Submission Type: **Public**

Wireless Coverage Solutions (WCS) is a privately owned Australian company supplying world-class Distributed Antenna Systems (DAS) solutions across all types of environments. We consult on Distributed Antenna Systems with building owners and technology managers to provide turnkey mobile coverage solutions utilising our in-house teams.

We supply full design and installation services for Distributed Antenna System Services available across all types of infrastructure ranging from commercial buildings, shopping centres, industrial facilities, residential towers, hotels and clubs.

With offices in Sydney and Melbourne we work with significant owners in the property sector. Some customers who have entrusted us with their projects include Dexus, Charter Hall, Mirvac and Investa.

Section 1.2

No information is provided on a mechanism under which the new specification will come into effect whether existing projects are expected to uplift their solution at once and/or whether that varies depending on the project's current state. Further clarity is required by the market on transition/grandfathering timelines from the existing MCF2018 Guidelines.

Section 2.1

"Futureproofing of the DAS for all carriers and technologies should be considered where possible and where necessary. Future proofing can be achieved by a simple pathway to sectorisation to increase capacity capability of the DAS system…"

Suggest that this also includes the addition of future bands in situations where 7 or 8 bands are not deployed from the outset, particularly given the low band penetration limitations discussed later in this response document.

This intertwines with the statement provided in section 2.5 that "*Active Systems should have the flexibility to operate on all bands **and be*** commercially available at the time of deployment."*

*Suspect this is a typo and should be *"on all commercially available bands."*

Section 2.3

In the description of system topologies, more information should be provided about what considerations may apply to certain environment types as parties will rely on this document in defining their solution, so they require complete education.

For example:

- Passive DAS needing the use of Remote Radio Units (RRUs) will require multiple secondary DAS rooms with sufficient power and cooling (as detailed in 8.2.2, however not front and centre as only technical individuals will review through to section 8)
- Active DAS will require the deployment of equipment within what can be 3rd party-controlled areas (Leased tenancies). This may not be suitable in environments where fit outs are commonly completed by 3rd parties contributing to significant loss and damage (as we see today). As such, commercial office buildings a2nd/or retail may want to ensure that they have robust processes in place if considering these topologies.

Section 3

"Traditional DAS using passive, active, or passive/active hybrid architecture may not support 5G"

The statement is misleading; it implies that no available DAS topology used currently "may" support 5G, which is particularly confusing given the number of DAS topology types with 5G services connected today. This statement is puzzling as the remaining document then describes the implementation criteria for these topologies to provide 5G. What is the intended meaning of 'traditional'? Suggest clarifying the intended meaning of the statement whether in relation to SISO, Band compatibility, or system topology.

"However, a decision to not incorporate MIMO and/or sufficient capacity into a DAS may result in the carriers being unable to supply 5G"

This statement does not align with and contradicts the various 5G deployments in the country on SISO DAS systems by Optus, TPG and Telstra in the marketplace today of which there are many examples spanning across retail, commercial, infrastructure, hospitals etc.

Section 3.2

"Carrier approved components list are available on the AMTA website"

No such documents have been accessible on the AMTA website for approximately 12 months, with only Telstra documents having been previously listed. Carriers should be required to list their approved components regularly or remove suggestions that they will be if there is no commitment to do so.

Section 3.4

Heading of Table 3, 3rd column “Passive/Hybrid/Active Solution Type” should read, “Minimum Band requirements”.

1st Column should read ‘Solution Category’, noting minimum element is in relation to the bands, which is moved to column 3 per above.

There is significant confusion in this overall section in the naming of solution categories between Limited and Standard in the notes associated with Table 3.

