ACKNOWLEDGEMENT

This document is created with inputs and contributions from the current UK 2G and 3G cellular operators EE, Three, O₂ and Vodafone.

REFERENCES.

- 1 3GPP TS 25.104, Technical Specification Group Radio Access Network; Base Station (BS) radio transmission and reception (FDD)
- 2 3GPP TS 25.101, Technical Specification Group Radio Access Network; User Equipment (UE) radio transmission and reception (FDD)
- 3 3GPP TS 45.005, Technical Specification Group GSM/EDGE Radio Access Network; Radio Transmission and Reception
- 4 3GPP TS 36.101, Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception
- 5 3GPP TS 36.104, Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception
- 6 3GPP TS 25.106, Technical Specification Group Radio Access Network; UTRA repeater radio transmission and reception
- 7 3GPP TS 36.106, Evolved Universal Terrestrial Radio Access (E-UTRA); FDD repeater radio transmission and reception
- 8 International Commission on Non-Ionizing Radiation Protection (ICNIRP), Guidelines for Limiting Exposure to Time Varying Electric, Magnetic and Electromagnetic Fields (Up to 300GHz), Vol 74, No. 4 April, 1998.
- 9 BSI EN 50383, Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunications system (110MHz – 40 GHz)
- 10 IEE Wiring Regulations (BS7671), Jan. 2008

ABBREVIATIONS

3GPP	3 rd Generation Partnership Project
BCCH	Broadcast Control Channel
ACI	Adjacent Channel Interference
ACIR	Adjacent Channel Interference Ratio
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
C/N	Carrier-to-Noise
CNO	Cellular Network Operator
CPICH	Common Pilot Channel
CW	Continuous Wave (i.e. constant power and amplitude)
DAS	Distributed Antenna System
dB _i	Decibels relative to the gain of an isotropic antenna
dB _m	Decibels relative to a milliwatt
DECT	Digital Enhanced Cordless Telecommunications
DIN	Deutsches Institute for Normung (Germans Standards Institute)
DL	Downlink
E _b /I _o	Energy per bit/total received signal
E _c /I _o	Energy per chip/ total received signal
EIRP	Effective Isotropic Radiated Power
EMF	Electromagnetic Fields
ER	Exposure Ratio
ETSI	European Telecommunications Standards Institute
EVM	Error Vector Magnitude
FDD	Frequency Division Duplex
GSM	Global System for Mobile Communication
GSM-R	GSM-Railway
HOT	Heads of Terms
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEE	Institution of Electrical Engineers
LOI	Location of Interest
LTE	Long Term Evolution
M&E	Mechanical and Electrical
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MCL	Minimum Coupling Loss
MIMO	Multiple Input Multiple Output
MT	Mobile Terminal
NDA	Non-Disclosure Agreement
NGR	National Grid Reference
NHC	Neutral Host Contractor
NMAS	National Measurement Accreditation Service
PCDE	Peak Code Domain Error
PMR	Private Mobile Radio
POI	Point of Interconnect
ppm	Parts per million
RBS	Radio Base Station
RE	Resource Element
RF	Radio Frequency
RI	Radiating Infrastructure
RS	Reference Signal of LTE
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
SAR	Specific Absorption Rate
SAT	System Acceptance Test
SIMO	Single Input Multiple Output
SLA	Service Level Agreement
TDD	Time Division Duplex
TRX	Transceiver
UL	Uplink

UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wide Band
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network

1. INTRODUCTION

Riding on the success of the 2G (GSM) & 3G (UMTS) joint operator neutral host projects in the UK, the 2G and 3G cellular network operators **EE, Three, Telefonica O₂ and Vodafone** agree to continue the scheme for the 4G (LTE) networks. With the recent completion of the LTE spectrum auction, **further changes of this document will be required due to the new LTE operator.** On the other hand, at least this document forms the baseline for the existing indoor system upgrade and the new deployment covering the requirements of both GSM, UMTS and LTE operations for the frequency bands given in Appendix A.

This document specifies the requirements of indoor cellular system for the 2G (GSM), 3G (UMTS) and 4G (LTE) operations of which the Cellular Network Operators (CNO) subscribe. The system will be designed, installed and tested by a Neutral Host Contractor (NHC) who has the full turn-key responsibility for delivering such system meeting the requirements defined in this document. The NHC can be either an independent third party or one of the CNO.

The indoor cellular system can take the form of a single radiating element or distributed radiating elements which can use omni antennas, sector antennas, radiating cables or a combination of both together with RF components and sub-systems. For convenience, such cellular system referred in this document is called distributed antenna system (DAS).

The technical requirements for both 2G, 3G and 4G operations are described in section 2. The coverage requirements, the system performance and the components characteristics are specified in details.

Section 3 defines the scope of work with which the NHC will provide.

It is expected that the NHC will be responsible for the maintenance of the DAS. Section 4 describes a high level Service Level Agreement (SLA) which will be negotiated under the commercial agreement with each individual CNO.

A DAS is only acceptable into operation when the NHC verifies and demonstrates to the CNO that the specifications defined in section 2 are met. Section 5 describes the system acceptance test requirements.

1.1 DOCUMENTATION STRUCTURE

The document is made up of sections dealing with different aspect of the 2G, 3G and 4G DAS. Each of the requirements is marked as **Q**, **I**, **R** or **M** defining the necessity. To qualify as a NHC, the Tender is required to answer the questions, requirements and mandatory requirements.

For the purpose of this document, NHC is used in the document for the successful Tender.

Question **Q** is normally raised to get information from the supplier aiming for a better understanding of the issue.

Information **I** is supporting information for the NHC to design the DAS.

Requirement **R** is raised when the performance of the DAS is required to fulfil the mobile cellular operation. Full details of compliance will be useful in supporting our evaluation. If the requirement cannot be fulfilled, the Tender should provide alternative solution and explain the effects of non-compliance.

Mandatory requirement **M** is a critical requirement for which Tender shall answer with a “Comply” or “Non-comply”. Details shall be provided where possible to support the evaluation.

1.2 QUALIFYING PROCESS

The Tender shall submit a soft copy of response in MS Word to each CNO for reviewing and making a decision on the suitability of the Tender to be a NHC. The Tender must response in full to the requirements. Where compliance is not possible, detailed explanation and alternatives shall be provided.

2. TECHNICAL SPECIFICATION OF THE DAS

2.1 GENERAL

1. R The NHC shall engage the CNO during the design stage.
2. M The DAS shall be capable of supporting radio signals of GSM, WCDMA and LTE technologies. Where the DAS incorporates other users such as the emergency services, public and private WLAN, the performance specification defined in this document shall not be compromised. However, such additional services should be contributing to the DAS CAPEX and OPEX cost.
3. M The DAS shall be with the provision of the capacity handling according to the expected traffic.
4. M The DAS shall cover the frequency bands given in Appendix A.
5. M The proposed DAS must be the most cost effective solution utilising the full capability of the CNO’s equipment. Details of the equipment are provided in separate document.
6. R The requirements of the DAS defined in this document are only applied to the general public accessible area. If non-public area is required by the site owner and/or a third party or a specific individual CNO, it shall be covered separately between the site owner and the party of interest.
7. M Where a location already has a DAS installed for the 2G or 3G operation, the NHC must carry out an assessment of the impact of upgrading the existing system for supporting all GSM, UMTS and LTE technologies. This is considered to be generally more cost effective. If this is not possible, a report on the shortcomings and a comparison of costs and performance between a new DAS and an upgrade to a sub-standard DAS shall be given in the design document.

8. M The DAS shall be of modular construction so that it can be easily expanded and upgraded for capacity reason by way of sectorisation, for example, without significantly compromising the existing performance.
9. M The upgrade shall minimise the disruption to the current operations.
10. M Although it is not essential that the 2G, 3G and 4G signals of a CNO shall be carried on the same sub-system, it is mandatory that the traffic of the same frequency band of the associated CNO shall be carried on the same sub-system.
11. R This document defines the technical specifications for a DAS supporting the operation of
 - GSM at 900MHz & 1800MHz bands,
 - UMTS at 900MHz, 1800MHz & 2100MHz bands and
 - LTE at 800MHz, 900MHz, 1800MHz, 2100MHz & 2600MHz bands
 - but excluding the GSM in the DECT guard band.
 - However, all passive components must be wide band covering both GSM, UMTS and LTE bands as given in Appendix-A except specific band selective units for the purpose of channelisation and filtering.
12. R Although there is no specific requirement defined for the DAS supporting the MIMO of the LTE at this stage and the baseline is referred to the LTE SIMO, the NHC should advise the potential upgrade paths of the DAS for accommodating the MIMO operation in future but without compromising the design and escalating the cost.
13. M The DAS shall be designed to operate with base station and mobile terminal meeting the 3GPP and ETSI standards [ref. 1-5]. Additionally, the DAS shall conform to all the current regulations, rules and the operation conditions imposed on CNOs by the UK Government and meet the 3GPP standards where appropriate i.e. [ref. 6 & 7].
14. M When either 2G, 3G or 4G is added to an existing system, it must be ensured that the systems and operations of both the 2G, 3G and 4G are compliant with the ETSI recommendations.
15. R The DAS shall be used in indoor and confined space environments such as, but not limited to, tunnel, shopping centres, conference and exhibition halls etc.

