Institut belge des services postaux
et des télécommunications

Communication du Conseil de l'IBPT du 14 avril 2025 concernant les spécifications techniques minimales des systèmes d'antennes indoor

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TABLE DES MATIÈRES

Synthèse

1. Les premières lignes directrices M-O DAS datant de 2017 ont été élaborées pour traiter de la couverture intérieure, où il était souhaitable que les grands bâtiments nouveaux et existants soient de préférence équipés d'un système DAS multi-opérateurs pour 2G, 3G et 4G. Des accords clairs ont donc été conclus avec les opérateurs de réseau mobile pour mettre en œuvre des systèmes DAS conformes aux règles de l'art. Ces lignes directrices ont désormais besoin d'une mise à jour.

2. Un groupe de travail incluant diverses parties prenantes du secteur a été invité à mettre à jour les lignes directrices existantes recommandées comprenant les spécifications techniques minimales. Ces réunions ont eu lieu en 2024.

3. Les lignes directrices jointes ne sont que des recommandations. Aucune spécification technique légalement obligatoire n'est donc imposée.

4. L'IBPT continue d'agir, comme précédemment, en tant que SPOC. Le module de notifications est mis à jour par l'IBPT par le biais de l'application en ligne https://www.modas.bipt.be/.

1. Systèmes d'antennes indoor (DAS[1])

5. Un système indoor ou DAS est un réseau passif d'antennes placées à l'intérieur d'un bâtiment et connectées à l'aide de câbles à un « hub » central. Ce hub est généralement installé dans un espace technique spécial.

6. Ce système peut appartenir au propriétaire du bâtiment ou à une firme spécialisée. Un tel système est de préférence neutre en ce qui concerne la technologie, la bande de fréquences et l'opérateur de télécommunications qui réalise le raccordement. Idéalement, un DAS doit donc être équipé pour desservir les différentes bandes de fréquences habituelles (700/800/900/1400/1800/2100/2600/3400-3800/3800-4200 MHz) pour la 2G/4G/5G et A.S.T.R.I.D. et ainsi permettre à la concurrence entre les fournisseurs de services sans fil de s'exercer pleinement.

[1] Distributed Antenna System

2. Problèmes liés aux systèmes d'antennes indoor.

7. Un certain nombre de situations problématiques se posent :

7.1. En cas de changement de locataire

Les infrastructures pour la couverture indoor peuvent poser des problèmes lors de la location d'un immeuble de bureaux. En quittant un bâtiment, le locataire est obligé de remettre le bâtiment en l'état d'origine. Cela signifie que les équipements pour la couverture indoor doivent être démontés. Il se peut que l'installation puisse être utilisée en tout ou en partie par le locataire suivant. Il est possible de convenir avec l'opérateur de réseau mobile de transférer les installations au locataire suivant, mais les responsabilités ne sont pas toujours clairement définies (qui paie pour l'arrangement, qu'en est-il du système DAS existant...).

7.2. Lors de l'évaluation des contrats existants

Bon nombre d'autorités publiques et de bailleurs privés réévaluent régulièrement leurs contrats avec les opérateurs de réseau mobile en vue de conclure un accord compétitif et conforme au marché. Une migration rapide entre les opérateurs requiert des exigences techniques minimales communes de manière à permettre une comparaison efficace des différentes offres et une migration sans accroc.

7.3. Besoin accru de systèmes multi-opérateurs

Pour les grands immeubles de bureaux, les hôpitaux, les centres commerciaux, etc., une couverture par un seul opérateur n'est ni suffisante ni souhaitable. Les locataires, visiteurs et/ou travailleurs apportent leur propre appareil terminal (BYOD[2]) de sorte qu'il doit y avoir une couverture par chaque opérateur mobile. Il est important que tous les opérateurs puissent se raccorder au même DAS.

7.4. Différenciation pour le propriétaire

Une bonne couverture mobile devient, de plus en plus, un besoin fondamental pour les bâtiments modernes. La couverture intérieure devient un atout pour chaque bailleur, lui permettant de se distinguer des autres offres sur le marché de la location.

8. Il est préférable de prévoir les systèmes DAS pour les nouveaux immeubles dès la phase de conception, tout comme la tension, les lignes téléphoniques, etc. En principe, un DAS peut appartenir au propriétaire de l'immeuble, à un opérateur ou à un tiers (par exemple un opérateur de télécommunications, une entreprise spécialisée dans la couverture intérieure). La construction d'une telle infrastructure de télécommunications nécessite des connaissances spécialisées en matière de propagation des ondes radio. Souvent, les architectes et les entreprises de construction ne disposent pas de ces connaissances et

[2] BYOD : Bring Your Own Device

doivent acquérir le savoir-faire nécessaire. Des firmes spécialisées pourraient idéalement fournir des avis ou des services à ce sujet.

3. Spécifications techniques minimales

9. Les premières lignes directrices M-O DAS datant de 2017 ont été élaborées pour traiter de la couverture intérieure, où il était souhaitable que les grands bâtiments nouveaux et existants soient de préférence équipés d'un système DAS multi-opérateurs et multi-technologie. Des accords clairs ont donc été conclus avec les opérateurs de réseau mobile pour mettre en œuvre des systèmes DAS conformes aux règles de l'art. Ces lignes directrices ont désormais besoin d'une mise à jour.

10. Un groupe de travail incluant diverses parties prenantes du secteur a été invité à mettre à jour les lignes directrices existantes recommandées comprenant les spécifications techniques minimales. Ces réunions ont eu lieu en 2024.

4. Pas d'obligation légale

11. Les lignes directrices ne sont que des recommandations. Aucune spécification technique légalement obligatoire n'est donc imposée. Une obligation légale impliquerait en effet qu'il faudrait prévoir un mécanisme de contrôle (par exemple sous la forme d'une certification par un organe de contrôle indépendant), ce qui alourdirait l'ensemble du processus. Les mesures de contrôle seront quoi qu'il en soit réalisées par les MNO avant de raccorder leur équipement actif au réseau DAS.

12. Plutôt que des obligations légales, il a été opté pour des mesures d'autorégulation, dans le cadre desquelles les parties prenantes ont développé un mécanisme et un processus de collaboration sur une base volontaire. L'IBPT est d'avis que suivre ces recommandations constitue une garantie pour les propriétaires que l'installation d'un DAS M-O sera réalisée correctement.

13. L'IBPT n'intervient que dans la phase de préconception. Lors de cette première étape, les propriétaires ou maîtres d'ouvrage envoient une notification à l'IBPT l'informant qu'ils souhaitent mettre sur pied un système DAS M-O. L'IBPT consultera ensuite les opérateurs de réseau mobile qui feront part de leur intérêt à participer ou non au projet. Toutes les étapes ultérieures se dérouleront entre les propriétaires de l'immeuble, les opérateurs et l'entrepreneur DAS.

14. Il va de soi qu'un maître d'ouvrage est libre de suivre ou non la procédure recommandée et d'opter par exemple pour un « single operator DAS » ou des mesures alternatives afin d'améliorer la couverture intérieure.

5. Système de notification IBPT

15. L'IBPT continue d'agir, comme précédemment, en tant que point de contact unique (Single Point of Contact, ou SPOC). Le module de notifications déjà existant est mis à jour par l'IBPT par le biais de l'application en ligne https://www.modas.bipt.be/.

16. Dans les lignes directrices générales concernant la construction de systèmes d'antennes indoor multi-opérateurs, toutes les étapes sont décrites avec précision dans le processus de collaboration entre l'IBPT, les opérateurs, les propriétaires et l'entrepreneur DAS.

17. Dans une première phase du projet, les candidats-maîtres d'ouvrage transmettent une demande de connectivité pour un DAS multi-opérateurs par le biais de l'application en ligne. Elle transmet la demande aux opérateurs qui confirment ou non leur intérêt.

18. Il s'agit d'une application relativement simple. Le maître d'ouvrage doit remplir un formulaire et charger un certain nombre de documents. L'IBPT consulte les opérateurs de réseau mobile. Après avoir reçu leur réponse, un rapport est envoyé au maître d'ouvrage, qui peut décider de poursuivre ou non le projet.

19. L'outil logiciel recevra également la mise à jour nécessaire lors de la publication des nouvelles spécifications techniques.

6. Couverture indoor en fonction de la technologie

20. En fonction de l'évolution de la technologie, les installations intérieures devront également être adaptées.

21. Une révision des recommandations techniques en fonction des développements technologiques est prévue à l'avenir.

22. L'IBPT agira également pour ces futures révisions en tant que SPOC. Si nécessaire, l'IBPT invitera à nouveau régulièrement les parties prenantes pour réviser les documents en fonction des derniers développements technologiques. L'IBPT souhaite réaliser de telles révisions des lignes directrices une fois tous les deux ans.

7. Entrepreneurs DAS

23. Le maître d'ouvrage fait en général appel à un entrepreneur DAS. Cette partie est généralement chargée de l'élaboration et de la construction du DAS. Il existe plusieurs sociétés sur le marché spécialisées dans ce domaine.

24. L'IBPT est un organisme indépendant et, pour des raisons de neutralité, ne publiera pas de liste d'installateurs recommandés. Les organisations sectorielles sont libres de conseiller leurs membres à ce sujet.

8. Annexes

25. Les documents suivants sont repris en annexe :

- Lignes directrices générales concernant la construction de systèmes d'antennes indoor multi-opérateurs (M-O DAS). Ces lignes directrices sont destinées au propriétaire du M-O DAS. Il s'agit généralement du propriétaire de l'immeuble.
- Annexe 1 : Exigences techniques détaillées pour l'élaboration et l'installation de systèmes d'antennes indoor multi-opérateurs (M-O DAS). Ces exigences techniques sont destinées au constructeur du M-O DAS. Il s'agit généralement d'un sous-traitant spécialisé.
- Annexe 2 : Liste des équipements techniques. Cette liste contient des références au matériel technique utilisé par les opérateurs de réseau mobile pour les systèmes DAS. Cette liste est indicative mais n'exclut pas qu'un maître d'ouvrage utilise des composantes équivalentes.
- Annexe 3 : Procédure PIM et VSWR Ce document contient la méthode de mesure de l'intermodulation (PIM) et les paramètres de connexion (VSWR) du système d'antennes distribué sur le réseau de l'opérateur.
- Annexe 4 : Formulaire de demande.
- Annexe 5 : Modèle de rapport PIM et VSWR.

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GENERAL GUIDELINES

ON THE CONSTRUCTION OF MULTI-OPERATOR DISTRIBUTED ANTENNA SYSTEM (M-O DAS) IN BELGIUM

A good indoor coverage of mobile services in buildings is crucial for a modern business environment and contributes to the efficiency of enterprises. A joint initiative of BIPT and stakeholders has led to the development of these guidelines to help construction and real estate companies to plan and build qualitative multi-operators indoor radio infrastructures.

Date: January 2025

Table of Content

1. INTRODUCTION

These general guidelines are addressed to the following parties (M-O DAS means 'Multi-Operator Distributed Antenna System'):

- **M-O DAS owner** is the party that will own the M-O DAS and that has the contractual relationship with the operators. In many cases the owner of the M-O DAS will also be the owner of the building ('building owner').
- **M-O DAS promoter** is the party that will bring all the stakeholders (including the M-O DAS contractor) together in the context of the construction of a new building or major renovation of an existing building where an M-O DAS is requested. In some cases (for smaller buildings), it can be the building / M-O DAS owner that will coordinate the different works.
- **M-O DAS contractor** can be composed of different technical parties that will be contracted by the M-O DAS owner or the M-O DAS promoter to design and build the M-O DAS. This party could also be in charge of the maintenance of the M-O DAS. Maintenance could however also be subcontracted to another specialized firm.
- **Operators** are the parties that will install the RAN active equipment connected to the M-O DAS.
- **A.S.T.R.I.D.** is a public company that has been created by the Law of 8 June 1998 on radiocommunications for emergency and security services and that provides a radiocommunication network for the benefit of Belgian emergency and security services. For certain buildings or infrastructure which can be sensitive from a security point of view, the law imposes building owners to foresee and provide an ASTRID indoor coverage on their own costs. ASTRID coverage may also be required on a voluntary basis by local authorities.

This document provides guidelines with regard to the design, construction and maintenance of an M-O DAS. The overall aim is to ensure that the M-O DAS will deliver good indoor mobile coverage for end-users situated in the building. It defines the responsibilities of the different parties during the whole process of design, construction and operation of the M-O DAS. Such M-O DAS may or may not be design and build in combination with an ASTRID indoor coverage.

For the installation of an MO-DAS on which mobile operators could connect, the following 3 main phases are relevant:

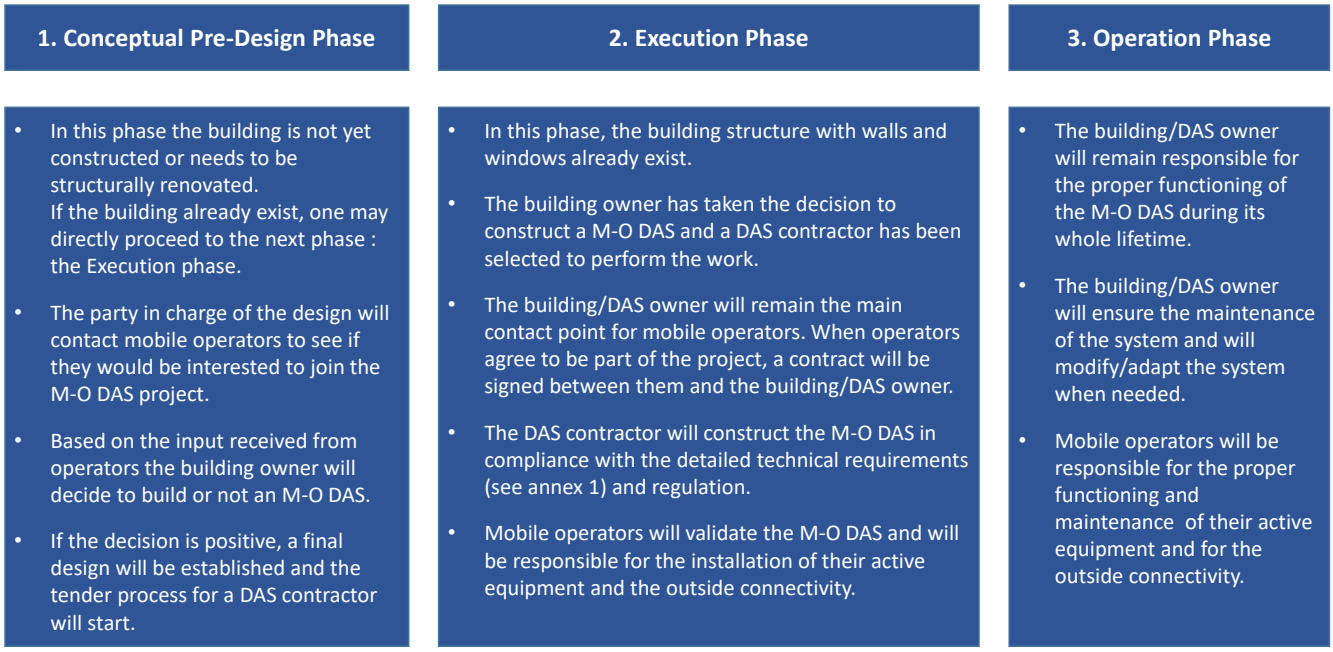

Figure 1: overall overview of the M-O DAS phases

In section 3 of this document, we will go through the 3 phases as described in the scheme above and we will provide a description of the overall workflow and responsibilities of the different parties.

The **Execution phase** is described in many details in the 'detailed technical requirements' (see annex 1) and aims at providing technical guidance to the party which will be in charge of the design and construction of the M-O DAS.

These general guidelines are not binding and have no contractual value. The mobile operators do however highly encourage M-O DAS owners to take them into account when they plan to invest in an M-O DAS.

At some stage in the process of construction of the M-O DAS, a separate commercial contract will need to be signed between the M-O DAS owner and each operator that will ultimately agree to connect their mobile network to the M-O DAS.

Mobile operators have drafted these guidelines with utmost care. However, they cannot be considered liable for any fault or inaccuracies contained in these documents. Any party which would carry out works based on these guidelines and/or the detailed technical requirements in annex would ultimately be responsible for both the works and the possible construction errors. In case of questions or doubts on the contents of these guidelines the reader is invited to take contact with the operators for clarification.

Operators will ensure the regular update of these general guidelines and the detailed technical requirements annex.

For the installation of an ASTRID indoor coverage in combination with an M-O-DAS or standalone, specific legal obligations, processes and workflows exist and must be respected.

The role and responsibilities of A.S.T.R.I.D. are defined in the 3rd party convention that must be signed between A.S.T.R.I.D. and the building owner (ASTRID Overeenkomst met betrekking tot indoordekking in gebouwen en infrastructuurwerken / Convention ASTRID relative à la couverture à l'intérieur des constructions et infrastructures).

The processes and workflows concerning ASTRID indoor coverage are the following:

1. Request & RF-Design validation
2. Works & Installation
3. Commissioning

It is not the purpose to explain all the ASTRID processes, workflows and requirements in these Guidelines. In case the building owner or promoter would also have to design and build an ASTRID indoor coverage, he should then refer to the ASTRID 3rd party convention and the related technical annexes, which are the only valid references when it comes to ASTRID indoor coverage.

A request to obtain these documents may be addressed to ASTRID Service Centre[1] by completing the contact form or via email[2]. Specific questions may also be addressed to ASTRID external advisor[3]. A brochure is also available op ASTRID website[4].

2. M-O DAS DESCRIPTION

A Multi-Operator Distributed Antenna System (M-O DAS), is a passive network which aims to ensure a correct distribution of radio signal strengths of all connected mobile network operators on all desired areas of a building (i.e. office space, warehouse, underground parking, meeting rooms, elevators…). Such system is not to be confused with active antenna-systems (such as femtocells, small cells, active-DAS systems, ...) which are not in the scope of the present guidelines.

An M-O DAS must be designed in such a way that it will be able to accommodate the mobile network operators at any moment in time. Doing so, at the design stage generates negligible additional costs and will save significant costs in comparison to

[1] https://www.astrid.be/nl/support (or) https://www.astrid.be/fr/support
[2] info@astrid.be
[3] https://www.astrid.be/nl/service-support/adviseurs
[4] https://www.astrid.be/sites/public/files/files/2021-10/brochure_radiodekking_in_gebouwen_indoor_astrid.pdf (and) https://www.astrid.be/sites/public/files/files/2021-10/brochure_couverture_radio_a_linterieur_des_batiments_indoor_astrid.pdf

adapting an existing MO-DAS afterwards. Operators are indeed free to connect to the M-O DAS as from the moment it is constructed or could also decide to connect to it at a later stage (several months or even years after the M-O DAS has been installed). The objective is to provide guidelines for the construction of an M-O DAS that will provide all the flexibility to accommodate any mobile operator at any time.

The active network elements provided and operated by mobile network operators are typically located in a dedicated technical room inside the building (see section 3.2.2. on the provisioning of technical rooms).

The passive M-O DAS can potentially support :

- all current mobile technologies (namely GSM, EDGE, LTE, LTE advanced, NR) on all supported licensed frequency bands (700, 800, 900, 1400,1800, 2100, 2600 and 3400-3800[5], 3800-4200 MHz[6])
- A.S.T.R.I.D. technologies (TETRA and other future technologies[7]).

[5] Concerning the band 3400-3800MHz, it is to be mentioned that there is in principle less or even no relevance to use it in a SISO configuration. This band should also be avoided in combination with Astrid (due to the large separation between Astrid band and 3400-4200MHz bands).

[6] The 3800-4200MHz band which is foreseen for private networks is only relevant in case the private network is combined with an MNO indoor coverage solution. If it is not the case, there would be no need to request that the passive M-O DAS would have to support this band.