“While a standard solution is the recommended mini category, the lack of low band in the solution may result in poor lift coverage”. This is a limitation, yet this category is defined as ‘standard’. While the ‘limited solution’ doesn’t have the same challenges. WCS would further suggest that areas such as bathrooms, plant rooms and basements may too experience coverage gaps associated with the lack of low band coverage, so much so that bathrooms may require explicit antenna or mention in the document to call out the expectations of bathroom coverage (suggest this to follow 3.5.1 regarding lift coverage and titled 3.5.2 Bathroom Coverage)

Referring back to Section 3 “*However, a decision to not incorporate MIMO and/or sufficient capacity into a DAS may result in the carriers being unable to supply 5G within that building potentially the need for an upgrades to the DAS to enable supply of 5G”* likewise it would appear given the concern on lift coverage that a decision to deploy only a 3 band solution may require additional bands be upgraded in the future should they not be deployed from the outset. Particularly noting the limitations within the document around lift coverage.

Suggest the ‘Limited’ and ‘Standard’ categories are renamed to Standard SISO and Standard MIMO. They cannot be compared directly as they are apples and oranges however wholistically they offer similar levels of overall capacity when comparing 3 Band 2x2 MIMO vs 7/8 Band SISO compatibility with respective pros and cons.

Having Commercial Office, Residential and Serviced Apartments in both “standard” and “limited” is contradictory, given section refers to a “Recommended Minimum Solution Category”. As it is a minimum requirement, it cannot be across both Standard and Limited such it should clearly list the minimum only for each category, with a choice to proceed beyond a at a voluntary one above the minimum.

Historically DAS solutions have future proofed through the allowance of additional bands for future deployment, given the limited band support of a “Standard” solution being is 1800, 2100 and 3500MHz MIMO. How does this solution make allowance for “future proofing” as requested in DAS planning principals 2.1 dot point 5?

Section 3.5

Table 4 notes: Dot point 4, refers to section 3.10, this should be 3.11

Section 3.5.1

Requires further clarification that the actual user experience and coverage within the lifts will vary depending on what bands the lead operator chooses to connect to the system at their discretion. Lower bands will produce a superior experience, but operators may choose not to deploy their lower band technologies (or they may not be supported on 'standard' sites)

"High Speed lifts should incorporate dedicated in lift solutions"

At the time of writing, there is no unanimously approved product for these solutions; as such, WCS suggests deletion until future iterations of MCF whereby an appropriate product is approved for use. Alternatively, update terminology to 'should consider incorporating'.

Section 3.8.2 (Residential Apartments) and Section 3.8.4 (Hotels)

There is significant ambiguity regarding the expected level of coverage inside rooms of apartments, with contradiction between these two sections.

3.8.4 – *"Experience suggests that typically corridor mounting cabling and antennas will not provide sufficient coverage to most hotel rooms"*. WCS agree with this statement, as it is already not possible to supply 2.6GHz compliance in hotel rooms (let alone 3.5GHz) without antennas inside hotel rooms.

3.8.3 "*Depending on the size and configuration, the design principles will be similar to Residential or Hotels".* WCS notes this is in contradiction to 3.4" Solution Categories" where serviced apartments are Limited whilst Hotels are Standard. WCS suggest both Hotels and Serviced apartments have similar requirements to be met by a Limited solution.

3.8.2 *"Wherever possible the DAS should be designed with antennas and infrastructure being placed outside apartments to provide service to the Target Coverage Areas within the apartments"*

WCS would suggest that typically a hotel room is smaller than an apartment, so, if coverage **cannot** be provided to a hotel room from the corridor, it certainly cannot be provided in an apartment context, as such the above statement in 3.8.2 creates confusion as it suggests it's possible to do so.

WCS note that 3.8.2 goes on to explain that in cases where it is not possible to supply coverage from corridors, then antennas should be deployed. By default, this essentially means that all antennas should be in apartments with an approach that allows them to be externally isolated, as that's the only way to achieve apartment coverage.

The MCF document should confirm whether compliant coverage in apartments/hotels is needed (as many have been accepted historically which do not supply internal coverage). If it is needed, any suggestion of providing coverage from the hallways only in 3.8.2 should be entirely removed, and/or updated more in line with the statements regarding hotels in 3.8.4 confirming it is not possible to provide compliant coverage from the hallways.

