Comments and an Expression of Interest

to the

Department of Communications and the Arts

Regarding the:

Design of Alternative Voice Service Trials Connecting Regional, Rural, Remote Australian Areas

The Department of Communication and the Arts

Firstly, I would like to thank the department for an opportunity to respond to questions put forward by the department regarding the design of Voice Service Trials Connecting Regional, Rural and Remote Australian Areas.

Coming from a telecommunications technical-engineering background, I was expecting these questions to be far more specific and far less vague; making it particularly difficult to know at what level of comprehension and telecommunications industry knowledge those in the department are at – so that I could answer these questions in a meaningful manner that will be useful to the department to make well-considered decisions for Australia's inland business and social community.

Because the questions are so non-specific (yet vital for Australia’s economic future), I have answered the questions in terms of referring to four comprehensive Appendices (in separate areas) to help those in the department get a far more complete picture about how and why Australia’s telecommunications (inland) infrastructure can be innovatively re-engineered so that the department not only provides reliable telephony (as a subset of low latency Broadband), but synergistically and inexpensively provides the inland telecoms infrastructure matrix that is imperative for building Australia’s RRR telecomms infrastructure and future economy.

The first Appendix historically links “Voiceband” (telephone) related telecoms technologies in Australia from pre-1960 through to today; describing why analogue Voiceband was replaced with digital Voiceband, where DRCS technology fitted into PDH digital transmission, why PDH was replaced with SDH transmission, how IP technologies dramatically unified Australia’s telecoms network infrastructure to be IP Broadband-based and why “Voiceband” telephony as VoIP is a subset of Broadband.

The second Appendix looks at why Australia’s National telecoms Backhaul / Core network infrastructure and why (and where) it is not unified IP in the massive Regional / Rural / Remote (RRR) areas. All those in the department involved with these trials need to fully comprehend how and why this mixed network infrastructure is cross-connected (and how it signals) to form the Backhaul / Core Network - which is the parent network to the Access Network component.

The third Appendix covers the area where I believe that the department may be very naively thinking that Voiceband Service Trials will provide an inexpensive fix so that the Universal Services Obligation (USO) can be terminated. This Appendix provides an overview of the available Customer Access Network technologies and narrows down the technology fields that will fit Regional Remote Australia.

The fourth Appendix provides a brief background of how and why Australia wrecked its world-leading national telecoms infrastructure and scuttled its Research / Innovation / Industry assist Manufacturing arm - all to have a Telecoms Sector in the ASX; why the USO exists, how both the USO and the Radio Black Spots "Gravy Trains" can be eliminated (or properly appropriated), why the ADSL2+ rollout was a competitive disaster, how Telstra avoided structural separation and - when and why the Digital Radio Concentrator System (DRCS) was left deserted as PDH in an sea of unified IP infrastructure.

What is not obvious is that when the DRCS was developed (1978/80) it was the first of a line of Remote Integrated Multiplexers (RIMs).

A RIM is a "complex" telecomms infrastructure component where the telephone line interfacing is done through a Line Concentrator - which is part of the Access Network (including the telephone's signalling), and the long distance transmission (behind the Line Concentrator) is part of the Backhaul Network (including the channel associated signalling) - which is "integrated" into the Backhaul Network.

This DRCS technology was very advanced for its time, and preceded the practical realisation of Single Mode Optical Fibre (SMOF) (1985/6) by over six years. RIMs using SMOF as the transmission medium did not appear until after 1988 - almost a decade after than the DRCS was first trialled!

Although those in the department may be looking for Access Network technology to replace the DRCS, it has to be realised that the DRCS is not just Access Network (the goalposts moved) and this long-haul point-to-point radio component in the DRCS is incompatible with unified long-haul IP technology of today.

In Appendix 2, I have specifically included an area that shows how this DRCS external plant radio equipment (that is still in excellent physical condition) could have the DRCS radio units very inexpensively and innovatively re-engineered to facilitate unified IP and by this simple rebuild process facilitate low-latency Broadband that would carriage VoIP ("Voiceband" telephony) - as per Appendix 3.

As I have a lived-experience with several decades in almost all areas of Australian telecommunications and have worked in many locations and at most technical and management levels in this industry; I will be available to assist the department to make technical / engineering informed and practical / economic decisions.

Answers to the "Request for Comments"

Question 1: Should the department be seeking to achieve other objectives through the trials? If so, how would this affect the design?

Appendix 1 "**Voiceband to Broadband**" provides a concise and detailed overview of Voiceband technology and its application together with an Australian historical timeline clearly showing that **<u>before 2010, Analogue Voiceband became a subset of Broadband</u>** as Voice on Internet Protocol (VoIP), with Session Internet Protocol (SIP) to effect the (telephone / mobile device / computer / tablet etc.) connection.

The department must focus with the prime objective of terrestrial low-latency unified IP Broadband technology in the Regional / Rural / Remote (RRR) areas.

It seems the department may be blissfully unaware that is uses Voiceband as VoIP/SIP (which is a subset of low-latency Broadband) in its everyday operations for analogue telephony / mobile devices / IP-PABX phone services for over a decade.

With this Broadband technology realisation, the department should take a big picture view of the Australia's existing inland (RRR) telecommunications infrastructure - well behind the RRR Access Network (where the department is currently focused); which is broadly covered in Appendix 2 "**Big Picture Australian Telecommunications**".

This area also describes how and why the long-haul transmission components in the current RRR Backhaul Network as Plesiochronous Digital Hierarchy (PDH) technology is awkwardly connected into Australia's Core Network (as unified IP).

Appendix 2 also provides an overview of the current RRR PDH-based "Backhaul" network structure; where a high proportion of this network is based on Digital Radio Concentrator System (DRCS) / High Capacity Radio Concentrator (HCRC) technologies that was developed in the late 1970s / early 1980s before Single Mode Optical Fibre (SMOF) technology became almost universal throughout Australia - except in the RRR areas. "**Basics of DRCS / HCRC Equipment**" is an overview.

Another major objective in providing "Voiceband" in RRR areas is for CSPs to back-connect their (Broadband) Access Network infrastructure into the Core Network (which passes through Points of Interconnect (POIs)).

Appendix 2 "**Restructuring Australia's RRR Backhaul / Core**" also includes a map that clearly shows a drought of RRR located POIs, where extra POIs could be located and how Single Mode Optical Fibre (SMOF) could be inexpensively "light" trenched in throughout RRR Australia (Appendix 2 "**Optical Fibre is very Economic**" and "**Why we have Deep buried Cables**") to make this inland network far more robust - to properly support and build Australia's inland economy and defensively build our telecoms infrastructure.

Question 2: In terms of the deliverables for customers, do you have any concerns about the proposed design of the trials or suggestions to improve it, for example, locations for the trials, how best to recruit consumers to take part, requirements on CSPs, and service requirements?

In the Davidson Report (1982) - see in Appendix 4 "**Davidson's USO Gravy Train**" - where the concept of the USO (Universal Services Obligation) of at least $170 M pa was granted by the Federal Government was handed to Telstra from 1989 onwards -

so far totalling over $6.8 Bn (apparently without Government department checks and balances) - for "maintaining the RRR telephone infrastructure". **The spirit of the wording in that era "telephone" really meant "telecommunications".** With Competitive Business mindset "maintaining" means to keep it working with reactive maintenance until it dies. With an Infrastructure Business mindset; "maintaining" means "proactive scheduled maintenance" and upgrade the technology.

In all those years this HCRC technology should have updated be unified IP centric such that Broadband (including VoIP) could be inexpensively connected to all RRR Premises in a very timely manner.

In this Call for Comments with "**Voiceband**", where the obvious wording must be "**low-latency Broadband**" (where VoIP will facilitate "Voiceband").

My main concern (see Appendix 4 "**Davidson's USO Gravy Train**") is that recently the USO has been pegged for termination, and in the past 30 years, apart from a lot of research work by the CSIRO in Sydney; nothing has been done to very inexpensively re-engineer / replace the technology in the DRCS / HCRC transceiver unit (see Appendix 2 "**Reengineering the DRCS for RRR Australia**") that back-connects the "analogue telephone" services in the RRR areas through this "Backhaul" network so that it is practical for VoIP telephone services and associated low-latency Broadband (see Appendix 3 "**Broadband Access in the Bush**") can be provided in these RRR areas.

As a very serious suggestion I have (in Appendix 2 "**Reengineering the DRCS for RRR Australia**") provided an overview of how this DRCS technology can be very inexpensively re-engineered to reuse >98% of the existing masts / antennae / cable etc. and relay (at least) 350 Mb/s Broadband to all RRR connected sites so that well over 20,000 Remote Homesteads / premises can very inexpensively have low-latency Broadband / VoIP (analogue "telephone") / 3/4/5GSM / Wi-Fi etc. and fit very comfortably with rest of Australia's Core Network infrastructure.

My other major concern is that the "Radio Black Spots" grant funding is entirely inappropriate beyond major urban centres. Details of my concerns and how to fix this policy and fix these associated engineering issues (see Appendix 3 "**The Radio Black Spots Gravy Train**").

To improve the trials: see Appendix 2 (for Backhaul / Core Network) and Appendix 3 (for Broadband Access Network and Premises technologies), it is imperative that the department has an excellent understanding of the entire Australian telecoms network infrastructure (not just part of the Access Network infrastructure). Without this understanding it is very obvious why the back-connection (i.e. the extended Core Network) into the RRR areas is in dire need of extremely serious / urgent development; before any "Voiceband" trials (using low latency Broadband technologies) could be even considered.

Judging from my more recent three years work relating to the engineering of Fibre to the Homesteads (FTTH) in Regional Rural areas (see Appendix 3 "**AON Fibre to Rural Homesteads**"), the positive customer responses well exceeds 90% pleading for low-latency reliable fast Broadband. So it stands to reason that virtually 100% of Homesteads in Regional Remote areas would welcome being connected with low-latency fast and reliable Broadband.

Question 3: In terms of the needs of Carriage Service Providers (CSPs), do you have any concerns about the proposed design of the trials or suggestions to improve it, for example, information required, capping of customer numbers, timeframes, level of funding available, and the approach to payment?

The NBN programme was conceived in utter ignorance of the existing Australian telecoms network infrastructure, and very stupidly did not build on - but separately to that infrastructure. Consequently this Broadband Access Network component of the Australian telecoms infrastructure is a very "awkward" fit that has cost Australia many years delay; has not optimally utilised the existing Backhaul / Core Network infrastructure (which has ballooned the NBN programme costs), and it "forgot" the RRR areas desperate requirement for low-latency Broadband - to be integrated into the existing Australian telecomms network infrastructure.

Appendix 2 includes several topics about the entire Australian telecoms Core and Backhaul network infrastructure build that must be very seriously considered, fully understood (and acted on by the department) well before any trials are considered.

Further, Appendix 4 "**Business, Politics and Gravy Trains**" includes several highly related policy topics that the department needs to also fully comprehend and learn from these glaring long-term mistakes before considering any CSP-related trial.

By now, the department should be acutely aware that satellite strategies to provide "Voiceband" are in the medium/long term by far the most expensive option - there are far less costly and far more innovative strategies other than satellite technologies, and therefore all satellite strategies must be deleted. I will be open to discuss and explain why and what far better strategies are far more applicable for RRR Australia.

In particular Appendix 2 includes in professional outline how the existing DRCS / HCRC infrastructure could be very economically re-engineered to provide low-latency “Voiceband” (as a subset of “Broadband) and in this description clearly explains the development processes (including the numbers and time frames) necessary for successful and practical product development. I welcome open discussion with the department (and industry) including project costing and the levels of funding.

Question 4: Do you have suggestions on what should happen at the end of the trials, noting that Government funding will cease?

Appendix 4 covers some of the policy issues regarding the gross mismanagement of government funding to major CSPs and where this has been abused for decades.

This Appendix 4 also provides some insights into the problems caused by allowing infrastructure businesses such as the Australian Telecommunications Commission be privatised (i.e. run as a Competitive Business) – and how the department (and other sub-Government organisations such as the ACCC and the PC) have in-effect sat on the sidelines (effectively hearing nothing and seeing nothing) while Australia’s economy is being slowly shredded by privatised infrastructures.

Hopefully the department can learn and reign in (stop) these “Gravy Trains” on seemingly endless massive funding without any checks and balances. If the department policies were correct, there would be no USO and there would be zero requirement for government funding of the "Radio Black Spots".

Appendix 4 includes an area "**The ACMA's Spectrum Auctioning Debacle**" about the lack of 4GSM coverage in non-urban areas and how the physical / business rules for Urban 4GSM are totally inappropriate for non-urban areas where Farmers and Graziers must have their own 4GSM coverage and not pay a "licence fee" as per the commercial carriers that cover urban areas.

My initial broad policy suggestions would be to:

- Immediately terminate the USO and Radio Black Spots funding,
- Re-engineer the HCRC / DCRS technology to be unified IP transmission,
- Extend several extra POIs well into the Regional Remote areas
- Transfer the NBN Corporation to be NBN Commission under the Department,
- Release the NBN Corporation CEO, Board and Executives,
- Transfer marketing and advertising out of NBN Commission,
- Transfer all Remote telecomms infrastructure to the NBN Commission,
- Terminate the (ACMA) auctioning of electromagnetic spectrum,
- Plough in Australian-manufactured SMOF cable through the RRR areas to build a future-proofed robust Australian Core Network,
- Facilitate 4GSM at all Regional Remote Homesteads and most Rural Homesteads.
- Build very substantial practical telecomms / IT engineering expertise into the Department's full time staff.