2.2 ASSUMPTIONS

16. R Where the DAS is used for in-building, road tunnel or high speed train tunnel, the propagation model and performance requirements specified in TS25.104 Case 1, Case 3 or Case 4 for a mobile terminal travelling at a speed up to 3km/hr, 120km/hr or 250km/hr respectively shall be used, or the highest mobile terminal travelling speed confined by the venue with an added 20% margin in the design for the purpose of call handover.
17. I Each of the CNOs shall provide the NHC with a specification pack detailing the mechanical, electrical and RF interface specifications of the base station equipment. This will be provided under separate cover and under the condition

of Non-Disclosure Agreement (NDA) with the NHC in order to comply with the confidentiality agreement between the CNO and their equipment vendors.

18. I Where information is not given by the CNO, the NHC can assume

- the 2G, 3G and 4G base station receiver noise figure of 4dB,
- Mobile terminal maximum transmit power of 30dBm, 21dBm and 23dBm for GSM, UMTS and LTE respectively,
- Mobile terminal minimum transmit power of 5dBm, 0dBm, -50dBm and -40dBm for GSM900, GSM1800, UMTS and LTE respectively,
- the dedicated indoor system should provide at least a dominant coverage of 6dB against the coverage from the external macro cell sites
- the dedicated indoor system delivers CPICH Ec/Io \geq -6dB with reference to the 3G cells of 20% loading (10% CPICH and 10% control signalling)
- a carrier-to-noise (C/N) ratio of 12dB for GSM voice calls in uplink and downlink, and
- 10% downlink RF composite power per 3G operating channel assigned to Common Pilot Channel (CPICH)
- Reference Signal (RS) power of LTE may be with 2.5dB boosting

19. R The following output level of a base station can be assumed, otherwise the lowest level and the highest level given in the CNO's standard pack shall be used for coverage design and power handling design respectively.

Base station type	Base station nominal output power per carrier	Power handling design per carrier (thermal consideration)
2G base station	40dBm	43dBm
3G base station	33dBm (CPICH), 43dBm (full load)	46dBm
4G base station (non-MBSFN transmission)	43dBm per 20MHz (12.2dBm of a resource element carrying a reference symbol (*))	46dBm per 20MHz

Table 1 : Base station output power.

Where an active DAS is proposed, the NHC shall provide a means to adjust the input level to the active elements if the DAS is sensitive to the output tolerance of the base station equipment. It is the responsibility of the NHC to provide appropriate safe guard protecting the DAS from overloading.

(*) For the system design, with reference to the downlink coverage requirements, it is referred to the linear average over the power contributions of the **Resource Elements** (the OFDM symbols) carrying **reference symbols only** instead of the full load power.

20. R For the purpose of coverage overlapping design including the tunnel portals to and from the CNO macro networks, the maximum and minimum handover time is 10 and 4 seconds respectively.

21. I The following link budget assumptions can be used for the purpose of the system design:

- body loss: 5dB
- car penetration loss: 7dB

2.3 THE DAS

22. R The DAS will comprise of a number of network sub-systems and interfaces as shown in figure 1.

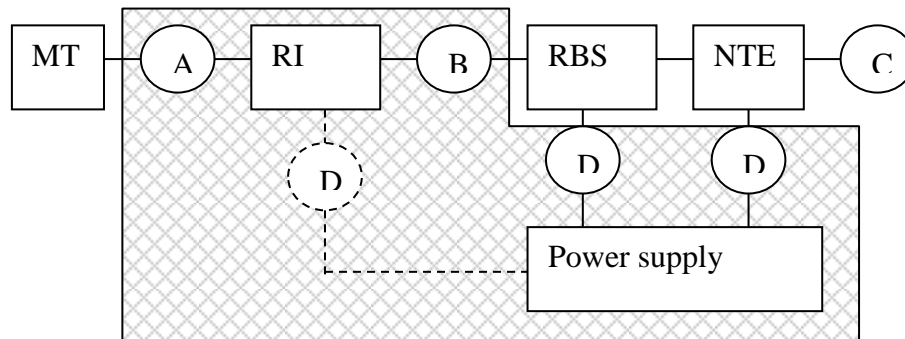


Figure 1: Schematic diagram of DAS system

Where

- MT is the mobile terminal
- RI is the Radiating Infrastructure
- RBS is the Radio Base station
- NTE is the Network Transmission Equipment for connecting the traffic to core network
- A is the air-interface
- B is the Point of Interconnect (POI) with the CNO's equipment
- C is the interface with the external transmission connections
- D is the interface with the power supply

23. R All the components within the shaded enclosure of figure 1 including any cables connected to the CNO's equipment are the responsibility of the NHC.
24. R The DAS is made up of RI and the interfaces A and B.
25. R Depending on the size of the Location of Interest (LOI) and the complexity of the design for reason of technicality and practicality, the RI can be made up of:-
- (a) passive elements such as filters, couplers, antennas, feeders and/or radiating cables
 - (b) active elements such as radio over fibre sub-system and amplifier
 - (c) a mixture of (a) and/or (b) with or without in-line amplifier(s).
26. I For the DAS with active elements, two types are referred in this document:
- wideband active DAS: all downlink and uplink active elements covering the whole mobile cellular's downlink and uplink operating bands respectively per GSM and/or and/or UMTS and/or LTE technology, and
 - narrow band active DAS: some active elements only covering the sub-bands of the GSM, UMTS and LTE operating bands with respect to the appropriate downlink and uplink directions.

27. R Where active DAS is proposed, the end-to-end system uplink loss shall be less than the end-to-end system downlink loss.
28. M The NHC is responsible for the DAS, the Power Supply and a safe interface (D) so that the CNO can connect their equipment to the power supply. The NHC is also responsible for the provision of a proper accommodation for the installation of the CNO's equipment, and provision of space for the installation of external transmission equipment (C) such as leased circuit or external microwave radio.
29. R Where the RI requires power for its operation, the NHC is entirely responsible for the provision and installation of the required power supply.

2.4 COVERAGE

30. R The coverage requirements are referred to both downlink and uplink within the coverage target areas of the LOI and with mobile terminal at the height of 0.5m to 2m above the local ground.
31. R Unless specified in a separate agreement between the NHC and the individual CNO, the NHC shall ensure that the DAS delivers coverage to the standard defined in Table 2 below.

GSM				
Type of location/zone		Hand held MT (in-building)	Car roof mounted MT (road tunnel)	
95% downlink BCCH Coverage Level (dBm)		≥ -95	≥ -85	
95% uplink link loss (dB) (*)	GSM900	$\leq (133 - N_d)$	$\leq (123 - N_d)$	
	GSM1800	$\leq (130 - N_d)$	$\leq (120 - N_d)$	
UMTS (hand held MT – in-building)				
Type of zone	UA: High Bit Rate Service	UB: Medium Bit Rate Service	UC: Low Bit Rate Service	UD: voice
95% downlink link loss of the target zone (dB)	≤ 110	≤ 120	≤ 123	≤ 130
95% uplink link loss of the target zone (dB) (*)	$\leq (110 - N_d)$	$\leq (120 - N_d)$	$\leq (123 - N_d)$	$\leq (130 - N_d)$
Typical area	Zone UA: Ports of entry, and Conference and exhibition centres including the meeting rooms, exhibition halls, lounges, waiting room, food court, restaurant and areas where people congregate and stay for a while Zone UB: Food court and restaurants in shopping centres Zone UC: Shops and stores Zone UD: LOI except Zone UA, UB and UC			
UMTS (car roof mounted MT – road tunnel)				
95% downlink link loss (dB)		≤ 120		
95% uplink link loss (dB)		$\leq (120 - N_d)$		
LTE (hand held MT – in-building)				
Type of zone	LA: High data rate service		LB: Medium data rate service	LC Low data rate service

95% downlink reference coverage (reference signal received power, RSRP) (**)	-95dBm	-105dBm	-110dBm
95% uplink loss (*)	$\leq (110 - N_d)$	$\leq (120 - N_d)$	$\leq (125 - N_d)$

Table 2: Coverage specification.

