

Embedded LNA Antenna

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ABSTRACT:

Tower Mounted Amplifiers (TMA's) are deployed in wireless networks to compensate for the signal losses that occur in the RF feed cable between the antenna and the base transceiver station ("BTS"). By amplifying the in-band signal, TMA's reduce the noise contribution to the overall receiver system, resulting in larger cell size, better customer experience and greater data rates. New Embedded LNA antennas from Jaybeam wireless provide the lowest possible System Noise Figure by eliminating additional cable losses between the antenna and the TMA. This improvement further increases the sensitivity of the Node-B and results in higher Quality of Service (Qos). In addition, Embedded LNA antennas provide a reduction in the Total Cost of Ownership (TCO) compared to Stand Alone Antennas (SAA) with external TMA's. These savings result from faster site deployment, lower maintenance costs and lower logistical costs for the operator.



SCOPE

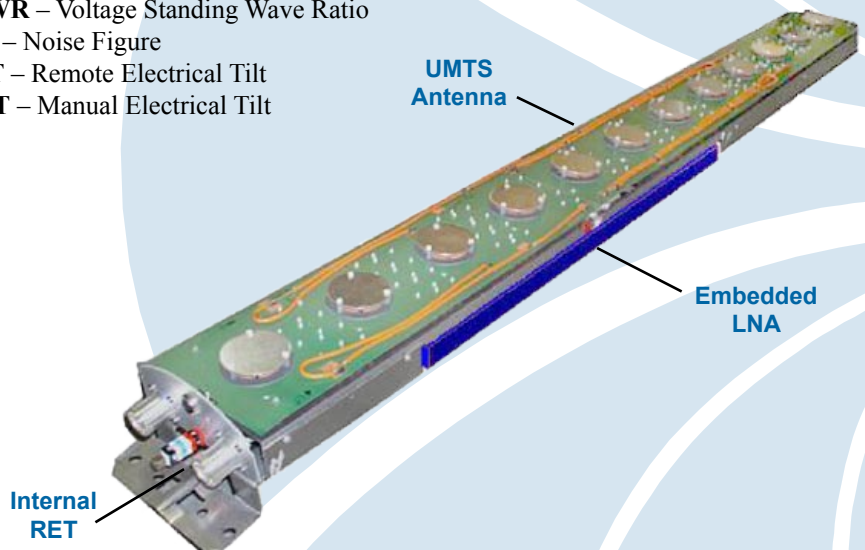
This document addresses Technical and Cost advantages for a site installation containing an Embedded LNA Antennas. The focus is on a UMTS system but can similarly apply to Dualband or Triband systems, where the benefits are even greater.