Details in Appendix 4 briefly explains how, where, what and why - leaving "when" for the department to action these suggestions.

I am available to discuss (in detail as asked) on all of these (and many other associated) telecommunications policy and technical / engineering topics - and a range of associated topics to help build our Australian economy.

Question 5: Do you have any comments on the stakeholder reference group? What stakeholders should be represented on the groups? Would you like to nominate anyone as a possible member?

Refer to Appendix 4 about stakeholders.

Considering that I have several decades of practical and professional knowledge and experience / expertise on this and associated topics, (Refer Appendix 1, 2, 3, 4) I am putting myself forward as a member of the stakeholder reference group in a wide range of professional: engineering / technical and policy capacities.

My prime interest is to synergise the current and future telecommunications network structures so that Australia's economy is optimally supported by inexpensive, robust, low-latency, fast Broadband connectivity for at least the next 50 years.

Question 6: Do you have any comments regarding the criteria for assessing proposals and contracting CSPs?

Appendix 2 and Appendix 3 contains several highly related topics that go a very long way to explain where and why the number of POIs is both grossly insufficient and poorly located to provide RRR connectivity – which negatively impacts the viability / practicability of CSPs from efficiently back-connecting into Telstra's Core Network.

Appendix 2 also includes a section on where new POIs could be initiated to resolve this issue for CSP (and Australia's economy).

Appendix 3 deliberately runs through the various Broadband Access technologies that can economically provide low-latency Broadband connectivity for VoIP.

In that process; this area strikes off the non-terrestrial (i.e. satellite) proposals as these are not synergetic with the rest of Australia's Backhaul / Core network and/or are high latency and detract from building Australia's robust inland core network.

In my professional opinion (and experience), because of the large physical area currently covered by legacy DRCS / HCRC technology in Australia and the critical requirement for low-latency, fast Broadband connectivity throughout this footprint, it is imperative that all CSP's proposing to provide connectivity must also have ample reserve bandwidth with the Core Network to concurrently pass through their portion of shared Core Network and also communicate their Access Network infrastructure.

If any proposal from a CSP does not take into account (almost) the entire Australian telecoms network infrastructure (i.e. how its proposed Broadband Access Infrastructure is going to back-connect through the terrestrial Australian telecoms network) then I would be extremely wary that those involved with that CSP either have a miniscule knowledge of the network and how it connects, and/or their proposal is most likely to fail in the short term - and prove to be extremely expensive.

It is very disappointing that although Telstra has been very handsomely paid to care for the "maintenance" of Regional Remote telecommunications infrastructure for over 30 years; nothing has been done to economically upgrade the DRCS to handle Broadband IP - which would have (at least) facilitated very inexpensive VoIP telephony (and provided low-latency Broadband), minimised Radio Black Spots and almost certainly negated the requirement for very expensive geostationary Satellites.

Appendix 1 – Voiceband To Broadband

Voiceband Physical Connection

The term "Voiceband" describes a frequency range 200 Hz to 3400 Hz that is central to human speech and hearing, and has its prime use in telecommunication technologies, in particular for telephones – including mobile devices being used for telephony.

The common transmission medium was originally based around open wire pairs on poles where the physical diameter of the wires plus their spacing resulted in a characteristic impedance of nominally 600 ohms, a reasonably "flat" frequency / attenuation response, and a relatively low attenuation / distance characteristic.

The upper and lower frequency limits were largely set by practical construction limitations of the electronic components in the switching and amplifying of the voice transmission connection through the Inter-Exchange Network, the attenuation in the Access Network (at each end) of the switched connection; and the electronics in the telephones at each end. These physical / electronic constraints limited the send and receive frequency range to be in the "Voiceband".

From the late 1880s transmission and switching equipment technologies have continually advanced with "Voiceband".

The introduction of twisted pair insulated copper cable miniaturised the space previously used by overhead open wire transmission and in the 1930s -1970s most of the urban open wire poles and wires were replaced with trenched underground cable and Australian telecommunications infrastructure virtually became "invisible"!

Because pair copper cable in the "Voiceband" has significantly different electronic characteristics than open wire, these cables were "loaded" (with coils every 1830 metres) to significantly flatten the Voiceband frequency response (and significantly reduce distance attenuation. This (Loaded Cable) technology had significant use in Regional / Rural areas for long telephone lines to Farm Homesteads.

Voiceband in FDM Analogue Networks

From at least the 1920s thermionic valves were very extensively used in line transmission amplification between post office located telephone exchanges. Because of the considerably large distances between towns and cities amplified circuits was commonplace and later replaced by Frequency Division Multiplex (FDM) technology for long-line transmission beyond the State Capital Cities – well into the Rural Remote areas of Australia.

Transmission systems are virtually identical to road highways where large volumes of traffic use a common road between two locations – only this is done electronically – and the same rules for "congestion" apply!

FDM is a special modulation technology that stacks many Voiceband (0.2 to 3.4 kHz) connections into adjacent 4 kHz "channels" (much like an AM radio) so that the many adjacent modulated Voiceband channels can use the one (long-haul) transmission medium as the bearer between two distant locations. At the distant end of the transmission bearer, the transmission terminal equipment then demodulates the stack of adjacent 4 kHz "channels" and this cleanly reproduces all the Voiceband connections that then are switched through to telephone / fax / dial-up etc. services.

The early “3 Channel” systems had a very extensive use in Rural / Remote Australia (and were physically quite large – taking up three full sized 19” (600 mm wide) racks. These were later followed by a 12 Channel FDM transmission system that took only one full rack space, and later 24 Channels could be fitted into the one rack space.

By 1954, the need for interstate transmission (particularly between Melbourne and Sydney) was so great that by 1957, a 7 tube coaxial cable was trenched in and multiple 960 Channel FDM systems were installed and commissioned to carry the Melbourne – Canberra – Sydney Voiceband telephony traffic requirements.

From the late 1950s to the early 1960s, Telecom Australia Research Labs (TRL) had actively worked with LM Ericsson (in Melbourne / Sydney and Sweden) to totally re-engineer Ericsson’s “4-Wire unidirectional transmission” Crossbar switch (ARM) technology to match with Australia’s fundamentally “2-Wire bi-directional transmission” technology, resulting in the ARF (later, the ARE) switch that became Australia’s workhorse electromechanical Voiceband telephony switch.

In the early 1960s, the transistor and the printed circuit board totally revolutionised telecommunications transmission equipment manufacturing and design processes to be far more reliable, much smaller, and use far less power.

By the mid-1960s, a 60 channel FDM transmission system could be comfortably fitted in half the height of a (600 mm wide) rack space. This technology dramatically reduced the call cost and improved the reliability of long distance Voiceband transmission, making Metropolitan – Regional telephone call costs far less costly.

While this FDM technology for Voiceband telephony was advancing, Telegraphs also was developing with the introduction of the Teletype machine that could punch out a telegram in less than a minute (at 50 baud) and later the development of a Teletype transmission system that (then) occupied a Voiceband channel!

Because Telegraphs (data) was even then so important, telegraphy transmission was transported by multiple channels within Voiceband FDM channels and network switched / stored / switched – which later became the Telegraph Repeater Electronic Storage System (TRESS) infrastructure – like busses queuing up at bus stops.

In the mid-1960s, TRL also worked with Ericsson and soon developed the much smaller Voiceband telephony (ARK) switch that had very extensive replacement in thousands of Regional, Rural and Remote (RRR) locations in what are commonly called Small Country Automatic Exchange (SCAX) huts that are in a high proportion of Small Towns and Villages.

The RRR areas soon had extensive transistorised long-haul FDM transmission systems installed and most used quad twisted copper cables as the transmission medium between the Country Cities / Towns / Villages – with evenly spaced underground repeaters to connect these long distances and keep the Voiceband well clear of the background noise floor.

Even in those times it (the late 1960s) became obvious to me that the overhead maintenance for thermionic valve long haul FDM transmission systems was a far higher (daily) proactive maintenance requirement than the newer transistorised FDM systems that were basically “watch and act”.

Because coax cable was incredibly expensive, point-to-point very high frequency (VHF) radio became the highly favoured long-haul high-capacity FDM technology of choice where hilltops were used to maximise distance connectivity.

It was not until the late 1960s (when I was incidentally involved with the overall design of the NSW RRR transmission network) that I realised that this transmission and switching network structure was Sydney-centric – and virtually all RRR inter-District telephone calls had to be switched through Sydney and back out again! Several years later in the mid-1970s, I realised that all the other States had the same conceptual tiered-STAR network structure (like bicycle spokes).

Voiceband in PDH Digital Networks

In the early-1970s Telecom Australia Research Labs (TRL) were involved with the development of digital encoding/decoding of Voiceband (for telephony); where a-Law (ITU G.711) Voiceband 8-bit digital encoding process was logarithmically encoded / decoded to get the equivalent of 13-bit encoding (with far lower noise and distortion). This encoding/decoding technology is universally used these days.

The big advantage of using Voiceband digital encoding is that the encoded digital signal is effectively “binary”, so wide variations in attenuation caused by temperature variations in the transmission medium now had virtually zero effect. Varying receive levels were the nemesis of long-haul analogue (FDM) transmission systems.

It was this very new, G.711 Voiceband encoding technology together with G.703 2 Mb/s Plesiochronous Digital Hierarchy (PDH), transmission that matured in the late-1970s and kicked into Australian telecommunications in style.

In the late 1970s, TRL also worked with NEC with the extensive development of the Digital Radio Concentrator System (DRCS) for Regional / Remote Voiceband connectivity. The trials were complete by 1986 and the rollout finalised by 1990.

> *Circa 1981, I was working in the Telecom NSW Transmission Laboratory (Alexandria), and I distinctly recall a TRL A4 poster heralding the DRCS technology as the answer for RRR switched Voiceband connectivity. A year or so later I distinctly recall directly hearing the sad news that while an HCRC tower was being erected being it folded killing two technicians (whom we knew). These events place the DRCS/HCRC rollout in the very early 1980s and not the mid-1990s.*
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> *The DRCS came out first and the HCRC came out a year or so later. My educated guess is that the radio electronics was totally re-engineered (probably to utilise the then new ceramic (surface acoustic wave) filters and new Medium Scale Integration (MSI) components – and/or because some more rare components in the DRCS were no longer available)!*

In 1980, Telecom Australia Commission contracted LM Ericsson to manufacture digital AXE switching equipment (in Australia) as the widespread replacement of the very ageing Step-by-Step / SE52 switches and the more recent (1960s) LM Ericsson (Australian manufactured) Crossbar switches.

The rollout of new LM Ericsson AXE Voiceband telephony exchanges in metropolitan sites brought with it itemised electronic metering and a choice of 2.048 Mb/s or 8.448 Mb/s PDH streams of “concentrated” digital Voiceband into the Inter-Exchange Network’s transmission component.

In each of the metropolitan areas (Brisbane/Gold Coast, Sydney, Melbourne, Adelaide, Hobart, Perth) there was a mesh-structured Voiceband pair copper “Loaded Cable” network consisting of thousands of cables connecting between the many local exchanges. (There are 124 Local Exchanges in Sydney’s Metropolitan area and 400 Local Exchanges in Australia’s total Metropolitan area!)

As it turned out, the 2 Mb/s “Megalink” was a perfect fit to the pre-existing transit network with the Loading Coils being removed and replaced by inexpensive small remote powered 2 Mb/s regenerators!

Two pairs of what was loaded cable (that previously carried two Voiceband circuits) were replaced with a 2 Mb/s link carrying 30 Voiceband channels. The productivity of this was immense, and the cost was almost nothing.

> *Unfortunately, the sole (USA) manufacturer of the silicon chip in these 2 Mb/s regenerators decided to make the chip considerably smaller (so they could manufacture far more chips on the same sized silicon wafer and maximise their short term profits)!*
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> *Part of the physical clock timing circuit was on the chip, so when the chip was made considerably smaller the clock timing became significantly faster – resulting in thousands of unstable 2 Mb/s regenerators that occasionally dropped out 30 telephone calls at a time – for years!*

These AXE Digital Switches were a very ugly fit in an analogue FDM long-distance transmission world. For long-haul connections, the 2 Mb/s “Megalinks” from the back of the AXE switches had to be converted back (with a 2 Mb/s “Loop Mux”) to Voiceband channels then to be interconnected with the pre-existing and extensive Analogue Voiceband channels in the very much FDM-based Inter-Exchange Network (and changed back at the other end if going into another AXE switch)!

In the background of all this there was some frantic research and trials being done to use pre-existing quad cables (particularly in country areas) to run 8.448 Mb/s PDH and connect 120 “digital” Voiceband channels over distances that earlier 120 FDM analogue Voiceband long haul transmission equipment would have used.

Analogue Frequency Division Multiplex (FDM) technologies fitted very well with electromechanical Crossbar “Voiceband” telephony switching as a technology pair.

Likewise the new Plesiochronous Digital Hierarchy (PDH) transmission technology and AXE / System 12 digital “Voiceband” switches is also a technology pair.