Statement should, at a minimum, read, "Antennas in hallways will only be accepted when it can be clearly demonstrated that coverage will meet KPI on all bands within the apartments or else antennas are required within apartments and required to be isolatable from common space."

Should the coverage within hotels/apartments be a discretionary item and/or not required, then the building owners need to be tasked with deciding on its inclusion or exclusion, which can then determine the location of antennas.

If coverage in rooms/apartments is desired, as evident above and by the MCF's own statements in 3.8.4, this can only be achieved with antennas inside the rooms/apartments. To only provide coverage outside the apartments/hotel rooms will not provide compliant coverage.

However, this is up to the landlord, and their aspirations should be clearly stated as too often we see specifications call for full 100% apartment coverage, however solutions accepted by the Telcos for hallway only antennas, when we know this will not be compliant with the original coverage requirements.

This also relates to 3.8.3 (Service Apartments) which refers to 3.8.2.

Various 3.8.x

All 'Inside Lift Cars' from performance requirements should include the extra information as provided within 3.8.6

"Inside Lift Cards (travelling no-stop the entire lift run – Best efforts required but does not need to be included in RF design contours)"

Suggest including a reference back to 3.5.1, which defines the approach for lift cars, noting that this approach is unable to provide the defined levels of coverage within lift cars, particularly on the higher bands. As such, this mandated approach is a 'best efforts' approach, as stated within 3.5.1.

"Fire Stairs - Best Effort"

Much like defining the coverage approach for lifts, the approach for providing a best-effort fire stairs implementation should be clearly defined so that differing parties do not offer differing 'best effort' solutions, some of which would not be best effort.

Suggesting defining best effort as an antenna within 5m of a fire stairs door with an unobstructed line of sight.

Section 3.9

"These levels should be used as the basis of the link power budget, maximum signal level limits and ***EME Design requirements.****"*

It is not an appropriate method to calculate EME as it doesn't account for the industry's typical amount of low band attenuation or prescribe how to add up the various band combinations for operators.

EME should be calculated based on the operator's spectrum holdings in the relevant geographical area, considering the maximum input power (as a maximum not a default). This allows DAS integrators to balance the EME by allocating maximum power to the high bands and an appropriate amount to the Low Band (whilst still achieving coverage). If this is too complex. then Low Band EME power should just be set to a number for 700/850/900 @ +30dBm as this will, on any wideband DAS, provide KPI-compliant coverage

Section 3.11

Whilst the methodology for spectrum-based power allocation is sound it does not provide the bandwidth information required to complete the calculations accurately state by state. Suggest that included within the operation approved equipment lists mentioned in Section 3.2 that the uploaded documents included a simple table that demonstrates the total bandwidth per state per band for that operator as the basis for these calculations. These tables can be updated accordingly as the operators acquire, dispose, or trade bandwidth. Should these not be provided it will not be possible for designers to present accurate information to a lead operator (who may be able to confirm their own holdings, but unlikely others)

Examples provide below

Operator *xxx*

State	Band	FDD Downlink Bandwidth OR TDD total Bandwidth
NSW	700	20MHz

	850	10MHz
	900	None
	1800	15MHz
	2100	20MHz
	2300	None
	2600	40MHz
	3500	100MHz

Section 3.11

Clarify what to do when a 20cm input power limit doesn't exist, presumably use the 10cm measurements.

Section 3.18

*"In addition to the coverage, power and loss specifications above, a **passive** DAS shall meet"*

Replace with *"In addition to the coverage, power and loss specifications above, **all** DAS shall meet"*

Section 3.20

Section 3.2 previously stated these lists were available on the AMTA website. This section says they are on request, suggest combining aligning messaging.