[7] ASTRID will make a transformation from the actual TETRA network to a Hybrid broadband network with his own dedicated Core network and his own RAN (MC-RAN on 700 MHz – Band 28 & 68) and will also interconnect with Mobile Network Operators (MNOs). Furthermore, ASTRID plans to use the spectrum and the RAN of one selected MNO (4G/5G) in an MOCN architecture.
Today it is not defined yet what the future obligations for ASTRID coverage in buildings will be. It will depend on the decisions of the "Federale Overheidsdienst Binnenlandse Zaken" / "Service public federal Intérieur" - IBZ).
The actual TETRA network will stay operational until 2030-2032.

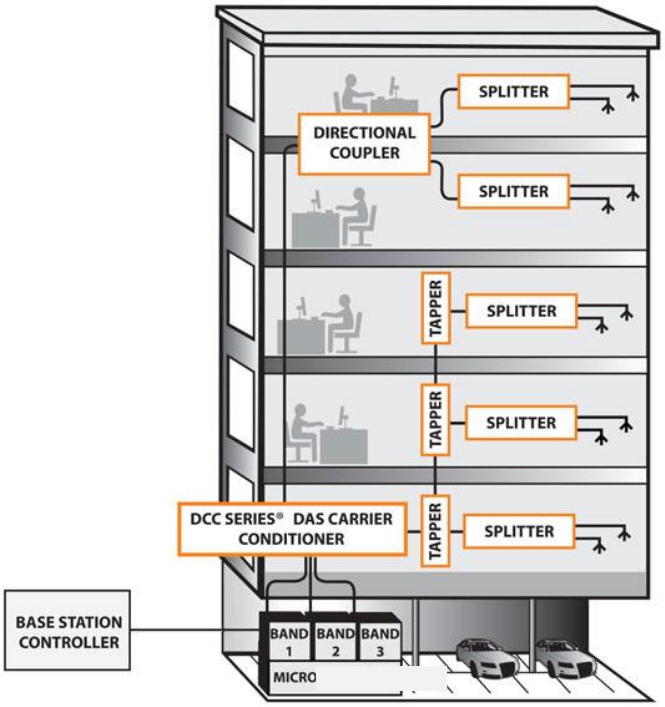

Figure 2: example scheme of a typical DAS

3. DESCRIPTION OF THE WORKFLOW

For mobile operators, the only official point of contact will be the M-O DAS owner with which it has signed a contract.

The M-O DAS owner (which in many cases will be the building owner) or M-O DAS promoter may delegate the construction of the M-O DAS to a contractor which he has chosen to work with. The role of the DAS contractor can be taken up by different parties, and the DAS contractor must have the necessary technical skills to build the M-O DAS in accordance with these guidelines. This party should commit itself to respect the processes and detailed technical requirements as described in detail in annex 1. It is therefore recommended to include the annex 1 in the contract with the DAS contractor. Operators will not interfere in the contractual relationship between the M-O DAS owner/promoter and M-O DAS contractor.

The complete workflow can be divided in 3 main phases:

1) Conceptual pre-design phase
2) Execution phase (preparation – installation – acceptance)
3) Operations phase.

Each phase consists of different steps. Those different phases are described in more detail in what follows, together with the responsibilities of the mobile network operators on one side and of the M-O DAS owner & contractor on the other side.

3.1. Conceptual pre-design Phase

This Conceptual Pre-Design Phase is normally applicable when the building is not yet constructed (the building is in a project phase and exists only on paper) or when the building will undergo a major structural renovation.

Eventually the actions described in this Phase might be applied for existing buildings too in case building owners want to have a first high level idea of project impact and cost before starting a real M-O DAS project. Actions described and documents/input required to provide to mobile operators via the Notification tool of BIPT remain the same.

If the building is already constructed or does not necessitate a structural renovation or a first high level impact analysis is not required, one may then proceed directly towards the Execution Phase. The Execution Phase is also the one that will be relevant for the DAS contractor as soon as it will be selected by the M-O DAS owner.

In an early Conceptual Pre-Design phase, the party in charge of the design of the new building or renovation of the building will need to interact with mobile network operators (through the BIPT notification process) in order to:

- make a first conceptual evaluation of the technical feasibility of a M-O DAS
- explore operators' interest in sharing the DAS
- get a first rough M-O DAS and mobile operators cost estimation

It is of upmost importance that mobile operators are contacted and included in the process as soon as possible so that they can evaluate their interest to be part of the project.

The Conceptual Pre-Design Phase can be summarized as follows:

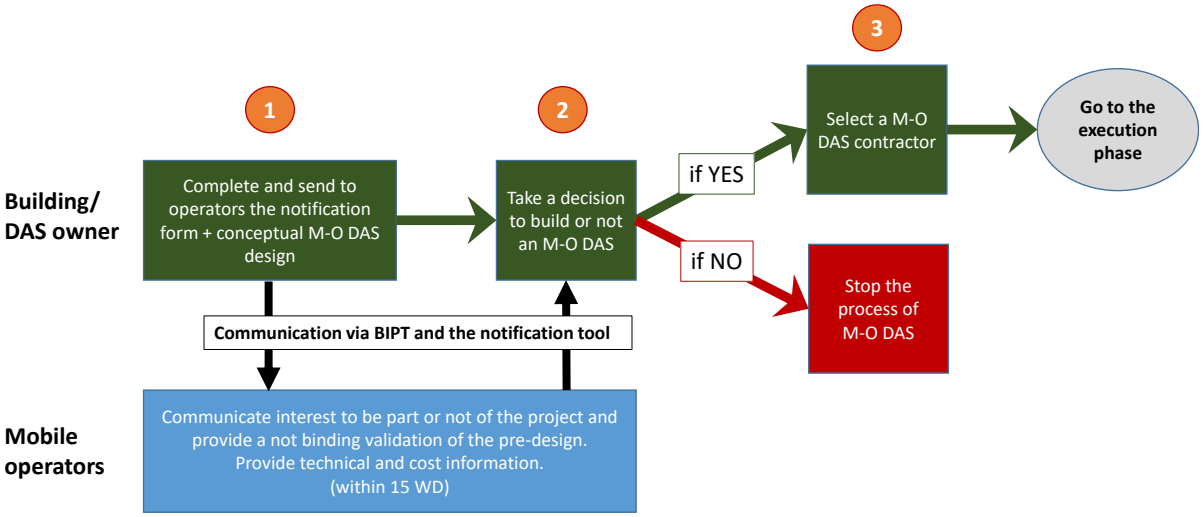

Figure 3: M-O DAS conceptual pre-design process flow

We present below one-by-one all the steps in detail (step 1 ➔ step 3).

3.1.1. DAS connectivity request (step 1)

The building owner/promoter (or its duly representative which can be the M-O DAS contractor) completes and sends the notification form (see annex 2) together with a conceptual M-O DAS pre-design to the mobile operators using the notification-tool.

The design requirements and all the documents required with the design as mentioned below will have also to be provided (see the detailed technical requirements in annex of this document).

Overall pre-design requirements

The conceptual M-O DAS pre-design will include:

- Plans of the building to be covered
- Expected capacity needs per floor/area (number of people and type of activity)
- Implementation plan of the existing and new or renovated installation, indicating the floor space dedicated to the transmission room, M-O DAS technical rooms for the active radio equipment, location of the antennas, location of the tappers, splitters, combiners….
- One-line scheme of the installation including the needed input level per technology to meet the baseline thresholds below.
- iBWave design or equivalent.

A building should be covered independently from the outdoor coverage. In case of existing indoor coverage provided from outdoor (i.e. solution with repeaters), it is necessary to have a significantly stronger indoor signal. The indoor signal level should always be at least 10 dB higher than the outdoor signal in order to avoid interference in urban environment (6dB for rural or suburban environment). In case of repeater the serving indoor signal level must be 10dB higher than the best neighbour signals.

The acceptance for construction phase will be based on the below mentioned requirements. In this phase it should already be made clear that the DAS contractor will have to respect the following baseline thresholds for indoor coverage:

- 2G: Indoor BCCH signal level -85 dBm (@ 95%).
- LTE (4G): Indoor RSRP signal level -95 dBm (@ 95%) + (20MHz bandwidth LTE band 7).
- 5G: Indoor RSRP signal level: -105 dBm (@95%), at least 100 MHz bandwidth per operator in band n78 (3300 – 4200 MHz)

These levels should be verified /confirmed by means of the final integration walk test at the very end of the process when the DAS active equipment will be connected.

By respecting these thresholds, the DAS contractor will minimize indoor signal leakage outside the building to avoid an impact on macro sites. Signal leakage to outdoor environment should be 15 dB lower than the dominant cell. In case outdoor signal levels are below -100dBm, the leakage signal levels measured outside are allowed to be -100dBm as well.

Those considerations are important as they will prevent as much as possible interferences, handover and quality problems for end-users inside but also outside the building.

The design needs to be compliant with the applicable regulation for electromagnetic emission and urbanism. In Belgium, regulation is different in the 3 regions (see below point 3.2.1).

Drawings and schemes of the design need to be provided in pdf format and/or iBwave format (without password). They shall also contain a clear legend explaining the different symbols used.

The DAS contractor should consider the implementation of both repeaters and base station solutions in its design. In case repeaters would be used (subject to operator's approval), the design should mention the pickup antennas positions, the coverage levels per technology-band and cell-ids measured on the potential pick-up antenna location and the positions of the cables between the pickup antennas and the repeaters.

It is important to note that a MO-DAS solution requested for A.S.T.R.I.D. services does not support Mobile Operator services natively. In case Mobile Operator coverage is also to be provided by the MO-DAS system, additional requirements – specifically for Mobile Networks – must be integrated into the design to support both A.S.T.R.I.D. and Mobile Operators.

One-line drawing

This is a drawing identifying radio, cables, splitters, connectors, attenuators, antennas, and how they are connected. It contains indications such as the type of cables, cable lengths, type of antennas, splitters… and includes a list of all materials that will be used.

Other elements relevant for the analysis of the radio engineer of each operator may be added to this drawing, such as the cable attenuation per frequency.

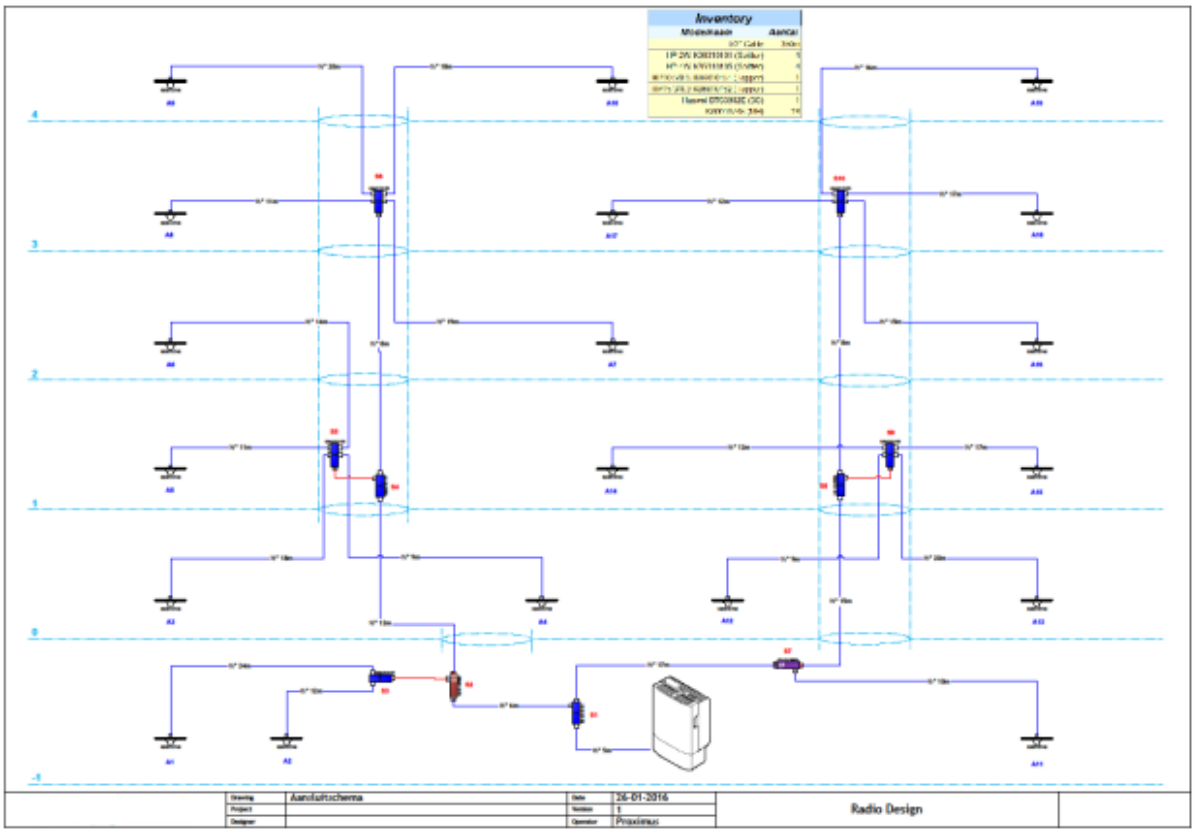

Figure 4: example of one-line drawing

Implementation plan

The implementation plan is a set of floor plans (one for each floor) which shows the location of the antennas, technical rooms, transmission room and the cable paths and the connections to other floors (vertical technical shafts) as shown in the example hereunder.

Figure 5: example of implementation plan

Mobile operator response

Based on all the information provided, mobile operators will communicate within 15 working days (starting upon reception of all complete and correct documents and information) if they are interested or not to be part of the project and will provide a not binding validation of the conceptual pre-design. The operator will also provide technical input to the building owner allowing him to make the complete design and high-level cost estimation of the full M-O DAS project.

Information required from operators are:

- Power consumption
- Cooling needs
- Cabling requests (between technical and transmission rooms)
- Cost estimation of operator-related elements for the project (transmission and active radio equipment)
- Zone type of the building (rural, sub-urban, urban) to determine required indoor signal level for the design.

This information should allow the building/DAS owner to make a reliable project evaluation and help him in making the decision if an M-O DAS is feasible or not.

At this early stage, the answer provided by the operator may not be considered final. **It is only at a later stage in the process, when operators will proceed with the validation of the final RF design (see step 6), that they will communicate their final decision and depending on this decision sign a contract with the building**

owner for the connection of their equipment to the M-O DAS. Up until then, operators have the possibility to withdraw from the project at no cost.

If the M-O DAS is designed for at least one mobile operator, then even though other operators may decide not to connect to the DAS in a first stage, the indoor installation will always be designed in such a way that it will be able to accommodate all operators at any moment in time. In case another mobile operator wants later to connect to the M-O DAS it will have to do it within the limitations (in terms of available technology and spectrum bands) of the existing indoor installation.

3.1.2. Building owner decision (steps 2 & 3)

Based on the info obtained from the operators, the building owner will then decide whether or not to integrate the construction of an M-O DAS in its final building project.

Depending on its decision the building owner will then:

- Either stop the process of M-O DAS. The building owner may then for example decide to go further bilaterally with only one operator or could decide to completely stop the project of having a mobile indoor system.
- Or select an M-O DAS contractor and proceed towards the Execution Phase (step 4).

3.1.3. Additional measures for improved connectivity

New or retrofitted buildings are generally well insulated and have a high level of façade attenuation. Although this strong attenuation can be beneficial for the protection of a dominant signal when installing a Distributed Antenna System (DAS), this high insulation often results in insufficient indoor coverage.

As an addition or alternative to deploying a DAS, enhancing building transparency for radio signals can be an effective solution for small to medium-sized buildings to achieve indoor coverage for multiple operators. Building transparency allows outdoor signals to naturally penetrate the building façade. It can be achieved by selecting façade materials with reduced radio attenuation during the building design phase or by applying treatments that improve their radio transparency during building occupation.

It is important to note that building transparency uses the existing outdoor network without adding additional capacity. Key factors to consider when deploying such a solution include the level of the outdoor signal, the surface area of radio-transparent materials and the level of interference present outside.

For example, the glass façade treatment provides a sustainable solution. The network present outside the building can be used without additional infrastructure inside the building. As a result, building transparency provides a solution with virtually no additional energy consumption. It is always strongly recommended to perform a case-by-case analysis to verify the optimal solution for improved indoor connectivity.

3.2. Execution Phase

This phase consists of the necessary preparation activities, the execution and finally the acceptance, and can only start when the building is sufficiently advanced to plan the first site visit (internal walls, windows, doors are built) - see fig 7 for the detailed steps (steps 4 – 10).

At this stage, the building owner/promoter should have selected and concluded a contract with a DAS contractor which will be responsible for the construction of the M-O DAS installation.

During the execution phase, the building owner/promoter and/or the selected DAS contractor together with the operators having communicated their interest to be part of the project, will go through the different steps as described in the process flow below with the aim to build an M-O DAS to which operators will connect their equipment.

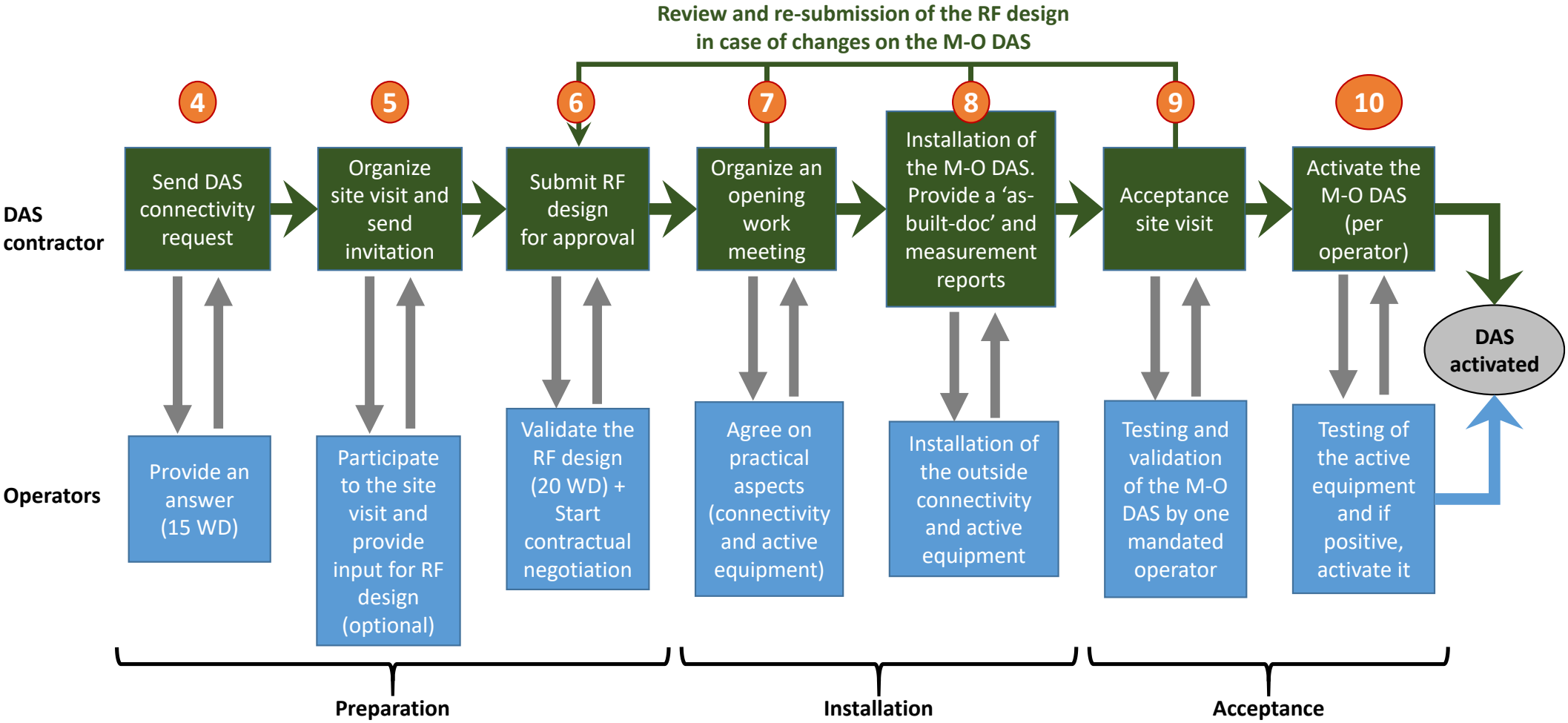

Figure 7: M-O DAS Execution process flow

Detailed technical requirements are annexed to the present general guidelines (see annex 1). Those requirements are addressed to the M-O DAS contractor that has been contracted by the M-O DAS owner or the M-O DAS promoter to design and install an M-O DAS that will be operational and ready to connect with the mobile operator's network. They provide a full overview of the processes to be followed with all steps (from step 4 to step 10) explained in detail and a minimum set of basic technical requirements.