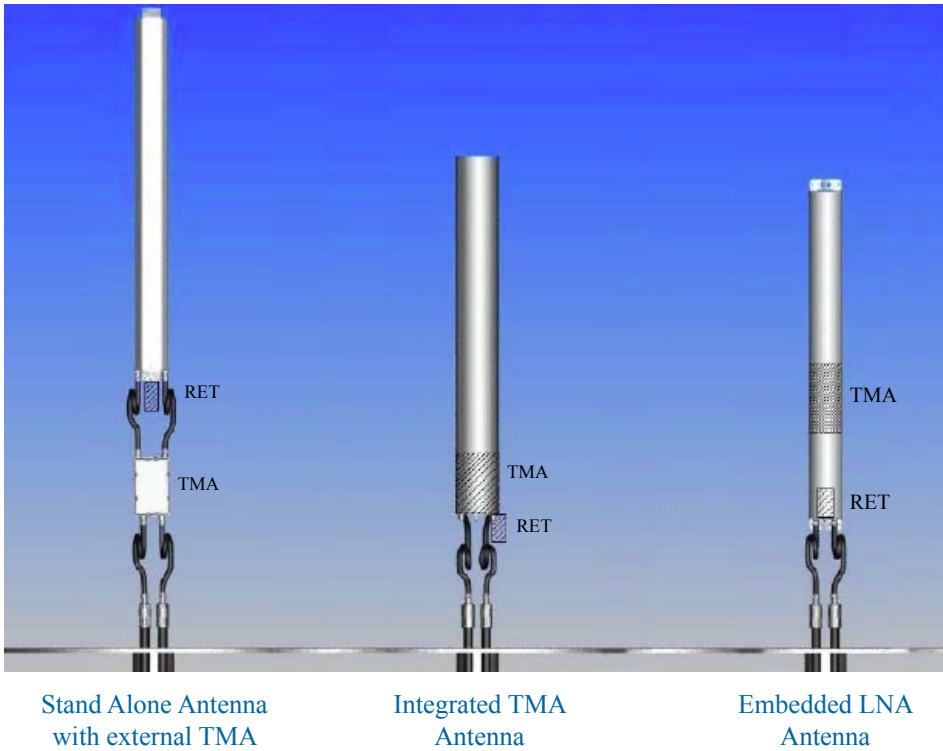
DEFINITION OF TERMS AND ABBREVIATIONS

Directivity – The gain of the antenna in the bore sight azimuth, measured at the common feeding point of the radiating array, which is the centre of the antenna, in order to balance the phase shifters.

System Gain – The gain of the total antenna measured at the physical connectors, ie. at the bottom of the antenna, at the external feed point.

- LNA** – Low Noise Amplifier
- TMA** – Tower Mounted Amplifier
- AISG** – Antenna Interface Standards Group
- SAA** – Stand Alone Antenna
- VSWR** – Voltage Standing Wave Ratio
- N.F.** – Noise Figure
- RET** – Remote Electrical Tilt
- MET** – Manual Electrical Tilt





1. Stand Alone Antenna (SAA)

- Requires jumper cabling on site, high installation and commissioning time.
- Faulty units are only covered by a single component warranty.
- Fault diagnosis is difficult and time consuming.

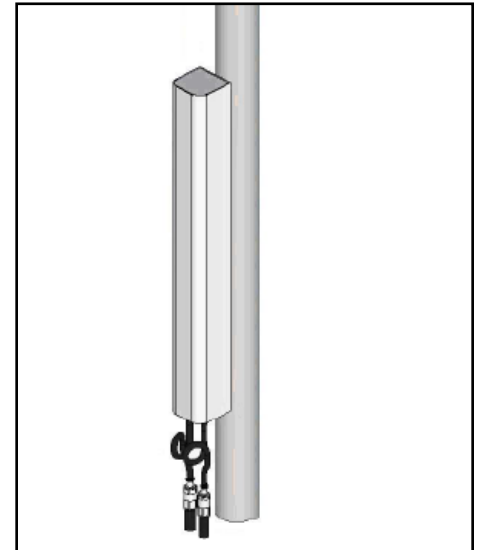


Figure 3: Scale Diagram of an Integrated TMA Antenna with TMA's mounted behind the antenna

Figure 1: Scale Diagram of the considered antenna assemblies with critical components.

ANTENNA ASSEMBLY VARIANTS

The above diagram, from left to right, may be considered as an historical evolution of a UMTS site.

The benefits are:

- Improvement in performance and quality;
- Reduction of visual impact;
- Reduction of Clutter on site;
- Reduction of wind load;
- Reduction of installation time and cost.

A description of each of these antenna variants follows.