(*) where N_d in dB is the increase of receive noise floor at base station receiver due to the uplink noise of the DAS at the relevant band, and the base station noise floor is assumed to be -170dBm/Hz at the receive band.

Illustration of the base station noise floor degradation calculation:

Base station receive noise floor = -170dBm/Hz (or 10^{-17} mW/Hz, noise figure = 4dB)

Uplink noise of DAS at base station interface = -165dBm/Hz (or 3.2×10^{-17} mW/Hz)

Composite uplink noise due to DAS and base station \approx -163.8dBm/Hz (or 4.2×10^{-17} mW/Hz)

Increase of receive noise floor at base station, N_d , ≈ 6.2 dB = $(-163.8 - (-170))$ dB

(**) RSRP for each cell is the linear average over the power contributions of the **Resource Elements** that carry cell-specific **Reference Signals** within the considered measurement frequency bandwidth. It can therefore only be referred to and measured in the OFDM symbols carrying **reference symbols**.

32. R The NHC shall propose and define the zone types in each design for the CNO to comment and agree.
33. R The link loss defined in table 2 is the end-to-end loss between the mobile terminal (the interface A of figure 1) and the last connection of the individual CNO's base station (the interface B of figure 1).
34. R The NHC must make allowances for the floor variations, fading, clutter loss and environment etc. in the design in order to ensure the required percentage of the agreed areas of the LOI covered. If the DAS is for train tunnel, the NHC shall make provision in the design of train carriage losses.
35. R For the 3G and 4G, busy traffic zones such as Zone UA, UB, LA and LB do not necessarily mean that more antennas will be required. The placement of the antennas (including radiating cable if appropriate) shall take into consideration that the demand of higher data rate is most likely at places where the 3G and/or 4G mobile terminal can be stationary or quasi-stationary such as lounges, restaurants and cafés etc.

2.5 COVERAGE OVERLAP BETWEEN RADIATING ELEMENTS OF DAS

36. R The NHC shall design the coverage delivered by each antenna of the DAS has adequate overlap without discontinuity of service in the coverage area.
37. R This requirement for coverage overlap also applies to boundaries where sectorisation is most likely to be employed when capacity expansion is required. Based on the local knowledge of the location, the NHC shall highlight these boundaries within the DAS.

38. R Where multiple cells are proposed, the cell boundary shall have adequate coverage overlap enabling a mobile terminal to complete a handover within the handover time defined above.
39. R Any sectorisations of the DAS shall avoid the high traffic area in order to minimise the handover between them.
40. R The coverage overlapping areas provided by any two adjacent indoor cells of the DAS shall be less than 15% with reference to
- the coverage target area of that particular two indoor cells and also
 - 3dB link loss window as shown in an example of figure 2 below.
41. R No area of the LOI shall be simultaneously served by more than 3 indoor cells.

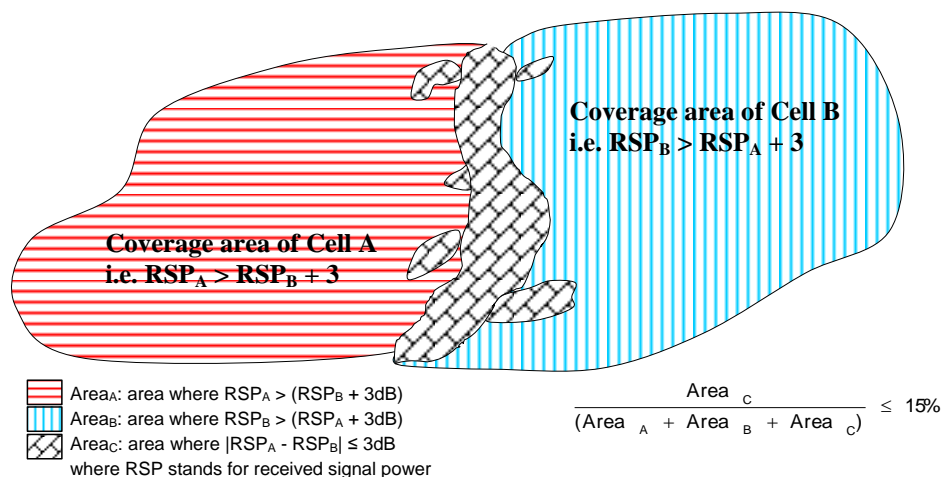


Figure 2: Coverage overlapping illustration of any two adjacent indoor cells.

2.6 COVERAGE OVERLAP BETWEEN THE INDOOR CELL AND OUTDOOR CELLS

42. R The NHC shall position some of the antennas of the DAS so that the portal shall be adequately covered without breaching the controlled leakage requirements defined in section 2.7. This shall ensure a proper handover in both directions between the indoor cell and the external cells which are defined as the cell(s) not under the responsibility of the NHC.
43. R The handover between the outdoor macrocells and the indoor cells may be of inter-frequency nature, i.e. hard handover which will take longer time to complete. Therefore, the coverage overlapping distance between the outdoor macrocell and the indoor cells at the portals shall ensure continuous voice call of a mobile terminal at the speed as defined in sector 2.2
44. R For reason of avoiding uncertainty and conflict of responsibility, it is a preference that all handover shall occur outside the LOI and at the portal. However, the CNO may request that the handover occurs inside the LOI in special cases.

2.7 CONTROLLED LEAKAGE AND HANDOVER

45. R The distance of the controlled leakage from the LOI is with reference to a mobile terminal at the speed as defined in section 2.2.
46. R As shown in figure 3, the distance of the signal overspill from any portals of the LOI shall be less than the double of the handover distance for the uplink link loss greater than 142dB. Where the DAS is designed for the rail or road tunnel, the controlled signal overspill shall be confined along the rail track or road route outside the tunnel for a proper handover between the tunnel cells and the CNO macro cells.
47. R With the exception of the portals of the LOI and as shown in figure 3, the distance of the signal overspill shall be less than the handover distance for the uplink link loss greater than 142dB.

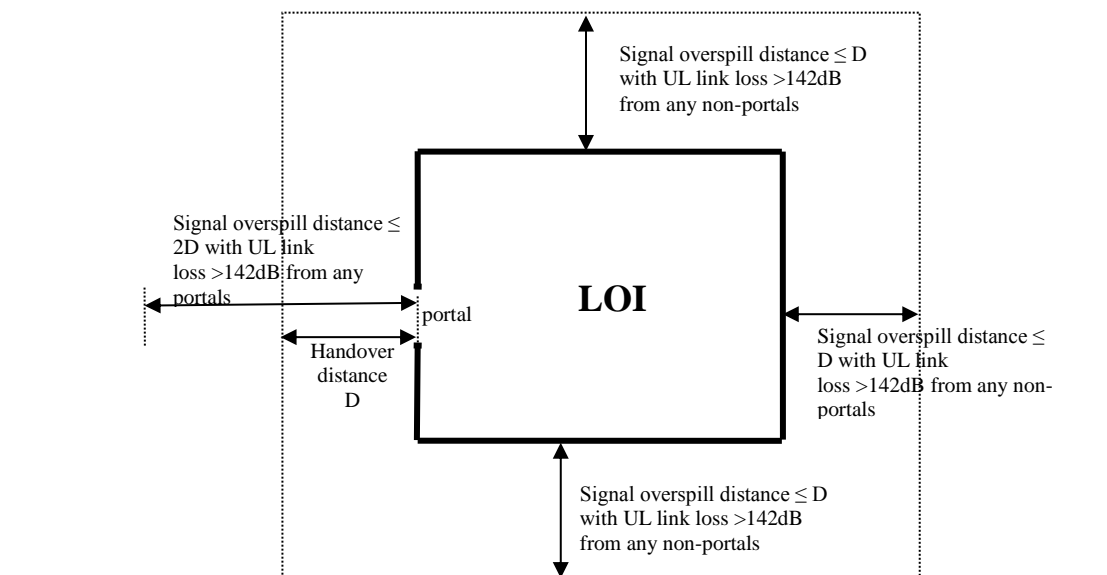


Figure 3: Illustration of the controlled leakage and handover distances.

2.8 OVERLOAD AND INTERMODULATION

48. R The selection and the placement of the radiating elements of the DAS shall not cause overloading, blocking and de-sensitisation to the mobile terminal in the downlink direction, and the CNO's base station and any active units of the DAS in the uplink direction due to the presence of a mobile terminal transmitting at full power within the coverage range of the radiating element, especially in close proximity to the radiating element concerned.
49. R The minimum coupling loss (MCL) is referred to the location at where the minimum path loss between the mobile terminal and the DAS will occur, and

the mobile terminal will receive the maximum downlink signal and the CNO's base station will receive the maximum uplink signal.