In Rural and Regional areas, small Village SCAX huts and non-Urban SCAX huts now had their electromechanical telephone switches back-connected with a 2 Mb/s Loop Multiplexer (Loop Mux) and the loading coils in the cable back to the “Local” Exchange replaced by regenerators.

When these occasionally faulty 2 Mb/s regenerators dropped out – there was little choice but to replace the pair copper cable with a new 6 fibre cable - or use a point-to-point radio hop like (or as) that used in the DRCS. Basically, the RRR telephony network was and is hanging on by its fingernails; and Integrated Pair Gain Systems and Remote Integrated Multiplexers (RIMs) saved the day!

Optical Fibre Changed Everything

In the early 1980s, Telecom Australia was in a particularly frustrating situation because the now well over-aged MEL-SYD coaxial cable link (that used thermionic valves that were fast becoming unreliable / unavailable and the cable insulating spacers were breaking down) so the biggest inter-city network system in Australia was literally on its last legs!

There were several other Voiceband based FDM long haul equipment in much the same situation elsewhere around Australia but this one was the big one. Oh, and the 30 channel 2 Mb/s PDH Voiceband systems in the Metropolitan areas were still dropping out like flies (because of the faulty manufactured regenerators)!

TRL was also actively involved and the development of digital transmission systems using since the mid-1970s using the then new Plesiochronous Digital Hierarchy (PDH), but what TRL (and I) did not know was that the technology of Single Mode Optical Fibre (SMOF) was highly imminent.

> *This was an absolute watershed moment. I happened to be right at the dawn of applying the first Single Mode Optical Fibre (SMOF) technology in Australia – and probably the World!*
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> *A few weeks earlier I was deliberately tasked with engineering the structure of the "proposed SMOF cable between Melbourne and Sydney - and its wayside connections"! (Then, Optical Fibre was an illusion – and yes this was "detention"!) I was given a very partial "plan" and told to fill in the missing parts – and this project was massive – it would take months!*
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> *It was fairly obvious to me that the planned PDH structure was based on two parallel cables of 7 tube coax cables and probably 12 or 18 interstitial quads for connecting much shorter distance wayside cities. (The interstice quad copper would sit between the external rounds of the coaxial cables making a firm cable structure with a minimum of wasted cross-section space.) Of course this was all going to be using the new PDH technology and not the very widely entrenched FDM transmission technology.*
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> *The Optical Cable was to be of 31 fibres (15 pairs for transmission and one spare if a fibre breaks – a classical mindset of the 1930s recession / WW2 thinking). To a very large degree, the PDH transmission structure was already decided (trimmed down from the earlier coax cable model) so really this was a case of making the unspecified network transmission requirements fit the equipment and provide "Voiceband" connectivity to the District telephone exchanges in the cities on the way through.*
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> *My earlier studies indicated that the national telephone traffic growth had almost come to a saturation point and that Wideband data and Voiceband data (although only about 7% of the Voiceband telephone traffic) was very rapidly increasing in bandwidth requirements – but nobody was looking at future data bandwidth requirements and the fast growing applications! To the management it was all about "Voiceband" telephone traffic (and this is 1985, not 2020, some 35 years later)!*
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> *On charting and extrapolating / analysing this data, I could see that data traffic would exceed telephone traffic by about 2000 (some 15 years*

away). Worse still, I could see that if this mirage of PDH based digital Voiceband traffic on this new Single Mode Optical Fibre (SMOF) cable was to actually happen, the PDH system would be fully occupied on day 1!

About four or five weeks after I was assigned to this project and had the basics worked out – except for the regenerator spacing and locations – my phone rang. It was the Telecom Research Lab (TRL) research people!

Little did I know that the TRL had been very diligently researching the physics of optical fibre for upwards of 10 years and in mid-April 1985 the breakthrough happened while I was "in detention"! Their PDH digital transmission was able to be sent and received through about 600 metres of SMOF, which was far longer than they had ever achieved.

A week later the next phone call confirmed they could transmit over 3 km – which was considerably shorter than coax repeater spacing (about 8 km) – but much further than the previous week! This was very exciting – and I kept "mum" and continued with the planning processes!

All was quiet for a week later I received the very excited call that they could get 12 km, then a few days later 18 km, then 22 km, then 60 km – it's on! As other Engineers found out – my work was quickly usurped and I was transferred to learn at yet another network engineering area!

After the technicalities of SMOF transmission were resolved, this SMOF cable technology was very quickly developed for production (all around the world). The priority in Australia was to initially connect MEL-SYD (and other inter-metropolitan links); then the metropolitan transit networks (using 2 Mb/s on SMOF to replace the faulty regenerators), then major centres from State Capital Cities, etc..

The SMOF rollout in country areas kicked in by 1990 and abruptly stopped in 1993 with two seeming diametrically different technologies screaming out for funding and promising massive returns on investment. One was Mobile Phones and the other was the Full Services (Pay TV) Access Network – using Hybrid Fibre Coax (HFC).

Voiceband PDH in Synchronous Networks

The problem with PDH is that as the transmission portion of the long distance Inter-Exchange / Backhaul Network hierarchy climbs (2.048 Mb/s, 8.448 Mb/s, 34 Mb/s, 63 Mb/s, 140 Mb/s, 565 Mb/s etc.); the transmission becomes more unstable.

The reason is that with PDH, the timing/clocking is not tightly synchronised and the transmission deliberately and continually "slips" to re-synchronise, and also includes variable "bit-stuffing" to bring the digital bit count aligned. It's messy!

Because the clocking is not synchronised, by 2.44 Gb/s and above, "bit stuffing" in PDH became precarious to say the least (but it "works" for Voiceband use because our hearing can easily hear through sound blemishes)!

With the introduction of Synchronous Digital Hierarchy (SDH) long haul transmission in the mid-1990s, this technology required clock-synchronising of every piece of transmission and switching equipment in a tiered-down strategy with a pair of atomic clocks as the reference synchronising clock / timing element.

This synchronising process was not that hard to implement as virtually every piece of digital equipment (for transmission and switching) has a synchronisation port, and a switch or link for synchronising from an external or internal or received signal source.

With the rules worked out and set in place the process took about a month (for the whole of Telstra national network) and the results were amazing with Faxes not having lines on the pages, and data not needing to “retry” to send packets nearly as much as before – and PDH transmission systems being far more “stable”!

Synchronising locked the timing and paved the way for virtual containers of PDH to be seamlessly carried by SDH over SMOF with much wider digital bandwidths than PDH could have ever provided (and using the pre-existing SMOF cables).

By the mid-1990s, large (national) telecommunications long-haul networks were now all top-down synchronised, and this paved the way for far faster data rates than before, using SDH.

Typically 140 Mb/s (0.14 Gb/s) PDH transmission equipment was virtually contained in SDH as 155 Mb/s (STM-1) and these virtual containers were commonly slotted into an STM-192 (9.953 Gb/s) synchronous data stream – along with 63 other 155 Mb/s virtual containers - and used the same fibre pair! This was immense engineering productivity for very little capital outlay, as everything was synchronised!

Fixed Phones, Mobile Phones and Number Portability

From the days of Magneto Phones with Ring-Up/Ring-Down Drop Indicator line signalling (where to cause the drop-down indicator at the your (Post Office located) manual telephone exchange's Manual Sylvester Switchboard; you quickly wound the handle before picking up the handset to talk with the manual switchboard operator.

Your Telephone number was implicitly allocated by the physical location of the line socket and associated Drop-Down indicator on the front panel of the manually operated Switchboard.

With technology advances to having a centralised Battery (to power the then active Carbon Microphone and facilitate loop-disconnect signalling - the subscriber could then use a Rotary Dial to use loop-disconnect signalling to "automatically" directly connect through to the desired "B" end subscriber.

These "automatic" telephony connections were facilitated by a series of step-by-step vertical / rotary electromechanical switches, that "automatically" responded to the series of pulses from your rotary dial and connected through to the next available step-by-step switch. The subscribers telephone number that you were dialling was implicitly defined by a physical position / termination on the Final Selector - that may well be in another metropolitan suburb.

From the introduction of Crossbar (telephone) switching technology in 1960, this advanced telephone switching technology facilitated alternate path routing and greatly extended phone number / locations connectivity such that national Subscriber Trunk Dialling (STD) was introduced in 1967. Every subscriber / customer phone line now had a number including an optional two or three digit area code number! Every line's phone number was implicitly directly associated with the physical wiring into its line relay circuit in the Local (electro-mechanical) Exchange.

Until now - there has been no mention of the complex mesh of "Voiceband" channel-based transmission and signalling technologies, nor the mention of inter-exchange signalling / metering technologies that back-connect and through-connect these telephony switches. Because of the very wide span of technologies, most engineers and technicians / lines staff specialised in a single technology - and were largely oblivious of the highly associated (but very different) technologies that brought all of this telecomms infrastructure together as a "network".

In the early 1970s Electronic (telephone) Line Circuit (LIC) interfacing was in its embryonic life stages with printed circuit boards, and later with medium scale integrated (MSI) circuits and the birth of digital transmission technologies (ITU G.703 for 2 Mb/s PDH and ITU G.711 for 64 kb/s Voiceband encoding/decoding).

In another not so far away but fast approaching galaxy of (mainframe) computers, the concept of an "Abstraction Layer" like a floor over house foundations set the scene for physically different computers / printers / etc. to use common programming languages (e.g. COBOL, FORTRAN etc.) and run applications over these computer operating systems.

Also, the dawning of Large Scale Integration (LSI) circa 1977 set another scene for personal computers to emerge. By applying an abstraction layer as DOS (disk operating system), and UNIX / Linux / Windows to do far more than what mainframe computers did, but on your desk - not an entire multi-story building!

Also emerging was the concept of the direct Inter-connection of computers by a communications network (**Internet**) that identified computers by a digital address associated to the interfacing transmission medium technology (called the Media Address Control (MAC). This advanced technology is now all taken for granted!

Back to telephony telecommunications: this abstraction layer in digital exchange technologies facilitated (telephone) Line Interface Circuits (LIC) to be recognised by a unique physical electronic address on the printed circuit board / card to a unique numbered address (just like the MAC identifies a computer / printer etc.) that could then be directly associated to a fixed telephone number - as a telephone service!

Behind the scenes, the rapid development of electronic metering (associated with digital exchange technologies) involved far less overhead than electromechanical / photography / pen and paper very slow manual recording / accounting processes.

With (GSM) mobile phones, each Mobile Phone has a unique International Mobile Identity Equipment (IMIE) number - that just like the MAC identifier; that in this case is directly related to a national phone number!

My understanding is that the first generation of Ericsson AXE digital switches did not include fixed access telephone number portability - but Telecom Research Labs (TRL) and Ericsson were world first in developed Radio Base Station (RBS) hopping so that when a mobile phone transferred between RBSs the radio connection would also move to the RBS with the now stronger signal - preventing the mobile call dropping out (in most cases)!

This number portability technology flowed back into fixed line digital switching and facilitated telephone numbers to be physically transferred to other cities and between competing service providers - and use a range of phone numbers that could call other telephone numbers - like the 13xxxx; and do this on a time of day basis!

In the Inter-Exchange / Backhaul Network, Channel Associated Signalling (CAS) was commonplace with analogue Frequency Division Multiplex (FDM) and the then newer Plesiochronous Digital Hierarchy (PDH) long-haul transmission systems that connected between the old electro-mechanical switches and later Ericsson AXE switches to set-up and drop out telephone call connections.

Circa 1985 the then new technology of Common Channel No.7 (CCS7) was introduced; which included far more data than just the A and B number. Several electronic telephony-based digital switches could understand where the call is from and going to - and set up the best route - and electronically record the metering.

With the widespread introduction of VoIP by 2010, CCS7 signalling is imperative as this links with Session Internet Protocol (SIP) that directs the switch / routers while recording the metering - and facilitates investigative call tracing!

It is imperative that any implemented RRR technology does not use PDH / CAS technology as now, but uses unified IP technology through its Core Network!

Voiceband as VoIP and Unified IP Networks

From around 1980 (40 years ago) the concept of Internet Protocol (IP) for network connectivity gradually took off and continually expanded in the background (and then the foreground) of PDH / SDH transmission by about 2000.

The very subtle difference between PDH/SDH and IP is that the traffic on PDH/SDH is literally physically switched / hard-wired so it is a “locked connection” between nominally two locations and at these end locations, the typically Voiceband signal is decoded back all the way down to the “digital” Voiceband and electronically switched.

With IP traffic, the physical transmission connection is there – but the data packets (like a coal train) includes a header address and the data packets are switch/routed by their header addresses on the way through. Because the IP data packets stay as short held connections these can “stream” and concurrently constitute a fabric of virtually long-held connections between many different physical locations.

The other advantage is that when the traffic gets congested through one path, IP has the internal intelligence to load-share and seek out alternate paths where otherwise PDH / SDH structured networks simply clot up and highly congest.

Initially, IP traffic was put in virtual containers (like for SDH) and transported over high bandwidth SDH long-haul transmission bearers, but it became rather obvious that internally synchronised IP traffic could be directly connected to SMOF as the prime transport bearer and the IP Routers / Switches could be externally programmed to extremely efficiently direct the overall IP traffic flows.