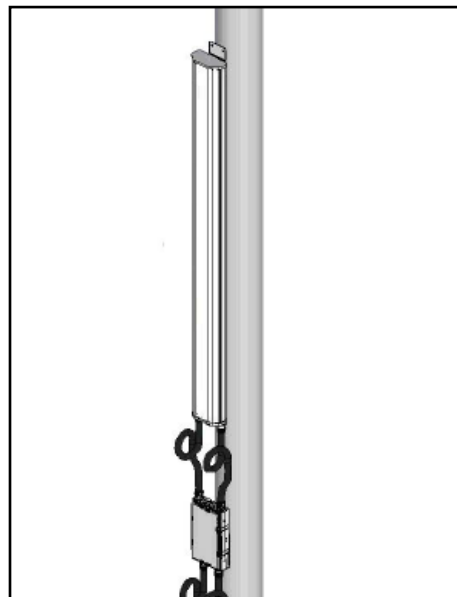


Figure 2: Scale Diagram of a Stand Alone Antenna with separate TMA

2. Integrated TMA Antenna

An assembly housed in a single shroud of “outdoor” equipment ie. an SAA, outdoor TMA, all interconnection RF jumpers and AISG cabling contained in one radome to offer protection from the elements. Factory Tested and Certification of Total system behaviour (VWSR, inter-modulation/PIM, isolation...). The RET system is pre-commissioned ie. all Firmware is written in memory, RCU calibrated and all AISG datafields stored with relevant antenna properties, linking the RCU, TMA and physical assembly serial number.

- Requires a larger (width, breadth, depth) antenna than SAA. High visual impact and greater wind load.
- The TMA may sometimes be situated directly below the antenna, extending the length of the antenna shroud to 2metres,

rather than the 1.7metres shown above in the piggy-back TMA position. This adds feeder loss of around 0.6dB in both Uplink and Downlink.

- The jumper cables are housed within the radome giving equivalent or greater internal losses to the SAA case, but it is assembled in a factory by skilled personnel.
- The Voltage Standing Wave Ratio (VSWR) is raised due to accumulated non-optimally matched components. There is also a larger risk of inter-modulation as the number of installation connections is increased, similar to the SAA case.

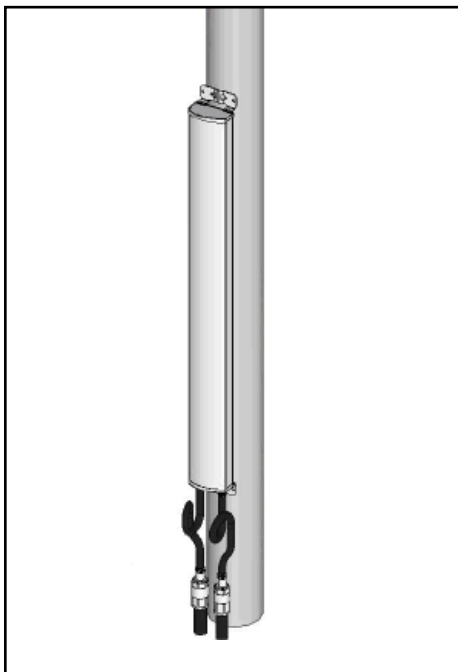


Figure 4: Scale Diagram of an Embedded LNA Antenna

3. Embedded LNA Antenna

An antenna array with optimally positioned Uplink LNA, and a single shared micro-controller for both amplifier and RET in-built.

- Identical physical dimensions as SAA, but with TMA and RET/MET in-built. It is a direct replacement for any SAA or Integrated TMA Antenna on any site.

- Very low internal antenna feeder losses leading to a best achievable Uplink Noise Figure (N.F.). Directivity approximates to Antenna Gain in the Downlink, giving a higher gain with a smaller antenna.
- Better quality and easier site installation leading to far less risk exposure. Antenna have been pre-commissioned at the factory, the SW for the RET has been pre-loaded, tested and calibrated, again reducing installation time.
- Future proof as the same technology is used in Dualband and Triband units, which are readily available and for forthcoming products such as the Tri-Sector antenna.
- Logistical costs are simplified and reduced as only one stock reference for Purchasing Departments. It is the smallest “Line Replaceable Unit” (LRU). Only one site visit is required as the antenna is one unit from a single manufacturer.