- 50. R The NHC shall carry out an assessment for each design, state the MCL which will be achieved and ensure the downlink and uplink overload, blocking and de-sensitisation will not occur. The maximum downlink signals at a 2G, 3G and 4G mobile terminal shall be less than -40dBm, -25dBm and -25dBm respectively, and the maximum uplink signal level per cellular channel at the CNO's 2G, 3G and 4G base stations shall be less than -35dBm, -52dBm and -50dBm respectively.
- 51. R The NHC shall endeavour to position the radiating element such that a far mobile terminal at the edge of an antenna coverage area will not be affected by a near and uncoordinated mobile terminal at the MCL position of the same radiating element, transmitting 30dBm, 24dBm and 23dBm at the GSM, UMTS and LTE frequency band respectively. The uncoordinated mobile terminal is due to the CNO who does not subscribe to the DAS.
- 52. R In the absence of 3GPP specification specifically for the DAS, the design of the DAS shall ensure that the total intermodulation and spuri generated by the DAS and the CNO's base station(s) under full load conditions shall still comply with the appropriate specifications recommended by the 3GPP [Ref. 1,3, 5, 6 and 7].
- 53. R When connected to all the base station equipment permitted by the design, the DAS must meet the same requirements as specified for a single GSM, UMTS and LTE base station.

2.9 CO-SITING

- 54. R The NHC shall ensure that the system is designed, either by suitable filtering or other means, to prevent any significant mutual interference between any 2G, 3G and 4G channels and other telecommunication installations in the premises at the time of design and installation. This includes but not limited to the presence of GSM-R, PMR, wireless local access network (WLAN) and ultra wide band (UWB) device.
- 55. R The effective degradation to the UL and DL receive sensitivity due to the effect of co-siting shall not be more than 0.1dB over the additional RF branching loss essential for co-siting implementation. This is applied to where the GSM, UMTS and LTE signals are distributed over different or same signal distribution layers with different or same radiating elements.

2.10 HEALTH AND SAFETY

- 56. R In terms of the DAS design related to human exposure to electromagnetic fields (EMF), appropriate exposure limits defined by ICNIRP standard [ref. 8] according to the implementation conditions shall be used.
- 57. R The NHC shall take the full responsibility for the risk assessment in where the public or occupational EMF limit is applied to each radiating element. The

EMF exposure limit for the general public shall be used in any public accessible locations.

58. R Maximum radiated power from any single radiating element shall not expose anyone to an EMF level which exceed the current guidelines in the ICNIRP standard. This shall take into account of the maximum number of carriers (2G, 3G and 4G as appropriate) to be carried by the DAS concerned.

- Where the radiating element will be installed at the general public accessible location and can be reached without any aids i.e. stand or ladder, the Specific Absorption Rate (SAR) threshold, i.e. 2W/kg within 10g volume, for the general public is applied.
- Where the radiating element can only be reached with aids i.e. stand or ladder, the SAR threshold, i.e. 10W/kg within 10g volume, for the occupational can be used.

59. R Any SAR thresholds such as the maximum input power to the radiating element established and used in the design shall be based upon either measurement or calculation according to the appropriate methodology as stated in Ref. 9.

60. R The total exposure ratio (TER), as defined in eq (1), of any radiating elements to be deployed at any public or occupationally accessible area shall be less than or equal to 1, and is given by

$$TER = \frac{T_{x800}}{P_{SAR800}} + \frac{T_{x900}}{P_{SAR900}} + \frac{T_{x1800}}{P_{SAR1800}} + \frac{T_{x2100}}{P_{SAR2100}} + \frac{T_{x2600}}{P_{SAR2600}} \quad \text{eq(1)}$$

where

- T_{x800} , T_{x900} , T_{x1800} , T_{x2100} and T_{x2600} represent the composite RF powers (stated in Watts) fed into a radiating element of the DAS for the mobile cellular signals at 800MHz, 900MHz, 1800MHz, 2100MHz and 2600MHz band, and
- P_{SAR800} , P_{SAR900} , $P_{SAR1800}$, $P_{SAR2100}$ and $P_{SAR2600}$ represent the maximum powers (stated in Watts) at 800MHz, 900MHz, 1800MHz, 2100MHz and 2600MHz band respectively that can be fed into a radiating element and whilst ensuring that the resulting exposure levels are less than the limits stated by ICNIRP. See [8] for further details on occupational and public exposure limits.

61. M The NHC shall issue a ICNIRP compliance statement for every design of the indoor cellular system and indicates which radiating elements are compliant with the public and occupational exposure limits.

62. M The equipment room shall be designed to meet all the relevant building regulations in particular in areas concerning health and safety.

63. M All the electrical installations shall follow the IEE wiring guidelines [Ref 10].

64. M With the exception of the CNO equipment, the NHC is wholly responsible for the health and safety of the DAS.

2.11 PERFORMANCE CHARACTERISTICS OF DAS ELEMENTS

65. M Where an active or a hybrid system is used for the DAS, all the active equipment must be type approved to the appropriate 3GPP recommendations.
66. M The spectral emission from the DAS together with the 2G, 3G and/or 4G base station(s) shall comply with the 3GPP standards offset according to the output power difference between a base station and the remote unit of an active DAS, i.e. the spectral mask in the specification shall be maintained.
67. R The overall gain flatness of the DAS over the whole CNO's licensed bands per technology shall be less than 3dB. In addition, within each CNO's 3G & 4G 5MHz band and 2G 200kHz channel, the gain flatness of the DAS shall be less than 1dB.
68. R The maximum single trip propagation delay caused by the DAS and air interface shall not be more than 66 μ s due to the cell range limitation of some vendor's base stations. The differential delays of 2G signals received by a mobile terminal from the same source shall be less than 16 μ s because of equalizer limitation of the mobile terminal. The group delay difference shall be no more than 30ns per 3G channel.
69. R The Error Vector Magnitude (EVM) introduced by the DAS shall be less than 6% for both 2G and 3G operation, and less than 8% for all RE allocated for shared channels (PDSCH) with the modulation schemes of QPSK, 16QAM and 64-QAM of 4G operations.
70. R The DAS shall not degrade the phase noise performance of the UL and DL signals. If frequency conversion is involved in the DAS, the local oscillator shall use a single common reference with a frequency stability conforming to 3GPP recommendations. The frequency deviation of the output signal with respect to the input signal shall be no more than +/- 0.01ppm.

2.12 BASE STATION EQUIPMENT (B)

71. R The DAS shall provide separate 2G, 3G and 4G interface ports for each CNO.
72. R Although the requirements for the MIMO interface ports of the DAS are not defined at this stage, the NHC should provide information regarding the upgrade path for accommodating the MIMO operation of 4G.
73. R The preferred operation mode is **duplex** unless specified differently by individual CNO.
74. R The interface impedance shall be 50 ohm with a VSWR of less than 1.4:1 over the whole 2G, 3G and 4G band detailed in Appendix A.
75. R To avoid any interference effect between the UL and DL, and between different operators, the isolation between any two ports of the 2G/3G/4G system shall be

more than 45 dB except different mobile cellular technologies at the same operating frequency band.

- 76. R Where the DAS is for the 2G, 3G and 4G operations, the isolation between any 2G, 3G and 4G ports shall be more than 45dB except different mobile cellular technologies at the same operating frequency band.
- 77. R The DAS, in particular all the elements for interface (B), shall be rated to handle the total average power with an additional 3dB margin while all CNO equipment are under full load conditions.
- 78. R The interface connector shall be DIN 7/16 of female type connector unless specified differently for the LOI by individual CNO.

2.13 SUPERVISORY

- 79. R The NHC shall provide a summary alarm per cell of an active or hybrid DAS for connection to the external alarm interface of the CNO's base stations. The alarm shall be of the dry-contact type. A connection terminal per technology shall be labelled with the wiring details for easy access wiring.
- 80. I Where an active system is provided, it is the responsibility of the NHC for the provision of a full supervisory system with the capability of identifying faulty unit(s) to facilitate maintenance.
- 81. R The alarm shall remain on until specific remedy actions have been taken to clear the fault conditions.
- 82. R The supervisory system shall be able to suppress any transient to minimise incorrect alarms.

2.14 SYSTEM AVAILABILITY

- 83. R The availability of the whole DAS shall be better than 99.95% of the time measured over a sliding one-year period with reference to the last 12 months from the date when the current fault of the cellular system is fixed.
- 84. R Sum of partial failure of any active elements of the DAS will be permitted for 0.1% of the time measured over a sliding one-year period with reference to the last 12 months from the date when the current fault of any elements is rectified.
- 85. R Partial failure shall not require the shut down of the whole DAS except in exceptional circumstances such as health and safety becomes an issue.