Section 3.22

These subsections are largely legacy and predate the operators having approved equipment lists. The messaging throughout the document dictates that only equipment from approved lists is to be used. As such, there is little value (and if anything, provide opportunity for abuse) to prescribe the requirements of those components from a selection perspective. Ultimately, the consistent messaging should be that if a component is not on the approved list, then it's not available for use. Providing selection criteria only implies the contrary and creates an opportunity for abuse.

Suggest the complete deletion of section 3.22.1 through to 3.22.7

Section 3.22.9

Suggest including firm guidance around cabling practises for active topologies that require 'hub' infrastructure to feed only the floor on which it is located. This is widespread practice

in enterprise ethernet or fibre cabling, as troubleshooting hubs that feed multiple floors can be problematic, particularly if floors have different tenants.

It cannot be assumed access is available to tenanted areas for isolation that are a different tenant to the area of works.

Optical fibre-fed Active DAS may require the use of a Hybrid DC/fibre cable. Structured cabling alternatives may require a separate 230v AC power supply. Both AC and/or DC power to be fed from the same level as the Active DAS unit is located to ensure safe isolation and fault-finding

Should the isolation of a floor's power not disable all cabling and remote units on that floor, it creates a significant electrical risk and liability should a party assume the floor is entirely isolated. This is widespread safe electrical practice during commercial office fit outs.

Likewise, this approach ensures that only that floor is impacted when power to a floor is isolated for safety.

Section 4.5

Dot Point 3: *"For Active/Hybrid DAS systems, all configuration information, including but not limited to: Active/Hybrid DAS parameter settings;"*

The configuration of the active DAS in the context of 3rd party DAS is often left to the lead operator and not available at the time of DAS completion as it requires operator connection in the case of modern equipment such as Commscope ERA. As such the only thing that can be definitively provided is screenshots of an error free system in terms of fibre connectivity

Dot Point 4: *"Location of DAS equipment spares:"*

Spares are not mentioned anywhere in the document except for here, nowhere has detailed a requirement for spares, their quantity or type. Suggest deletion

Dot Point 6: *"IBC EME Guide prepared by an AMTA Approved RF Assessor (list available on the RFNSA.com.au home page)."*

This is a lead carrier responsibility is subject to both the lead and subsequent operators' connection injections powers, bands and configurations. This is known at build completion but rather at connection. This is a operator responsibility per ACMA spectrum requirements. Delete dot point.

Section 6.6

Given the returning market interest in low-power active DAS, several learnings from previous generations of hardware deployments and the associated maintenance challenges mandate the importance of proper installation practices to ensure longevity. Based on WCS

experience, most faults associated with low-power active topologies are because of damage to the fibre or power cable runs. Noting that these cables are not as resilient as coaxial, which is often disturbed with no consequences, it is destroyed when a fibre is snagged. Typically, these situations happen when non-DAS contractors complete electrical or mechanical works and push other cables through ceiling spaces. **As such the cables need to be physically secured and protected.**

Historically, this element of fibre protection has been less important. Fibre has largely been isolated to back-of-house riser locations only. However, expanding fibre onto horizontal cabling will result in significant system integrity issues should it not be appropriately protected as a minimum requirement.

The section should also make clear that hybrid cable (Power and Fibre) is to follow the prescribed installation practices as standard fibre cables and must be protected.

*"All cabling should be supported on cable trays / ladders, **catenary** cables or in conduits."*

Suggest removing the catenary as it offers no actual physical protection of fibre (or hybrid fibre).

Suggest clarifying that the conduit is to be mechanically fixed to the base building soffit (ceiling) to ensure conduits are not loose in ceiling voids.

Suggest requirement for physical separation from other building ethernet and or fibre cabling.

Section 7.3

Provide clear direction over what band is expected to be swept. Legacy test equipment can only support 700-2700MHz sweep capability. If there is a desire to sweep up to 3800MHz, this should be documented, and the industry should be allowed a transitionary period to adjust future equipment purchases and minimise the e-waste of current equipment.

The section calls for Return Loss measurements and Distance to Fault** measurements to be completed.

