

■ **White Paper**

**Network modelling in technology
choice**

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Introduction

We have seen that as yet there are no standards in BFWA – although some are emerging – though there are technology groupings, (perhaps into single carrier and multi-carrier) and we can see some of the differences between them. You are now faced with the task of technology selection. How do you do that??

The task of technology selection is complex. Choice revolves around requirements. I would suggest therefore that the correct way to amplify the differences between technologies and map to requirements is using scenario modelling.

We can set about this scenario modelling in a variety of ways but to include all the variables we should choose to use radio network modelling software. I have used such software in the examples used within this presentation.

Once we have modelled we can then look for fit with requirements. I will take you through some of the elements of this modelling in the next 8 slides ending with a look at the nature of some of the differences we might see.

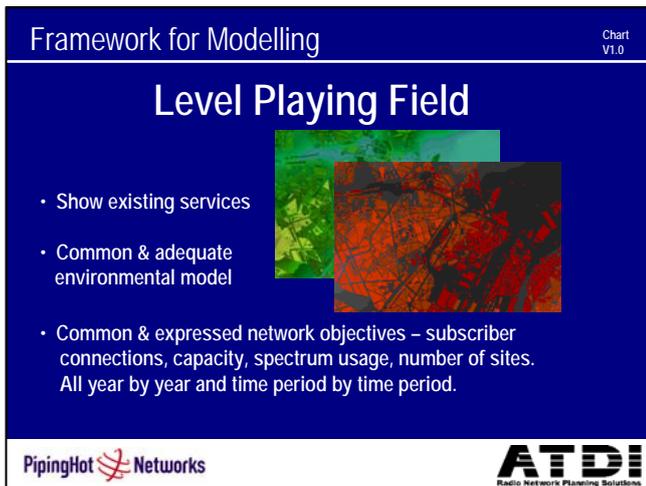


Figure 1: What the Level Playing Field Achieves

Technologies in Context

We are going to model the technologies in a context – in an environment and in relation to other services. We need then to create a framework. Get the framework wrong and our modelling will give wrong or inconclusive answers.

The first aspect is a need for an environmental model. You will see here a high resolution digital elevation model and a roof top definition file that express this environment hopefully without bias toward a particular technology. An example of a common

failure is the use of two dimensional modelling only assuming that line of sight will be achieved to all rooftops. Firstly that would be unrealistic but secondly it would not show the strength of technologies such as multi-carrier.

The second aspect is clearly expressed network objectives – what do we expect the network to do for us: subscriber connections, availability, capacity, expansion capacity, spectrum usage, number of sites etc. Express this in terms of time too or differentiators such as ease of expansion in later years may be lost.

Finally do include how the BFWA network is to integrate within you overall telecomms network. Some BFWA technologies integrate more easily than others. With these three elements in our framework we are ready to look at what our scenario modelling should include.

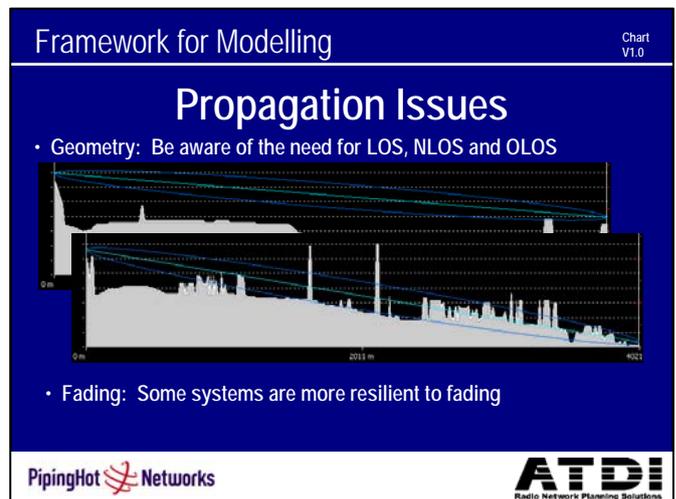


Figure 2: The Physics of the Radio path

Activities

The first activity is evaluation of the technology considering the physics of radio and the radio path. With the value placed today on high rooftops in cities, we need to be very aware of technologies that require line of sight between node and subscriber – First Fresnel Zone clearance. At 26GHz this requires a clearance around the optical boresight of 6 metres allowing for errors in even high resolution DEMs. At 3.5GHz this rises to 18 metres – a tall order in cities.

Some technologies can tolerate Fresnel zone obstruction so long as the reflected vector is small compared to the direct vector. This state is valuable to operators since the equipment system-value may also permit reasonable path lengths supporting good area coverage.