With this realisation that IP traffic was effectively homogenous the whole long-haul transmission and switching network - that was previously called the Inter-Exchange /

Backhaul Network could be “Unified” as an hierarchical IP infrastructure (with SDH) and was re-named the “Core Network”!

From about 1998 the introduction of ADSL and Cable Internet “Broadband” instead of Dial-Up Internet was a block-change to the telecommunications infrastructure with Digital Services Line Access Multiplexers (DSLAMs) being added to the vast majority of Local Exchange sites (with more than 250 lines).

The back-connection of these DSLAMs (for internet over ADSL) and Broadband Routers (for Cable Internet over Hybrid Fibre Coax (HFC)) was IP, and it connected to what was previously called “Inter-Exchange (Backhaul) Network” and now called the “Core Network” as a hierarchical IP “Cloud” of long haul-transmission and IP routed switching.

Internet Protocol had really upset the status quo. The big difference with IP is that it is “short-held” (time-synchronised) packets – not long-held circuits as with Voiceband telephony. Also, IP traffic is self-directing through a software Router which is far more “network switching” efficient than a physical set of hard-wired circuits and physical switches – even more efficient than `software controlled physical switches.

By about 1990 (30 years ago) analogue “Voiceband” as we knew it, was almost all back-connected as 64 kb/s streams as per ITU Recommendation G.711 as part of a 2 Mb/s stream (ITU Rec. G.703) - and this includes all DRCS/HCRC technology!

The big problem was that telephony was long-held physically switched connection and IP is very short held virtually routed connectivity that can look very much like a long held “stream” if the addressing is consistent.

The concept of Voice over IP (VoIP) was first trialled in 1995 where a telephone “Voiceband” was converted to streaming IP and priority transmitted to the receiving end where it was re-constructed as (analogue) “Voiceband” into that telephone.

This VoIP technology, along with Session Internet Protocol (SIP) to control the switched path, took several years to mature to make VoIP/SIP both practical and widespread accepted. Once VoIP/SIP was accepted – this technology exploded over the world’s telecommunications infrastructures with a frightening speed because of the massive efficiencies VoIP/SIP brought with it.

1GSM and 2GSM mobile phones had a major problem Voiceband transmission because the radio bandwidth was too narrow and consequently the Voiceband predictive encoding / decoding processes were slow (too delayed) and very distorted – (sounded “metallic”) because it inherently had a lot of “Quantisation” Distortion.

With 3GSM – this used VoIP/SIP and a wider radio bandwidth, and the Voiceband uses VoIP; so not only was the audio far clearer than 2GSM, but there was virtually no delay. Also, because VoIP was used, the channel occupation was lower than with long held 9 kb/s PCM in the 2GSM service – meaning that more mobile telephone calls could concurrently communicate through the one Radio Base Station.

Virtually concurrently, (circa 2010) the concept of transferring the analogue telephone interfaces from the Local Telephone Exchange to the Home Premises (using ADSL etc. Broadband as the common carrier) became a reality.

Analogue Voiceband as we knew it has been totally replaced by VoIP over Broadband.

Appendix 2 – Big Picture Australian Telecommunications

Being Indigenous with Australia's Telecoms Infrastructure

As one of very few Electrical Engineers in Australia with a very solid engineering and very solid practical / technical background in Australian telecoms infrastructure, one of my major concerns is that very few (if any) of those involved in evaluating / funding this trial will have any extensive practical knowledge / lived-experience approaching a total picture of the overall Australian telecoms network infrastructure.

My concern is that there are telecommunications-based engineers / designers / sales / technical people may be (most probably are) promoting a narrow range of Access Network products / services and concurrently be totally aloof about the directly associated Backhaul/Core Network infrastructure that must be a major (if not centre) consideration in their trial – particularly for trials outside the metropolitan cities.

Unfortunately; most (virtually all) of these people have a very limited / biased Australian telecoms lived-experience / knowledge / wisdom. That is; they are not indigenous with the Australian telecommunications infrastructure.

Performing a "trial" of a particular Customer Access Network technology in a Regional / Rural / Remote (RRR) location may appear to be a stunning success in itself. Because the highly associated RRR Backhaul / Core Network infrastructure is not seriously considered and thoroughly (synergetically) included – these network isolated Access Network tests will almost certainly result in extremely uneconomic / piecemeal outcomes.

Another cause for real concern is the structural design of the NBN Corp. infrastructure (of the Broadband Customer Access Network). From all credible accounts it seems that this Network was conceived in complete ignorance of the structure and size of the extremely closely associated Inter-Exchange (Backhaul) Network - now called the "Core Network" – that back-connects the NBN Corp. and other Carriage Service Providers Access infrastructure.

> *Circa 2017/8: Telecom Society / Telsoc in Sydney held lecture about the structure of the then NBN, given by one of the University Professors as one of the Expert Panel as apparently specifically chosen by the department.*
>
> *There were about 20 attendees (including three of us as a group) in the lecture room. It did not take too long before others were asking some questions – primarily because the Inter-Exchange / Backhaul / Core Network was not actually shown on any of the large overhead diagrams – apart from a short line about 100 mm long in a couple of diagrams on a screen about 2000 mm wide.*
>
> *We were expecting to see about half the diagrams to include this Core Network infrastructure in some considerable detail as this literally covers and connects all over / under and through Australia – and overseas too!*
>
> *It became apparent to us that the University Professor's telecoms knowledge and expertise was basically on Satellite technology – and he had apparently spent some 6 months with OTC (which is effectively a very different network structure). He was chosen by the department as one of the very few engineers in the "Expert Panel" to guide the overall design of the NBN infrastructure.*

To my surprise one of the other attendees (who not with us) and was previously a senior Telstra executive and engineer; berated the Professor on his incredible lack of technical / telecoms engineering knowledge / expertise about Australia's telecommunications network infrastructure.

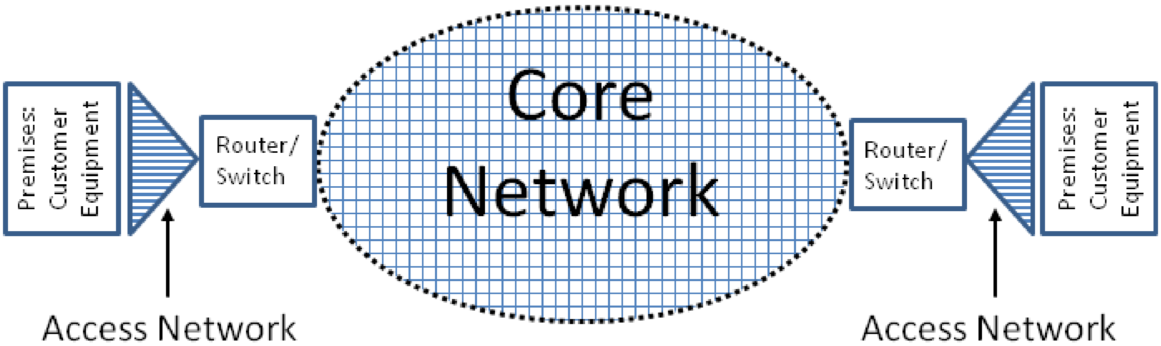
This person then (in equally colourful language) described why Telstra's short-term financial / business focus was virtually entirely in major metropolitan areas (because this is where the big profits are – and nowhere else) and the further the distance from the major metropolitan areas – the greater the "Cost Centres"!

In a later outburst he confirmed my initial thoughts on how and where, when and what ADSL technologies were rolled out in Australia; and why the competitive rollout of ADSL Broadband was yet another expensive competitive infrastructure disaster for Australia!

Frankly, this Professor clearly demonstrated that he had very little knowledge about the role and purpose of Australia's telecoms Core Network – where it is and what it does (and why it is there). This was extremely frustrating for us all.

After the lecture, the three of us had our own little meeting and postulated as to how and why "the department" chose university academics and had obviously not chosen life-experienced telecommunications specialist engineers to be the "NBN Expert Panel". <u>This blatant mistake by "the department" has cost the Australian economy very dearly – counting in many tens if not hundreds of $Bn.</u>

The Customer Access Network (CAN) connects from the customer premises (or mobile device) to the edge of the Core Network (through "Nodes") as a simple STAR structure (like bicycle wheel spokes) - has no switches - and this network is usually short (typically about 2600 metres in most urban areas, shorter in towns / villages).

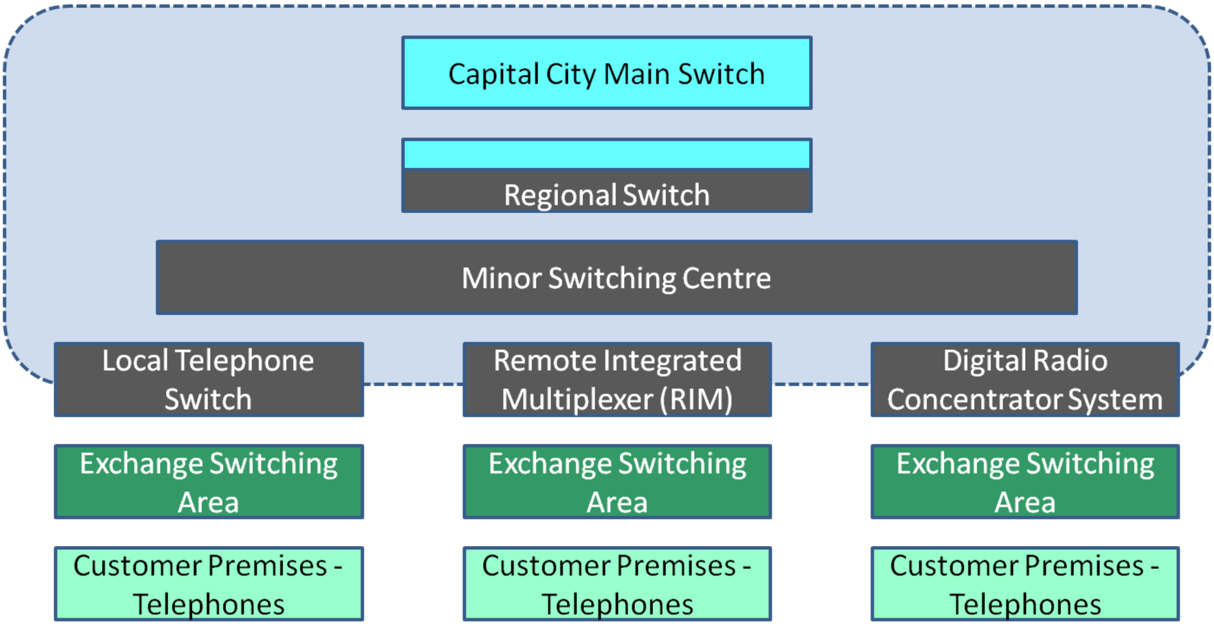


Unfortunately what seems to be universally not comprehended is that the Core Network is physically far longer than the CAN infrastructures that hang off the edge of the Core Network! ***Edge Routers that directly connect to Nodes (Access Interfaces) are shown above as a thick dotted black line***.

The Core Network consists of a complex multi-layer grid / matrix of (mainly underground) electronic highways (usually constructed with Single Mode Optical Fibre (SMOF) cables) with long-haul transmission terminals at each end; that is cross connected to IP switches/routers to interconnect transmission links that connect with "Edge Routers".

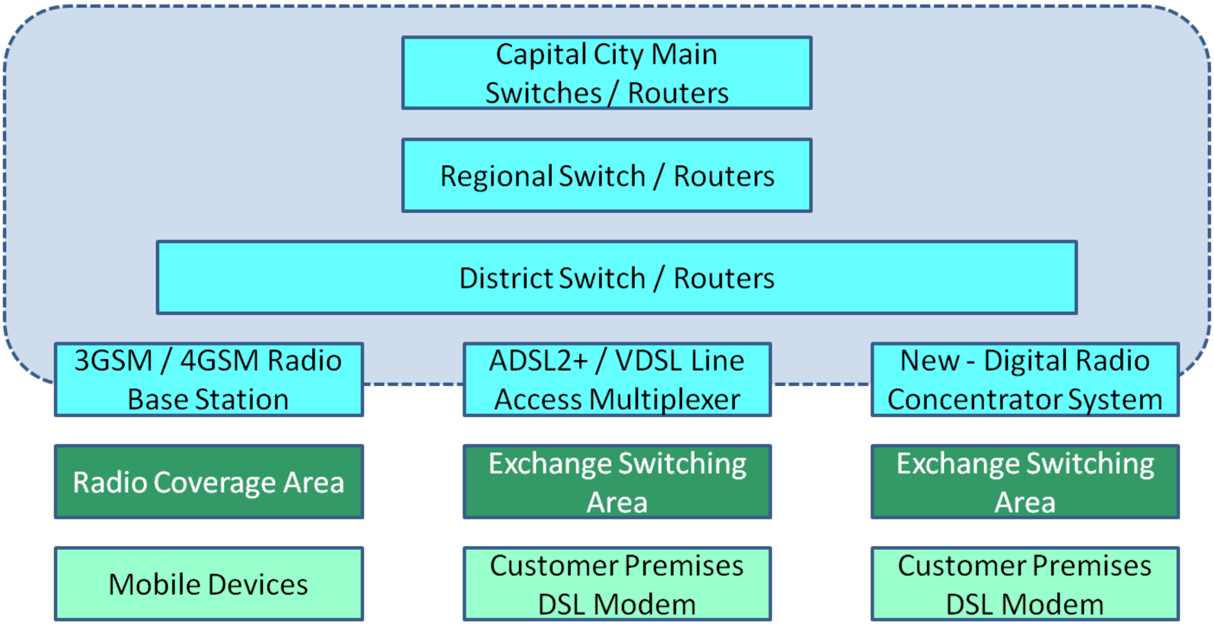
My understanding is that currently in the RRR areas, the telecommunications network is very much a large legacy of the old long-held call digital switching technologies using Remote Integrated Multiplexers (RIMs) and AXE (as the Local

Telephone Switch / Interfaces) and this is where the DRCS / HCRC also parallels as the analogue telephone interface - over very long distances!