It does not prescribe a pass/fail metric for either of these tests; however, it refers to having the result demonstrate a pass/fail outcome. Please confirm pass/fail metrics, noting that the frequency at which the cable is tested, as mentioned in paragraph 1, has a significant impact on the result.

In the case of Return loss, the connector and the cable and its respective specifications largely determine what return loss should be **achievable**. For example, to put a ½" JMA 4.3-10 Male Connector on ½" RFS LCF12-50JFN cable would inherently have its VSWR/Return loss limited by those elements of the cable assembly by the below specifications.

Return loss/VSWR		
Frequency band	**VSWR**	**Return loss (dB)**
555–1000 MHz	1.02	40
1000–2700 MHz	1.03	38
2700–3800 MHz	1.07	30
3800–6000 MHz	1.15	26

Extract from JMA CXP-4MT-12 Spec Sheet Rev A

Return Loss (VSWR) Performance		Standard or Premium
Min. Return Loss (Max. VSWR)	dB (VSWR)	Standard 20 (1.222), Premium 24 (1.135)/ 23 (1.152)

Extract from RFS LCF12-50JFN Spec Sheet Rev T

Noting the above it can be seen that cable is typically the limiting factor of a Return Loss/VSWR measurement with its standard performance to have a return loss of 20db (or equivalent VSWR or 1.222)

** Note VSWR and Return loss have a direct relationship and are converted between. Distance to fault VSWR is an altogether different measurement largely aimed at identifying fault locations by distance to troubleshoot a return loss/VSWR fail, not determine the pass/fail of a cable assembly.

Section 6.1.3

Suggest explicitly not accepting the securing of cable to ceiling hangars as is currently common, as this results in complete destruction of DAS systems during fit-out works. Remaining silent on the issue will not resolve poor installation practices.

Section 7.6.4

"High speed lifts, defined as a lift that travels 8m/s or two floors per second should incorporate dedicated in lift solutions (where possible) to provide coverage and seamless network performance and handover. The solution to be implemented should be in consultation with the Lead Carrier."

This seems like an oversight. This is included towards the end of the document in a section around walk testing process for lifts. Suggest Deletion of this section as the lift coverage approach is defined sufficiently in 3.5.1.

Section 8.2.23

Suggest splitting up Active and Hybrid systems into their own section as their spatial requirements largely differ.

Active will have more consideration of 1 rack location per floor for hubs and power distribution.

Hybrid will require infrequent locations but larger locations. Suggest 4 racks per location is not a relative measurement are most of the time as equipment is typically wall mounted. The requirements will differ depending on the class of solution and the bands required and may, at times, be split over consecutive levels. required and may at times be split over consecutive levels.

Overall PIM Testing Commentary

The topic of PIM testing appears 3 times throughout the document, this does to a degree complicates understanding the PIM requirements, suggesting these are combined, particularly 7.5 and 3.18.2, while section 5 is largely more educational and could take the form of an appendix.

Strongly encourage these elements of changes to testing procedure (which are well understood in the industry to be needed) once ratified to take precedence over all MCF2018 testing PIM methodologies. with immediate effect (there would be no industry resistance)

Section 3.18.2

Refers to Table 6 for input powers associated with testing. Unclear how these are mapped as the Table 6 is an example of splitting power and will vary site to site. Based on discussions with Telstra to date, I believe this is intended to be Table 5 – Maximum Input Power. Whilst WCS believe this is a sound approach, based on the later discussed use of 1800/2100 to approximate high band, WCS suggest that the mid-band be slightly 'over-tested' at 20 watts as detailed in our final PIM testing recommendations at the back of this document.