TOTAL COST OF OWNERSHIP (TCO)

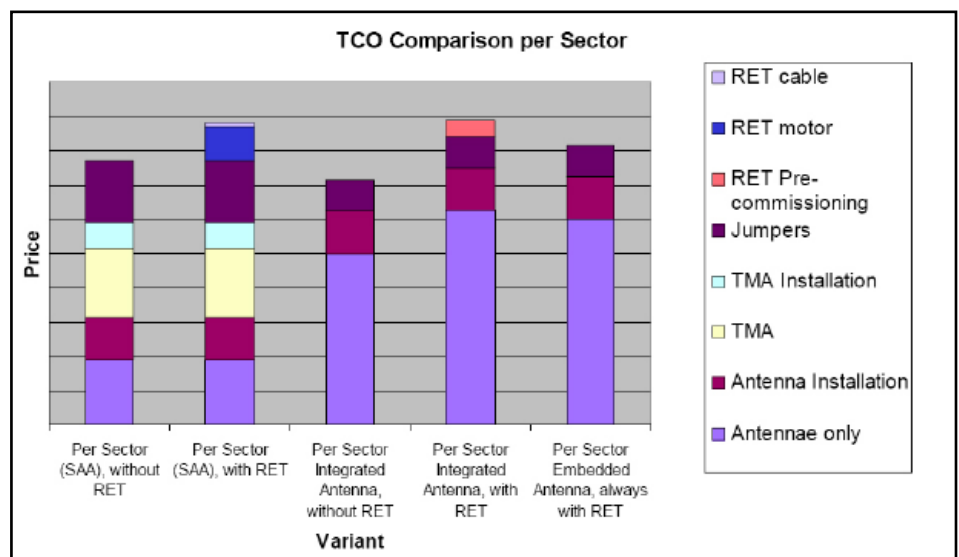
This encompasses rigger cost, logistical and HW/SW installation costs.

It assumes single-band UMTS only sectors which require at least 2 man hours/sector of installation and commissioning.

It is possible to see that of all the systems with RET that the Embedded LNA Antenna is the cheapest at sector level, and site level. A significant cost reduction has been made over the SAA and Embedded systems. The cost difference between the Embedded LNA Antenna with RET and the SAA and Integrated TMA Antenna without RET has also been reduced. This makes RET an even more attractive option, considering it simplifies the installation and commissioning phase of deployment and any future network enhancements.

The most important cost advantage for Network Operators is the performance increase in both Uplink and Downlink which the Embedded LNA Antenna entails, as described in the next section. This may be viewed either as a saving at the roll-out phase, or as greater data rates/quality throughout the network when swapped in, which will, of course, mean more potential revenue.

Further cost savings are introduced by the Jaybeam Embedded LNA Antenna when in a Dualband configuration. The cost of the RET motor and controller has reduced during evolution and will result in additional savings in the future.