The blue shaded area is the Inter-Exchange / Backhaul Network - without including transmission equipment (apart from the DRCS). The dark green is the analogue pair copper to the customer premises. The grey filled equipment is based on long-held call 64 kb/s channels of Voiceband. The cyan / blue is VoIP/SIP switch / routing.

At the Regional Switch level this digital "Voiceband" (64 kb/s) and uses System 12 switches that converts to/from VoIP/SIP through the Core Network.



The above conceptual picture shows the influx of IP technologies that have already taken place (and what can be done)! Mobile devices connect through the Radio coverage area to the 3GSM / 4GSM Radio Base Station; which is based on VoIP/SIP and is back-connected into the core network via the District Switch/Routers.

In local customer premises ADSL/ADSL2+ modems connect via pair copper (legacy of the analogue telephone) and the Analogue Telephone Adaptor (ATA) connects the existing "Voiceband" Telephone.

With special reference to the Regional Remote areas, the Re-engineered DRCS "talks" Broadband IP and the Access connection would be via a VSDL / ADSL2+ modem or by Active Optical Network (AON) Fibre (modem); or by p-p IP Radio!

It should be very obvious that by Re-engineering the DRCS equipment to use IP instead of PDH as the long haul transmission and interface medium, there are immense savings to be made by rationalising out old equipment at Regional and District Switch Exchange sites and replacing this with new IP Switch / Routers to create a conformal unified IP core Network throughout Australia.

Partly because of the USO instigated by the Davidson Report (Appendix 4) and partly because of Telstra restructuring (Appendix 4) the DRCS infrastructure was "lost" (Appendix 4) from being re-engineered to provide inexpensive low-latency fast Broadband to the RRR areas.

Because of changes in switching technology over several decades, the definition of the demarcation point from the Core / Backhaul / Inter-Exchange Network infrastructure has been "moved" (Appendix 4). In RRR areas, there is a proliferation of DRCS equipment that was originally part of the Inter-Exchange Network (IEN) - based around FDM and PDH technologies - and the 1.5 GHz point-to-point radio links used in this DRCS equipment were part of the IEN.

The NEC 30 (pair copper) line Concentrator (to 2 Mb/s PDH) was also originally part of the Inter-Exchange/ Backhaul Network (IEN) - that too changed!

It should be extremely painfully obvious that the geostationary satellite strategy to provide Broadband to the "7%" not in range of "direct wired / terrestrial radio" was an immensely expensive financial mistake by the NBN Corp. against growing the Australian economy.

The department seems to be not aware that the highly active Better Internet for RRR (BIRRR) group is living proof of this massive political and engineering mistake with Australia's telecommunications infrastructure. Almost all the satellite's immense overhead costs inflate Australia's negative Balance of Payments (BOP), and this transmission system is at best rather unreliable.

A very short-sighted and ultimately and extremely costly BOP strategy that would retard building Australia's economy would be to introduce low-orbit satellite as a "quick-fix" for providing "Voiceband" in RRR areas.

Australia has a lot of sunk investment with inland (RRR) long distance telecomms infrastructure based around the DRCS / HCRC technology that is in excellent physical condition but this PDH-based transmission technology is severely outdated.

The department would be very well advised to expedite the inexpensive re-engineering of the DRCS / HCRC radio transceivers (only) to "talk Broadband IP" and simply replace this equipment. This simple - yet really obvious strategy will open the doors to provide low-latency reliable Broadband in RRR areas that will in turn provide the inexpensive and reliable provision of "Voiceband" telephony, and provide the RRR areas with reliable and fast Broadband to build Australia's RRR economy.

Basics of the DRCS / HCRC Equipment

My understanding is that the DRCS technology started in Telecom Australia Research Labs - Melbourne (TRL) with a significant development phase in the late 1970s with the implementation of new 2 Mb/s PDH transmission technology being used as the prime “Voiceband” channel concentration process using 64 kb/s (G.701), and the Digital Radio technology using solid state electronics to link many 2 Mb/s (G.703) PDH streams in a 1.5 GHz “L Band" digital transceiver to facilitate effective radio transmission. (*In hindsight this all smacks of early satellite technologies!*)

The technology of DRCS / HCRC pre-dated the realisation and development / introduction of Single Mode Optical Fibre (SMOF) by several years, but the digital radio link technology was advanced for its time.

The below left picture is a DRCS / HCRC Radio Repeater (tower and antennae) at Burraganna off Mt Magnet in Western Australia. This is a typical massive structure. The picture on the right is a close-up of the parabolic antennae and the mast.

The antenna dish is parabolic (like a huge >2 metre wide headlamp) so that the radiated (and received) radio beam is like a pencil with a very narrow width and a rather high “gain” over the intrinsic (reference) radiation. This “gain” is imperative to get the transmitted signal to the receiving end well above the noise floor so the signal can be cleanly received. These parabolic dishes are deliberately made with a grid of thin aluminium pipes to minimise wind drag in stormy conditions.

Each 1.5 GHz parabolic dish antenna has a thick (low attenuation per length) coaxial cable connected to it, running down the height of the tower’s antenna to the Repeater hut at the base of the mast where the radio transceiver equipment is located. This mast / antennae / transceiver structure typically has radio hops of 40 to 50 km (basically limited by the curvature of the earth - even with these massively high masts) and using 1.5 GHz for minimum attenuation over distance but retaining an excellent pencil-like radiation directivity.

The picture above is the base of the Tower and Radio Repeater hut. Note the thick metal straps forming an “Earth Mat” (with very deep metal spikes) that extends out to at least the base of the guy wires (as seen in the upper two pictures). This Earth Mat is there to dissipate the very high current spikes resulting from lightning strikes – and therefore minimise equipment damage.

On the far centre of the above picture is a solar panel to provide power to the batteries in the Repeater hut. There are two thick coaxial cables connecting to the 1.5 GHz parabolic antennae. (The third coax cable is for an omnidirectional antennae (at the top) to connect Homesteads via analogue radio - "Voiceband".)

The operating frequency of 1.5 GHz was chosen so the bandwidth in the “passband” could be wide enough to support many 2 Mb/s digital channels and the attenuation over distance would not be a major factor. Higher frequency transmissions (like the Wi-Fi frequencies of 2.4 GHz and 5 GHz) are now commonly used for much shorter distance point-to-point telecommunications.

Using carrier frequencies greater than the "L Band" 1.5 GHz for trials to replace the existing HCRC radio transceiver equipment is not a practical engineering strategy.

The HCRC transceiver radio frequency spectrum basics are as follows:

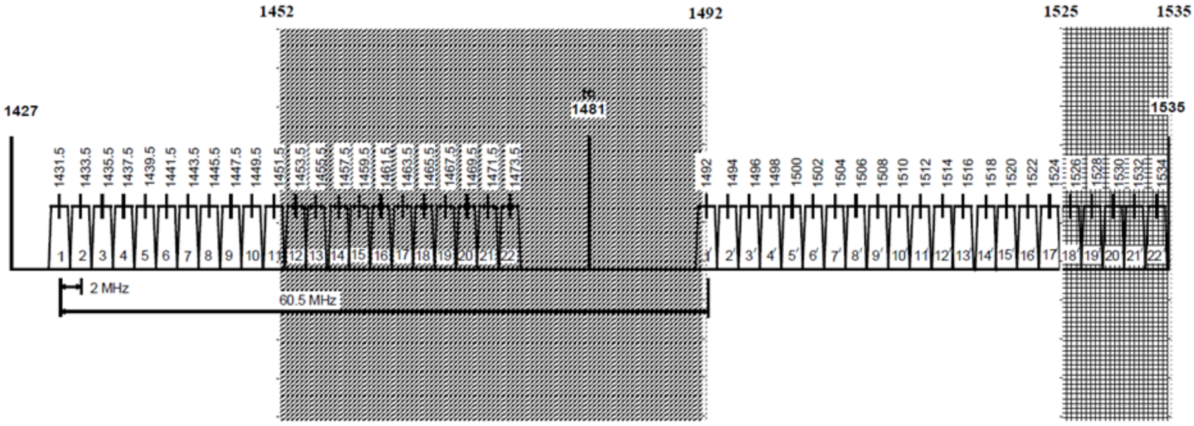
- L Band (Reserved) Spectrum 1.427 GHz to 1.535 GHz
- Two sets of 22 Adjacent Channel frequencies, spaced at 2 MHz each
- Return Channels offset by 60.5 MHz from the Send Channels
- Advanced Digital Radio encoding/decoding technology for its time
- Simplistic Alarm Monitoring and Control

Basically the input of the DRCS / HCRC transmitter has up to 22 * 2 Mb/s (PDH) digital streams (from the NEC Digital (telephone circuit) Line Concentrator) and these digital streams are interfaced with a bank of up to 22 amplitude modulators that are spaced by 2 MHz increments.

This “bank” is then frequency-shifted to the send frequency band range (i.e. in the 1.5 GHz "L Band" as above) and amplified for transmission then passed through the coax cable to the highly directional parabolic reflector antenna.

This Band usage shown more graphically in the following picture / chart:

THE 1.5 GHz DRCS BAND (1427-1535 MHz)
(Point-to-Multipoint Services)
RF CHANNEL ARRANGEMENTS



The radio receive path radio signal (in the 1.5 GHz L Band as above) is received through the antenna and transmitted through the coax cable where the weak signal is initially amplified to get the signal level strong enough, then frequency shifted down to a stable intermediate frequency band; the “bank” is then demodulated to produce up to 22 “analogue” outputs that are converted into digital 2 Mb/s (PDH) streams.

Each of these bi-directional 2 Mb/s PDH digital streams back-connects into the NEC telephone circuit line concentrator. The Telephone Line Concentrator is the interface between the 2 Mb/s PDH bi-directional stream and 30 Ring-Down/Loop Disconnect (signalling) analogue “Voiceband” telephone circuits.

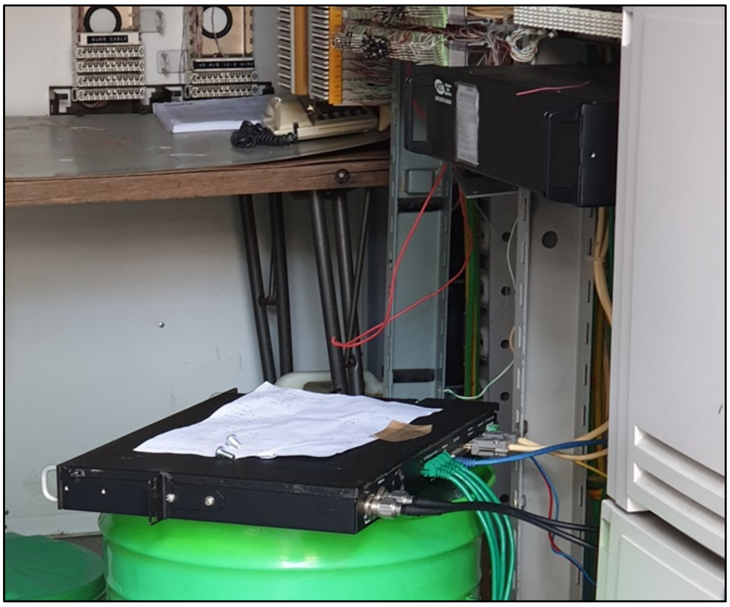
The hidden engineering beauty about the DRCS technology is that several 2 Mb/s (ITU G.703) DRCS radio links can be cross-connected between DRCS units forming a serially connected virtual “Party Line” with multiple 2 Mb/s PDH connections centralised at the “Local” (District) Exchange. (*These days we cascade connect 1 Gb/s IP Switches in exactly the same manner - think about it!*)

A maximum of 13 cascaded HCRC hops at nominally 45 km adds up to a maximum nominal radial coverage of about 600 km from the one centralised “Local” exchange HCRC Base Station!

An alternate strategy is that branch radio links can connect along the “Party Line” and be concentrated at the DRCS 2 Mb/s level towards the “Local exchange – thus covering massive Remote areas providing telephone connectivity from the NEC 2 Mb/s - telephone line interface. (Again: *These days we cascade connect 1 Gb/s IP Switches in exactly the same manner - think about it!*)

A simple out-posted DRCS remote location may have one 2 Mb/s PDH stream (30 telephone channels) and as the links get nearer the parent Local DRCS Terminal, many other DRCS 2 Mb/s PDH streams can be added / concentrated (to a maximum of 22 * 2 Mb/s channels) which is a total of 30 * 22 = 660 remote telephone lines on the one fully fleshed-out DRCS “Voiceband” (only) telephone Remote Access Network, that may consist of several DRCS locations.