<u>3.5GHz testing</u>

A substantial portion of this section starting with the paragraph *"In most cases a breach of the DAS system..."* through to the end of the section is a direct copy and paste from Kaelus paper TN122871-A *"Simulation of PIM levels across wide frequency range in Passive DAS Network in a Test Case"* dated 4th February 2022. WCS have discussed this paper with the authors of the document who were unaware of its use (dating back to previous MCF2022), suggest at a minimum referencing their contributions. However, sections of text which have been used have been largely taken out of context. The purpose of the paper wasn't to assess the best frequency to imitate 3.5GHz, it was to assess the correlation between existing bands and 3.5GHz. However, the findings that 2.6GHz has a high correlation doesn't mean that 1800/2100MHz doesn't either.

For example, the Kaelus report states that "Testing PIM at 2600MHz while not testing PIM at 3500MHz is no worse than testing PIM at 2600MHz and not testing PIM at for example, 2100MHz". Discussion with Kaelus indicated that the choice of 2600MHz in this case study was arbitrary and their findings would apply to other mid bands. As such overall their findings were in fact that measuring 1800/2100/2600MHz would all be a good representation of 3.5GHz PIM performance, whilst 2600 might be 'closer' it is also a largely unused band for PIM testing with little market penetration.

The other important fundamental finding of the Kaelus report located within their ultimate conclusions is the overall lack of importance of PIM performance at 3.5GHz **"Finally, the 3500MHz being a TDD system, the PIM generated by the 3500MHz transmitted in its own band is not as critical as if it was a FDD system".** Overall, this is why as an industry there has been little development of portable 3.5GHz testers given the limited impacted of PIM in a TDD environment and little interest in measuring 3.5GHz PIM globally for DAS. This TDD

nature is not indifferent to the MCF not encouraging a PIM result in the 2300 TDD band, as there would be little value add, but then there is also no value-add testing at 3500MHz.

Noting that the industry has long been testing the 1800/2100 bands and overall, a poor uptake of 2600MHz testers globally. There are no commercially available portable testers for 3.5GHz, as overall there is no demand for them given the similar behaviour to the existing mid bands and its TDD nature. Requiring the industry to purchase 2600MHz testers will require a complete swap out of existing integrators test equipment and while it could be 'encouraged' for future purchases, it seems unreasonable to introduce such an onerous expense more than ~$25,000 per tester, costs which will only be pushed on the end customers whether operators or building owners, particularly given the limited relevance of any representation of a 3.5GHz PIM result

Overall WCS suggest that 1800/2100 MHz results remain as an approximation for 3.5GHz performance and a progressive shift upwards to 2600MHz testers is encouraged for future purchases.

Hybrid DAS

"For the purpose of PIM performance requirements on a Hybrid DAS each active remote unit will be viewed as if it is a 'multi network combiner' with the above passive DAS testing"

This element is noted and will be covered in section 7.5 response; however, the current legacy phrasing is somewhat convoluted, suggesting its removal. Per previous comments combining 7.5 and 3.18.2 will provide a concise methodology as currently its split between these two sections.

<5-Watt Testing

This element is noted, as it sets a precedent for adjusting the test power of a PIM tester based on the expected injection power, however, suggest removing this sentence for a more sophisticated methodology to be detailed in the 7.5 section (detailed below). At the least suggest deleting this statement here as it reappears in section 7.5 anyway.

Section 7.5

Context: Over the last 24 months WCS has actively been engaging with Telstra on all things relating to the current PIM testing methodology. Various case studies have been created and presented by WCS around the following topics:

- The volatility of low band PIM day by day across a ~2-week study
- The reduction in DAS loss since the MCF PIM testing methodology was established going from low band 850/900 systems to wideband systems now with loss DAS loss to accommodate 2600MHz and 3500MHz
- The inherit relationship of test power, DAS loss and dBc
- Interpretation of the IWPC white paper, particularly around the difference between testing components vs systems

- Adjusting test power based on location within the DAS
- The importance of appropriate low band injection power through POI Couplers (EME, Leakage)
- International precedence for testing thresholds differing by band

WCS went on to arrange a call with Telstra and Thomas Bell the Co-Chair of the IWPC PIM white paper and highly respected expert on the matter to seek guidance on developing a relevant specification and interpreting the recommendations of the IWPC. Thomas provided his recommendations here: https://concealfab.com/blog/pim-testing-in-das-networks/. Thomas clarified the purpose of the 2x43 test power standard within IWPC was for testing components, not overall systems.