3. SCOPE OF WORK

- 86. M The NHC shall adopt quality processes starting from feasibility conception to the completion of the installation and integration of the DAS.
- 87. I This section describes the area of responsibilities and the processes that the NHC shall comply. Please note that each CNO may have a specific

requirement on milestones for activating their own internal processes such as calling off of equipment.

88. I High level processes and responsibilities are outlined in the table below.

Step	Process	Initiat or	Note
1	Feasibility Proposal	NHC	The NHC nominate a location on offer
2	Intention to participate	CNO	The CNO indicate their interest of participating in the project, or the CNO initiate a request to the NHC of a location requiring a DAS
3	Design with cost	NHC	A design is submitted to the CNO for comment. Project cost is also submitted to start the commercial discussion
4	Proposal acceptance	CNO	Indicating the acceptance of proposal and agree to participate in the scheme
5	Project review	NHC	Regular project review is held between the NHC and the individual CNO
6	Acquisition and Implementation	NHC	The NHC is wholly responsible for the acquisition of the site and the implementation of the DAS
7	Installation of the CNO equipment	CNO	The project needs to satisfy a certain prior-agreed conditions before the CNO can call off their equipment and start the installation.
8	Commissioning	NHC	Before the CNO's equipment is connected to the DAS, the NHC will carry out a system commissioning test
9	Integration	CNO	The CNO connect their equipment to the DAS and carry out functional tests ensuring the normal functioning of their equipment
10	System acceptance test	NHC	A fully functional system is tested for confirmation of the performance

Table 3 Processes and Responsibility Definition

3.1 RESPONSIBILITIES

89. I A successful completion of a DAS project relies on each party in the project fulfil their responsibilities in an effective and efficient manner.

3.1.1 NHC Responsibilities

- 90. R Entirely responsible for the acquisition of the site and delivering the best deal for the CNO.
- 91. R Carry out system design of both the DAS and the equipment room to accommodate the participating CNO's equipment
- 92. R Review and amend the design, if necessary in response to CNO's comments on the design.
- 93. R Provide an equipment room drawing in a scale agreed with each individual CNO for detail positioning of the CNO's equipment
- 94. R Procure and supply the DAS equipment appropriate to the design.
- 95. R Provide an accommodation for the DAS and the CNO's equipment. The equipment room must be appropriately designed to meet the environmental, health & safety and thermal management requirements. It must be suitably air-conditioned, if necessary to accommodate all the equipment including all designed future expansion.
- 96. R Provide an easily accessible space for a third party telecommunication provider for the installation of transmission interface (C) as shown in figure 1.
- 97. R Carry out installation of all the equipment for the DAS and those in the equipment room with the exception of the CNO's base station and transmission equipment.
- 98. R Provide and install the power supply equipment if necessary, and provide the CNO with a main power supply connection point meeting the appropriate electrical regulations currently in force.
- 99. R Advise the participating CNO of technical difficulties in a timely fashion.
- 100. R Issuing a handover document including an electrical certificate confirming that the site is safe for the CNO to install their own equipment.
- 101. R Carry out commissioning test prior to the integration of the CNO's equipment, review and rectify non-conformance if any.
- 102. R Invite the CNO's to witness the tests with an advance notice of at least 2 weeks.
- 103. R Improve the DAS where there is a performance short fall. If improvement is not possible, a formal concession application shall be submitted for CNO's approval. The project is not completed until the CNO have signed off the system acceptance certificate which will only be signed off if the system conforms to this specification, or concessions been approved.
- 104. R Carry out individual regular project review with the participating CNO.
- 105. R Provide project report to the participating CNO in an agreed format and frequency.

3.1.2 Participating CNO's Responsibilities

- 106.R Provide a standard pack of the mechanical, thermal and electrical specification of their equipment to the NHC. Update the pack promptly when there is a revision of the specification.
- 107.R Agree with the NHC of the project review processes and the project report format and frequency of both.
- 108.R Carry out design review and feedback comments to the NHC in a timely fashion.
- 109.R Participate in technical review discussions with the NHC of complex project if necessary.
- 110.R Participating in the commissioning test and verification test if necessary.
- 111.R Review the verification test results and approve concession applications if acceptable.

3.2 DOCUMENTATIONS

- 112.R Over the course of the project, the following documentations will be provided by the NHC to the CNO.
 - (a) feasibility report
 - (b) Design document
 - (c) Test methodology document
 - (d) System commissioning and acceptance test report
 - (e) As built document
 - (f) Concession application
 - (g) Factory acceptance test data on new products

3.2.1 Feasibility Report

- 113.I This report is produced when a NHC identify a location of interest on their own initiatives.
- 114.R The report shall have the following information as a minimum to assist the CNO to make a decision of participation.
 - (a) Location with the postcode and NGR,
 - (b) Local environment including the road access, and a comment of the nearby commercial activities and development,
 - (c) A map showing the position of the location of interest (LOI),
 - (d) Photographs showing the LOI from different angles if necessary,
 - (e) Size and footfall figures, and the site owner,
 - (f) Facilities and amenities, number of shops and the name of the major shops if the LOI is a shopping centre. These shall be shown on a floor plan,
 - (g) An indication of the construction method of the LOI, such as roof type and the location of the car parking facilities,
 - (h) Current 2G, 3G and 4G network coverage where appropriate,

- (i) A statement confirming landlord's consent,
- (j) An indication of the chance of acquisition success and built within a period of 6 months.

3.2.2 Design Document

115. R Design documents will be issued over a different period of the design phase. The first document will be issued after the CNO confirm their interest of participation. The second design document will be issued confirming the final design after comments from the CNO.
116. R The design document shall be made up of two parts, namely the technical part and the commercial part.
117. R The technical part will have the following information as a minimum:-
- (a) Project plan identifying the forecast dates of main milestones such as design approval, acquisition HOT, site access, start of installation, installation completion, commissioning test, verification test and the project completion. The project plan shall be presented in MS Project format.
 - (b) System schematic diagram with the component appropriately label. Where necessary, the loss and power at each of the major DAS elements shall be given. Appropriate symbols shall be used for different type of antennas.
 - (c) Link budget calculations which shall include the link loss for the near mobile and the far mobile at the edge of the coverage delivered by the antenna concerned.
 - (d) Noise and intermodulation calculations if the proposed DAS is an active system. Each individual branch and the overall system noise calculations shall be provided. Degradation to the receiver sensitivity shall be provided.
 - (e) The area over which the DAS will deliver the coverage is shown by a polygon(s) drawn over a floor plan, also showing the potential sectorisation boundaries.
 - (f) An overall site plan showing the location of the antennas, its orientation and height information,
 - (g) Photograph showing the proposed locations of the antenna and its surroundings.
 - (h) An appendix of the technical specification of the equipment used for the DAS, in particular if the equipment is used for the first time
 - (i) ICNIRP compliance calculations and statement. A certificate confirming the compliance shall be included as part of the engrossment documentation.
 - (j) A large scale equipment room layout drawing for the M&E engineer of the participating CNO designing their equipment room layout.
 - (k) A declaration of compliance to this specification.
 - (l) Proposed survey routes for the System Acceptance Test (SAT).
 - (m) The required structure and cable duct for supporting the transmission link for carrying traffic back to the CNO core network.
 - (n) Part list summary table.
 - (o) Transmission termination.
118. R The commercial part may be different for each of the participating CNO, however, the NHC will provide the information as agreed.

- 119.M The NHC shall provide a complete final design document which will detail all the agreed amendments. This document will be used as the reference for the system build and acceptance verification. No change to the system design is permitted without the agreement from the participating CNO's.

3.2.3 As Build Document

- 120.R This document shall reflect the actual build of the system covering the following areas:-
- (a) Actual installation in the equipment room.
 - (b) Certification of the electrical installation.
 - (c) A statement of conformance to all the health and safety regulations.
 - (d) Confirmation of the ICNIRP compliance and verification work carried out.
 - (e) Drawing showing the routing of cables.
 - (f) Drawings showing the location of the actual antenna positions
 - (g) As-built system diagram and set-up.
 - (h) A summary table to confirm the antenna type, position, orientation, height and EIRP, and justification for any change from the design document.
 - (i) As-built part list summary table..
 - (j) A photograph showing the location of the antenna and its surroundings.
 - (k) A table summarising deviations from the design.

3.2.4 Commissioning and System Acceptance Test Report

- 121.R This report is part of the handover document providing details of the tests carried out on the DAS and records all the measurements results.
- 122.R Where the results indicate that the design target is not met, the NHC shall carry out an internal review to rectify the deficiency.
- 123.R This report provides the test results of the final version of DAS. Copies of this report shall be provided to the participating CNO.
- 124.I The test items are described in section 5.