LINK BUDGET BENEFITS FOR OPERATORS

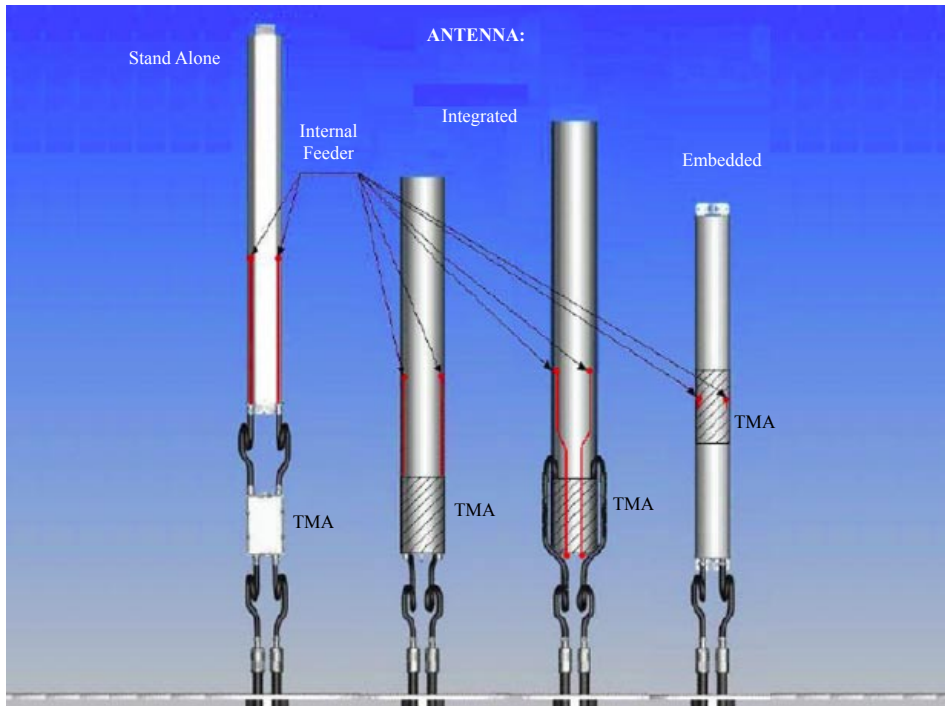


Figure 5: Diagram illustrating the internal feeder point and internal cable lengths leading to the TMA in the Uplink

The above figure highlights the optimisation of the Embedded LNA Antenna. Internal feeder losses are minimised in the Uplink path, after phase shifting and before amplification at the TMA stage. Two cases are shown for the Integrated TMA Antenna, the one on the left for TMA situated below the antenna, and the one on the right for the Piggy-back case.

Until today, Thermal Noise Floor for an antenna system has been considered from the physical connectors at the bottom of the antenna, characterised by “System Gain”. With the advantages of the Embedded LNA Antenna it becomes clear that instead “Directivity” (as defined above) must be used, and that Thermal Noise Floor must be considered from the central feeding point.

UMTS Uplink per Sector

Uplink System Noise Figure can be considered per sector in four cases:

- SAA with no TMA;
- SAA with TMA;
- Integrated TMA Antenna (with TMA Piggy-Back or Below);
- Embedded LNA Antenna.

The Noise Figure of each Uplink system is critically dependant upon the presence of a TMA (to compensate for feeder cable losses) and its interconnection via jumper cables ie. additional losses. The Uplink System Noise Figure falls with the reduction in length of jumper cables. The significant advantage of the Embedded LNA Antenna is that it almost eliminates these cables and their associated losses.

SAA with Outdoor TMA

Internal Antenna Feeder	0.3 dB
Jumper Cable (1m) Losses	0.3 dB
TMA Noise Figure (gain 12dB)	1.5 dB
Total Uplink Noise Figure	2.1 dB

Directivity of UMTS Antenna	18 dBi
Uplink NF	-2.1 dB
Secondary Jumper Cable (1.5m) Losses	-0.4 dB
Best Achievable Uplink "System Gain"	15.5 dBi

Integrated (TMA below)

Internal Antenna Feeder	0.3 dB
Interconnect Feeder Antenna-TMA	0.2 dB
TMA Noise Figure (gain 12dB)	1.5 dB
Total Uplink Noise Figure	2 dB

Directivity of UMTS Antenna	18 dBi
Uplink NF	-2.0 dB
Ext. Jumper Cable (1m) Losses	-0.3 dB
Best Achievable Uplink "System Gain"	15.7 dBi

Integrated (TMA Piggy-Back)

Internal Antenna Feeder	0 dB
Interconnect Feeder Antenna-TMA	0.2 dB
TMA Noise Figure (gain 12dB)	1.5 dB
Total Uplink Noise Figure	1.7 dB

Directivity of UMTS Antenna	18 dBi
Uplink NF	-1.7 dB
Ext. Jumper Cable (1.5m) Losses	-0.4 dB
Best Achievable Uplink "System Gain"	15.9 dBi