These processes and requirements are inspired from existing best practices and processes based on the experience of mobile network operators for the design and installation of M-O DAS.

It is highly recommended to use the detailed technical guidelines (annex 1) as a reference for the selection of the M-O DAS contractor and to include them in the contract with the company that will be in charge of the installation of the M-O DAS.

This will ensure that the M-O DAS will meet all the technical, regulatory and quality requirements. Operators will only be able to connect their active radio equipment to the M-O DAS if all the processes and requirements are correctly respected.

3.2.1. Building and health permits

The DAS owner/contractor must ensure that the indoor installation is fully compliant with the applicable regulations concerning building permit and electromagnetic emission norms. In Belgium, regulations are different in the 3 regions.

If needed by the applicable regional regulation, a building permit is to be introduced by the building/DAS owner only if the M-O DAS RF design foresees the installation of a pick-up antenna on the roof.

Taking into account the important administrative burden of having to prepare a health permit and the related cost that would have to be supported by the DAS owner, operators strongly recommend that the design would be done in such a way that the M-O DAS would remain below applicable health norms in all places, floors and so that there would be no need to introduce a health permit (see the detailed technical requirements for more details about the applicable permit thresholds). This is also the best way to ensure that the effective indoor installation will be fully in line with applicable health norms.

If a health permit would still need to be introduced, it will be handled by each concerned operator based on information provided by the DAS owner/promoter/contractor. Only operators are allowed to introduce such health permit.

Mobile operators will inform the building/DAS owner duly in time in case of a modification/strengthening of the applicable health regulation. The building/DAS owner will then have a legally pre-defined period to modify its M-O DAS according to the new applicable norms.

In case the activated M-O DAS would not comply with applicable health norms, the building/DAS owner will have 24 hours to modify the M-O DAS. If this would not happen, operators will be authorized to lower the power or to de-activate their equipment.

In case of fines due to health norms infringements, operators will also be authorized to pass them on to the building/DAS owner.

3.2.2. Repartition of the responsibilities

Below you will find a short overview of the respective responsibilities of the mobile operators, the building/DAS owner and the M-O DAS promoter during the whole execution phase of the M-O DAS.

Mobile operators

1. Provide an answer to the DAS connectivity / notification request (15WD)
2. Participate to the initial site survey (optional)
3. Validate the RF detailed design
4. Participate to work meetings organized by the building owner or DAS contractor (e.g. to determine all needed cabling, power & cooling details, etc.)
5. In case of need, introduce a health permit
6. Draft an offer & contractual agreement to be submitted to the building owner for the active network components (base-stations, repeaters)
7. Participate to the M-O DAS acceptance site visit (testing and validation of the M-O DAS)
8. Ensure the installation, operation and maintenance of the active radio equipment (including connection to the DAS and to the transmission lines)
9. Draft and submit mandatory files to administrations (e.g. health files)

Building/M-O DAS owner (and/or its delegate which can be the M-O DAS contractor or the M-O DAS Promoter)

1. Ensure the overall project management and coordination (prepare site survey, design, as-built plan and organize work meetings when needed…).
2. Establish and follow-up of the contract with the DAS contractor.
3. Ensure that the installation of the M-O DAS occurs according to the 'detailed technical requirements' (see annex 1)

4. Ensure that the M-O DAS is fully in line with applicable health norms regulation (different in the 3 regions)
5. Introduce a building permit in case a pick-up antenna is foreseen (different in the 3 regions)
6. Provide the needed access rights to the building for the DAS contractor
7. Provide the needed access rights to the building and technical room(s) for mobile operators (or mobile operator's subcontractor)
8. Ensure the availability of cabling in the building according to the specifications of the operators.
9. Provide technical room(s) which are fully equipped (power, cooling, etc.) to host the active radio equipment of each operator.
10. Provide PIM measurement report once the MO-DAS installation is completed and before the operators connect to it.
11. Ensure the proper maintenance and repair of the M-O DAS during its whole lifetime (see specific section 3.3.1 below).
12. Follow-up of the contract with mobile operators having decided to connect to the M-O DAS.

3.2.3. Follow-up of the contract with M-O DAS Contractor or M-O DAS Promoter for the building of the M-O DAS and the DAS-maintenance activities once activated.

Provisioning of the technical room(s)

All details related to this topic are linked to the type of active equipment an operator will install. This is always depending on the design made by the DAS contractor. During the validation of the design or later on in the process during the opening works meeting (step 7) all related info will be provided towards the building owner.

One or more technical rooms must be foreseen by the building/DAS owner to host active radio equipment owned and operated by each mobile operator. Different types of technical rooms can be foreseen depending on the building size and RF design and configuration.

- **The main equipment room** is the room where the mobile operator's main equipment will be installed (i.e. BTS, repeater…).
- **The remote equipment room** host additional mobile operator's equipment (i.e. remote radio heads,…).
- **The transmission room** is the room where the operator will enter with the transmission cable from outside the building.

For smaller buildings all these various types of technical rooms could be regrouped in one single technical room.

Access to the technical rooms

Access to the technical room(s) must be guaranteed to the mobile operators during the installation phase and afterwards during the whole lifetime of the M-O DAS. Entrance to the room(s) will be reserved only to authorized and skilled people and measures must be taken to prevent any unauthorized access to these room(s). Access to the technical room(s) can be granted by operators on demand. Operators shall warn the building/DAS owner upfront in case of on-site interventions and shall make sure that the building/DAS owner can clearly link the identity of the technician with the concerned operator company that will do the intervention.

The building owner will be responsible for the implementation of all adequate logistic and security measures in relation with the technical rooms. Such implementation can be performed by the DAS contractor (in which case the listed specifications below should be included in the DAS contractor contract) or another third party. These requirements will be discussed and agreed in detail during the opening work meeting before the construction phase. Some rules of thumb can be found below.

Surface on ground

For a medium indoor coverage project (of 30 to 40 indoor antennas) each mobile operator will need a floor space for 2 radio cabinets and 1 supporting cabinet for the powering and backhauling. Minimum surface on ground for housing the cabinets is 2 m^2 per operator. Additional space in the equipment room can be needed, depending on the telecom equipment choice. Additional space can also be needed for housing remote equipment, depending on the building configuration.

Load on floor

Load on floor: 250 kg/m^2 for telecom and supporting equipment. The deviation in planarity of the floor will not exceed 5 mm per meter. Floor surface has to be clean, dry and free from obstacles.

Equipment room(s) environmental characteristics

The technical room(s) of each mobile operator is located as close as possible to the common DAS connection point (for aim of equal cable losses). The building owner is responsible for setting up and maintaining a cooling system to create the right environmental conditions for the technical room. Mobile operators will deliver the heat load data for the installed telecom equipment during the opening work meeting (step 7).

- **The main equipment room** is the room where the mobile operator's main equipment will be installed (i.e. BTS, repeater…). Free useable height of the room ≥ 2,5 meters. Environmental conditions inside the room are compliant with ETSI standard ETS 300 019-1-3 class 3.1: Temperature controlled locations. 99% of time the temperature will be between +5°C and +40°C, 99% of time the relative humidity will be between 5 and 85%.

Minor presence of sand and dust, not situated in proximity to sources of sand or dust. With insignificant vibration or shock, not subjected to water, condensed water or icing. Without particular risks of biological attacks (clean location where there is no molding (fungus) or attack by animals).

- **The remote equipment room** host additional mobile operator's equipment (i.e. remote radio heads,…). Free usable height of the room ≥ 2 meters. Environmental conditions at the remote location are compliant with ETSI standard ETS 300 019-1-3 class 3.3: not temperature-controlled locations.

Power connection & grounding at equipment locations

Each mobile operator will have access to individual electrical power connection:

- AC power connection for the Technical room: 3 x 400V +N _ 20 Ampère is preferred (other power connection to be discussed when applicable)
- AC power connection for remote location: 1 x 230V +N _ 20 Ampère is preferred (other power connection to be discussed when applicable)
- 10 Ohm electrical grounding point
- Equipotential connection between all grounding points used in the DAS in the main/secondary technical rooms

Transmission

Each operator will provide the needed connectivity from outside the building up to the transmission room via a tube foreseen by Das contractor. The connectivity cabling will be provided and installed by operators. The DAS contractor will have to foresee a tube/subduct (HDPE 50mm) for each operator in the project, between private property (building intro) and public domain + along the route, every 50m and for every direction change, a waiting pit needs to be foreseen. The building/DAS owner is responsible for the placement of a tube that will be adequate internal cabling inside the building from the transmission room to the equipment room (in case these rooms are distinct).

The radio interface with the M-O DAS must be made available within the technical room.

In some cases, the active radio equipment of the mobile operators will require an external antenna (i.e. use of repeater); in such case, enough space on the roof or on external walls must be planned for the external antenna.

3.3. Operation Phase

3.3.1. Maintenance of an existing M-O DAS

In order to maintain a good quality of experience for end-users inside but also outside the building (as the indoor coverage installation may interfere with the outdoor mobile network), it is essential that the M-O DAS/building owner foresees proper maintenance of the M-O DAS during its whole lifetime and ensures that there is no deterioration of the quality of the mobile networks connected to the DAS.

In this context, it is important to clearly define a single point of contact in case of a DAS quality issue. It is not the responsibility of the operators to intervene on the passive DAS infrastructure. Operators are only responsible for the proper functioning and maintenance of their own respective active radio equipment and for the outside connectivity.

Building/DAS owner

The DAS owner will be responsible for or ensure the operation and the maintenance of the DAS during its whole lifetime. In most cases, this task will be delegated to a 'DAS maintenance company' which could be the DAS contractor itself or any other third party contracted by the DAS owner to ensure the maintenance of the M-O DAS.

At contract signature (contract DAS/Building Owner <-> Operator), the DAS owner provides the coordinates (company name, email, mobile number) of a point of contact that can be reached in case a maintenance problem would occur. If during the life cycle of the installation, the DAS maintenance company or point of contact changes, the DAS Owner will proactively inform the Operator of these changes.

It is important that the DAS owner chooses a qualified DAS maintenance company that has all the qualifications required to ensure the full maintenance of the DAS (radio skills and experience in designing passive DAS systems). For performing such work, the DAS contractor should dispose of the necessary tools and equipment (e.g. scanner/spectrum-analyser/PIM-measurement tool/ ...). The DAS maintenance contractor must be able to investigate problems caused by external interferers. These interferers could come from outside but also from inside the building (Wifi, DECT systems,.....).

In case of observed quality issues or technical problems (including problems of power supply, electromagnetic emission issues, etc.), operators may, at any time, ask to the DAS owner to modify the design of an activated M-O DAS upon guidance of the impacted operator.

In case of PIM/VSWR-problems, the DAS Maintenance contractor will be in charge of measuring the potential root causes with the measurement equipment most suited

for this. The contractor will also be responsible for the coordination with the concerned operators to resolve potential alarms and customer impacting issues in a reasonable time (5 working days).

In case the DAS owner is planning to do an intervention on the M-O DAS, power supply or any other intervention that might fully or partially impact indoor mobile services, the DAS owner (or its delegate) will inform the concerned operator 10 working days before the planned intervention/outage date.

For any intervention of an operator – planned or not – and if the root cause of the intervention is not under the responsibility of the operator, then the operator will charge the building owner for all costs incurred.

All possible changes and/or extensions of the M-O DAS due to e.g. to the inclusion of additional coverage areas and/or the increase in capacity needs will fall under the responsibility of the DAS owner.

Mobile operators

Each operator will be responsible for the proper functioning and maintenance of their respective active radio equipment (repeaters and base stations) and for the connectivity that has been provided from outside the building towards the technical room inside the building. Operators will also support all the costs related to their own active radio equipment.

In case an electromagnetic emission health issues would arise, operators will be responsible for the handling of the complaints and all related administrative tasks. However, it would be the responsibility of the DAS owner to solve the identified problem if it is caused by the M-O DAS. The building/DAS owner will have 24 hours to modify the M-O DAS. If this would not happen, operators will be authorized to lower the power or to de-activate their equipment.

In case of fines due to health norms infringements, operators will also be authorized to pass them on to the building/DAS owner.

If one operator's service is down or after investigation it seems a detected problem is linked to the radio equipment of an operator (or more operators), the maintenance and repair will be done by the concerned operator(s).

3.3.2. Change requests impacting an existing M-O DAS

Following the construction of an M-O DAS, different types of change requests could be introduced to the existing M-O DAS. For example, an additional operator could request to join an existing M-O DAS. It could also be needed to proceed with the extension or the reduction of an existing M-O DAS. At last, there could be a request to dismantle an indoor installation.

Mobile operators will inform the building/DAS owner duly in time in case of a modification/strengthening of the applicable health regulation. The building/DAS owner will then have a legally pre-defined period to modify its M-O DAS according to the new applicable norms. If this would not happen, operators will be authorized to de-activate their equipment.

In case of fines due to health norms infringements, operators will also be authorized to pass them on to the building/DAS owner.

These processes are described in the detailed technical requirements (see annex 1).

4. COST REPARTITION

Building/DAS owner

The building/DAS owner will support all costs related to the design, construction, maintenance, power supply and modification of its M-O DAS, except for the costs that are explicitly identified and attributed to mobile operators (see next sub-section).

Mobile operators

Without prejudice to what would be contractually negotiated by each individual operator with the building/DAS owner, operators will only take at their charge one final validation of the RF design (step 9 of the 'Execution Phase). In case additional validations are requested, they will then be charged to the building/DAS owner.

The costs related to the installation and use of operators' active equipment and of the outside connectivity will be part of the contract signed with the building/DAS owner. The usage fee that will be foreseen for the equipment and connectivity usually include all maintenance and repair costs.

5. CONTACT POINT (NOTIFICATION PROCESS)

BIPT

Gino Ducheyne

Phone number: 032 2 226 88 18

Email: gino.ducheyne@bipt.be

Project email: indoorcoverage@bipt.be

Abbreviations

BTS:	Base Transmission Station
RF:	Radio frequency
M-O DAS:	Multi-Operators Distributed Antenna system
MH:	Mexican Hat
MNO:	Mobile Network Operator
EP:	Environmental Permit
VSWR:	Voltage Standing Wave Ratio
EIRP:	Effective Isotropic Radiated Power
PIM:	Passive Intermodulation Measurement

ANNEXES

Annex 1

Detailed Technical Requirements for the installation of multi-operators mobile indoor Distributed Antenna System (M-O DAS)

For the M-O DAS promoter
and/or the M-O DAS contractor

Version : January 2025

Table of Contents

1. INTRODUCTION

This document is addressed to the party that will be in charge of the design, construction and maintenance of a Multi-Operator Distributed Antenna System (we will call this party, the M-O DAS contractor).

Mobile operators strongly recommend to insert this document in annex to the contract signed between the building/DAS owner (or a duly representative of the building owner which can be for example a tenant) and the DAS contractor. By including these detailed technical requirements to the contract, the DAS contractor agrees to comply with the set of formalized processes and requirements.

The overall M-O DAS process may include the 3 following main phases.

- The **Conceptual Pre-Design Phase** is only applicable in situations where the building is not yet constructed or needs to be structurally renovated.
- The **Execution Phase** starts when the building structure is in place with wall and windows and provides technical guidance to the DAS contractor for the design and construction of an M-O DAS.
- Finally, the **Operation Phase** refers to everything which needs to be done to ensure the proper maintenance of an existing M-O DAS. This phase could also be of interest for the DAS contractor if this party would also be in charge of the maintenance of the M-O DAS after its construction.

1. Conceptual Pre-Design Phase	2. Execution Phase	3. Operation Phase
• In this phase the building is not yet constructed or needs to be structurally renovated. If the building already exist, one may directly proceed to the next phase : the Execution phase. • The party in charge of the design will contact mobile operators to see if they would be interested to join the M-O DAS project. • Based on the input received from operators the building owner will decide to build or not an M-O DAS. • If the decision is positive, a final design will be established and the tender process for a DAS contractor will start.	• In this phase, the building structure with walls and windows already exist. • The building owner has taken the decision to construct a M-O DAS and a DAS contractor has been selected to perform the work. • The building/DAS owner will remain the main contact point for mobile operators. When operators agree to be part of the project, a contract will be signed between them and the building/DAS owner. • The DAS contractor will construct the M-O DAS in compliance with the detailed technical requirements (see annex 1) and regulation. • Mobile operators will validate the M-O DAS and will be responsible for the installation of their active equipment and the outside connectivity.	• The building/DAS owner will remain responsible for the proper functioning of the M-O DAS during its whole lifetime. • The building/DAS owner will ensure the maintenance of the system and will modify/adapt the system when needed. • Mobile operators will be responsible for the proper functioning and maintenance of their active equipment and for the outside connectivity.

Figure 1: overall overview of the M-O DAS phases

This document will only cover the 'Execution Phase' and the 'Operation Phase'. The 'Conceptual Pre-Design Phase' is explained in detail in the General Guidelines.

The detailed technical requirements provide a detailed overview of the processes and define a minimum set of basic technical requirements with the aim to help a DAS contractor to design and install an indoor Multi-Operators Distributed Antenna System (M-O DAS) that will be operational and ready to connect with mobile operator and possibly Astrid networks.

These processes and requirements are inspired by existing best practices and processes based on the experience of mobile network operators for the design and installation of M-O DAS.

2. M-O DAS DESCRIPTION

A Multi-Operator Distributed Antenna System (M-O DAS), is a passive network which aims to ensure a correct distribution of radio signal strengths of all connected mobile network operators on all desired areas of a building (i.e. office space, warehouse, underground parking place, elevators…). Such system is not to be confused with active antenna-systems (such as femtocells, small cells, active DAS systems, …) which are not in the scope of the present guidelines.

An M-O DAS must be designed in such a way that it will be able to accommodate the mobile network operators at any moment in time. Doing so, upfront at the design stage generates negligible additional costs and will save significant costs in comparison to adapting an existing MO-DAS afterwards. Operators are indeed free to connect to the M-O DAS as from the moment it is constructed or could also decide to connect to it at a later stage (several months or even years after the M-O DAS has been installed). The objective is to provide guidelines for the construction of an M-O DAS that will provide all the flexibility to accommodate any mobile operator at any time.

The active network elements provided and operated by mobile network operators are typically located in a dedicated technical room inside the building (see chapter 6 on the provisioning of technical rooms).

The passive M-O DAS can potentially support :

- all current mobile technologies (namely GSM, EDGE, LTE, LTE advanced, 5G) on all supported licensed frequency bands (700, 800, 900, 1400, 1800, 2100, 2600 and 3400-3800, 3800-4200 MHz[1])

[1] Concerning the band 3400-3800MHz, it is to be mentioned that there is in principle less or even no relevance to use it in a SISO configuration. This band should also be avoided in combination with Astrid (due to the large separation between Astrid band and the 3400-4200MHz bands).

– Astrid technologies (TETRA and other future technologies[2]).