3.2.6 Concession Applications

- 125.R Where the NHC has not been able to deliver as promised in the design, a concession application shall be submitted at the time of providing the system acceptance test report. Please note concessions on matters relating to health and safety shall not be granted under any circumstance.
- 126.R The concession application must be submitted on a concession template for which a sample is given in Appendix D.
- 127.R The concession application shall provide the reason for the non-compliance, action plan and estimated time by which the non-compliance will be rectified, a drawing showing the area of non-compliance and the coverage/performance statistics as appropriate.

3.2.7 Factory Acceptance Test Report

- 128.R Where a new product is deployed, the NHC shall provide a complete set of factory acceptance test results. The factory acceptance tests are mainly the responsibility of the NHC and are carried out for their own benefit in order to support the DAS design and confirm the sub-systems to be used in the DAS meeting the design requirements of this specification and also the 3GPP's specifications, in particular the active elements and sub-systems of the DAS.
- 129.R The test methodology for the factory acceptance test shall be provided in the same report.

3.2.8 Test Methodology Report

- 130.R This report is a general description of the method the NHC employed for the system commissioning and acceptance tests.
- 131.R It shall outline the quality processes adopted, and define the method by which the test routes are defined.

4. SERVICE LEVEL AGREEMENT

- 132.R With the exception of the participating CNO's equipment, it is expected that the NHC will be responsible for the maintenance of all the equipment used in the DAS and the equipment room and its accessories.
- 133.R The maintenance regime and a service level agreement shall be agreed with the individual participating CNO reflecting the system reliability specified in section 2.1.4.
- 134.R The NHC shall make arrangement with the site owner permitting the CNO unlimited access to the equipment room for the maintenance of the CNO's equipment and checking the functioning of the DAS for network quality assurance purposes.
- 135.I Contractual details shall be covered in the commercial part of the specification. Therefore it will be handled separately.

5. DAS TESTINGS

- 136.R Commissioning and system acceptance tests for verifying the design and installation of the system shall be conducted by the NHC who will provide the participating CNO with the test results.
- 137.R These tests are carried out and completed by the NHC before the CNO's equipment is integrated to the DAS..

5.1 TEST EQUIPMENT

- 138.R All the test equipment must be fully calibrated by nationally recognised establishment such as National Measurement Accreditation Service (NMAS).
- 139.R All the test equipment used shall have a next calibration date that is at least one month away.

- 140.R The test report shall have a chapter listing all the equipment used in the tests with the specific details on the type, model, calibration date and the next calibration.
- 141.R Calibration certificate shall be made available for inspection if required.
- 142.R All test equipment used shall be fit for purpose i.e. the test equipment is sensitive enough to distinguish the DAS system noise and the test equipment noise. The sensitivity of the test system shall be at least 6dB better than the DAS's.

5.2 COMMISSIONING AND SYSTEM ACCEPTANCE TESTS

- 143.R The commissioning and system acceptance tests shall be carried out by the NHC after the installation of the DAS. The main objectives are to verify the performance of the DAS under a controlled environment. Therefore majority of the tests will be carried out with CW signals.
- 144.R The test results and calculations of each test shall be included in the report which shall form part of the handover document.
- 145.R Some of the tests may not be required or may be partially required if the DAS is referred to the existing and operational 2G one and is upgraded to cover the 2G, 3G and 4G operations, and vice versa. Where appropriate, the NHC shall submit the concession and partial test detail against each requirement defined in this section for the CNO's approval prior to the commissioning tests or even the design phase of the project.
- 146.R For any new DAS designed and built for providing the 2G, 3G and/or 4G services, all tests defined in this section are required

5.2.1 VSWR, Noise Level and System Gain/Loss

- 147.R The VSWR of each interface port shall be measured and recorded. The results shall be better than 1.4.
- 148.R With reference to the downlink path of the active or hybrid system, the insertion loss from each interface port (B) to the downlink input interface of each FIRST active sub-system or module of the DAS shall be measured and reported.
- 149.R With reference to the uplink path of the active or hybrid system, the insertion loss from the uplink output interface of each LAST active sub-system or module of the DAS to the interface port (B) shall be measured and reported.
- 150.R The uplink noise level at the interface point (B) due to the active or hybrid system shall be measured with all the radiating element ports terminated with appropriate loads unless the NHC is confident that the radiating elements (antennas) are not picking up signals which cannot be separated from the noise due to DAS itself. The alternative is to measure the uplink noise level at an appropriate access point of the system and the insertion loss from the selected access point to the interface point (B).

- 151.R The downlink levelling measurements are only applied to the active or hybrid system. A CW signal of appropriate level is injected at the interface point B and the output level at each RF stage of any cascaded active sub-systems or modules shall be measured. Where the wideband active DAS is deployed, the CW signal shall be at the downlink centre frequency of 800MHz, 900MHz, 1800MHz, 2100MHz and 2600MHz mobile cellular bands. Where the narrow band active DAS and multiple RI layers are deployed, the CW signal shall be at the centre frequency of each designated layer.
- 152.R The uplink levelling measurements are only applied to the active or hybrid system. A CW signal of appropriate level is injected at each remote unit and the output level at each RF stage of any cascaded active sub-systems or modules shall be measured. Where the wideband active DAS is deployed, the CW signal shall be at the uplink centre frequency of 800MHz, 900MHz, 1800MHz, 2100MHz and 2600MHz mobile cellular bands. Where the narrow band active DAS and multiple RI layers are deployed, the CW signal shall be at the centre frequency of each designated layer.
- 153.R The results shall be presented in a structured table for easy tracking and review.
- 154.R Where the active DAS is deployed, the NHC shall confirm that the end-to-end system uplink loss plus the base station noise floor degradation is not greater than that of the downlink according to the system insertion gain/loss measurement results.

5.2.2 Coverage

- 155.R For reason of convenience, the measurement can be conducted over the downlink direction. However, with the measurement results of the downlink coverage and the uplink system performance (gain, loss and noise), analysis shall be provided to confirm the coverage level, coverage quality and system link loss meeting the requirements given in this specification, in particular the DAS with active sub-systems.
- 156.R A CW test signal injected at the interface point B or an appropriate access point of the RI agreed by the CNO shall be set to the level according to the system design budget. For the passive and the wideband active DAS, the test frequency shall be at the downlink centre frequency of 800MHz, 900MHz, 1800MHz, 2100MHz and 2600MHz mobile cellular bands. For the narrow band active DAS, the test frequency shall be at the downlink centre frequency of each layer of the RI. The signal levels measured at a height of 1.5m above floor level are collected over the agreed test routes within the coverage area. The measurements shall be carried out under the normal operation conditions within the LOI.
- 157.R Where the DAS is designed for rail tunnel, the coverage tests shall be carried out in the train carriages of all types for that particular rail route. Where the DAS is designed for road tunnel, the coverage tests shall be carried out with a 0dBi roof mounted antenna attached to a typical saloon vehicle (not a transit van).

- 158.R Where the coverage or link loss fails to meet the requirements of this document, the NHC shall carry out an investigation to identify the cause(s) of the shortfall. Where the shortfall is due to the design, the NHC shall seek for the resolution. Where the rectification is not possible, a concession has to be submitted to the CNO for an approval. Where the shortfall of the system is due to the installation, no concession will be accepted, and the NHC shall get the system fixed prior to the CNO base station integration.
- 159.R The statistics of the results shall be provided to demonstrate that the requirements of the coverage and the link loss are met.
- 160.R For the confirmation of the downlink coverage met, 95% of the measured downlink signals, $R_{x95\%}$ (the level at 95% of the cumulative distribution function of the measured downlink coverage signals), in the coverage target area shall be greater than or equal to the requirements given in section 2.4.
- 161.R For demonstrating the downlink link loss meeting the requirements given in section 2.4, the downlink link loss, $L_{DL95\%}$, at 95% coverage of the target area shall be calculated with:

$$\bullet \quad L_{DL95\%} = T_{xDLB} - R_{x95\%} \quad ,$$

where T_{xDLB} is the equivalent level of the CW test signal applied to the last connection of the DAS (the interface point B of figure 1) at the CNO's base station,

- 162.R Without taking the radio propagation difference at the downlink and associated uplink bands into account, for the confirmation of the uplink link loss met as the requirements given in section 2.4, based upon the downlink coverage measurement results, the uplink link loss, $L_{UL95\%}$, at 95% coverage of the target area shall be calculated with:

- $L_{UL95\%} = T_{xDLB} - R_{x95\%} \quad , \quad \text{for the passive DAS and}$
- $L_{UL95\%} = T_{xDLB} - R_{x95\%} - S_{ddL} \quad , \quad \text{for the active DAS,}$

where

$$\bullet \quad S_{ddL} = \frac{1}{M} \sum_{i=1}^M (S_{D,i} - S_{U,i})$$

is the average system loss difference between the downlink and uplink sub-system loss, M is the total number of the remote active units feeding N distributed antennas and/or radiating cable branches (see figure 4 below), $S_{D,i}$ is the downlink system loss from the interface B to the remote active unit "i", and $S_{U,i}$ is the uplink sub-system loss from the remote active unit "i" to the interface B. i.e. if $S_{D,i}=30\text{dB}$ (base station power at interface B = 40dBm and remote unit = 10dBm) and $S_{U,i}=10\text{dB}$ (UL active gain = 30dB and passive loss = 40dB), then S_{ddL} of the branch "i" will be equal to 20dB.