Other technologies can cope with significant obstruction loss over



free space – up to say 25dB – and with its significant reflections such that resultant signal distribution moves up the Ricean K factor toward Rayleigh behaviour.

Balancing all of this is the equipment performance under fade conditions. Clearly if we have sufficient path budget we can simply allow a high fade margin. If our technology is resilient to fading – and in particular frequency selective fading – then we can use this margin elsewhere to reduce antenna sizes or extend range and coverage.

mined by hardware limitations are all significant differentiators. Plastic support structures may be attractive but when LOS is needed they may prove wholly inadequate. If you value a contingency approach you may also find flexibility important as you proceed with caution pending subscriber take up.

Like the other aspects, all equipment parameters can be modelled at the same time as those relating to path.

Wastage Potential

In an industry without standards there is significant scope for wastage. Modelling the various technologies throws up some of the most obvious spectrum wastage –

- bad fit with regulator channel plans with half channels lost at either end of the available spectrum caused by out of step equipment rasters.
- 3MHz in 12 MHz unused since the technology was designed for a different occupied bandwidth.

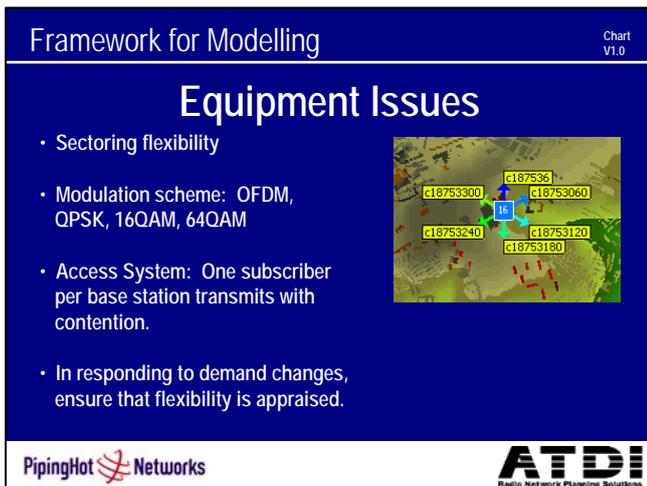


Figure 3: Advantages from Different Equipments

So we have some idea of how our various technologies behave across a radio path. What about the advantages of each physical equipment?

Equipment Advantage

Inevitably we will sector to maximise the station bits/second/Hertz metric but architecture, available product and type approvals achieved may force a specific sector structure. I have seen several examples where a forced sector structure yielded a far from optimum frequency plan with wasted spectrum and higher than desirable interference.

Every modulation scheme has a unique receiver threshold, fade performance, transmit power and capacity. Every modulation scheme must therefore be modelled and be balanced against requirements. On the face of it the higher order modulation schemes are attractive since capacity and spectrum efficiency tends to be high – 3 to 5 bits/sec/Hz – but the downside is usually a higher C/I requirement stemming from lower interference rejection capability.

I could go on. Issues such as access schemes governed by air interfaces embedded in equipment software to issues deter-

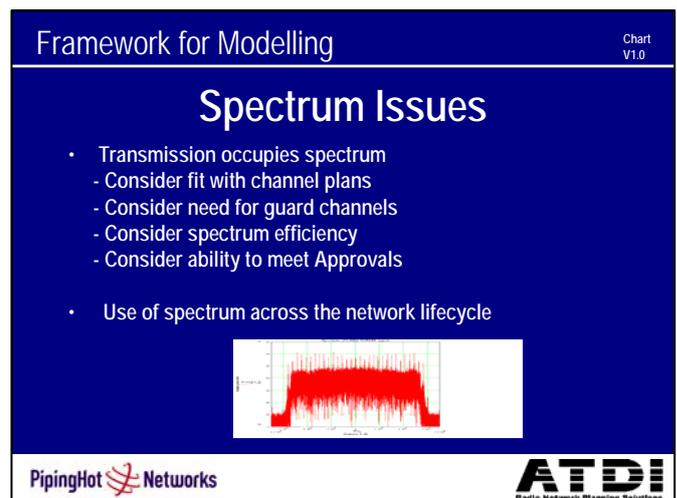


Figure 4: Spectrum Misalignment Does Cause Wastage

Sometimes the technology performs so well that such wastage is lost in the noise. Sometimes it is significant – after all you are paying for it! Also significant is the equipment’s ability to fit spectrum masks to meet type approval. Adjacent channel performance is as important as co-channel.