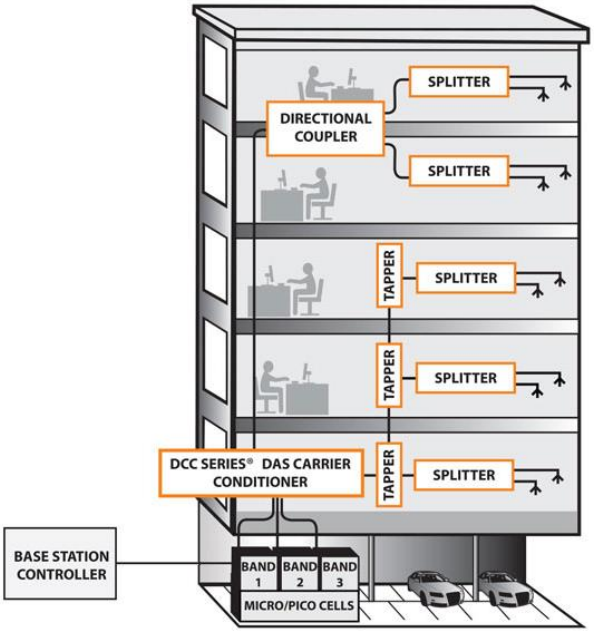

Figure 2: example scheme of a typical DAS

3. PROCESS DESCRIPTION

As already said before, these detailed technical requirements are addressed specifically to the DAS contractor (i.e. party that will design, build and eventually ensure the maintenance of the M-O DAS) that has been selected by the building/DAS owner/promoter and are focusing on the Execution Phase, which is the phase including the design, the construction and finally activation of a M-O DAS.

The Execution phase can only start when the building is sufficiently advanced to plan the first site visit (internal walls, windows, doors are built).

During the execution phase, the building owner/promoter/DAS contractor together with the operators will go through the different steps as described in the process flow below with the aim to build an M-O DAS to which operators will connect their equipment.

This will ensure that the M-O DAS will meet all the technical, regulatory and quality requirements. In particular, the M-O DAS shall be compliant with the applicable

[2] ASTRID will make a transformation from the actual TETRA network to a Hybrid broadband network with his own dedicated Core network and his own RAN (MC-RAN on 700 MHz – Band 28 & 68) and will also interconnect with a Mobile Network Operator (MNO) to use the spectrum and the RAN of the selected MNO (4G/5G) in an MOCN architecture.
Today it is not defined yet what the future obligations for ASTRID coverage in buildings will be. It will depend on the decisions of the "Federale Overheidsdienst Binnenlandse Zaken" / "Service public federal Intérieur" - IBZ).
The actual TETRA network will stay operational until 2030-2032.

regulation for electromagnetic emission and urbanism (in Belgium, regulation is different in the 3 regions).

Operators will only be able to connect their active radio equipment to the M-O DAS if all the processes and requirements are correctly respected.

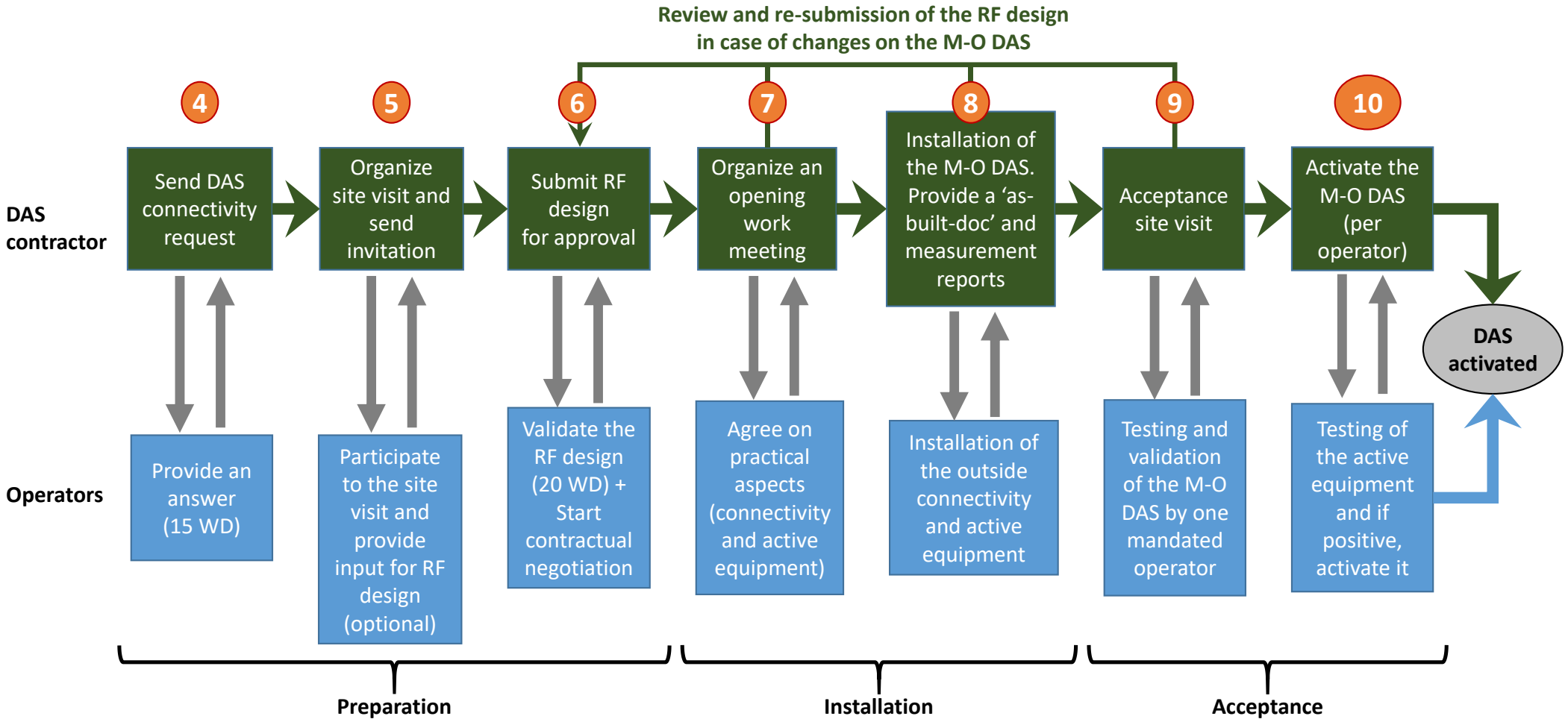

Figure 3: M-O DAS Execution process flow

3.1. DAS connectivity request – Step 4

The building/DAS owner/promoter or its delegate initiates a request to the operators and possibly Astrid to join the DAS (via the notification-tool) and includes all the requested informations as already described in step 1 of the General Guidelines document.

In case a conceptual pre-design phase occurred previously, when the building/DAS owner will provide all the requested documents together with the notification form, he will either confirm or modify the building information and customer information that he already provided in Step 1. A new official request is however required as technical & commercial interests of the operators could have changed in time due to for example network evolution or churn of customers.

The operators will confirm their interest within 15 working days as from the moment that all required information has been properly provided.

3.2. First site visit (optional for operators) – Step 5

A first site visit should be organized by the building owner/DAS contractor and an invitation will be sent via the notification system to the operators and possibly Astrid.

It is up to each operator and Astrid to decide on the need to participate to this site visit. The presence of the DAS contractor is mandatory for this meeting. Operators / Astrid who would decide to participate to the visit will be able to provide advice to the DAS contractor based on their first assessment on the location. Such provided advice should be taken into account by the DAS contractor in the subsequent design phase.

During this visit, the objective is that the DAS contractor would collect on site all the needed information about the building(s), the propagation environment in and around the building and the usage in each zone. All this information will help him to determine exactly the coverage needs. The survey will also allow to determine the location of the technical equipment room(s), transmission rooms, the antennas, potential pick-up antenna locations, signal strengths (all operators and technologies) indoor and on the roof (for repeaters) and the cable routes. In case a pick-up antenna would be foreseen, the DAS contractor will then have to introduce a building permit (different procedure in the 3 regions).

Site visit report will be sent by the DAS contractor via the notification system to each operator (including operator that would not have participated to the visit) with the plans of the areas to be covered together with the measurement reports.

Measurements reports shall include: the best server outdoor signal, indoor measurements and measurements performed on the roof of the building.

3.3. RF Detailed Design – Step 6

3.3.1. Tasks of the DAS owner/DAS contractor

a. Overall design requirements

The M-O DAS must be designed by the DAS contractor in such a way that it can accommodate the services and related frequencies of mobile network operators and can support the existing technologies (2G & 4G). As far as possible and considering technology evolutions, the M-O DAS should be designed in a way that it will allow upgrades and additions of future technologies according to the requirements provided by the mobile network operators (e.g. 5G).

To ensure a good indoor quality of experience the design needs to consider the capacity that is expected to be needed for the specific location. Expected capacity needs will depend on the foreseen number of end-users on this location and must be conform to the frequency bands in use by the operators.

The DAS contractor will make a design based on a measurement report of the different technologies and frequencies (receiving level of the existing outdoor coverage which is measured on the different floors inside and outside the building and on the roof). This design will also contain the input level needed per technology to meet the baseline thresholds below.

A building should be covered independently from the outdoor coverage. In case of existing indoor coverage provided from outdoor, it is necessary to have a significantly stronger indoor signal. The indoor signal level should always be at least 10 dB higher than the outdoor signal to avoid interference in urban environment (6dB for rural or suburban environment). In case of repeater the serving indoor signal level must be 10dB higher than the best neighbouring signals.

The acceptance for construction phase will be based on the below mentioned requirements. Baseline thresholds for indoor coverage acceptance are:

- 2G: Indoor BCCH signal level -85dBm (@ 95%)
- LTE: Indoor RSRP signal level -95dBm (@ 95%) + (20MHz bandwidth LTE band 7).
- 5G: Indoor RSRP signal level: -105 dBm (@95%), at least 100 MHz bandwidth per operator in band n78 (3300 – 4200 MHz)

These levels should be verified /confirmed by means of the final integration walk test at the very end of the process when the DAS active equipment will be connected.

By respecting these thresholds, the DAS contractor will minimize indoor signal leakage outside the building to avoid an impact on macro sites. Signal leakage to outdoor environment should be 15 dB lower than the dominant cell. In case outdoor signal levels are below -100dBm, the leakage signal levels measured outside are allowed to be -100dBm as well.

Those considerations are important as they will prevent as much as possible interferences, handover and quality problems for end-users inside but also outside the building.

The DAS owner/contractor must ensure that the design of the indoor installation is fully compliant with the applicable regulations concerning building permit and electromagnetic emission norms. In Belgium, regulations are different in the 3 regions (see below point f).

Drawings and schemes of the design need to be provided in pdf format and/or iBWave format (without password). They shall also contain a clear legend explaining the different symbols used.

The DAS contractor should consider the implementation of both repeaters and base station solutions in its design. In case repeaters would be used (subject to operator's approval), the design should mention the pickup antennas positions, the coverage levels per technology-band and cell-ids measured on the potential pick-up antenna location and the positions of the cables between the pickup antennas and the repeaters.

ASTRID specific RF Design requirements

It is important to note that a MO-DAS solution requested for ASTRID services does not support Mobile Operator services natively. In case Mobile Operator coverage is also to be provided by the MO-DAS system, additional requirements – specifically for Mobile Networks – must be integrated into the design to support both Astrid and Mobile Operators.

To reduce the risk of intermodulation and interferences between the ASTRID TETRA network and the network of the Mobile Operators that are participating in the MO-DAS, ASTRID requires a minimum RF-isolation of 40dB.

This can be achieved with the use of combiners that can reach this isolation between the "TETRA-port" and the ports for the MNO's and/or by installing an additional bandpass-filter (TETRA) between the combiner and the active installation (Base Station / repeater) of ASTRID.

For further information on the ASTRID indoor solutions you may also refer to ASTRID 3rd party convention and the related technical annexes. A request to obtain these documents may be addressed to ASTRID Service Centre[3] by completing the contact form or via email[4]. Specific questions may also be addressed to ASTRID external advisor[5]. A brochure is also available op ASTRID website[6].

b. One-line drawing

This is a drawing identifying radio, cables, splitters, connectors, attenuators, antennas, and how they are connected. It contains indications such as the type of cables, cable lengths, type of antennas, splitters… and includes a list of all materials that will be used.

Other elements relevant for the analysis of the radio engineer of each operator may be added to this drawing, such as the cable attenuation per frequency.

[3] https://www.astrid.be/nl/support (or) https://www.astrid.be/fr/support
[4] info@astrid.be
[5] https://www.astrid.be/nl/service-support/adviseurs
[6] https://www.astrid.be/sites/public/files/files/2021-10/brochure_radiodekking_in_gebouwen_indoor_astrid.pdf (and) https://www.astrid.be/sites/public/files/files/2021-10/brochure_couverture_radio_a_linterieur_des_batiments_indoor_astrid.pdf

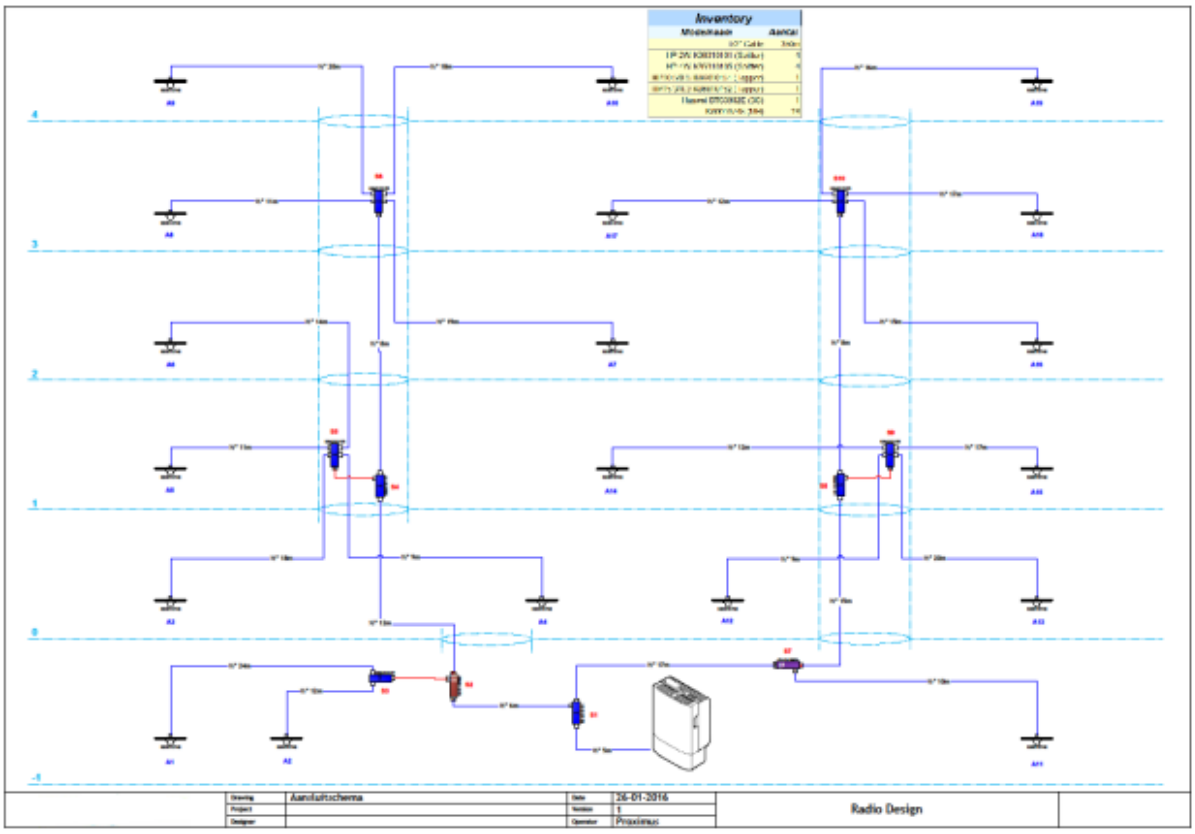

Figure 4: example of one-line drawing

c. Implementation plan

The implementation plan is a set of floor plans (one for each floor) which shows the location of the antennas, technical rooms, transmission room and the cable paths and the connections to other floors (vertical technical shafts) as shown in the example hereunder.

Figure 5: example of implementation plan

d. Signal loss calculations

For each antenna, a precise loss calculation (loss between the common entry point of all operators and each individual antenna) has to be made by the DAS contractor. This calculation will be based on coaxial cable length, coax cable type, frequency band, type of passive component (combiner, diplexer, splitter, tapper, attenuator …) using materials from the agreed portfolio. This will allow operator(s) to determine the appropriate power to configure on its (their) active equipment(s) to comply with the health regulations (see point f).

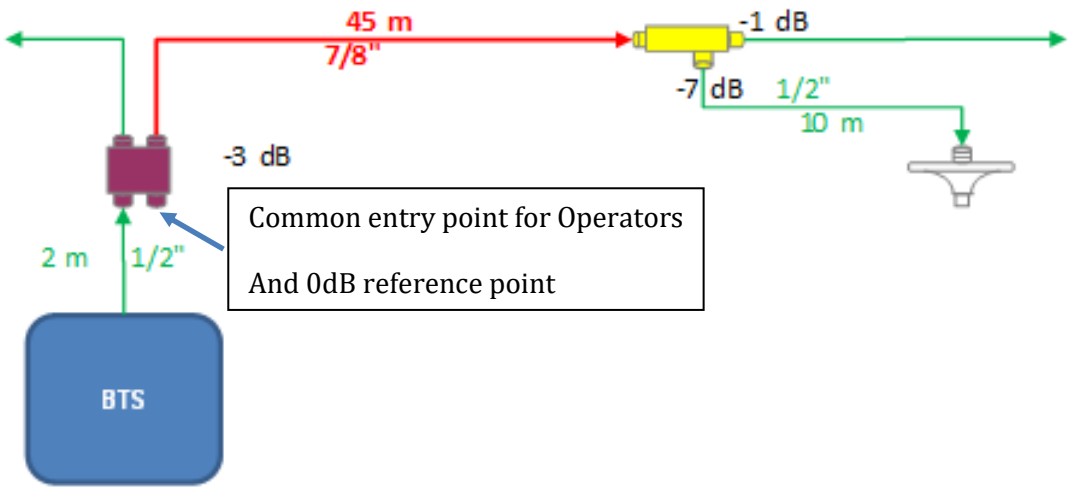

Figure 6: example of loss calculation

Loss between BTS and antenna for the 900 MHz band :

Cable loss : 45m 7/8" (3.75dB per 100m) and 12m ½" (7.07dB per 100m)

➔ 45*0.0375+12*0.0707 = 1.69dB + 0.85dB = **2.54dB**

Passive components loss : 3dB for the combiner, 7dB for the tapper

➔ 3+7 = 10 dB

Insertion loss : 2 passive components (0.2dB loss for each component)

➔ 2*0.2dB = 0.4 dB

Total loss 900 MHz band: 2.54+10+0.4= **12.94 dB**

In the same way :

Total loss 1800 MHz band = 3.67+10+0.4 = **14.07 dB**

Total loss 2100 MHz band = **14.37 dB**

e. Other information to be provided by the DAS contractor

Together with the one-line drawing, the implementation scheme and the loss calculations as explained above, the DAS contractor needs to provide to each operator the following additional information:

- Plans of the building to be covered
- Link budget: to allow the operator to fill in its obligation in terms of health file and to verify if the installation is indeed permit-free. The link budget file must be in a format that allows easy simulations by mobile operators (for example Excel) and has to be provided with the formulas.
- Measurement reports
- Coverage simulation (optionally - if available)
- Data sheets in case of use of non-listed components (see chapter 3.5 and annex)

f. Building and health permits

The DAS owner/contractor must ensure that the indoor installation is fully compliant with the applicable regulations concerning building permit and electromagnetic emission norms. In Belgium, regulations are different in the 3 regions.

If needed by the applicable regional regulation, a building permit is to be introduced by the building/DAS owner only if the M-O DAS RF design foresees the installation of a pick-up antenna on the roof.

Concerning health issues, the relevant norms on electromagnetic emission are the following:

1) The applicable norm on electromagnetic emissions
2) The environmental permit (EP) exemption Rule

Indoor installations are not subject to an environmental permit/notification or certification of conformity provided that the antenna power does not exceed certain thresholds defined at regional level:

Flanders

2W ERP = 3,28W EIRP for each antenna by operator, technology, frequency band
Based on the maximum power.