Because of some amazing technological advances in the mid-1970s all this DRCS / HCRC equipment could be inexpensively manufactured on a printed circuit board and the whole radio system then fitted in a 1Rack unit (RU) 44.45 mm high sub-rack!



The above left picture is a Small Country Automatic Exchange (SCAX) hut located at Cottage Point in the Sydney Metropolitan (northern peninsular) area. This SCAX hut contains DRCS equipment and has a nearby mast with a 1.5 GHz high gain antenna.

The picture on the right (above) shows the HCRC radio transceiver (on the rubbish bin) with (green) 2 Mb/s cables connecting to the NEC 30 analogue "Voiceband" telephone line Digital Concentrators (part of the large grey cabinets to the right).

All these premises are all less than less than 500 metres from the SCAX hut. There is also an ADSL multiplexer (DSLAM) in this hut connected via some spare 2 Mb/s links in the same 1.5 GHZ point-to-point radio providing slow ADSL to this area.

In the early/mid-1980s, this HCRC PDH-based technology became a common arrangement in Regional / Rural / Remote Australia. This rollout stopped by 1990.

My analysis of the departments then publically available DataCube data (2016) clearly indicates there are 2545 SCAX huts in Australia with 250 telephone lines (or less) including about 1500 SCAX huts that have 90 and less telephone lines.

Where the topography is substantially flat, most of these SCAX huts would be back-connected with HCRC 1.5 GHz point-to-point (digital) radio. In more hilly areas these SCAX huts are commonly now back-connected by a 6 strand SMOF cable replacing a previous pair copper loaded cable (that had become unrepairable).

There are several economic strategies to provide low-latency and reliable Broadband connectivity to the "nearby" premises from these SCAX huts - and this is discussed in detail in part 3 of this Appendix. Broadband connectivity such as this will facilitate clear and practical "Voiceband" telephony at these nearby premises.

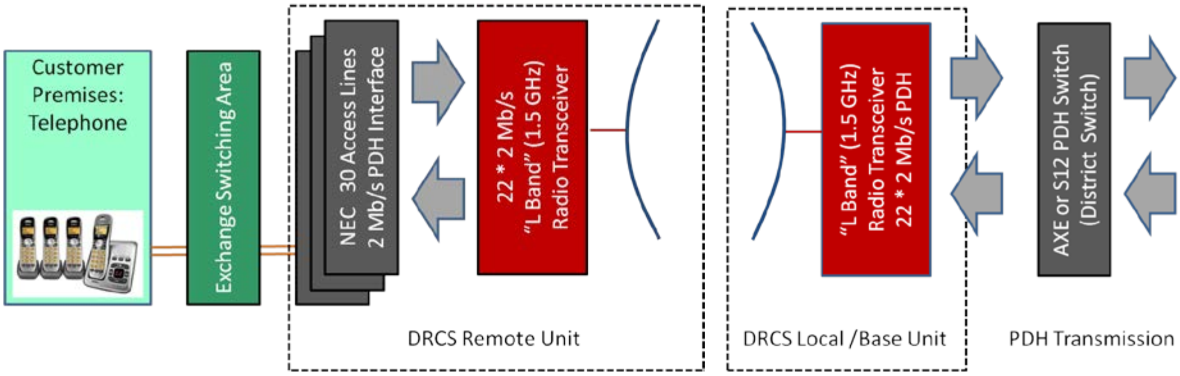
On the right is the Finley telephone exchange in the southern MIA area of NSW.

Note the mast with two large 1.5 GHz point-to-point radio dishes for DRCS / HCRC. One antenna is vertically polarised and one horizontally polarised).

These dishes are connecting to two distant SCAX huts that have DRCS equipment for telephony.

Finley has a nominal population of about 2500 people. The DataCube data showed Finley has having 1410 phone lines all with ADSLx Broadband included; most of these are centred around 20 Mb/s and the worst is 17 Mb/s. But there are 125 customers at nominally 6 Mb/s ADSLx downstream data speed.

The Data Cube data shows a strong possibility that the two nearby villages are part of the Finley Exchange – so there is every chance that two villages are connected by DRCS (totalling 125 lines) and have ADSL that is limited to 6 Mb/s by using three 2 Mb/s PDH links to each village - or the 125 customers are on the one town area with about 40 metres of moisture in their main cable; and the nearby villages have no Broadband services to those premises!



This (above left) is the typical block overview setup at a Remote locality where the Customer Premises "Voiceband" (analogue telephony) equipment is connected the DRCS Remote Unit.

This connection is through their Exchange Switching Area (ESA) part of the Customer Access Network (CAN) with pair copper (as per a an Urban Village / Town), or by analogue radio if further than 4.5 km from the SCAX hut.

These analogue (Ring Down/Loop Disconnect signalling) "Voiceband" (pair copper) telephone lines connect to the NEC 30 line concentrator where the channel associated signalling (CAS) for the 30 telephone circuits is in channel 31 of the 2 Mb/s PDH link; and the 30 "Voiceband" channels are now a (ITU G.711) digitally encoded channel 64 kb/s in the 2 Mb/s PDH hierarchy.

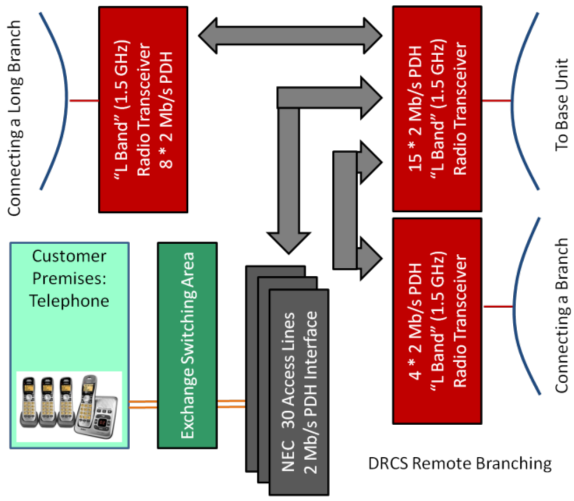
The 2 Mb/s PDH link (up to 22 of these) connect to the DRCS transceiver where the signal is connected to the other DRCS transceiver (on the right).

The DRCS transceiver (on the right) is located at a District Exchange site and these multiple 2 Mb/s PDH links connect (as part of the "Backhaul" Network) into the middle of a legacy digital telephony switch (called a "Minor Switching Centre" (MSC)).

All this transmission is PDH which from about 2010 is not compatible with the Core Network and is entirely based on unified IP technology. For telephone calls passing through the MSC outside this Remote District (large as it physically is,) the telephony traffic goes through a conversion to become VoIP/SIP and enters into the Core Network. External telephony ("Voiceband") traffic terminating in this Remote District goes through the reverse process.

A Minor Switching Centre (MSC) has no customer telephone (analogue) interfaces but cross-connects long-held (PDH transmission-based) circuits that are passed up and connected down from the Local telephone exchange switch.

In this mindset, the DRCS is seen as a Integrated Pair Gain System (PGS) and yet not part of the Inter-Exchange Network - but it is! (See Appendix 4 as to where it was "lost"!)



The conceptual schematic picture on the left shows a remote DRCS with three 1.5 GHz transceivers, where a branch would come in and the Base station would be to the right of this picture.

Note the count of 2 Mb/s streams: 4 from the short branch, 8 from further up the main route and 3 from the local NEC analogue line interface to 2 Mb/s - totalling 15 * 2 Mb/s PDH links in through the District Base Station.

It is extremely important to really understand that the DRCS is really two distinct parts:

- One part is the NEC analogue telephone ("Voiceband") line concentrator that has a back-interface that is 2 Mb/s PDH and;
- The other part is a 1.5 GHz point-to-point radio link (including the masts and antennae) that has a back-interface of up to 22 * 2 Mb/s PDH.

In its time this technology was brilliant engineering, but since then, the technology of IP and more particularly VoIP/SIP has become the standard leaving the RRR areas in an extremely awkward situation where the PDH-based "Voiceband" technology in the DRCS is not homogenous with the rest of the Australian telecoms network.

Because Telstra executives see the RRR as a "Cost Centre" virtually nothing has been done to upgrade this DRCA technology. Reengineering the DRCS is highly economic and very practicable - it just needs innovative synergies to make it happen!

Restructuring Australia's RRR Backhaul / Core

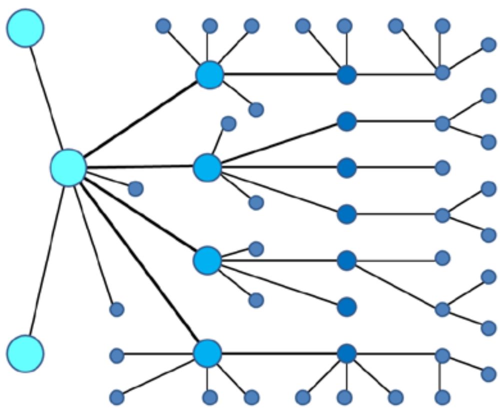
It virtually goes without saying that no large industry / business can now set up and operate efficiently outside any of the main Australian metropolitan areas because the Broadband telecoms infrastructure just simply is not there. Farmers and Graziers are now in virtually the same uneconomic situation as they cannot do efficient business without reliable, fast, low-latency Broadband connectivity.

Satellite Broadband is certainly not the answer because of excessive congestion, high latency, susceptible to weather, very limited bulk bandwidth and very (extremely) high outgoing/ongoing (international) maintenance overheads. Using Satellite is highly flawed "thought bubble". There are far more economically viable engineering strategies that practically build on (and replace) Australia's existing Remote telecomms infrastructure and remove that legacy equipment.

In the early 1900s, when Australia's Voiceband-based telephone / telegraph network was grown beyond the State Capital Cities, lot of engineering thought and consideration to optimally utilise the very limited scarce and expensive transmission and switching infrastructure.

As a direct consequence, the further the Inter-Exchange Network extended from major population centres, the much thinner is network very quickly became the more sparse the network construction was – primarily because the cost of transmission bearers (before the technology of Single Mode Optical Fibre) was so expensive.

The schematic picture on the right is highly representative of Australia's State / Regional Tiered–Star telephone-based inter-exchange network (IEN) structure.



Each of these blue filled circles represents a telephony switch. The State Capital City (light Blue) connects with many near outer suburbs and to distant Regional cities that each has their own star networks; and the towns have star networks to the nearby villages.

It is fairly obvious that calling from any of the country Regions to any other Region requires the "Voiceband" call path to pass through a big switch in the State Capital City. The more local the call; the less the "Voiceband" (based) transmission and switching hierarchy is climbed. Because of this hierarchical tiered star structure; nearby Towns / Villages in different Regions have to switch via the Capital City (light Blue). Inter-State calls would have to pass through each State Capital City switch.

Within the metropolitan areas (i.e. State Capital Cities), the Inter-Exchange Network was more a mesh than a star paths to minimise network switching, and the cost of short-haul "Junctions" was relatively inexpensive.

It is extremely rare to find a major optical fibre link that actually bypasses a State Capital City and inter-connects adjacent regional city centres.

As outlined in Appendix 1: Inter-Exchange / Backhaul / Core Network transmission technologies have advanced from Physical and Amplified (pair wire, and undersea cable) to FDM on (quad copper and Coaxial cable) to PDH (on pair copper then Single Mode Optical Fibre and Radio), then SDH and mainly unified IP (on Single Mode Optical Fibre and Radio).

The rollout of SMOF cable outside the metropolitan areas fundamentally followed the same long-haul (highway) routes as the pair / quad / coax cables - and this was excellent for FDM / PDH / SDH (telephony-based) network infrastructures.

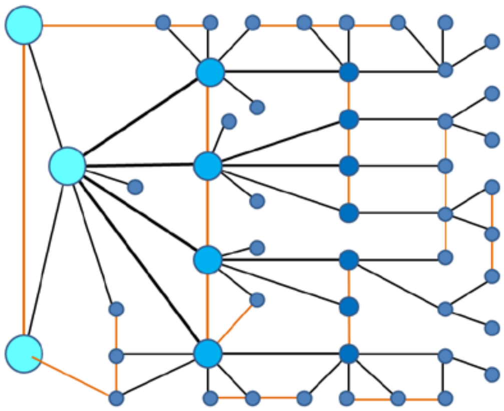
The fundamental problem for Australia is that the network transmission is now almost all unified IP, which really struggles with RRR tiered-STAR long-haul Inter-Exchange / Backhaul Network that was previously engineered for long held calls of switched telephony – not streams of IP packets!

With IP Switching: the call and destination (Local Router) locations are identified and a "best-fit" path is identified then the call stream uses this (or near) direct path.

Australia’s telecoms infrastructure is still basically capital city based Star structured long-haul network that <u>is almost exactly the opposite network structure is required for fast, economical and efficient “Broadband” connectivity in the Bush</u>, through the Country and between the large metropolitan centres! The chances of alternate path IP routing outside the metro areas is almost zero.

An efficient IP Core Network would have intersecting inland “circles” to provide alternate / "best fit" paths so some of the traffic can self-divert to another route and get to the destination in about the same time.