Finally, then, some technologies, and in particular those utilising all-spectrum techniques, perform well considering that the network will be rolled out over time. One strategy is to retain part of the spectrum allocation to be used later once service take up is seen. Yet more physical equipment is needed however to ulti-



mately make use of this retained spectrum. Technology that permits capacity increase without new plant or which permits new plant introduction without change in frequency plan is highly desirable

Effect on ROI

Finally to the bottom line. All technology is fine – if it meets your aims for the network. Aims are expressed in terms of return on investment and for this we need to balance the cost of the infrastructure against the revenue available from each unique user. Again the only way to achieve this is to scenario model. Scenario model, that is, with each technology probing each mix of costs and revenue for each basket of broadband services offered.

Again expressing this on a real (or as near real as we can get) environment with real equipment parameters will allow the best picture of reality.

We come back to the common theme. The only way to see the difference between two or more complex and different technology offerings in the absence of standards is to model against several scenarios developed from your business aims.

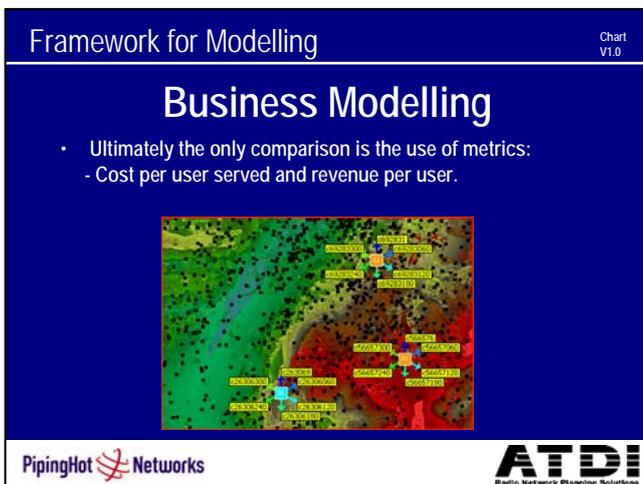


Figure 5: Expression of Metrics

Scenario Models

Let us now turn our attention to a case study – setting out to use the principles outlined in the last few slides to appraise two differing technologies.

Those of you attending previous conferences will recognise my crusade on requirements modelling. The statement of requirements forms the basis of any analysis and would be developed from the network or business aim.

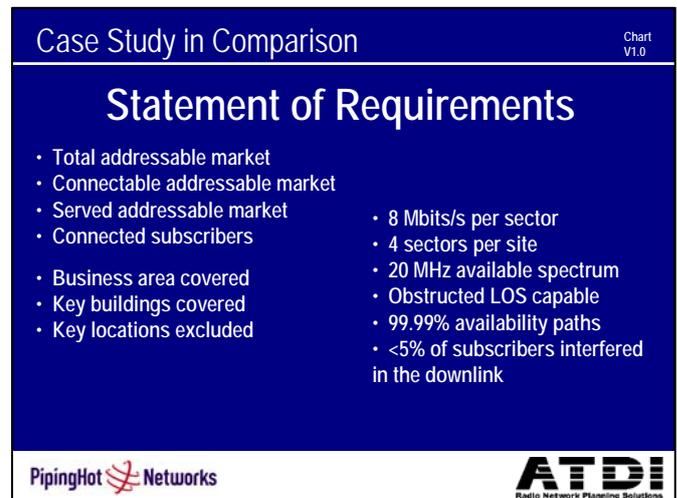


Figure 6: Stating Requirements

We need to determine the total addressable market – the TAM – in this case some 8,000 SME's. Our target Served Addressable Market – here a target of 60% of the TAM – those SME's that we could connect to if only we can agree contracts. Finally we have the connected addressable market – those subscribers finally connected. By choice I have limited the geographic area also. We might also for completeness list specifically all principle buildings and other points of interest to be connected and you should certainly consider your existing network infrastructure and complementary service offering.