Wallonia

4W EIRP for each antenna by operator and technology (frequency bands on the same technology are cumulated except 2G 900 and 2G 1800)
Based on the maximum power.

Brussels

2W EIRP for each antenna all operators, technologies and frequency bands cumulated

Mobile operators will only check that all installed antennas emit below the above mentioned exemption threshold so as to know if a health permit must be introduced.

Taking into account the important administrative burden of having to prepare a health permit and the related cost that would have to be supported by the DAS owner, operators strongly recommend that the design would be done in such a way that the M-O DAS would remain below applicable health norms in all places, floors and so that there would be no need to introduce a health permit. This is also the best way to ensure that the effective indoor installation will be fully in line with applicable health norms.

If a health permit would still need to be introduced, it will be handled by each concerned operator based on information that has to be provided by the DAS owner/contractor. It is therefore very important that the DAS RF final design which is submitted for approval to each operator perfectly reflects the reality and is also updated and communicated again to the operators in case of modifications to the M-O DAS later. The list of the documents to be communicated and their format will be provided by the operators after evaluation of the design. The cost of such permit will be supported by the DAS owner/contractor.

It is important to add that being exempted from having to introduce a health permit is a pure administrative relaxation and does not mean that the applicable norms on electromagnetic emissions do not have to be respected. The applicable levels of allowed exposure still have to be respected - even if they are below the exemption thresholds. They are still to be considered, particularly because people can be close to the antennas. This aspect depends fully on how the M-O DAS will be constructed and so will remain the responsibility of the DAS owner/contractor.

Mobile operators will inform the building/DAS owner duly in time in case of a modification/strengthening of the applicable health regulation. The building/DAS

owner will then have a legally pre-defined period to modify its M-O DAS according to the new applicable norms.

In case of complaints, the competent administration may be asked to verify the exposure levels. If the activated M-O DAS would not comply with applicable health norms, the building/DAS owner will have 24 hours to modify the M-O DAS if the M-O DAS is the cause of the infringement. If this would not happen, operators will be authorized to lower the power or to de-activate their equipment.

In case of fines due to health norms infringements, operators will also be authorized to pass them on to the building/DAS owner.

3.3.2. Tasks of the mobile operators

If a health permit needs to be introduced, it will then be handled by each concerned operator. Health permits are linked to the use of mobile operators' spectrum and so will remain the responsibility of operators.

Operators are also responsible for the validation of the final RF design. Such task must be performed by the radio engineering department of each mobile operator. Each operator will review the design on compliancy for connection to the operator infrastructure and compatibility with the operator macro network. Such a review will be provided within 20 working days, on the condition that the operator received a full and complete design file.

The validation will include the following information:

a. Technologies that will be activated and the frequency bands that will be used
b. The type of radio equipment that will be connected
c. The space requirement for its equipment (typically 2 racks per operator in case of use of BTS)
d. In case of repeaters: number of pickup antenna(s) needed and their preferred location and orientation on roof or outdoor walls
e. The power requirements

Because operators are constantly investing in their network and their network are evolving over time, operators cannot guarantee that the design will still be valid for over 12 months. This means that the final installation should occur within the 12 months after the RF Detailed Design validation. If the final installation occurs only after 12 months a new validation will be needed. Operators will provide an answer within 20 working days.

At this stage, the operators will have to confirm to the building owner that they will connect to the M-O DAS. This will be formalized through the signature of a contract

between each operator and the building owner. Enough time will be needed to come to a final agreement and finalize the contract conditions.

3.4. Opening works meeting – Step 7

Once all contractual agreements have been closed and before starting the physical rollout of the project, the building owner will organize an 'opening works meeting' in the concerned building with all involved operators. During this working meeting the following details will be discussed in the field:

- Verify correctness of the Detailed Design & potential changes in design during construction
- Verify location and type foreseen for the active equipment
- Verify location, type and direction of pickup antenna
- Verify power connectivity for active equipment
- Verify cabling connectivity foreseen for the operators inside the building (number of single mode fibre lines)
- Verify transmission entry point and/or transmission room
- planning of installation (active radio equipment and transmission)

After this meeting and if no questions remain open, the operators will be able to order all the active equipment and the required transmission/connectivity equipment and will be able to start planning all works together with their own subcontractors.

3.5. Installation of the M-O DAS – Step 8

During this phase, the DAS contractor will proceed with the installation of the different passive components of the M-O DAS in accordance with the latest validated RF design.

To ensure the correct operation and compatibility of the M-O DAS with the equipment of the mobile network operators, only components which are approved by the mobile operators may be used. The list of approved components may be reviewed and updated regularly and is attached to this document. In case a DAS contractor wants to use other components not included in the pre-defined list, it has then to provide to each operator all the technical characteristics of these components. Operators may also request a sample at no expense in case they want to test the concerned component.

In case one (or more) operator has decided to work with repeaters, the DAS contractor will be responsible for the installation of the pick-up antenna on the roof and the cables between the pickup antenna(s) and the repeater(s).

The DAS contractor will make sure the requested power requirements for radio equipment and/or connectivity are made available for each operator.

If for any reason, some changes in the design are required during the construction phase, the DAS contractor will submit to the operators - for consultation and validation - a new revised design with the proposed changes. Operators will have 20 working days to respond to it.

Connectivity & transmission cabling

Each operator will provide the needed connectivity from outside the building up to the transmission room via a tube/subduct foreseen by Das contractor. The connectivity cabling will be provided and installed by operators. The DAS contractor will have to foresee a tube/subduct (HDPE 50mm) for each operator in the project, between private property (building intro) and public domain + along the route, every 50m and for every direction change, a waiting pit needs to be foreseen. As explained hereafter, all other connectivity and transmission cabling will be provided by the DAS contractor.

All passive components that allow an operator to connect its equipment to the DAS will be provided by the DAS contractor. The type of equipment will depend on the number of operators that will connect to the DAS and on the technologies (frequency bands) that will be activated by each operator.

The DAS contractor is responsible for providing enough single mode fibre lines from the transmission room to the equipment room in case these rooms are distinct. Depending on the building size and the availability of technical rooms, transmission room(s) and/or equipment room(s) may be provided in one single room or in different rooms.

A connectivity point to the M-O DAS must be provided by the DAS contractor in the equipment rooms. This point should be located at more or less equal distance of the respective operator's DAS connection point (aiming for equal cable losses). A dummy load should be put on the combiner on all ports that are not yet used until an operator connects. For all the components in the antenna line we recommend the use connector type 4.3-10 or 7/16 DIN or N-connectors. If requested by an operator, optical fiber lines should be provided with connectors of the requested type and link quality.

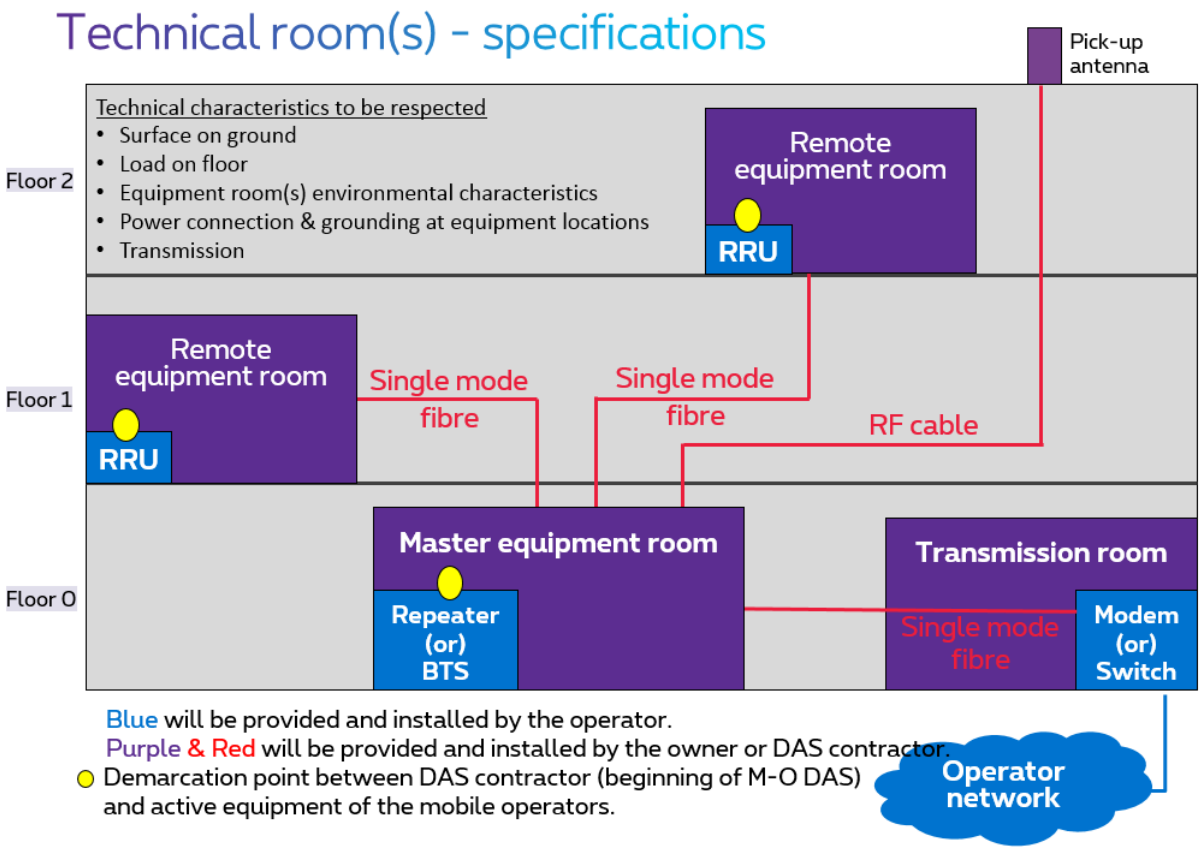

Figure 7: illustration of technical rooms

At commissioning phase the DAS contractor will provide an "as-built-document" to all operators (including operators which would have decided not to connect to the DAS as from its construction – to be documented in the notification-tool). This document will include:

- The final design and the final implementation plans
- A contact list that has been agreed with the M-O DAS Owner including all points of contact relevant for the maintenance of the M-O DAS (during business hours and outside business hours)
- The access procedures the operators should respect in terms of access to their active equipment and technical rooms (in case of repeater, also access procedure to the roof where the pick-up antenna is installed)

The DAS contractor will also provide a full measurement report (see annex for more info concerning the PIM & VSWR measurements).

3.6. Acceptance site visit – Step 9

Once the DAS is completely installed by the DAS contractor and everything has been foreseen to accommodate the equipment of each operator (room, power, connectivity cabling, etc.) an acceptance site visit will be organized.

The DAS contractor needs to be present during this site visit, together with the building owner or its duly delegated representative.

Operators will mandate one of them to carry out the acceptance visit. Operators will only take one acceptance visit at their charge. During this acceptance visit, the mandated operator will perform the following tasks:

- Measurements to evaluate the M-O DAS system on design and link budget.
- A quality control with the aim to limit the risk of poor functioning of the installation and ensure a correct maintenance afterwards. This will include check of ground cables, labelling of the cables, fixation of the antennas and any point that could have an impact on the correct operation of the installation.

3.7. Activation of the M-O DAS – Step 10

In case of positive validation by the mandated operator, each operator will then proceed with the installation and effective connection of its radio equipment to the M-O DAS and the site will be put on air. It is to be noted that the radio equipment could also be installed by the operators during the installation phase and so before the acceptance visit occurs.

Each operator will then perform additional tests. If the tests show that some areas of the building do not have sufficient coverage, it will be the responsibility of the DAS contractor to adapt the installation according to operator request (for example by adding additional antennas).

In case the design has to be reviewed, an adapted new design is to be provided within 20 working days.

In case of negative validation by the mandated operator (because some aspects of the installation are not compliant with the requirements of the operators) the site will not be put on air.

In such case the operator will explain why the installation does not comply with the requirements and as a result cannot be put on air. The DAS contractor will have 20 working days to proceed with the necessary adaptations.

When all operators have activated their equipment and the site is on-air, the DAS contractor will execute a walk-test measuring the signal strengths and quality in all covered areas for all operators and all activated technologies. This coverage measurement report must confirm that the indoor installation is fully in line with all relevant building and environmental regulation and will be transferred to the building owner and to the operators by adding the report to the project-folder in the notification-tool.

4. CHANGE REQUESTS IMPACTING AN EXISTING M-O DAS

4.1. Additional operator on an existing M-O DAS or inclusion of Astrid

If an extra operator is to join an existing M-O DAS (owned by the building owner), a very similar process is to be respected:

- New operator has to introduce a request to join (Step 4)
- The building owner informs the existing operators of an extra operator using the notification process
- The building owner/DAS contractor verifies the potential impact on the existing Detailed Design and decides whether an extra Site measurement would be required (Step 5)
- The building owner/DAS contractor submits the modified Detailed Design to the other operators for approval (Step 6)
- If no modifications on DAS are required:
    - Building owner/DAS contractor & new operator plan 'Opening Works Meeting' (Step 7)
    - Building owner/DAS contractor & new operator plan installation of active equipment and connectivity (Step 8)
    - If no new combiner needed:
        - New operator activates connectivity and active equipment (Step 10)
    - If new combiner needed:
        - Building owner/DAS contractor plans new combiner installation and aligns with existing operators on intervention window
        - New operator activates connectivity and active equipment (Step 10)
- If modifications on DAS are required:
    - Building owner/DAS contractor & new operator plan 'Opening Works Meeting' (Step 7)

- Building owner/DAS contractor & new operator plan installation of active equipment and connectivity (Step 8)
- Building owner/DAS contractor & new operator do DAS acceptance (Step 9)
- Building owner/DAS contractor aligns with existing operators on intervention window of activation DAS modifications + new operator activates connectivity and active equipment (Step 10)

NOTE:

- If a combiner is already present and has a spare connection, no downtime is to be foreseen.
- If no combiner is present or no free connection on the existing combiner, a new combiner will be installed. In mutual agreement with the building owner, this intervention can be planned during non-office hours to keep the impact towards the client limited to a maximum downtime of 2h.
- In case of Detailed Design changes of the existing DAS would be required outage time can be longer.

4.2. An operator decides to quit the M-O DAS

The operator will dismantle the active equipment in the contractually agreed timeframe. The remaining operational operators will be informed by the building owner but there will be no impact on them or on the M-O DAS installation.

4.3. M-O DAS modification

By modification we understand for example, the introduction of a new technology (e.g. 5G) or an extension/reduction of the indoor coverage (e.g. a new area to be covered) or capacity (e.g. switch from repeaters to base station solution). A modification of the M-O DAS could also occur following a modification of the relevant electromagnetic emission regulation.

In this later case, mobile operators will inform the building/DAS owner duly in time of such modification/strengthening of the applicable health regulation. The building/DAS owner will then have a legally pre-defined period to modify its M-O DAS according to the new applicable norms.

Any request of extension/reduction of an existing M-O DAS will in most cases initiate the launch of a new Execution Phase process (Step 5 to Step 10).

If an extension/reduction of an M-O DAS would lead to an impact on operator active equipment or connectivity, this change will also require a review of the commercial agreement between the impacted operators and the building owner.

4.4. Full dismantling of an existing M-O DAS

Each concerned operator will be informed in the contractually agreed pre-notice timeframe (period depending on the commercial agreement between each individual operator and the building owner) to allow the dismantling of the active equipment and the transmission.

The coordination is to be organized by the building owner/DAS contractor.

Abbreviations

BTS:	Base Transmission Station
RF:	Radio frequency
M-O DAS:	Multi-Operator Distributed Antenna system
MH:	Mexican Hat
MNO:	Mobile Network Operator
EP:	Environmental Permit
VSWR:	Voltage Standing Wave Ratio
EIRP:	Effective Isotropic Radiated Power
PIM:	Passive Intermodulation Measurement
RRU:	Radio Remote Unit
BTS:	Base Transceiver Station

Annex 2

Portfolio

DAS RF Equipment

Q1 2025

Passive DAS interoperator workgroup

Purpose

This document lists the portfolio of DAS RF Equipment products which are allowed to be used or have been used in the indoor DAS coverage networks of Mobile Network Operators (further referred as MNO). This document is therefore a reference to know which materials to use for a new indoor DAS coverage network design or to know when a such a network needs to be adapted or in case of need of repairs. For that purpose the status of use of these DAS RF equipment products (ie. NEW, LTB, PHASE OUT) are provided in here.

This document doesn't provide the full requirements of usage or installation of this equipment. For that the applicable vendor documentation, legal requirements (AREI, BIPT) and indoor DAS design guidelines are referred to. Specific vendor documents and legal requirements are not named in this document. The user of this document is expected to have, know and apply these.

Scope

DAS RF equipment products that are part of the RF signal path from antenna to the connection point where MNO connects their active equipment to (the infrastructure connection point).

So coax cables, connectors, tappers, splitters, antennas etc. are listed. Other materials like cable ducts, cable clamps, power cables, labels etc. are not part of the signal path and are therefore not listed in here.

Requirements concerning these are indicated in the indoor DAS design guideline or indicated during the DAS design validation by MNO (i.e. DAS RF equipment power connections).

How to use this document

All DAS RF Equipment products used for the network of the MNO, should be of the types and as listed in this document until a new version of this document is released. Updates are published depending on need, taking into account latest information on DAS equipment development.

It is the responsibility of the user of this document to verify he or she is using the latest version available.

For every RF equipment a column is added in which the equipment status is indicated (i.e. NEW, LTB)

Definitions

DAS (Distributed antenna system): Signal distribution system installed to provide coverage in a specific building to enable users to use their mobile/smartphone in agreed communication bands and services (i.e. 2G, 4G, 1800, 2100,…), also called RF signals and services.

RF equipment products: All RF equipment used on a base station/site, excluding the equipment responsible for transmission services, like modems, microwave equipment and AC power cabinets.

DAS RF equipment products, further referred as DAS equipment: all RF equipment to distribute RF signals and services.

Mobile network operators (MNO): In the context of this document these are the companies Orange Belgium, Proximus, Telenet.