The extra orange lines included in this diagram illustrate how it can be relatively easy and quite inexpensive to slightly restructure Australia’s Regional / Rural / Remote telecommunications Core Network – and very economically re-utilise a lot of the pre-existing RRR infrastructure to provide reliable and robust inland telecommunications that is optimised for transporting high capacity Broadband all through Australia <u>including the RRR areas</u> – not just the (metropolitan) State Capital Cities.



With Broadband Internet connectivity: the more alternate paths, the more reliable (and faster) is the Internet connection. So, a large grid – or matrix – is by far the best Core network structure for the Regional / Rural / Remote (RRR) areas of Australia.

Because the PMG was established under State Management (and the RRR Inter-Exchange Networks all terminated into the Capital cities) there are many towns / cities close to borders – with no connection to nearby towns / cities over those borders except through both State capital cities / States Inter-Exchange Networks.

With unified IP, (and the capital city centric IEN infrastructure) the VoIP call paths would take the same routes to make the phone to phone connection – but – if there were direct inter-state links between these towns/villages, then these VoIP calls would use the direct link as first preference and free-up the rest of the network!

In many cases these extra cross-State boundary links could and would provide substantial bandwidth capability on what is otherwise isolated / separate sets of SMOF links (and/or may be the end of a DRCS / HCRC system). *Further – by very inexpensively upgrading the DRCS / HCRC to be Broadband IP "friendly" the local bandwidth capacity may be very substantially increased for very little financial outlay.*

Along the South Australian / Victorian border south of Bordertown to the southern coast south of Mount Gambier, there are 18 localities that are very near the border but have no connection across the border. In most cases the distances are less than 10 km. Cross-connecting many of these localities with SMOF and using IP as the transmission medium would provide a wealth of alternate paths between Adelaide/Perth and Melbourne/Canberra/Sydney – and locally of course.

Towards the border between NSW and Queensland; there is SMOF cable from Dubbo to Bourke and in Queensland extending south to Cunnamulla. These two transmission systems could be inexpensively linked by SMOF cable. Alternatively there are several (over 12) DRCS towers that are well within 50 km of each other but have no cross border links. These could have point-to-point 5 GHz radio (at nominally 50 Mb/s because of the radio hop length) and provide plenty of extra bandwidth into the South-west Queensland / NW NSW areas.

With a bit more lateral thinking a 24 or 96 strand SMOF cable along this route could very inexpensively provide upwards of 10 Gb/s (10,000 Mb/s) to interconnect Dubbo through to at least Charleville and all the localities in between instead of using the coastal transmission bearer. This way the DRCS towers could be reutilised for Broadband distribution to Homestead premises as an almost "Unified" Core / Access Network where the very expensive infrastructure components are shared and re-used for an optimum outcome for Australia's economy.

By thinking in terms of large circles and not long spurs, the whole inland Regional / Remote areas of Core Network can be very economically reconfigured to become a low-latency high-capacity Broadband connectivity shared Access and Core Network providing Homestead Broadband very near many thousands of Remote Homesteads.

What SMOF cables were traditionally used for telephone connectivity using 2 Mb/s PDH can be very economically re-engineered for 1 Gb/s (1000 Mb/s) per pair.

It is imperative for Australia's immediate economic future that inland Regional / Rural and Remote (RRR) areas of Australia are urgently provisioned with a large high capacity mesh-structured Single Mode Optical Fibre (SMOF) Core Network to provide considerable alternate path routing between all inland Cities, all inland Towns and most Inland Villages; and provide considerable alternate paths to the existing State Capital City Centric Core Network(s) – which have far too few fibres in these cables to support Australia's future economic / technology growth.

This in map[1] below shows DRCS / HCRC in yellow; Long-Haul Radio in Blue and Long-Haul SMOF in red. These Long-Haul transmission systems make up a considerable part of Australia's inland "Backhaul / Core Network".

[1] Australian Geographic, No29 Jan-Mar 1993: "The Phone goes Bush"; Ken Brass.
Map credit AG Cartography Division (https://www.agriculture.gov.au)

Very little has changed since 1993, but virtually all Long-Haul (SMOF and Radio) transmission systems are now all using SDH / IP, leaving the DRCS decades behind with a maximum of 22 * 2 Mb/s (44 Mb/s) as PDH transmission.

With the understanding that each pair of strands in a SMOF cable has considerably more bandwidth capacity than any radio link, this map shows the immense lack of inland SMOF cable (Red) infrastructure – particularly in RRR Queensland and NSW.

In much the same way that (magneto) telephone based Customer Access Network (CAN) "Party Lines" operated in country non-urban areas (until about 1973), a strategy of (almost) shared Inter-Exchange (and Access) network connectivity was alluded to with the introduction of the DRCS / HCRC technology in the late 1970's through to the late 1980's.

The subtle inclusion of SMOF through the Regional rural areas (plus a solid backbone of inland SMOF will inexpensively provide substantial bandwidth and alternate path routing that is imperative for inland Australia, and this SMOF backbone plus its tributaries towards the coast will really take the load off the SkyMuster Satellite technology mistake that (in my professional opinion) has proven a financial disaster for Australia's economy.

Re-Engineering the DRCS for RRR Australia

DRCS equipment was developed and manufactured in the late 1970's / early 1980's and rolled out from 1980 until 1990. This DRCS technology was around several years before the technology of SMOF existed (circa April 1985) and the rollout of SMOF really did not start until 1986 in the major urban areas and SMOF was (very reluctantly) rolled out in Regional Rural Remote areas from 1990 to 1993.

> *From 1967-1984 inclusive; I was primarily based in PMG / Telecom's NSW Transmission Laboratory where we prototyped, trialled and developed for manufacturing a very wide range of highly advanced telecoms-related analogue transmission, switched mode power, field test instruments, alarm control equipment etc. – to go into most NSW telecom sites. We continually used the latest electronic technologies available. This lived-experience was very strongly supported by my "going into the field" to trial and improve prototype equipment for larger scale manufacturing.*
>
> *This very rare technical background provided an almost unique reference framework for my ongoing technical, engineering, leadership, supervision, and management career.*

The problem is that because the DRCS is effectively Bandwidth limited and stuck in the PDH technology era – it cannot (in its present form) provide extensive Broadband connectivity. This problem could be inexpensively and radically changed to provide wide bandwidth low-latency Broadband. **Here is how to do it:**

This DRCS technology was specifically developed for a maximum of 22 * 30 = 660 64kb/s digital Voiceband channels.

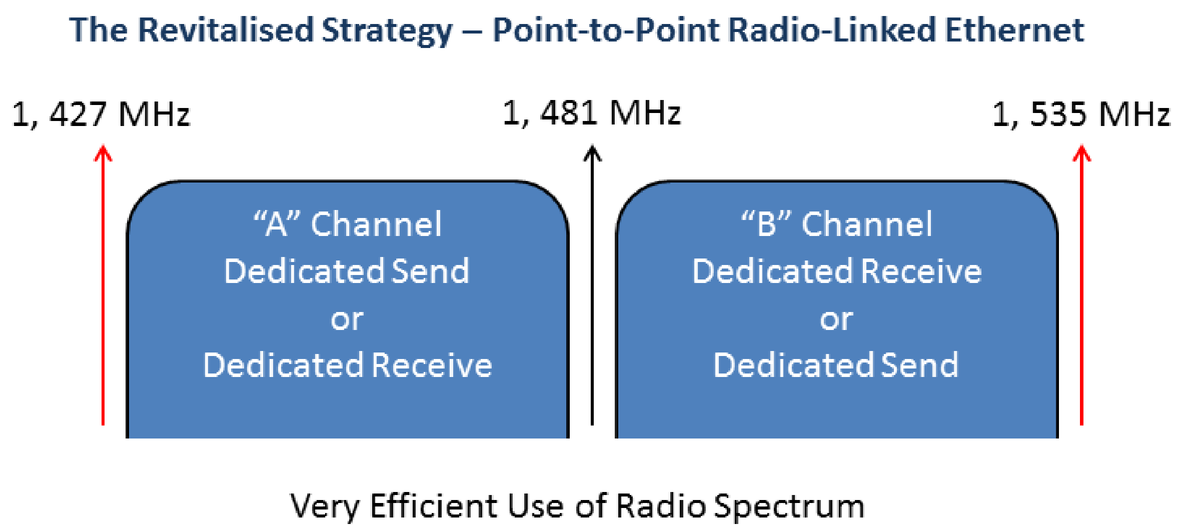
Drawing from my technical engineering knowledge and experience, I believe it would extremely economical and highly practical to simply re-use the towers, and the high gain 1.5 GHz antennae, and the low attenuation coaxial cables connecting from the antennae to the Radio / SCAX hut, and the solar panels etc..

From what I have recently heard from those in the field, these towers/masts (except those near (<50 km) the sea) are still in excellent condition. As such these "inland" towers / masts / antennae / coax cable / radio huts / solar panels etc. could be totally reused and replace the legacy PDH-based DRCS transceiver units with IP-based DRCS transceivers - which would facilitate inexpensive reliable and fast Broadband connectivity to the Homesteads / premises in these Regional / Remote areas.

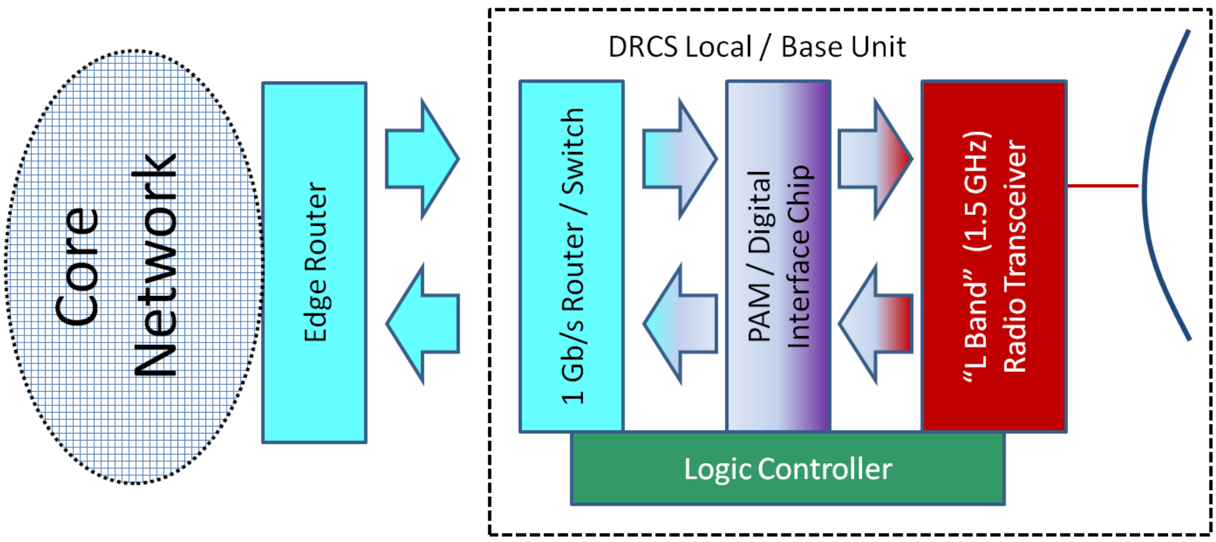
From here – everything changes to IP based Broadband!

Instead of all this complex electronics based on multiple 2 MHz channels, it should be far more practical and simple to utilise the whole available 1.5 GHz L Band as two Broadband channels – one for upstream and the other for downstream, as per the spectrum chart below:

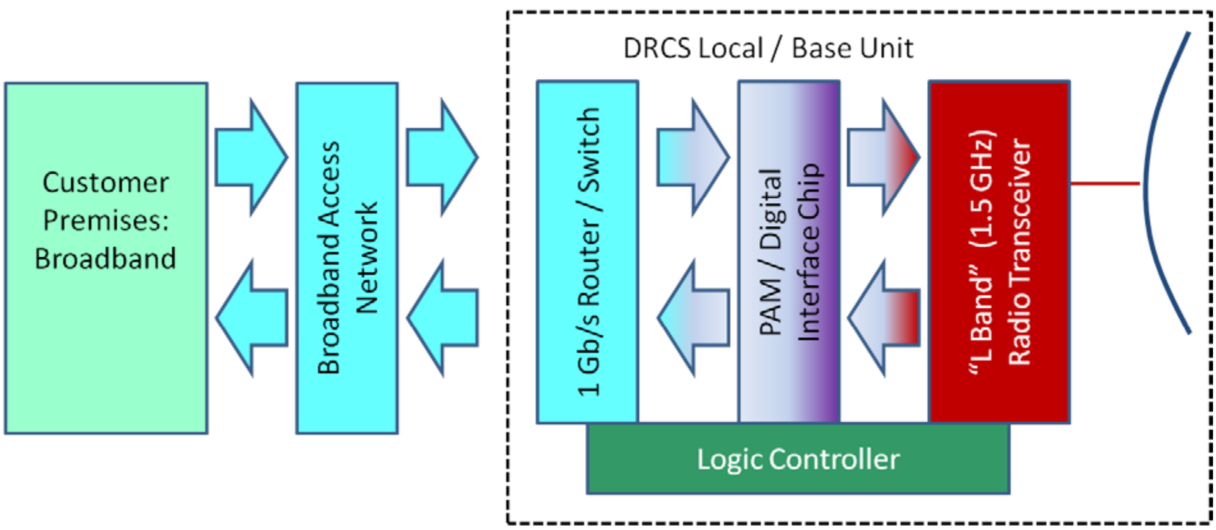
Each of these (Send / Receive) bands is nominally about 56 MHz wide and with Phase Amplitude Modulation (PAM), of which a lot of research and development has already been done in Australia by the then TRL and the CSIRO (at least); the expected data rate should be at least 350 Mb/s (concurrent and both ways) and be reliable over 50 km as it would be based on the existing 1.5 GHz antennae that are tuned for this.