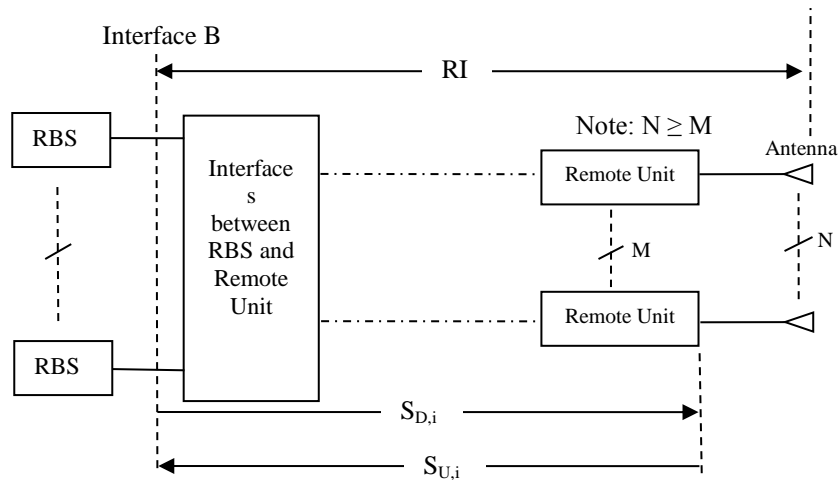


Figure 4: Illustration of the link loss calculation reference points.

163.R The measured coverage results are plotted on the floor plan layouts for the GSM, UMTS and LTE technologies. The threshold levels in dBm and dB used in the coverage and link loss plots respectively shall be

- Coverage plot: ≥ -55 , $(-55, -70]$, $(-70, -80]$, $(-80, -90]$, $(-90, -95]$, $(-95, -100]$, $(-100, -105]$, $(-105, -110]$ and < -110
- Link loss plot: ≤ 50 , $(50, 65]$, $(65, 80]$, $(80, 90]$, $(90, 100]$, $(100, 115]$, $(115, 120]$, $(120, 123]$, $(123, 133]$ and > 133

Where $(\underline{x}, \underline{y}]$ is referred to any values within the range from \underline{x} to \underline{y} and including \underline{y} but excludes \underline{x} .

164.R The NHC shall propose the survey routes for each of the LOI. A guide on the generation of survey routes is given in Appendix C.

165.R Where LOI has a very large footprint, the coverage area shall be divided into multiple survey zones and the coverage statistics of each zone shall be produced. Each of the zones shall meet the agreed coverage requirement. The NHC shall propose the zones for CNO agreement.

5.2.3 Coverage Overlap Between Antennas Of The Same DAS

166.R This test is not required for every antenna serving the same cell because it is the NHC's responsibility ensuring contiguous coverage within the LOI, however this test is required at the expected coverage boundaries where the DAS is or will be divided for serving different cells for capacity expansion reason, and also at the coverage boundaries of different live cells serving the same LOI. Within the coverage overlap area, the signal level shall not be less than that derived from the permitted link loss by 3dB for both 2G, 3G and 4G.

167.R For reason of convenience, the measurement can be conducted over the downlink.

- 168.R Two CW signals of appropriate level at different downlink frequencies of each technology are simultaneously injected at the appropriate access points of any two adjacent indoor cells; one CW for each cell. The coverage levels of these two CW signals are simultaneously measured within the coverage target areas of these two cells. The measured signal level difference in the coverage target areas shall be plotted on the layout map. The test results shall be analysed to confirm the coverage overlapping requirement met, and the coverage overlapping region(s) are adequate for call handover according to the handover time required and the speed of the mobile terminal defined.

5.2.4 Coverage Overlap Between Indoor and Outdoor Cells

- 169.R This test shall be carried out at each of the portals of the LOI.
- 170.R A CW signal of appropriate level at the centre frequency of 800MHz, 900MHz, 1800MHz, 2100MHz and 2600MHz mobile cellular bands is injected to the antennas of the DAS from which the handover coverage will be delivered to the portals of the LOI, or an appropriate access point of the RI. The downlink coverage overlapping distance between the indoor and outdoor cells shall be measured from the portals to the external of the LOI at where the equivalent uplink link losses as defined in section 2.6 are delivered.

5.2.5 Controlled Leakage and Handover

- 171.R To assess the impact of the interference to the existing cellular network due to the DAS, the NHC shall carry out measurements of the RF leakage immediately and at a distance of 20m (wherever possible) around the building external wall of the LOI, 600m from the portals of the road tunnel, or 1.2km from the portal of the high speed train tunnel. Where the leakage measurement cannot be taken at 20m around the building external wall of the LOI, the distances from the LOI and the corresponding signal levels shall be noted and reported.

5.2.6 RF Exposure

- 172.R The NHC shall confirm that the DAS installed is compliant to the ICNIRP recommendation according to the SAR thresholds established for the associated radiating elements of the DAS. Based upon the downlink end-to-end system gain/loss test results, the NHC shall calculate the composite RF power to be delivered at the connector of each radiating element under full load condition.
- 173.R The analysis results shall be presented in a table format confirming the compliance of each radiating element.

5.2.7 Supervisory

- 174.R Where an active or hybrid DAS is used, the NHC shall carry out a test on the supervisory system by simulating all the appropriate faulty conditions. An alarm and the corresponding indicator shall turn on and a summary alarm shall be created.
- 175.R The alarm shall remain on until a remedy action has been specifically taken.

- 176.R Test conditions shall also be created simulating faults for the triggering of a summary alarm in the CNO's network management centre. This test will require the co-operation of the participating CNO after the CNO's base station integration.

5.3 BASE STATION INTEGRATION AND LIVE COVERAGE VALIDATION

- 177.R The NHC shall provide logistical support to the CNO carrying out the base station integration.
- 178.I It is the CNO's responsibility to make to the last interface connections from the DAS to the base stations with the cables properly labelled and provided by the NHC at the top of the base station racks.
- 179.R Due to different cabling from each CNO base station to the DAS interface, if the DAS is an active one, the NHC shall be responsible for carrying out the system gain/loss levelling of the DAS to the appropriate and optimum settings after the CNO base station integration according to the system equipment specification.
- 180.R If the DAS is an active one, the NHC shall assist the CNO to establish and test the summary alarm connections in the CNO's network management centre via the external alarm ports of the base stations.
- 181.R The NHC shall assist the site access for the CNO to carry out post-integration coverage and service surveys.
- 182.I If an individual CNO requires the NHC to carry out the post-integration coverage and service surveys, it will be a separate agreement between the NHC and that specific CNO and the other CNO will not bear the cost of such managed services for another CNO.