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1 Antennas

This section lists all antennas allowed for usage or ever used for indoor usage

Indoor antennas

Antenna type	Vendor	Band	description
1399.31.0019	H+S	7/8/9/18/21/26/35	Low PIM directional MIMO 2x2 antenna SENCITY® Urban 300 - 4.3-10 connector
1399.31.0008	H+S	7/8/9/18/21/26/35	Low PIM SiSo Omnidirectional antenna SENCITY® Rondo SISO Antenna - 4.3-10 connector
78712313	ESB	7/8/9/18/21/26	Panel Antenna 698-960, 1710-2700 - 4.3-10 connector
78712323	ESB	7/8/9/18/21/26/35	1-Port Panel Directional 698-960 (SISO)/1425-4000 (SISO) 4.3-10
78712330	ESB	7/8/9/18/21/26/35	2-Port Directional 698-960 (MIMO)/1710-4000 (MIMO) 4.3-10
78712019v01	ESB	7/8/9/18/21/26/35	1-port Omni 698 - 4000 MHz ; 3 dBi ; 4.3-10
78712030	ESB	7/8/9/18/21/26/35	2-Port Omni 698-960 (MIMO)/1710-4000 (MIMO) 4.3-10
80011846	ESB	7/8/9/18/21/26/35	1-port Stick 698 - 4000 MHz ; 3 dBi ; 4.3-10
78712035	ESB	7/8/9/18/21/26/35	Mexican Hat 1-port - 698Mhz-4Ghz - 4.3-10 Slim Version
78712034	ESB	7/8/9/18/21/26/35	Mexican Hat 2-port - 698Mhz-4Ghz - 4.3-10 Slim Version
78712031	ESB	7/8/9/18/21/26/35	Mex hat V-Pol 1-port 2/4dBi 698-960 / 1425-4000
78712330	ESB	7/8/9/18/21/26/35	1-Port Directional 698-960 /1425-4000 (SISO) 4.3-10
78712019	ESB	7/8/9/18/21/26/35	1 port omni Indoor 698-960/1425-4000 2/5dBi (Dome)
7825700	Amphenol	7/8/9/18/21/26	Vpol OMNI STICK antenna 2.5 dBi N female connector
80010846	Ericsson	7/8/9/18/21/26	Vpol OMNI STICK antenna 2 dBi N female connector
7835700	Amphenol	7/8/9/18/21/26	Vpol OMNI STICK antenna 4 dBi N female connector
7835700-4310	Amphenol	7/8/9/18/21/26	Vpol OMNI STICK antenna 4 dBi 4.3-10 female connector
5052400	Amphenol	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling antenna 5 dBi N female connector
CMAX-O-43-UW-i53	Commscope	7/8/9/18/21/26/35	Vpol OMNI° ceiling antenna 5 dBi 4.3-10 female connector
I-ATO5-698/4000	RFS	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling spotlight antenna 6dBi N female connector
I-ATO5-43-698/4000	RFS	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling spotlight antenna 6dBi – 4.3-10 female connector
I-ATO5-43-617/6000	RFS	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling spotlight antenna 6dBi 4.3-10 female connector
CMAX-OUS1-UW43-i53	Commscope	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling spotlight antenna 6dBi 4.3-10 female connector
UWB-I-380-6000	Amphenol	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling antenna 5 dBi shark fin N female connector
CELLMAX-O-TCPUSEWi	Commscope	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling antenna 5 dBi N female connector
5052460	Amphenol	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling antenna 5 dBi N female connector
5052460-4310	Amphenol	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling antenna 5 dBi 4.3-10 female connector

I-ATO5-43-380/6000	RFS	7/8/9/18/21/26/35	Vpol SISO OMNI ceiling antenna 4 dBi 4.3-10 female connector
I-ATO1-350/600	RFS	Tetra only	Vpol SISO OMNI 350-600 MHz 2 dBi N female connector
CMAX-OMF8-43-UWi53	Commscope	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 5dBi 4.3-10 female connectors
CMAX-OMF6-43-UWi53	Commscope	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 5dBi 4.3-10 female connectors
5086500A-4310	Amphenol	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 6dBi 4.3-10 female connectors
5005370A-4310	Amphenol	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 5 dBi 4.3-10 female connectors
I-ATO5-698/4000M	RFS	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 5dBi N female connectors
I-ATO5-43-698/4000M	RFS	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 5 dBi 4.3-10 female connectors
I-ATO5-698/3800M	RFS	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 5dB N female connectors
I-ATO5-43-617/6000M	RFS	7/8/9/18/21/26/35	XPol OMNI MIMO 2x2 ceiling-antenna 6dBi 4.3-10 female connectors
I-ATO5-43-617/6000M4	RFS	7/8/9/18/21/26/35	XPol OMNI 360° ceiling-antenna MIMO 5dBi 4.3-10 female connectors
CMAX-OMF7-43-UWi53	Commscope	7/8/9/18/21/26/35	XPol OMNI ceiling-antenna 5dBi 4.3-10 female connectors
CMAX-OMF9-43-UWi53	Commscope	7/8/9/18/21/26/35	XPol OMNI ceiling-antenna 5dBi 4.3-10 female connectors
I-ATP5-698/3800	RFS	7/8/9/18/21/26/35	Vpol SISO panel 7dBi N female connector
I-ATP5-43-698/3800	RFS	7/8/9/18/21/26/35	Vpol SISO panel 7dBi 4.3-10 female connector
5003500	Amphenol	7/8/9/18/21/26	Vpol SISO panel 7 dBi N female connector
CELLMAX-D-43-WI	Commscope	7/8/9/18/21/26	Vpol SISO panel 7dBi 4.3-10 female connector
CMAX-D-TCPUSEi53	Commscope	7/8/9/18/21/26	Vpol SISO panel 7dBi N female connector
7834450-4310	Amphenol	7/8/9/18/21/26	Xpol MIMO 2x2 panel 7 dBi 4.3-10 female connectors
I-ATP5-43-698/3800M	RFS	7/8/9/18/21/26	Xpol MIMO 2x2 panel 7 dBi 4.3-10 female connectors
I-ATP5-43-698/4000M4	RFS	7/8/9/18/21/26	Double XpolMIMO 4x4 7 dBi -4.3-10 female connectors
KRE 101 2572/1	Ericsson	7/8/9/18/21/26	dual-lobe Vpol Bi-Directional Antenna 5.0 dBi

TABLE 1: INDOOR ANTENNA PORTFOLIO

The indoor antennas are not to be used in outdoor environment applications. Outdoor environment applications include tunnels or semi-indoor environments where equipment is exposed to risks comparable to outdoor environments, like dirt or water (i.e. high water pressure cleaning). Tunnel and micro cell antennas can be used in indoor environments when the area that needs to be covered can be solved by an antenna of this kind.

Outdoor antenna

Antenna type	Vendor	Band	description
7478000	amphenol	9/18/21	Yagi antenna - 12dBi
80010753	Ericsson	8/9/18/21/26	2- port dual band panel antenna 8 dBi
742192v02	Ericsson	7/8/9/18/21/26	1-Port Yagi Antenna 11.0 dBi
I-ATD5-698/4000	RFS	7/8/9/18/21/26/35	pick-up antenna N female connector
I-ATD5-43-698/4000	RFS	7/8/9/18/21/26/35	pick-up antenna 10 dBi - 4.3-10 female connector
I-ATD5-698/4001	RFS	7/8/9/18/21/26/35	pick-up antenna N female connector
KRE 101 2571/1	Ericsson	7/8/9/18/21/26/35	X-Polar 65° 11 dBi – 2 conn. 4.3-10
80010828v01	Ericsson	8/9/18/21	X-Polar yagi 15 dBi DIN 7/16“ female
7385900-OF	Amphenol	8/9	Yagi 9 dBi for 800-900
7175890-OF	Amphenol	8/9	Yagi outdoor 12 dBi
7132900-OF	Amphenol	8/9	Yagi outdoor 16 dBi
7486000	Amphenol	18/21/26	Yagi Antenna 12 dBi N female
7499000	Amphenol	9/18	circular polarised YAGI 14.7 dBi N female
7469400	Amphenol	8/18	Xpol YAGI 17 dBi 7/16 female
7361003	Amphenol	18/21	Xpol Yagi 17 dBi - 2 rear DIN 7/16 female
7361008	Amphenol	21/26	Xpol YAGI 17 dBi DIN 7/16 female
CMAX-EXT-43-i53	Commscope	7/8/9/18/21/26	Vpol SISO panel 65° 11 dBi 4.3-10 female
CMAX-DMF2-43-Wi53	Commscope	7/8/9/18/21/26/35	Xpol MIMO panel H65° -8.5 dBi 2 connectors 4.3-10 female

TABLE 2: PICKUP ANTENNA FOR REPEATERS

For repeaters we will need an antenna we can add outdoor on the roof or wall mounted to capture the outdoor signal that will be used by the repeater.

Antenna installation clamps and brackets

Only standard antenna installation materials (i.e. clamps and brackets) provided by the antennas supplier are approved for use.

2 Feeders

Eupen, RFS and H+S are approved by operators for new installations as suppliers for feeders with the types mentioned below. Default feeder colour is black, grey colour is allowed if this is required from an acquisition point of view. Cables should be halogen free, flame retardant and low smoke density. For re-use of feeders of other types (or vendors) already present on site, the MNO should be contacted for approval. We advice to use the low loss feeders. We add fire proof cabling for new installations to be in line with new standard EN 50575:2014/A1:2016 and effective as from 01/07/2017. This CPR 50575 (Construction Products Regulation) concerns the Reaction to Fire for Power, Control and Communications Cables intended to be used in permanent installation for general applications in construction works.

typenumber	supplier	description
LCF12-50JFN	RFS	½" feeder
LCF78-50JFNA	RFS	7/8" feeder
LCFS114-50JFNA	RFS	1.1/4" feeder
LCF158-50JFNA	RFS	1.5/8" feeder
EC4-50-FRC	Eupen	½" feeder
EC5-50-A-FRC	Eupen	7/8" feeder
EC6-50-A-FRC	Eupen	1.1/4" feeder
EC7-50-A-FRC	Eupen	1.5/8" feeder
SUCOFEED_1/2_HF_FR	H+S	½" feeder
SUCOFEED_7/8_LA_FR	H+S	7/8" feeder
SUCOFEED_1 _1/4_FR	H+S	1.1/4" feeder
SUCOFEED_1_5/8_LA_FR	H+S	1.5/8" feeder

TABLE 3: APPROVED FEEDER TYPES

Feeder grounding kits

Approved are the grounding kits from Eupen, RFS and H+S with either parallel or angular outlets. Parallel outlet is to be used when the grounding bar is installed lower from the grounding kit position, angular outlet is to be used when the grouding kit is installed next to the outlet. Grounding bars are NEVER installed on a position higher than the grounding kit on a feeder.

A grounding kit should always be of the same dimension of the feeder on which it needs to be applied. Grounding kits are not needed indoor, but should be installed whenever a cable enters a building from outside to inside (i.e. from a repeater antenna).

3 Jumpers

Pre-fabricated jumpers are preferred to be used. Hand-made jumpers need to be measured to have their quality confirmed. This is not needed for newly installed pre-fabricated jumpers when handled within installation specifications (bending radius, installation torque, pulling strength etc.).

H+S, RFS, Amphenol and Eupen are approved by operators as suppliers for these jumpers with the types mentioned below. Jumpers from these vendors can be mixed in use on a site.

In the table below, the "x" in the typenumber need to be replaced by the desired length. E.g:

- the Eupen low loss 4,3-10 male to 4.3-10 male jumpers of 5 m is EC4-FR-S-500-43DM43M

- the RFS low loss 4,3-10 male to 4.3-10 male jumpers of 5 m is 43M43MS12F-0500FFP

- the H+S low loss straight male 7/16 to straight male 7/16 of 5 m is LIS-C12F-11-716-11-716-05000-52

- the Amphenol low loss straight male 7/16 to straight male 4.3-10 of 5 m AAS-12ST-43SMDM-5M

typenumber	supplier	loss type	lengths	description
EC4-FR-S-xxx-43DM43M	Eupen	low loss	2 m-10 m	4,3-10 male to 4.3-10 male jumpers
EC4-HF-FR-S-1X0-43DM43M	Eupen	Hiflex	1 m-1,5 m	4,3-10 male to 4.3-10 male jumpers Hiflex
EC4-FR-S-xxx-DM43M	Eupen	low loss	2 m-10 m	7-16 male to 4.3-10 male jumpers
EC4-HF-FR-S-1X0-DM43M	Eupen	Hiflex	1 m-1,5 m	7-16 male to 4.3-10 male jumpers Hiflex
43M43MS12F-0XX0FFP	RFS	low loss	2 m-10 m	4,3-10 male to 4.3-10 male jumpers
43M43ML12F-0XX0FFP	RFS	Hiflex	1 m-1,5 m	4,3-10 male to 4.3-10 male jumpers Hiflex
7M43MS12F-0XX0FFP	RFS	low loss	2 m-10 m	7-16 male to 4.3-10 male jumpers
7M43ML12F-0XX0FFP	RFS	Hiflex	1 m-1,5 m	7-16 male to 4.3-10 male jumpers Hiflex
43MNXMS14F-0XX0FFP	RFS	Hiflex	1 m -20 m	NEX10 male to 4.3-10 male Hiflex
LIS-C12F-11-716-11-716-xxxxx-52	H+S	low loss	1 m - 10 m	straight male 7/16 to straight male 7/16
LIS-C9F-11-716-11-716-xxxxx-52	H+S	Hiflex	0,5 m-5 m	straight male 7/16 to straight male 7/16 Hiflex
LIS-C9F-11-716-11-N-xxxxx-52	H+S	low loss	1 m - 10 m	straight male 7/16 to straight male N
LIS-C12F-11-716-11-N-xxxxx-52	H+S	Hiflex	0,5 m-5 m	straight male 7/16 to straight male N Hiflex
LIS-C9F-11-716-11-431X-xxxxx-52	H+S	low loss	1 m - 10 m	straight male 7/16 to straight male 4.3-10
LIS-C12F-11-716-11-431X-xxxxx-52	H+S	Hiflex	0,5 m-5 m	straight male 7/16 to straight male 4.3-10 Hiflex
SPJ-11-716-11-716-01000	H+S	Hiflex	0,5 m -5 m	straight male 7/16 to straight male 7/16 plenum
SPJ-11-716-11-N-01000	H+S	Hiflex	0,5 m -5 m	straight male 7/16 to straight male N plenum
SPJ-11-716-11-431-01000	H+S	Hiflex	0,5 m -5 m	straight male 7/16 to straight male 4.3-10 plenum
AAS-12HF-43SMNM-XM	Amphenol	Hiflex	1 m-10 m	straight male 7/16 to straight male N Hiflex
AAS-12ST-43SMDM-XM	Amphenol	low loss	3 m- 5 m	straight male 7/16 to straight male 4.3-10
AAS-12HF-43SMDM-XM	Amphenol	Hiflex	1 m-5 m	straight male 7/16 to straight male 4.3-10 Hiflex
AAS-12ST-43SMSM-XM	Amphenol	low loss	1 m - 10 m	4,3-10 male to 4.3-10 male jumpers
AAS-12HX-43SMSM-XM	Amphenol	Hiflex		4,3-10 male to 4.3-10 male jumpers Hiflex

TABLE 1: JUMPER TYPES

4 Indoor DAS feeder system materials

Combiners

Most units are available with or without internal DC stops. For DAS networks these can be considered equal. Unused ports should be decoupled by using a 50Ω (dummy) load of applicable power capability.

typenumber	supplier	bands	ports	description
E14F06P38	CommScope	18 + 21	4-2	DBC 1710-1880 + 1920-2200 MHz (4-2), DC bypass all ports, 4.3-10
E14F06P58	CommScope	18 + 21	4-2	DBC 1710-1880 + 1920-2200 MHz (4-2), DC bypass 1920-2200 MHz, 4.3-10
E14F06P48	CommScope	18 + 21	4-2	DBC 1710-1880 + 1920-2200 MHz (4-2), DC bypass cross version , 4.3-10
E14F05P10	CommScope	7/8/9 + 18/21/26	4-2	DBC 470-960 + 1695-2700 MHz (4-2), DC bypass all ports, 4.3-10
E14F05P31	CommScope	7/8/9 + 18/21/26	4-2	DBC 470-960 + 1695-2700 MHz (4-2), DC bypass cross version , 4.3-10
E12F13P25	CommScope	8 + 9	4-2	DBC 790-862 + 880-960 MHz (4-2), DC bypass cross version, 4.3-10
E12F01P80	CommScope	18 + 21 + 26	6-2	TBC 1710-1880 + 1920-2170 + 2300-2700 MHz (6-2), DC bypass all ports, 4.3-10
E14F15P34	CommScope	7/8/9 + 18 + 21 + 26	8-2	QBC 380-960 + 1427-1880 + 1920-2200 + 2300-2690 MHz (8-2), DC bypass all ports, 4.3-10
E14F55P08	CommScope	7/8/9 +18/21/26	4:2	Ultra Compact Diplexer Low / High(380-960 / 1695-2690MHz) - Double Unit (DC Bypass on lowband ports)
E12F05P96	Commscope	18+21	2:1	Diplexor (1710-1880 MHz / 1920-2170 MHz) Single unit - (DC bypass on all ports)
E14F06P03	Commscope	18+21	2:1	Ultra Compact Diplexor - Single Unit (1710– 1880 MHz / 1920-2170 MHz) NO DC BYPASS - All Ports DC Ground
E14F05P17	Commscope	18+21	2:1	Diplexor (1710-1880 MHz / 1920-2170 MHz) Double unit - (DC bypass on all ports)
E14F05P20	Commscope	7/8/9/18/21 + 26	2:1	Diplexor (380 - 2200 // 2300 - 2690 MHz) Double unit - (DC bypass on all ports)
E14F55P09	Commscope	18/21 + 26	2:1	Ultra Compact - Double Unit Diplexer 1695-2200 // 2300-2690 MHz (NO DC BYPASS – All Ports DC Open)
E14F05P16	Commscope	18/21 + 26	2:1	Diplexor 1695-2180 // 2300-2690 MHz - Double unit - (DC bypass on all ports)
E14F06P32	Commscope	18 + 21/26	2:1	Ultra Compact – Single unit Diplexer (NO DC BYPASS – All Ports DC Ground)
E14F06P33	Commscope	18 + 21/26	2:1	Ultra Compact – Double unit Diplexer (NO DC BYPASS – All Ports DC Ground)
E14F06P05	Commscope	7/8 + 9	2:1	Ultra Compact – Single unit Diplexer (NO DC BYPASS – All Ports DC Open)
E14F05P89	Commscope	7/8 + 9	2:1	Ultra Compact – Double unit Diplexer (NO DC BYPASS – All Ports DC Open)
E14F05P08	Commscope	7/8 + 9	2:1	Diplexor - Single unit - DC SMART BYPASS
E14F10P47	Commscope	7/8/9 +18 +21	3:1	Ultra Compact Triplexor – Double unit (DC bypass on Low Band Port Only– All other ports DC Open)
E14F11P01	Commscope	7/8/9+18/21+26	3:1	Triplexor – Single unitn(DC bypass on all ports)
E12F01P93	Commscope	7/8/9+18/21+26	3:1	Triplexor Legacy – Single unit (DC bypass on all ports)
E14F10P59	Commscope	7/8/9+18+21/26	3:1	Ultra Compact Triplexor - Single unit DC bypass on Low Band Port Only – All other ports DC Open
E14F10P78	Commscope	7/8/9+18+21/26	3:1	Ultra Compact Triplexor - Single unit DC bypass on Low Band Port Only
E14F10P79	Commscope	7/8/9+18+21/26	3:1	Ultra Compact Triplexor - Double unit DC bypass on Low Band Port Only
E14F60P24	Commscope	7/8+9+18/21/26	3:1	Triplexor - Single unit DC SMART BYPASS
E14F60P19	Commscope	7/8+9+18/21/26	3:1	Triplexor - Double unit DC SMART BYPASS
E14F60P25	Commscope	7/8+9+18/21/26	3:1	Triplexor - Single unit DC bypass on ALL ports