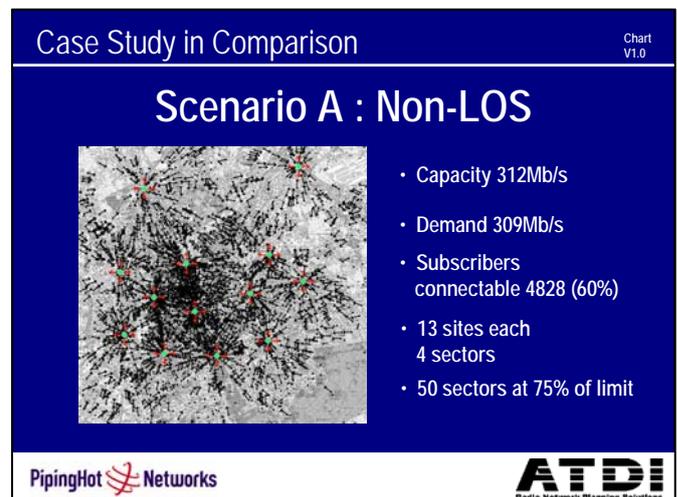


Figure 7: Scenario Modelling Non-Line of Sight Technology

I could go on now to amplify some of technical parameters although we need to be careful not to limit the vendor's scope to offer against your higher level requirements. I would simply caution against demanding high path availabilities. I have seen some



shocked looks when the resulting network is presented against a demanded 99.999%.

Originally I had set out to complete a case study based on real scenarios and real technologies employing real equipment in a real environment. It soon became clear that if I was to keep things non-partisan my presentation would be several hours long with several pages of caveats and assumptions – rather like carrying out a real life modelling exercise in technology choice. I have therefore kept things simple. Imagine that we had two technologies. Once technology requires LOS with full Fresnel zone clearance with an allowance for environmental errors.

We see here a 13 site solution for this city reaching 22% of the total addressable market. The system is only at 33% load.

Under the same circumstances permitting obstructed paths with up to 25dB excess loss over free space yields 60% of total available market servable better matching our network objectives. In this case the network is at full load with most base station sectors at their limit given real individual subscriber demand.

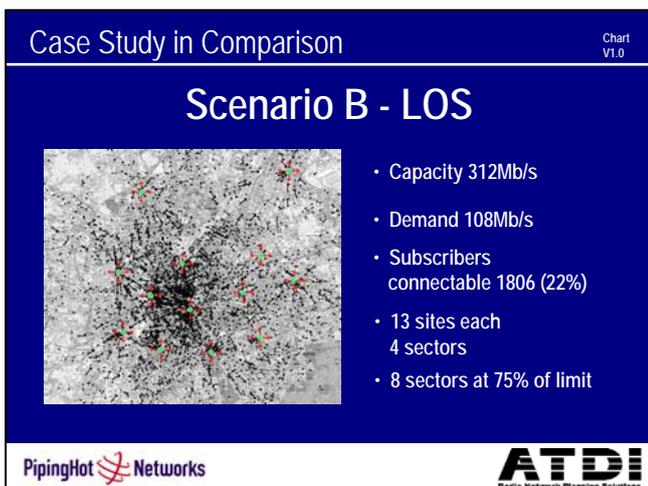


Figure 8: Scenario Modelling Line of Sight Technology

Now, as I indicated, before I would hold these two examples up for scrutiny I would need to spend some time discussing the conditions under which the comparison was made and such activity is beyond the scope of this paper. Suffice to say that I have illustrated a stark comparison between one aspect on which technology may be judged. There are many other aspects and you will only be able to illuminate technology differences by modelling.

Conclusions

In a world where there is no black and white, where differing technologies have differing advantages, where solutions are

driven by your chosen markets, you must model technologies by simulating the environment, the technology and your requirement together. In scenario modelling remember that you need to probe all the aspects to illuminate all the differentiators. Use as many scenarios as necessary to fit your network aims and as necessary to show all technologies in BFWA in their true light.

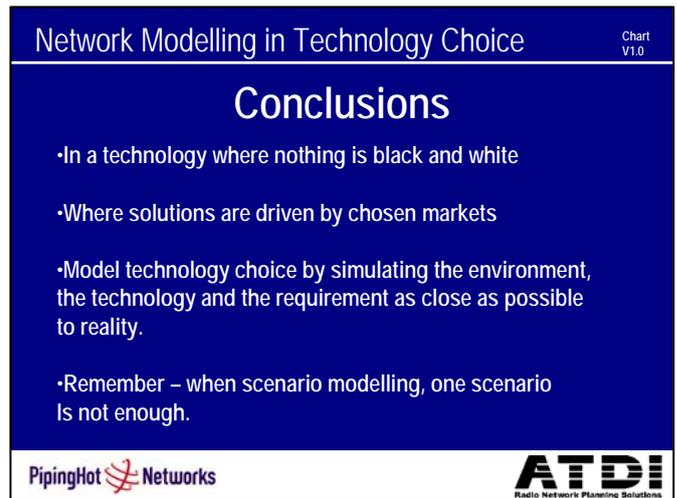


Figure 9: Conclusions

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For further information on modelling methods visit www.atdi.co.uk.

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