The overall findings of importance from his commentary:

"In the conference call that initiated the writing of this document, a concern was raised that some people interpret the test power recommendations in both the IWPC and the IEC documents to mean that ***"PIM tests are not valid unless they are conducted using 20W (2x43dBm) test tones." This could not be farther from the truth!*** *Table 2 of the IEC document states that other test powers may be used as does Section 2.1 of the IWPC document which states that* ***"Lower test power may be required for Small cell and Distributed Antenna System (DAS) testing."***

The response then goes on to document the relativeness of testing at different points in the DAS system and adjust the test power relative to the relative loss between the frontend radio (BTS/RBS) and the test point location. Figure 4 and the introduction of a 4x4 MNC combiner with a known loss of 6dB is of particular interest. In his terminology he defines the input of the MNC as a 'System Test' and the Output of the MNC as a 'Floor' Test, although it may realistically cover more than one floor, the terminology is semantics. Noting that there is 6dB of loss between these location Thomas then documents the adjustments to be made to the PIM test tones adjusting downwards form 2x43dBm to 2x37dBm along with an example of further adjustments for hypothetical other locations in the system (although these should be adjusted on a site-by-site basis as their purpose is purely for the sake of troubleshooting).

Thomas summarises his findings: *"Applying* ***system*** *level PIM test criteria* ***at points inside a DAS, without accounting for network loss results in significant over-testing of the DAS.*** *Requiring higher than necessary linearity at points inside the system can be very expensive and* ***may be impossible to achieve.*** WCS would expand on this to suggest that they are impossible to achieve **consistently,** as has been evident repeatedly in industry, whether that be a difference of hours or days.

Recommended Testing Procedure

NOTE: WCS has provided a secondary document providing for the draft text for a combined PIM section

While the new proposed procedure does make progress in the right direction, it appears that it intentionally avoids the issue and education required to industry on the concepts of

adjusting test powers where appropriate and likewise doesn't carry over to Hybrid systems particularly well.

Testing should be done in at least three frequency bands comprising a low band test (one off 700/850/900 MHz), a mid-band test (one off 1800/2100/2600 MHz) with an ongoing preference for 2600MHz over time.

Passive DAS

Each input port of the multi-network combiner (MNC) with all output legs of the system fully connected.

The input test powers into the MNC are to be in line with the maximum allowed injection power in Section 3.9 to provide a representation of the impact to the noise floor for radio at the given powers (*which are the maximum an operator could inject, although a strong argument to be made for why an operator would likely inject at a lower power, particularly in the low band*)

Low Band Testing 700 or 850 or 900 to be completed at 2x40dBm with a pass of -140dBc

Mid Band Testing 1800 or 2100 or 2600 to be completed at 2x43dBm with a pass of -140dBc

There may be ad-hoc times such as after a fit out or change to the system when a party needs to demonstrate the performance of only a particular section of the DAS, whether that be an entire MNC or a floor, in which case the principals of adjusting test power based on DAS loss relative to that location should be applied (which will differ by band in situations where cable is involved, such as a floor test power)

There is little value in presenting output testing of any kind; ultimately, it is nothing more than a troubleshooting process. System performance all comes down to the point of radio connection at the respective radio output power. So, it's critical to understand the overall system's performance at that point, which all outputs fully connected. There is no overall value in testing the combiner itself meets a specification, if it fails, it will be impossible to achieve a passing system result, this is part of a troubleshooting step, not overall compliance.