E14F60P23	Commscope	7/8+9+18/21/26	3:1	Triplexor - Double unit DC bypass on ALL ports
E14F10P54	Commscope	18+21+26	3:1	Ultra Compact Triplexor – Single unit (No DC bypass – All ports DC open)
E14F10P46	Commscope	18+21+26	3:1	Ultra Compact Triplexor – Double unit (No DC bypass – All ports DC open)
E14F15P19	Commscope	7/8/9+18+21+26	4:1	Ultra Compact Quadriplexor – Single Unit All other ports DC Open
E16V90P59	Commscope	7/8/9+18+21+26	4:1	Quadriplexor - Single unit DC SMART BYPASS
E14F15P11	Commscope	7/8+9+18+21/26	4:1	Quadriplexor - Single unit DC SMART BYPASS
E14F15P12	Commscope	7/8+9+18+21/26	4:1	Quadriplexor - Double unit DC SMART BYPASS
E14F15P43	Commscope	7/8+9+21+26	4:1	Quadriplexor – Double Unit DC SMART BYPASS
E14F06P06	Commscope	7/8/9/18/21/26+35	2:1	Diplexor - Single Unit Ultra Compact Combiner DC Bypass on low band port
E14F06P07	Commscope	7/8/9/18/21/26+35	2:1	Diplexor – Double Unit Ultra Compact Combiner DC Bypass on low band port
E14F10P68	Commscope	7/8/9/18/21+26+35	3:1	Triplexor - Double Unit Ultra Compact Combiner DC Bypass on low band port
E14F10P63	Commscope	7/8/9+18/21/26+35	3:1	Triplexor - Double Unit Ultra Compact Combiner DC Bypass on low band port
E14F15P24	Commscope	18+21+26+35	4:1	Quadriplexor - Single Unit Ultra Compact Combiner DC Bypass on All ports
E14F15P23	Commscope	18+21+26+35	4:1	Quadriplexor - Double Unit Ultra Compact Combiner DC Bypass on All ports
E14F20P06	Commscope	7/8/9+18+21+26+35	5:1	Pentaplexor Single Unit Ultra Compact Combiner DC Bypass on All ports
E14F20P05	Commscope	7/8/9+18+21+26+35	5:1	Pentaplexor - Double Unit Ultra Compact Combiner DC Bypass on All ports
H-3-UW-43-Ai6	Commscope	7/8/9/18/21/26	2:2	Hybrid Combiner 4.3 -10 connectors female
VD-H2X2-CPUSEW-43B	Commscope	7/8/9/18/21/26/35	2:2	Hybrid Combiner 4.3 -10 connectors female
H-3-TCPUSEW-43-AI6	Commscope	7/8/9/18/21/26/35	2:2	Hybrid Combiner 4.3 -10 connectors female
H-3-UW-N-Ai6	Commscope	7/8/9/18/21/26/35	2:2	Hybrid Combiner N connectors female
H-3-TCPUSEW-N-AI6	Commscope	7/8/9/18/21/26/35	2:2	Hybrid Combiner N connectors female
H-3x3-CPUSE-43-Ai6	Commscope	7/8/9/18/21/26	3:3	Hybrid Combiner 4.3 -10 connectors female
H-4X4-UW-43-Ai6	Commscope	7/8/9/18/21/26/35	4:4	Hybrid Combiner 4.3 -10 connectors female
H-4x4-CPUSE-NAi6	Commscope	7/8/9/18/21/26	4:4	Hybrid Combiner N connectors female
CM-EP-4X4-738FE	Microlab	7/8/9/18/21/26/35	4:4	Hybrid combiner 4.3-10, 694 to 3800 MHz
CA-EP-2X2-738FE	Microlab	7/8/9/18/21/26/35	2:2	Hybrid combiner 4.3-10, 694 to 3800 MHz
CM-EP-4X4-738FN	Microlab	7/8/9/18/21/26/35	4:4	Hybrid combiner N-type, 694 to 3800 MHz
CA-EP-2X2-738FN	Microlab	7/8/9/18/21/26/35	2:2	Hybrid combiner N-type, 694 to 3800 MHz
CA-14D	Microlab	7/8/9/18/21/26/35	2:2	Hybrid combiner 7-16,350-5925 MHz
CM-80D	Microlab	7/8/9/18/21/26/35	3:3	Hybrid combiner 7-16,350-5925 MHz
CM-88D	Microlab	7/8/9/18/21/26	4:4	Hybrid combiner 7-16,694-2700 MHz
RD0557-H4-02	Radiodesign	7/8/9/18 +21	2:1	Diplexor (698 – 1880 MHz / 1920-2170 MHz) Double Unit - DC AUTO-BYPASS
RD0558-H4-02	Radiodesign	7/8/18 +21/26	2:1	Diplexer (700-800-900)+1800//2100+2600 (698-1880 / 1920-2690 MHz) Double Unit - DC AUTO-BYPASS

RD0696-H4-07	Radiodesign	7/8 + 9	2:1	Diplexer Double Unit - DC AUTO-BYPASS
RD0696-H4-06	Radiodesign	7/8 + 9	2:1	Diplexer Double Unit - DC to all ports
RD0562-H4-02	Radiodesign	7/8/9+18/21+26	3:1	Triplexor – Double unit DC AUTO-BYPASS
RD0563-H4-02	Radiodesign	7/8/9/18+21+26		Triplexor Double Unit - DC AUTO-BYPASS
RD0812-H4-01	Radiodesign	7/8+9+18+21/26	4:1	Quadriplexor - Double unit- DC AUTO-BYPASS
CDSDE2x2-694/3800	RFS	7/8/9/18/21/26/35	2:2	Hybrid Combiner 7/16 connectors
CDS3DE-380/2700	RFS	7/8/9/18/21/26	2:2	Hybrid Combiner 7/16 connectors
CDS2x2-43-694/3800	RFS	7/8/9/18/21/26/35	2:2	Hybrid Combiner 4.3 -10 connectors female
CDSE2x2-694/3800	RFS	7/8/9/18/21/26/35	2:2	Hybrid Combiner N connectors female
CDS4x4-43-694/3800	RFS	7/8/9/18/21/26/35	4:4	Hybrid Combiner 4.3 -10 connectors female
CDSDE4x4-694/3800	RFS	7/8/9/18/21/26/35	4:4	Hybrid Combiner DIN 7/16 connectors
CDSE4x4-694/3800	RFS	7/8/9/18/21/26/35	4:4	Hybrid Combiner N connectors female

TABLE 5: COMBINERS

DC-stop filters

typenumber	supplier	description
HR-26E	Microlab	DC Block Inner 250-5925MHz 500W/3kV 4.3-10m-f
HR-29E	Microlab	DC Block Inner/Outer 250-5925MHz 500W/3kV 4.3-10m-f

TABLE 6: DC-STOP FILTER

Couplers

The XX in the typenumber needs to be replaced by the desired coupling value. E.g: The Microlab DIRECTIONAL COUPLER 4.3-10, 694 to 3800 MHz with a coupling value of 5 is CC-EP-5-738FE.

typenumber	supplier	coupling values	description
787621XX	ESB	6,8,10,15, 20,30	Coupler 698-4000 MHz 4.3-10
C-10-UW-43-Ai6	Commscope	6,8,10,15,20,30	Directional Coupler 555-6000, 4.3-10
C-10-UW-N-Ai6	Commscope	6,8,10,15,20,30	Directional Coupler 555-6000, N female connectors -
CC-EP-XX-738FE	Microlab	5,6,7,8,10,13,15,20,30	DIRECTIONAL COUPLER 4.3-10, 694 to 3800 MHz
CC-EP-XX-738FN	Microlab	5,6,7,8,10,13,15,20,30	DIRECTIONAL COUPLER N-Type, 694 to 3800 MHz
CDSXX-43-694/3800	RFS	6,10,15,20,30	Directional Coupler 694-3800, 4.3-10 female
CDS10DE-694/3800	RFS	6,10,15,20,30	Directional Coupler 694-3800, 7/16 connectors female
CDS10E-694/3800	RFS	6,10,15,20,30	Directional Coupler 694-3800, N female connectors
VD-CXX-CPUSEW-43B	CommScope	6,8,10,13,15,20,30	Air Directional Coupler, 578–3800 MHz, 4.3-10
C-6-TCPUSEW-N-Ai6	Commscope	6,10,15,20,30	Directional Coupler 340-3800, N female connectors

TABLE 7: COUPLERS

Tappers

The X in the typenumber needs to be replaced by the desired rating. E.g: The Microlab 4.3-10 connector, 694 to 3800 MHz tapper with a rating of 3 is DN-EP-3-738FE.

typenumber	supplier	Rating (dB)	description
78720136	ESB	7	4.3-10 F, 698-4200Mhz 300W
78720137	ESB	10	4.3-10 F, 698-4200Mhz 300W
78720138	ESB	15	4.3-10 F, 698-4200Mhz 300W
CT-XX-TUW-43-i6	Commscope	6,8,10,15,20,30	2-way tapper - 340-960/1700-2700/3500-4500/4900-6000 MHz , 4.3-10 - (PIM -165dBc)
CT-XX-TUW-Ni6	Commscope	6,8,10,15,20,30	2-way tapper 340-960/1700-2700/3500-4500/4900-6000 MHz , female N - (PIM -160dBc)
DN-04FD	Microlab	20	7/16, 350-5850M, 500W/port
DN-14FD	Microlab	30	7/16, 350-5850M, 500W/port
DN-34FD	Microlab	3	7/16, 350-5850M, 500W/port
DN-44FD	Microlab	4,8	7/16, 350-5850M, 500W/port
DN-54FD	Microlab	6	7/16, 350-5850M, 500W/port
DN-64FD	Microlab	8	7/16, 350-5850M, 500W/port
DN-74FD	Microlab	10	7/16, 350-5850M, 500W/port
DN-84FD	Microlab	13	7/16, 350-5850M, 500W/port
DN-94FD	Microlab	15	7/16, 350-5850M, 500W/port
DN-EP-X-738FE	Microlab	3,4.8,6,8,10,13,15,20	4.3-10 connector, 694 to 3800 MHz
DN-EP-X-738FN	Microlab	3,4.8,6,8,10,13,15,20	N-Type connector, 694 to 3800 MHz
TPSXX-43-350/6000	RFS	6,8,10,15,20,30	2-way tapper 350 - 6000 MHz , female 4.3-10
TPSXX-43-694/3800	RFS	6,8,10,15,20,30	2-way tapper - 694 - 3800 MHz , female 4.3-10
TPSXXDE-694/3800	RFS	6,8,10,15,20,30	2-way tapper- 694 - 3800 MHz , female 7/16
TPSXXE-694/3800	RFS	6,8,10,15,20,30	2-way tapper- 694 - 3800 MHz , female N

TABLE 8: TAPPERS

Splitters

The X in the typenumber needs to be replaced by the desired splitting output. E.g: The Microlab 4.3-10 connector, 2-way, 694 to 3800 MHz splitter with a rating of 3 is D2-EP-738FE.

typenumber	supplier	splitting output	description
S-X-UW-H-Ni6	Commscope	2,3,4	power splitter 555-6000 MHz , female N connectors
S-X-TCPUSEW-H-Ni6	Commscope	2,3,4	power splitter 340-3800 MHz , female N connectors
VD-SX-CPUSEW-H-43B	Commscope	2,3,4	power splitter 578-3800 MHz , female 4.3-10 connectors
S-X-UW-H-43-i6	Commscope	2,3,4	power splitter 555-6000 MHz , female 4.3-10 connectors
S-X-TCPUSEW-H-43i6	Commscope	2,3,4	power splitter 340-3800 MHz , female 4.3-10 connectors

S-X-UW-L-43i53	Commscope	2,3,4	splitter 555-6000 MHz , female 4.3-10 connectors
787620X3v01	ESB	2,3,4	4.3-10F 500W 555-6000Mhz
DX-EP-738FE	Microlab	2,3,4	4.3-10 connector, 2-way, 694 to 3800 MHz
DX-EP-738FN	Microlab	2,3,4	N-Type connector, 2-way, 694 to 3800 MHz
DX-08FD	Microlab	2,3,4	7/16, 380-2700M, 500W/port
PDSXE-694/3800	RFS	2,3,4,6	power splitter 694-3800 MHz , female N connectors
PDSXE-350/2700-01	RFS	2,3,4	power splitter 380-2700 MHz , female N connectors
PDSX-43-694/3800	RFS	2,3,4,6	power splitter 694-3800 MHz , female 4.3-10 connectors
PDSX-43-350/2700-01	RFS	2,3,4	power splitter 350-2700 MHz , female 4.3-10 connectors
PDSXDE-694/3800	RFS	2,3,4	power splitter 694-3800 MHz , female 7/16" connectors
PDSXDE-350/2700-01	RFS	2,3,4	power splitter 380-2700 MHz , female 7/16" connectors

TABLE 9: SPLITTERS

Loads

typenumber	supplier	description
TK-3100FD	Microlab	7-16 (f) 350-3800MHz 100W
TK-3100FE	Microlab	4.3-10 (f) 350-3800MHz 100W
TK-3100FN	Microlab	N (f) 350-3800MHz 100W
TK-3100MD	Microlab	7-16 (m) 350-3800MHz 100W
TK-3100ME	Microlab	4.3-10 (m) 350-3800MHz 100W
TK-3100MN	Microlab	N (m) 350-3800MHz 100W
TK-625ME	Microlab	4.3-10 (m) 350-5925MHz 25W
TK-610FE	Microlab	4.3-10 (f) 350-5925MHz 10W
TK-610ME	Microlab	4.3-10 (m) 350-5925MHz 10W
TK-610MT	Microlab	NEX10 (m) 350-5925MHz 10W
TK-605FE	Microlab	4.3-10 (f) 350-5925MHz 5W
TK-605ME	Microlab	4.3-10 (m) 350-5925MHz 5W
TK-605MT	Microlab	NEX10 (m) 350-5925MHz 5W
75112004	ESB	4.3-10 (f) ;0 - 4000 MHz ; 200W
75122004	ESB	4.3-10 (m) ;0 - 4000 MHz ; 200W
78210484	ESB	4.3-10 male ;0-7500 ; 2W
TER-E-3800-2W	RFS	RF N male 50-ohm load, DC - 3800 MHz, 2Watts
TER-43-3800-2W	RFS	RF 4.3-10 male 50-ohm load, DC - 3800 MHz, 2Watts
T-2-UW-43-M	Commscope	RF 4.3-10 male 50-ohm load, DC - 6000 MHz, 2Watts
TER-DE-3800-5W	RFS	RF 7/16 DIN male 50-ohm load, DC - 3800 MHz, 5Watts
TER-E-3800-10W	RFS	RF N male 50-ohm load, DC - 3800 MHz, 10Watts

TER-43-3800-10W	RFS	RF 4.3-10 male 50-ohm load, DC - 3800 MHz, 10Watts
T-10-UW-43-M	Commscope	RF 4.3-10 male 50-ohm load, DC - 6000 MHz, 10Watts
TER-E-3800-30W	RFS	RF N male 50-ohm load, DC - 3800 MHz, 30Watts
T-25-UW-43-M	Commscope	RF 4.3-10 male 50-ohm load, DC - 6000 MHz, 25Watts
TER-43-3800-30W	RFS	RF 4.3-10 male 50-ohm load, DC - 3800 MHz, 30Watts
TER-E-3800-50W	RFS	RF N male 50-ohm load, DC - 3800 MHz, 50Watts
TER-43-3800-50W	RFS	RF 4.3-10 male 50-ohm load, DC - 3800 MHz, 50Watts
T-50-UW-43-M	Commscope	RF 4.3-10 male 50-ohm load, DC - 6000 MHz, 50Watts
TER-DE-3800-50W	RFS	RF 7/16 DIN male 50-ohm load, DC - 3800 MHz, 50Watts
TERP-E-6000-5W	RFS	RF N male 50-ohm load, 350-6000MHz, 5Watts
TERP-43-6000-5W	RFS	RF 4.3-10 male 50-ohm load, 350-6000MHz, 5Watts
TERP-E-6000-20W	RFS	RF N male 50-ohm load, 350-6000MHz, 20Watts
TERP-43-6000-20W	RFS	RF 4.3-10 male 50-ohm load, 350-6000MHz, 20Watts
TERP-E-3800-50W	RFS	RF N female 50-ohm load, 698-3800MHz, 50Watts
TERP-43-3800-50W	RFS	RF 4.3-10 female 50-ohm load, 698-3800MHz, 50Watts
TERP-DE-3800-50W	RFS	RF 7/16" female 50-ohm load, 698-3800MHz, 50Watts
TERP-43-3800-100W	RFS	RF 4.3-10 female 50-ohm load, 698-3800MHz, 100Watts
TERP-DE-3800-100W	RFS	RF 7/16" female 50-ohm load, 698-3800MHz, 100Watts

TABLE 10: LOADS

Attenuators

typenumber	supplier	description
FYE-06N	Microlab	N-type, 694-2700MHz 13W 6dB
FYE-10N	Microlab	N-type, 694-2700MHz 10W 10dB
FYE-15N	Microlab	N-type, 694-2700MHz 10W 15dB
FYE-20N	Microlab	N-type, 694-2700MHz 10W 20dB
FZE-03FD	Microlab	7/16"- 694-2700MHz, 80 W 3dB
FZE-06D	Microlab	7/16"- 694-2700MHz, 133 W 6dB
FZE-10D	Microlab	7/16"- 694-2700MHz, 110 W 10dB
FZE-20D	Microlab	7/16"- 694-2700MHz, 100 W 20dB
AT-3-43-MF	CommScope	4.3-10, 0- 3 GHz, 3dB
AT-6-43-MF	CommScope	4.3-10, 0- 3 GHz, 6dB
AT-10-43-MF	CommScope	4.3-10, 0- 3 GHz 10dB
AT-20-43-MF	CommScope	4.3-10, 0- 3 GHz, 20dB
AT-6-UW-43-MFI6	CommScope	4.3-10, 555–6000 MHz, 6dB low PIM
AP-10N	Microlab	N-type, 0- 3 GHz, 10dB (10W)
AP-20N	Microlab	N-type,0- 3 GHz, 20dB (10W)

TABLE 11: ATTENUATORS

5 Alternative Vendors

For some equipment the Installation partner is allowed to select an alternative supplier. The supplier and its equipment have to fulfil certain requirements in order to be allowed for usage in the mobile network. These can be split into two parts: the specifications of the equipment and the financial stability/reliability of the alternative supplier. These must be fulfilled and proven to MNO before any equipment of any alternative supplier is allowed to be used in the DAS network.

New proof of meeting these requirements must be provided in case of change of the specifications of the equipment

If this requirement is not met related equipment must be replaced by an approved type (indicated by MNO) on cost of the DAS contractor. The DAS contractor is accountable for any cost related. This applies in any stage in the site life-time.

RF equipment for which alternative suppliers to the preferred ones are possible are:

RF equipment	Preferred Vendor	Alternative Vendor
Feeder	Eupen/RFS/H+S	Telegärtner
Feeder connector	Eupen/RFS/H+S	Telegärtner
Jumpers	Eupen/H+S/RFS/Amphenol	Telegärtner/Microlab
RSB clip	Eupen/H+S/RFS	Telegärtner
Grounding kits	Eupen/H+S/RFS	Telegärtner

TABLE 12: RF EQUIPMENT AND THEIR PREFERRED SUPPLIER.

Requirements to the alternative supplier

Minimum company size

The value of the yearly consumption in DAS networks realized in Belgium should not be more than 20% of the company production.

Financial stability

Financial information of company should indicate a credit rating of B or better.

Meeting the specifications

Typical value information of from a specification sheet of equipment provides only an indication and is no proof of meeting the requirements mentioned below. A value range is much better, but in general specifications need to be proven by measuring at least 3 blind-picked samples, preferably from 3 different production series. Maximum values are the allowed peak values for any sample of the equipment. Minimum values are the lowest values that can occur for any sample of the equipment. The spread is the specification bandwidth which the equipment is allowed to have.

All measurements need to be done with calibrated equipment with a valid certificate of this.

Equipment durability

Specifications shall not deteriorate under the conditions in this document mentioned for the product for a period of at least 10 years.

Quality guarantee process

Each alternative supplier or the installation partner must have a quality guarantee process to ensure the quality of the used non-preferred RF equipment keeps meeting the promised specifications.

The sample method differs per equipment type.

Product requirements

Jumper requirements

The requirements insertion loss, VSWR return loss and intermodulation have to be proven by lab test.

For the other requirements a conformation of compliance by the supplier is sufficient.

Insertion loss

Cable sample		800-1000 MHz	1700-1900 MHz	1900-2200 MHz
1m Max.	:	0,2	0,3	0,35
2m Max	:	0,3	0,4	0,45
Loss spread	:	0,05	0,1	0,1

TABLE 13: JUMPER INSERTION LOSS REQUIREMENTS

VSWR/return loss

			VSWR		Return loss [dB]	
Cable sample		Connector	900MHz	1800MHz	900MHz	1800MHz
Max.	:	male / female	1,1	1,1	-26	-26

TABLE 14: JUMPER VSWR/RETURN LOSS REQUIREMENTS

Intermodulation

			900/1800 [dBm]
Cable sample		Connector	2x 43 dBm- IM3
Min.	:	male / female	-107

TABLE 15: JUMPER INTERMODULATION REQUIREMENTS

The 2x 40dBm must be provided with 600 KHz spacing.

Bend radius

		Allowed single	Allowed repeated
Cable sample		Bending radius	Bending radius
Max (low-loss)	:	<=70	<=125mm
Max	:		<=40mm

TABLE 16: JUMPER BEND RADIUS REQUIREMENTS

The minimum repeated bend (>10x) radius shouldn't cause change on any specification of the jumper. This repeated bend is applied with a bending moment of at least 5Nm.