APPENDIX A -- LICENCED SPECTRUM OF THE UK CELLULAR OPERATORS

Operator	designation band	technology	Mobile transmit (MHz)		Base transmit (MHz)	
			UPLINK		DOWNLINK	
			lower limit ⁽¹⁾	upper limit ⁽¹⁾	lower limit ⁽¹⁾	upper limit ⁽¹⁾
EE	1800MHz	GSM	1721.7 ⁽²⁾	1731.7 ⁽²⁾	1816.7 ⁽²⁾	1826.7 ⁽²⁾
		GSM	1731.7 ⁽³⁾	1736.7 ⁽³⁾	1826.7 ⁽³⁾	1831.7 ⁽³⁾
		GSM, UMTS, LTE	1736.7	1781.7	1831.7	1876.7
	2100MHz – TDD	UMTS, LTE	1899.9	1909.9	Duplex	Duplex
	2100MHz – FDD	UMTS, LTE	1959.7	1979.7	2149.7	2169.7
	800MHz - FDD	LTE	837	842	796	801
	2600MHz - FDD	LTE	2535	2570	2655	2690
Telefonica O2	900MHz	GSM, UMTS, LTE	885.1	889.9	930.1	934.9
		GSM, UMTS, LTE	894.9	902.1	939.9	947.1
		GSM, UMTS, LTE	910.1	914.9	955.1	959.9
	1800MHz	GSM, UMTS, LTE	1710.1	1715.7	1805.1	1810.7
	2100MHz – TDD	UMTS, LTE	1909.9	1914.9	Duplex	Duplex
	2100MHz – FDD	UMTS, LTE	1934.9	1944.9	2124.9	2134.9
	800MHz - FDD	LTE	852	862	811	821
Three	1800MHz	GSM, UMTS, LTE	1721.7 ⁽⁴⁾	1731.7 ⁽⁴⁾	1816.7 ⁽⁴⁾	1826.7 ⁽⁴⁾
		GSM, UMTS, LTE	1721.7 ⁽⁵⁾	1736.7 ⁽⁵⁾	1816.7 ⁽⁵⁾	1831.7 ⁽⁵⁾
	2100MHz – TDD	UMTS, LTE	1914.9	1920	Duplex	Duplex
	2100MHz – FDD	UMTS, LTE	1920	1934.9	2110.3	2124.9
	800MHz - FDD	LTE	832	837	791	796
Vodafone	900MHz	GSM, UMTS, LTE	880.1	884.9	925.1	929.9
		GSM, UMTS, LTE	890.1	894.5	935.1	939.5
		GSM, UMTS, LTE	902.3	909.9	947.3	954.9
	1800MHz	GSM, UMTS, LTE	1715.9	1721.5	1810.9	1816.5
	2100MHz – FDD	UMTS, LTE	1944.9	1959.7	2134.9	2149.7
	800MHz - FDD	LTE	842	852	801	811
	2600MHz - FDD	LTE	2500	2520	2620	2640
Niche Spectrum Ventures Limited	2600MHz - FDD	LTE	2520	2535	2640	2655
	2600MHz - TDD	LTE	2595	2620	Duplex	Duplex

Note:

- (1) Guard channels of 900MHz not listed
(2) frequency spectrum to be returned to Ofcom in 2013
(3) frequency spectrum to be returned to Ofcom in 2015
(4) from Sept 2013
(5) from Sept 2015

APPENDIX B – FACTORY TESTS: SUB-SYSTEMS AND SYSTEMS

B.1 I Although there is no specific factory acceptance test requirements defined in here, for the NHC's own benefit, the NHC should verify the performance of any new sub-systems or modules to be used in the DAS, in particular the active elements of the DAS. The CNO would not be responsible for the cost of carrying out the factory tests.

B.2 I The test items may include:

- (a) Operating frequency band,
- (b) Input and output levels at each stage of the system,
- (c) Frequency response and gain flatness,
- (d) Noise performance including the noise figure,
- (e) Output power, 1 dB compressed point and the IP3,
- (f) Intermodulation performance under normal and overloading conditions,
- (g) In band and out of band spuri,ii,
- (h) Phase noise performance,
- (i) Spectral mask conformance,
- (j) Adjacent channel leakage power,
- (k) Error vector magnitude (EVM) and Peak Code Domain Error (PCDE),
- (l) Power handling capability,
- (m) Delay and group delay,

APPENDIX C -- GUIDELINES ON THE GENERATION OF SURVEY ROUTES

Below is guidance on the generation of survey routes which shall be agreed with the participating CNO. The NHC shall use common sense bearing in mind the main objective of the testing is to verify that the DAS will deliver the required signal level to mobiles used by the general public. Where the guideline is not possible, the NHC should use common sense proposing alternatives.

C.1 Passages ≤ 7 metres wide

Passages not more than 7m wide shall be surveyed along a route defined by the centre-line of the passage with a tolerance of ± 1 m.

C.2 Passages > 7 metres wide

Passages wider than 7m shall be surveyed along routes on both sides of the passage at a distance of 2 ± 1 m from the passage walls.

C.3 rooms ≤ 5 metres wide

Rooms with an average width of not more than 5m shall be surveyed on routes around the internal perimeters, at a distance of 1 ± 1 m from the perimeter wall. Where this route is not accessible then the nearest public accessible route shall be taken.

C.4 $5\text{m} < \text{Room width} \leq 10\text{m}$

Rooms with an average width of between 5 and 10m shall be surveyed on routes around the internal perimeters, at a distance of 1 ± 1 m from the perimeter wall and along a centre-line parallel to the longest wall of the room. Where this route is not accessible then the nearest public accessible route shall be taken.

C.5 Room width $> 10\text{m}$

Rooms with an average width greater than 10m shall be surveyed on routes around the internal perimeters, at a distance of 2 ± 1 m from the perimeter wall and along zigzag route sweeping the floor area. The pitch of the zip-zap route shall be not more than 4m. Where this route is not accessible then the nearest public accessible route shall be taken.

C.6 stairs and escalators

Stairs and escalators shall be surveyed along the centre line of the stair or escalator. Where multiple stairs or escalators are located within the same passage way or bore, then the survey routes shall be along the stair or escalator located nearest to the centre-line of the passage way or bore. Where stairs and escalators are contained within separate passage ways or bores, they shall be treated as separate stairs and escalators.

C.7 port of entry (entrances and exits)

Entrances and exits shall be surveyed along a centre-line route normal to the entry or exit doorway, or as near as is practically possible by the general public. The route shall be extended to at least 20m on either side of the port of entry.

C.8 building perimeter

The perimeter of the building shall be surveyed along the nearest publicly accessible route. Surveying is not required if the nearest publicly accessible route is over 50m from the building perimeter. All section of road highway which falls within 100m of the building perimeter should be surveyed for leakage assessment purpose.

In all the above cases, where obstacles prevent or impede public access, then the nearest publicly accessible route shall be taken to get back onto the defined survey route.

C.9 Road tunnels

The road tunnel shall be surveyed using a saloon style vehicle in each direction/carriage way in the slow lane, i.e. the lane furthest from the tunnel centre line.

C.10 railway carriage

Railway carriage shall be surveyed with a walk along the centre line of the carriage and at sitting position on every five aisle seat inside the carriage.

C.11 car park

Car parks shall be surveyed using a typical saloon vehicle along all designated entrance, throughway and exit routes.

APPENDIX D - CONCESSION TEMPLATE

Site Details			
Cell ID	Cell ID as appropriate to the individual CNO	Date of issue	
Site Name		Issue version	
Site Address			

Concession Approval			
NHC : name	Prepared by	Name in block	Signature
	Telephone		date
	Checked by	Name in block	Signature
	Position		date
CNO	Approved by	Name in block	Signature
	Position		date

Concession Details		
Concession		
Affected Area		
Supporting Doc.	Performance statistics <input type="checkbox"/> Plots/Drawings <input type="checkbox"/>	Ref: Ref:
Remedy Proposal		
Est. Completion Date		

JOINT OPERATOR APPROVAL

NAME:

A handwritten signature in blue ink that reads "Adis Omeragic".

Adis Omeragic

Head of Special Projects &
Events

NAME:

A handwritten signature in black ink that reads "Dave Fraley".

Dave Fraley

Head of Hardware Design



NAME:

A handwritten signature in black ink that reads "Anil Darji".

Anil Darji

Head of RAN



NAME:

A handwritten signature in black ink that reads "Phil White".

Phil White

Network Senior Manager

DOCUMENT HISTORY

Issue	Date	Details
0.1	01/7/2005	Draft issued for comment.
0.2	12/10/2005	Updated draft issued for comment
0.3	02/11/2005	Updated draft issued for comment
0.4	20/04/2006	Updated draft issued for comment
0.5	02/05/2006	Updated draft issued for final comment
0.6	22/05/2006	Updated draft issued for final comment
1.0	18/07/2006	Final issue
2.0	09/04/2008	Update of Issue 1 with the main changes of section 5 (formal issue)
2.1	24/04/2009	Update for comment with reduction of the system tests (not formal issue)
2.2	28/07/2011	Update with the LTE draft
2.3	24/10/2011	Update with the LTE draft
2.4	22/05/2012	Update with LTE draft & the requirements for tunnel
2.5	15/01/2013	Update with the LTE draft for final comment
3.0	15/02/2013	Formal issue
3.1	05/04/2013	Correction of Appendix-A Licensed Spectrum (reverse DL & UL)
3.2	03/02/2014	Document classification changed from “Internal” to “Public”

TITLE - JOINT OPERATORS TECHNICAL SPECIFICATION OF GSM, UMTS & LTE
INDOOR CELLULAR SYSTEM

DOCUMENT APPROVAL

OWNER/AUTHOR (SIGNED)



NAME (BLOCK CAPITALS): KIN WAN

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