Hybrid DAS

From 3.18.2

“For the purpose of PIM performance requirements on a Hybrid DAS each active remote unit will be viewed as if it is a ‘multi network combiner’ with the above passive DAS testing”

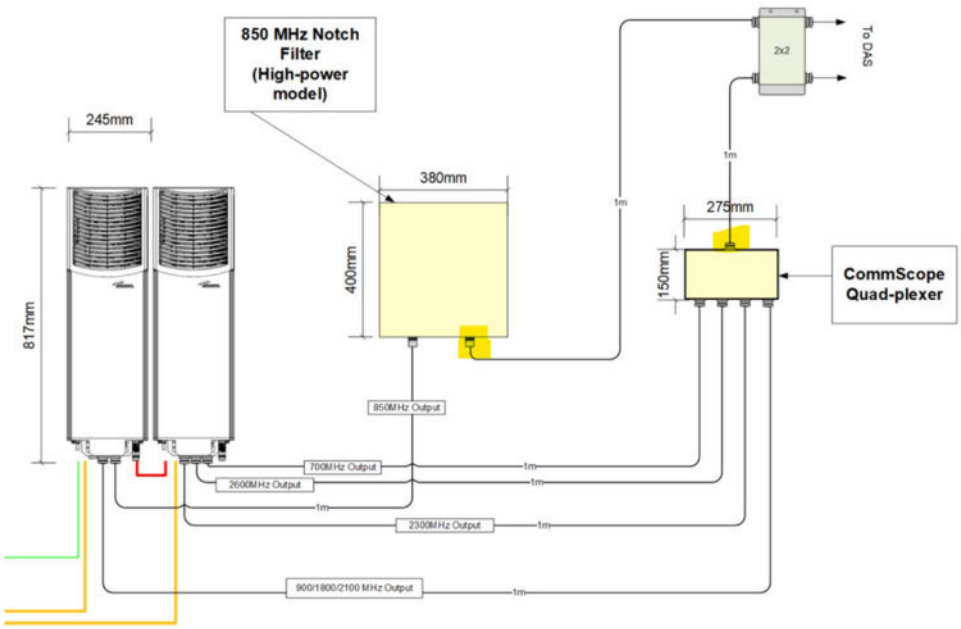
This conclusion is rational in nature given the shared nature of a Hybrid DAS remote unit, much like the shared/combined nature of the MNC output. This is where the application of DAS loss is critical to provide a relevant test. Knowing that a multi network combiner provides a loss of 6dB and the low loss nature of Hybrid segments the powers should be

adjusted accordingly to provide a test that provides a relative indication of performance based on how the system will be used

The test should be documented with a diagram (sample below) whereby the test is completed at the most forward location to the remote unit before any means of filtering/band-specific componentry would impact the tests.

Low Band Testing 700,850,900 to be completed at 2x34dBm (noting the 6dB sharing loss associated with an MNC) with a pass of -140dBc

Mid Band Testing 1800,2100,2600 to be completed at 2x37dBm (noting the 6dB sharing loss associated with an MNC) with a pass of -140dBc



Active DAS

There is still a way to progress here, however believe it's important to call out that some form of testing is required. This is more likely to differ from product to product and operator to operator.

Some products have elements of self-testing features or reporting the uplink noise floor remote by remote. This could form acceptance criteria.

Alternatively, it may be possible to PIM test at the appropriate BTS interface location at powers like those detailed above in Passive DAS BTS power (given the power is not shared like a Hybrid Remote) at the front end of the system. However, this will require all remotes be on, connected, running at max forward gain etc. There are likely configuration challenges here as modern Active systems typically need to be set up to pass through the signal (which they decode; a PIM signal won't be decoded and may need to be configured as CW).

Lastly, operators may have to rely on their BTS/RBS noise stats to make acceptance decisions. However, that would raise the question of why, as an industry, we don't do that wholistically for Passive and Hybrid DAS as well.

Ongoing Engagement

Wireless Coverage Solutions and its team respectively are available to engage in any means of further sessions/workshops to discuss the provided responses and feedback, particularly around some of the more nuanced technical topics of PIM testing, of which WCS has a variety of documentation, case studies and presentations to hand.

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