Allowed tightening torque

		Allowed repeated	Allowed Single
Cable sample		Tightening torque	Tightening torque
Min	:	15Nm	25Nm

TABLE 17: JUMPER ALLOWED TIGHTENING TORQUE REQUIREMENTS

The minimum repeated tightening torque (>10x) shouldn't change any specification of the jumper.

Water tightness

The jumpers need to meet the IP X8 and IP 68water tightness requirement. This can be tested this way:

The seals in the coaxial cable connectors must be able to withstand water pressure of 2.6 ±0,1bar (equivalent to a 25m head) ate a temperature of 20 ±5˚C for a period of 7 days. Testing method is performed by putting the open jumper connector under these conditions and sub sequentially measured if specifications are changed between before and after applying the water pressure (this way water leakage is tested).

Connector stress and vibration test

To be described later.

Other requirements

Cable sample		800-2200 MHz	Reason
Power handling	:	>=500W	12 TRU at 43dBm+3dB margin.
Impedance	:	50 Ohm (±1Ohm)	
Capacitance	:	75 pF/m	
Inductance	:	0,190 μH/m	
Insulating resistance	:	>1G Ohm	Between inner and outer conductor
RF Voltage Rating (peak)	:	>1 KV	Withstand remaining lightning field
Velocity propagation (low-loss)	:	88% (± 1%)	
Velocity propagation (High-flex)	:	82% (± 1%)	
Temperature range (installation)	:	-40-+60˚C	
Temperature range (Operating)	:	-45-+85˚C	
Maximum clamp spacing	:	>=1m	Jumper rigidness
Weight	:	<1,2kg	Load on active equipment
Tensile strength	:	>1KN	Pulling weights >100kg
Flat plate crush strength	:	>20 N/mm	

TABLE 18: OTHER JUMPER REQUIREMENTS

The tensile strength minimum is required so the jumper is able to withstand a pulling weight of 100kg.

The jumpers need to be corrosion and UV resistant for at least 10 years (Salt spray conditions norm ASTM B117 or IEC 60512-6 test 11f).

Quality check requirements

To ensure specifications are maintained during delivery the following sample check plan should be used. The sampling plan is derived from BS 6001: Part 1: ISO 2859-1, General Inspection Level II, with an Acceptable quality level of 1%-Normal inspection.

Lot or Batch size	Sample size	Accepted	Rejected
<14	100%	-	-
14-150	13	0	1
151-500	50	1	2

501-1200	80	2	3
1201-3200	125	3	4
3201-10000	200	5	6
10001-35000	315	7	8

For a batch of 1500 if 3 or less faulty jumpers are found it is sufficient if these are replaced with correct ones, if 4 or more are found in the sample size the entire batch is to be rejected

Annex 3

Mobile Indoor PIM and VSWR test procedures

Q1 2025

Passive DAS interoperator workgroup

1 Abbreviations

- PIM – Passive intermodulation
- DL – Downlink
- UL – Uplink
- BW – bandwidth
- SSV – site survey
- VSWR – Voltage to Standing Wave Ratio

2 Objectives

The main objectives of this document is to describe the method on how to measure the inter-modulation (PIM) and the mismatch between the feeder system and its connected loads (VSWR) on a Multi Operator passive Distributed Antenna System (M-O DAS) in order to achieve a well behaving system for Mobile services.
The PIM and VSWR measurements will be performed on the DAS system which may cover multi-operator scenario. Those measurements are very important and will be crucial for project validation.
Passive intermodulation (PIM) is a form of intermodulation distortion that occurs in passive components such as antennas, cables, connectors, or duplexers with two or more high-power input signals. PIM in the transmission path degrades quality of the wireless communication system.
Voltage to standing wave ratio (VSWR) indicates the ratio between the power that was connected to the system and what is actually transmitted or absorbed by the combination of antennas and loads connected to the DAS system.

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4 PIM and VSWR Sources

The primary sources of PIM sources at a cell site are inconsistent metal to metal contacts in high current density regions such as inside transmission lines, inside RF components or outside the system but in the main beam of the antenna. Clean metal surfaces with high contact pressure generally behave in a linear manner and do not generate PIM. Where there is loose contact between metal surfaces, a non-linear relationship develops between the applied voltage and the resulting current flow across the joint causing PIM to be generated.
In the field, PIM sources can be caused by:

I. Contaminated surfaces or contacts due to dirt, dust, moisture or oxidation;
II. Loose mechanical junctions due to inadequate torque, poor alignment or poorly prepared contact surfaces;
III. Loose mechanical junctions caused by transportation shock or vibration;
IV. Metal flakes or shavings inside RF connections;
V. Poorly prepared RF connections:
a. Trapped dielectric materials (adhesives, foam, etc.);
b. Cracks or distortions at the end of the outer conductor of coaxial cables caused by over tightening the back nut during installation.
c. Solid inner conductors distorted in the preparation process causing these to be out of round or tapered over the mating length;
d. Hollow inner conductors excessively enlarged or made oval during the preparation process;
e. Nearby metallic objects in the main beam and side lobes of the transmit antenna including roof flashing, vent pipes, guy wires, etc.

Though not influenced in the same way as PIM, sources of decrease of VSWR and PIM are the same as for example, metal surfaces can reflect signal back into the antenna, or poorly prepared RF connections cause signal to reflect back to the radio transmission unit.

5 Technology and Frequencies

5.1 GSM 900

For GSM PIM tests it will be considered Proximus GSM900-frequencies with channel bandwidth (BW) of 200 kHz.

DL Channel	DL Freq. (MHz)	UL Channel	UL Freq. (MHz)
2-4	935.4-935.8	2-4	890.4-890.8
28-93	940.6-953.6	28-93	895.6-908.6

Telenet is using the E-GSM band for GSM 900 and UMTS 900

DL Channel	DL Freq. (MHz)	UL Channel	UL Freq. (MHz)
975-1024	925.0-935.0	975-1024	880.0-890.0

Orange is using the GSM 900 band for GSM 900 and UMTS 900

DL Channel	DL Freq. (MHz)	UL Channel	UL Freq. (MHz)
32-59	941.4-947	32-59	896.4-902
95-124	954-960	95-124	909-915

5.2 UMTS900

This frequency band will most likely not being used for indoor solution, but it may be considered in the specific scenario as well in case of close by macro site located.

5.3 UMTS 2100

Proximus is using three carriers on the U21 band (listed below in the table) with channel BW of 5MHz.

UMTS Band	Uarfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
1	10564	2112.8	9614	1922.8	U
1	10589	2117.8	9639	1927.8	V
1	10614	2122.8	9664	1932.8	W

Telenet is using three carriers on the U21 band (listed below in the table) with channel BW of 5MHz.

UMTS Band	Uarfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
1	10639	2127.8	9689	1937.8	
1	10664	2132.8	9714	1942.8	
1	10689	2137.8	9739	1947.8	

Orange is using three carriers on the U21 band (listed below in the table) with channel BW of 5MHz.

UMTS Band	Uarfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
1	10787	2157.4	9837	1967.4	
1	10811	2162.2	9861	1972.2	
1	10836	2167.2	9886	1977.2	

5.4 LTE 800

Proximus is using one carrier on LTE band 20 with channel BW of 10MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
20	6300	806.0	24300	847.0	J

Telenet is using one carrier on LTE band 20 with channel BW of 10MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
20	6200	796.0	24200	837.0	

Orange is using one carrier on LTE band 20 with channel BW of 10MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
20	6400	816.0	24400	857.0	

5.5 LTE 1800

Proximus is using one carrier on LTE band 3 with channel BW of 20MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
3	1303	1815.3	19303	1720.3	K

Telenet is using LTE band 3 with channel BW depending on the area. BW is shared with DCS-1800.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
3		1855.0-1880.0		1760.0-1785.0	

Orange is using one carrier on LTE band 3 with channel BW of 20MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
3	1599	1844.9	19599	1749.9	

5.6 LTE 2600

Proximus will use one carrier on LTE band 7 with channel BW of 20MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
7	2850	2630.0	20850	2510.0	L

Telenet will use one carrier on LTE band 7 with channel BW of 15MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
7	3175	2655.0-2670.0	21450	2535.0-2550.0	

Orange will use one carrier on LTE band 7 with channel BW of 15MHz.

LTE Band	Earfcn DL	DL Freq. (MHz)	Uarfcn UL	UL Freq. (MHz)	Convention
7	3350	2680	21350	2560	

6 Measurements methodology

6.1 PIM

The 3rd order product (IM3) is primarily to be used to characterize PIM performance on the DAS system. The IM3 signal generated by a PIM source is usually higher magnitude than the other PIM products enabling higher measurement accuracy.
Measurement procedure and investigation is required for each segment/path of the installed DAS (like sector).

6.1.1 PIM Measurement Power

Due to magnitude of PIM generated by a defect changes depending on the applied test power, it is important that all specifications clearly state what power level to use when performing the test. In the scope of this procedure Proximus requires +43dBm (20W) per carrier/frequency test tones be used when performing PIM tests on DAS systems.

6.2 PIM Measurement Frequency

PIM test equipment is used to find and eliminate PIM sources on the DAS system. The specific following criteria should be respected:

1. All RF components in the segment/path (Cables, Antennas, Splitters, etc.) must be able to pass the two test frequencies, f1 and f2, and be able to pass the IM frequency you are measuring.
2. The mandatory two frequencies to be used during the PIM test on the **1800MHz**.

6.3 PIM test threshold

The entire DAS system will be considered validated in case:

1. At the DAS input the static result of the PIM tests must not be higher than -107dBm;
2. In case that DAS system is composed by multiple sectors then the pass/fail level is pplicable for each sector/RF path.

In case when then DAS system didn't pass the test, all correction has to be performed by the vendor in order to achieve values lower than -107dBm.
Vendor must calibrate the measurement equipment on quarterly based and must indicate the reference used for the calibration which must be much lower than -110dBm.
Vendor has to follow the Maintenance and Repair Model which is defined in the RFQ within agreed SLA.

6.4 Dynamic and Static PIM testing

Dynamic and static guidelines procedure is applicable for troubleshooting purposes to identify the PIM source when the PIM threshold are not fulfilled (see chapter 3: PIM test Threshold).

STATIC Tap Test Guidelines:

1. Tap RF components such as Filters and Antennas, etc. using a hard plastic or rubberized metal object to prevent nicking or damaging protective finishes;
2. Lightly tap the nut and/or back shell of RF connectors using a hard plastic or metal object. Do not tap the coaxial cable itself as this could cause dents in the line;
3. Tap with sufficient force to excite PIM problems if they exist but do not tap with excessive force. A good rule of thumb is that if you tapped your unprotected palm with the same force, it should not hurt;
4. Tap before weatherproofing is installed on RF interconnections. If weatherproofing is in place, substitute a "flex test" to apply stress to the interconnection.

Dynamic Flexible Test Guidelines:

This will be required in order to identify/locate the PIM source.

1. For stiff cables, rock the RF connector back & forth in two orthogonal directions while holding the cable rigid.
2. For flexible cables, hold the RF connector rigid and flex the cable back & forth in two orthogonal directions. Hold the cable approximately 12 inches (300mm) away from the connector and flex the cable ±1 inch (25mm) in each direction.

During the test only DAS is in the scope of the measurement and MAX, AVG and MIN values must be recorded and available in the report.

6.5 VSWR

VSWR is measured using a portable network analyser with valid certification of calibration. The unit must be suitable (and calibrated) to cover the complete frequency ranges of the operators (700-2700MHz). A copy of the calibration certification must be submitted with each measurement report.
Examples of suitable network analyzers for this purpose are the Anritsu site-master, models 331E or above or Viavi JD723C or higher.

6.5.1 VSWR measurement frequency

The frequency ranges for which the VSWR must be measured for meeting the VSWR threshold value are:

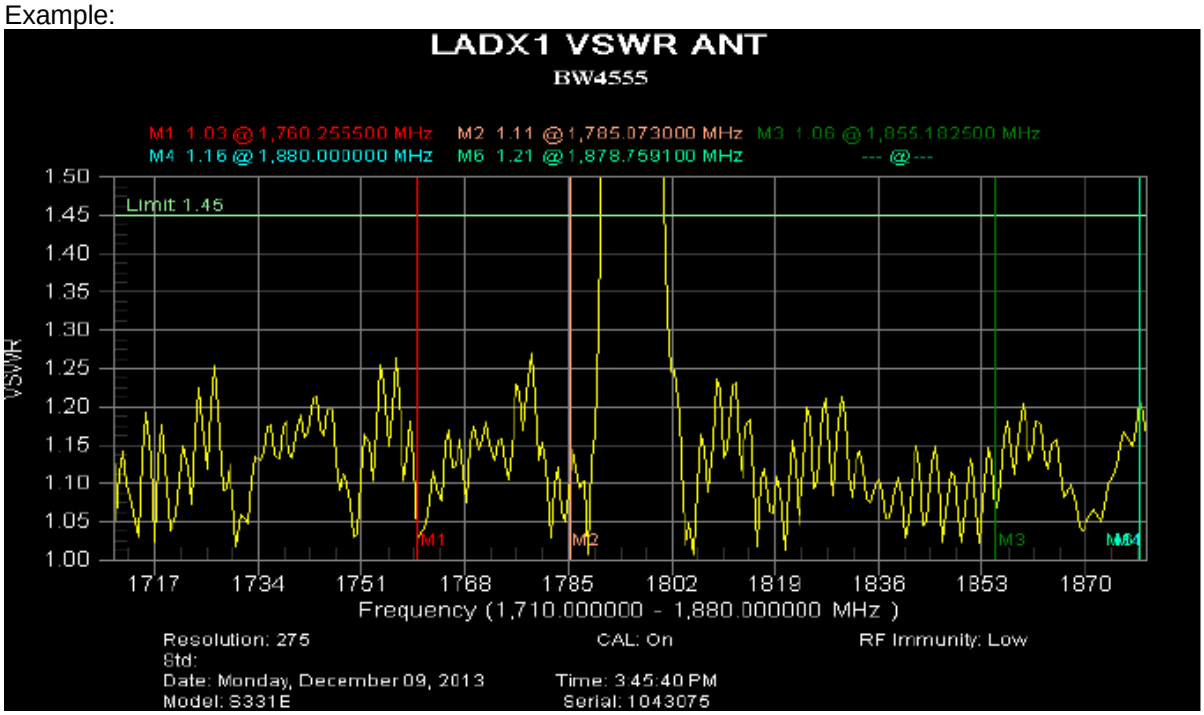
Band	UL Freq. (MHz)	DL Freq. (MHz)	Purpose
800	832.0-862.0	791.0-821.0	LTE
900	880.0-915.0	925.0-960.0	GSM, UMTS
1800	1710.0-1785.0	1805.0-1880.0	GSM, LTE
2100	1920.0-1980.0	2110.0-2170.0	UMTS
2600	2535.0-2550.0	2655.0-2670.0	LTE

These ranges incorporate the entire frequency ranges for these bands, thus also covering future possible refarming of the frequencies of the operators in these bands.

6.6 VSWR Threshold

In the frequency ranges identified for VSWR measurement, VSWR should not exceed 1.45 on any frequency.

Example:



This measurement graph shows that in the frequency range of the 1800 band nowhere the1.45 threshold is exceeded (1785-1805 is not considered part of this band).

6.6.1 Report template

The PIM and VSWR report must contain:

1. General information of the DAS system:
    a. Location, date/time, site reference;
    b. Sectors information;
    c. Equipment, frequency band used;
2. Graphical PIM reports and PIM thresholds (dBm) in static and/or dynamic mode;
3. Tabular PIM reports (This report compares the peak PIM value to the limit setting for each measurement and presents a “Pass / Fail” result.) in static or dynamic mode;
4. Graphical VSWR reports and VSWR thresholds in static and/or dynamic mode;
5. Tabular VSWR reports (This report compares the peak VSWR value to the limit setting for each measurement and presents a “Pass / Fail” result.) in static or dynamic mode;
6. Conclusions.

The report template to be used for this is the PIM/VSWR DAS quality report.

7 DAS components

For DAS projects for the part where mobile indoor coverage is in the scope, only operator accepted components must be used (listed in the Portfolio DAS equipment).

Annex 4: NOTIFICATION DOCUMENT
M-O DAS

Name and function of the requestor

- Last name: …….
- First name: …….
- Company: ……..
- Company number: ……..
- Function: ……
- Mobile phone: ……...
- E-mail address: …….....
- Address:
  ……
  …….....……...

Contact information (if different of the requestor):

Contact person can be the building owner, the tenant or the construction company depending on the project and situation. Specify who the contact person is, his/her function is and his/her coordinates:

- Last name: …….
- First name: …….
- Company: ……..……
- Company number: ……..
- Function: ……..……
- Mobile phone: ……...
- E-mail address: …….....
- Address:
  ……
  …….....……...

Description of the building and mobile indoor project

- State of the building (existing, to be renovated, to be built, other):
  ……
  ……
  ……
  ……
  - In case of building project:
    - Expected start date of the construction: ……/……/……
    - Expected end date of the construction: ……/……/……
  - In case of existing building:
    - Building to be renovated
      - Expected start date of the renovations: ……/……/……
      - Expected end date of the renovations: ……/……/……
    - Building ready for installation
- Location of the building (lambert coordination of the building and full address)
  ……
  ……
- Destination of the building (check the adequate box):

Industrial	
Commercial	
Offices	
Hotel/hospital	
Parking	
Other (please specify) :	

- Type of ownership (public, private, mix, other), please specify:
  ……
- Estimated number of users and types of users (operator's specific users, visitors, can be different per floor, building area, etc.):
  ……
  ……

- Building to be rented or owned
    - Name and coordinates of the building promoter:
        - Last name: ……
        - First name: ……
        - Company: ……..……
        - Company number: ……
        - Function: ……..…….
        - Mobile phone: ……...
        - E-mail address: …….....
        - Address: ……
          ……..……...
    - <u>If rented</u>: name and coordinates of the tenant(s) and possible contact person(s) (if already known):
        - Last name: ……
        - First name: ……
        - Company: ……..……
        - Company number: ……
        - Function: ……..…….
        - Mobile phone: ……...
        - E-mail address: …….....
        - Address: ……
          ……..……...
    - <u>If owned</u>: name and coordinates of the owner and possible contact person (if already known):
        - Last name: ……
        - First name: ……
        - Company: ……..……
        - Company number: ……
        - Function: ……..…….
        - Mobile phone: ……...
        - E-mail address: …….....
        - Address: ……
          ……..……...

- Building layout:

Area description	# floors	m^2/floor	Total m^2

- Which floors/areas are to be covered (including undergrounds):
  ……..

Description of the M-O DAS system:

Which mobile technology (2G en/or 3G and/or 4G) is requested, please specify as completely as possible:

…….....
…….....

List of attached documents (building(s) drawings, indoor installation pre-design (should also mention the references of the party that has made the pre-design), other):

…….....
…….....
…….....
…….....

Annex 5 PIM/VSWR passive DAS quality report

Adress of the measured location			
Name of the building			
Street			
Zip code		City	
x		y	

DAS contractor information	
Company	
Engineer	
Phone	
Test date	

	Operator	Site code	Service 1	Service 2	Service 3	Service 4	Service 5
1							
2							
3							
Number of sectors in measured location	10		Sector 1	Sector 2	Sector 3	Sector 4	Sector 5
		Feeder system	single	single			
			Sector 6	Sector 7	Sector 8	Sector 9	Sector 10
		Feeder system					

VSWR limit: 1,45

PIM limit: -107 dBm

		Frequency range		800		900		1800		2100		2600	
				UL	DL	UL	DL	UL	DL	UL	DL	UL	DL
		1800MHz PIM	Low	832	791	880	925	1710	1805	1920	2110	2535	2655
			High	862	821	915	960	1785	1880	1980	2170	2550	2670
Sector 1	Feeder 1												
Sector 2	Feeder 1												
Sector 3	Feeder 1												
Sector 4	Feeder 1												
Sector 5	Feeder 1												
Sector 6	Feeder 1												
Sector 7	Feeder 1												
Sector 8	Feeder 1												
Sector 9	Feeder 1												
Sector 10	Feeder 1												