Embedded (TMA built-in)

Internal Antenna Feeder	0.1 dB
TMA Noise Figure (gain 12dB)	1.5 dB
Total Uplink Noise Figure	1.4 dB

Directivity of UMTS Antenna	18 dBi
Uplink NF	-1.4 dB
Internal Feeder from TMA to ANT port	-0.2 dB
Ext. Jumper Cable (1m) Losses	-0.3 dB
Best Achievable Uplink "System Gain"	16.1 dBi

The above table characterises Uplink System Noise Figure (in four TMA cases) from the central feed point to the top of the Feeder Cables as displayed in Figure5.

Summary of System Uplink Performance, considered at the top of the feeder:

Antenna Type	System NF	UL Antenna Gain	Ranking
Stand-alone Antenna with outdoor TMA	2.1	15.5	★
Integrated (TMA below)	2.0	15.7	★★
Integrated (TMA Piggy-Back)	1.7	15.9	★★★
Embedded (LNA built-in)	1.4	16.1	★★★★

Therefore the Uplink Power at the top of the Feeder is optimal for the case of the Embedded LNA Antenna, some 0.6dB better than for the SAA case. This, when installed with the other site equipment, will significantly increase the sensitivity of the NodeB, allowing for a larger cell size, better customer experience or greater data rate.

UMTS Downlink per Sector

<i>SAA</i>		
Directivity of UMTS Antenna	18	dBi
Internal Losses (cable...)	-1.2	dB
Gain of Generic UMTS Antenna	16.8	dBi
<hr/>		
Jumper Cable (1m) Losses	-0.3	dB
TMA Downlink Losses	-0.3	dB
Secondary Jumper Cable (1.5m) Losses	-0.4	dB
Best Achievable Downlink "System Gain"	15.8	dBi

<i>Embedded</i>		
Directivity of UMTS Antenna	18	dBi
Embedded Losses (inc. TMA & internal feeder)	-0.8	dB
Secondary Jumper Cable (1m) Losses	-0.3	dB
Best Achievable Downlink "System Gain"	16.9	dBi

As can be seen from the above table, the Embedded LNA Antenna has reduced internal feeder losses, and negates one jumper cable, leading to a far higher (~1dB) Downlink power at the top of the feeders.

TECHNICAL ASSESSMENT

- A 1.55m Embedded LNA Antenna is better than a 2.25m SAA system for both Uplink and Downlink, with greater Node B sensitivity thanks to TMA improvements.
- Jaybeam's product has both RET included and MET with auto-calibration, in one antenna. An operator not using the RET feature can still adjust the Electrical Tilt manually, allowing anticipation of RET equipment with delayed investment.
- The RET and LNA sub-components are fully compliant to Antenna Interface Standards Group (AISG) v1.1, and have passed several tests with all major primary controllers.
- The Jaybeam "Embedded LNA" is compatible with Current Window Alarms (CWA) of UTRAN NodeB Vendors (Nokia/Ericsson/Alcatel...), allowing it to be connected to any NodeB without AISG control, while handling any TMA alarms.
- Site installation time is reduced due to pre-commissioning and pre-loading of SW at the factory in a controlled environment.

Chapter 7: Conclusions

- Large Cost reduction benefit and ease of logistical organisation.

- Significant technology performance increase.
- Size reduction leading to easier site deployment (building permit application).

The Jaybeam Embedded LNA Antenna System is different to and in the words of at least one operator, "superior to other supposed embedded systems".



Figure 6: Site installation of a Stand Alone Antenna with separate TMA that would be enhanced by use of an Embedded LNA Antenna.



Figure 7: Embedded LNA Antenna.

Geoffrey Woodcock earned his degree in Electronics and Applied Physics from Durham University and has over 15 years experience as a design engineer and consultant in the Wireless industry.