In the past 40 years (since 1980) inexpensive Medium Scale Integration (MSI) and Large Scale Integration have introduced silicon chips that can do all this signal processing – and digital interfacing too (plus lots more).



Above is the conceptual block diagram of the re-engineered base DRCS, which is essentially very simple and it "talks" in IP, which directly matches the Core Network!



Above is the conceptual block diagram of the re-engineered Remote DRCS. Again this is very simple and it "talks" IP, which directly matches with the Broadband Access Network.

In other words, the re-engineered DRCS unit would be the same for everything as it would be a Broadband point-to-point Radio system optimised for 40 to 60 km radio hops that "talks" IP at each end and has a nominal data speed of 350 Mb/s low latency, low jitter and inexpensive.

The Broadband Digital Radio Transceiver could/would (very) comfortably fit in a 1 RU (Rack Unit = 44.45 mm high) sub-rack and require no special cooling (fans etc. – which would compromise the very low maintenance requirements). This is the same sized sub-rack as the existing old DRCS / HCRC Radio Transceiver.

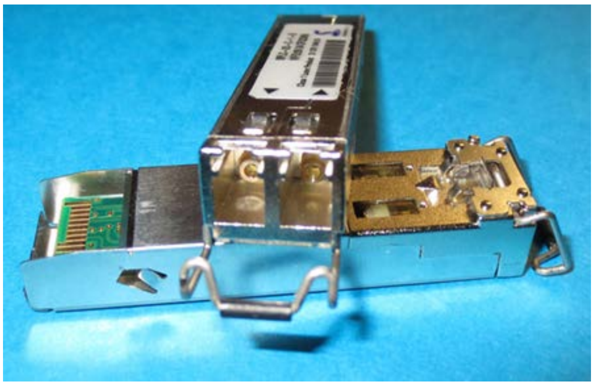
One of the reasons for the RJ45 LAN connections is that at a network concentration point, there may be two or three (or more) 1.5 GHz antennae on a mast connecting to different locations and the radio links need to be connected. Connecting these Radio links is very straightforward by simply including a rather short (300 mm) Cat5 (or Cat6) to cross connect with an inexpensive 1 Gb/s LAN Switch.

From about 2005, the concept of a Small Form Profile (SFP) Optical Fibre interface component has revolutionised the connection of IP with SMOF cable being able to be virtually directly connected with a printed circuit board assembly.

This picture shows a couple of SFP modules – top and bottom. These very inexpensive and highly reliable.

The SFPs include their own electronics to interface with optical fibre – which simply plugs in the front!

An SFP module simply plugs into a SFP socket that is mounted on the main printed circuit board.



With the very wide proliferation of SMOF cable throughout much of Australia – and the highly anticipated subtle increase in SMOF cable in the inland of Australia to provide inter-city alternate path routing (which is essential for efficient IP network connectivity throughout Australia to build Australia’s economy) – it makes a great amount of sense to include an SFP socket and connection into the IP Network side of the re-engineered DRCS as a: **Broadband Radio Network Interface (BRNI) Unit**.

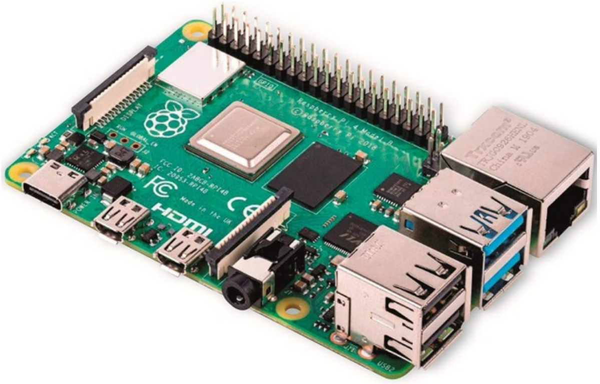
The inclusion or option of an SFP port would facilitate the very inexpensive and highly reliable ability to back-connect a BRNI with SMOF cable with the Switch / Router in a SCAX / Radio Repeater hut or nearby building / site.

The department needs to be acutely aware that another Australian sub-Government organisation (called the CSIRO) has already done a huge amount of world-leading research and development work in this area under the project name "Ngara".

This amazing work is almost a decade old and was termed the Ngara Microwave Backhaul Technology. From what I have seen on the CSIRO's web pages the information is very thin and seems to omit any information relating to where and how this Ngara Backhaul technology could be most gainfully applied.

In a somewhat similar mindset, personal computers have dramatically shrunk in size since the mid-1970s when the concept of a single board computer became real.

Since then, microprocessors have become commonplace with industry and it is now standard practice to have an industrial microprocessor and its interfacing mounted in much the same size as a circuit breaker and these process controllers and their interfacing are often mounted in the power distribution box or similar.



In the two pictures above the Raspberry PI on the left is virtually a mini (low level) Personal Computer board including two HDMI video, RJ45 LAN, and four USB slots plus a 3.5 mm audio interface. There are also three sets of interfacing pins to control / respond to other electronic signals.

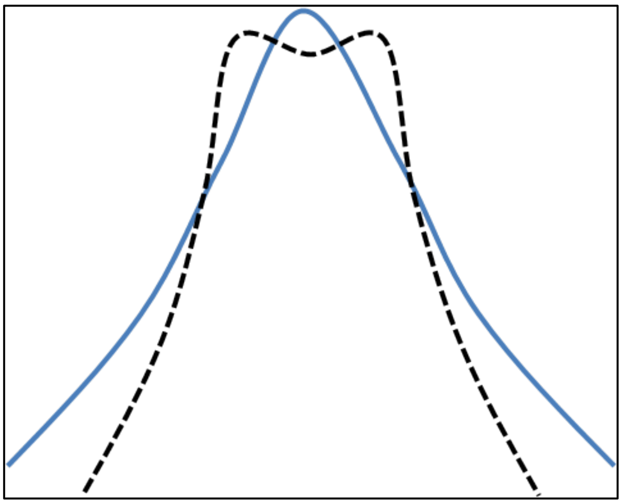
On the upper right is the Arduino which is basically an electronic interface controller and could be far better suited for controlling the settings of the small new generation **Broadband Radio Network Interface (BRNI) Unit** circuit board.

Taking this thinking a little further, the completely revitalised DRCS transmitter / Receiver / Encoder / Decoder / SFP plug / Power Filter; could all be mounted on a printed circuit board about the size of a playing card and together with an Arduino micro controller / interface mounted (upside down) in the unit.

Computer-assisted engineering using Finite Element Modelling (FEM) was in its infancy when the DRCS point-to-point radio system was conceived and constructed in the late 1970s. Also, using the "L Band" in remote areas - the radio interference (of "competing" point-to-point spectrum) is virtually zero. My guesstimation is that the parabolic dish antenna was engineered to have a maximum gain of about 32 dBi, a beam width of about 9 degrees, a bandwidth (around 1500 MHz) of about 150 MHz and the antenna could handle about 100 W.

Considering that the Antennae are already in place it (and the large majority of the antenna is the reflector - about 2.2 metres across) would be highly practical to reengineer the just (small) active element (and replace this part) and leave the main body (reflector) in place. Here is a hint of what could inexpensively be done:

With some intuitive computer antenna modelling and physical trials, it should be practicable to make a "double hump" (or flat) peaked frequency response at say 1250 MHz and 1750 MHz and have the (interchangeable) send and receive frequencies centred on say 1360 MHz and 1630 MHz and each have a separate nominal bandwidth of 200 MHz for send and receive (and Group Delay equalise the frequency bands to optimise the Phase Amplitude Modulation (PAM) index for maximum data throughput.



The guard band between the send and receive would be 60 MHz and this should make the RF and IF stages (for send and receive) relatively straightforward.

*This minor reengineering of the antenna would mean the "L Band" would be used to its limits and the 200 MHz bandwidth would facilitate bi-directional duplex data speed in the vicinity of 350 Mb/s * 200 MHz / 56 MHz = 1250 Mb/s.*

This data speed is getting in range of SMOF (1 Gb/s) and because the carrier frequency is nominally 1.5 GHz, the attenuation over distance would be substantially less than Wi-Fi technology using 2.4 GHz and 5 GHz etc. and 1.5 GHz has the advantage that it is low enough to can "see through" trees, rain etc.

Now, the attenuation through the large coaxial cable at 1.5 GHz is something like about 4 to 6 dB from the hut up the very tall mast to the antenna. Considering the small size of this reengineered unit and with a little more innovation - there is very little stopping the transceiver unit being mounted up the mast very near the antenna and have an SMOF cable connecting via the mast, and use the existing heavy Coax Cable as the power feed. This strategy means the mast-mounted amplifier / receiver amplifier can be (much less than) half the power it would be if it was in the hut and the (receive) noise floor is minimised.

In this case the back-to-back connections would be done with SMOF patch leads and use a 1 Gb/s or 2 Gb/s SFP interfaced optical switch.

With the specifications tightened up (including power and alarm etc.) a few prototypes (probably 10) of the Broadband Radio Network Interface (BRNI) Unit could be built up in less than a month (after the components are sourced) or so while suitable trialling grounds are identified and the logistics worked out to start testing.

With the prototype tests trialled and the feasibility worked out, which I would (from my extensive previous work in this technology area) would take at least a couple of months to get the bugs out of the prototype (allow 6 months).

The next stage is to prepare the reworked specifications and circuit / physical design for a “Proof of Concept” model – that is substantially improved from the prototype. It would be unsurprising to have the whole printed circuit board totally re-structured and include several features not considered in the prototype.

One possibility / probability (if this unit was rack mounted in the hut) could be the inclusion of a pair (or more) of back-to-back connected SFP sockets to facilitate the regeneration of SMOF at a radio site, special alarms, and maybe a USB interface for a Tablet to do updating / maintenance / address settings on site.

Building about 50 “Proof of Concept” Broadband Radio Network Interface (BRNI) Units would be enough to put out a sustained trial in several conditions where several network spurs and links can be added to find out what problems are in the wider field.

This process could take up over three months (preferably in the dry season – but it also had to be proven in the wet season – so this testing of the proof of concept stage could take as much as a year)! The DRCS took a few years to develop.

With the operational bugs tuned out of the Broadband Radio Network Interface (BRNI) Units, the next stage is to manufacture a “Small Scale Production” run of about 200 units and trial these for the next three months.

From here with this OK; these Units should be contracted to an Australian electronics manufacturing business to mass manufacture as required for Australia and export.

So far this is only part of the innovation, development and engineering required to bring good Broadband to the Homesteads in RRR areas.

If the BDRI unit ended up being mounted behind the antenna, then the wiring in the radio hut becomes very simple and straightforward.

Either way, the BRNI radio interface would back-connect into a 1 GB/s Switch / Router and this would be the connection point for the Access Network in this Regional Remote area to connect Homesteads and Premises etc..

At each locality, a Router / Switch (like this above) can very inexpensively interface between the reengineered DRCS units (that would have SMOF tails on them from the mast-mounted transceivers) - connecting through the four SFP module slots on the left, and provide Broadband IP connectivity to a range of Access Network equipment through the 12 RJ45 ports to the Homesteads / Premises.

Optical Fibre Is Very Economic

Circa 1986, the project cost of the Melbourne – Sydney Optical Fibre Network and its wayside stations (connecting country cities) was nominally $44.5 M and the length of the fibre was nominally 940 km. Unlike the NBN Corp, that has an immense amount of overhead in totally unnecessary politically based advertising; this $44.5 M project in 1986 was basically the engineering and equipment costs - no advertising!

The regenerators / wayside country cities were spaced nominally 60 km apart and that meant the number of equipment sites is 940 / 60 +1 = 16 + 1 = 17.

Looking a little closer at the equipment costs, the network design was originally based around a pair of (7 tube) coaxial cables visioned for replacement of the critically failing single Melbourne – Sydney coax cable system, that would be using the then state of the art 565 Mb/s PDH coax equipment and the remaining 18 interstice pairs / quads would have been using 140 Mb/s PDH equipment.

With the instant reality of Single Mode Optical Fibre (SMOF) happening in mid-April 1985, the mindset of the transmission medium was effectively directly converted from two rather heavy and "thick as your wrist" coaxial cables to one thin and light cable of SMOF about as thick as your thumb!

Circa 1985, the 7 tube coax cable cost about $80/metre ($80,000 per km) so for the MEL-SYD run of about 940 km would have cost about $75.2 M before it is trenched in. Oh – and there are two coax cables – so the coaxial cable cost alone would have been at least $150.4 M (and this cable has to be physically (manually) "laid" – which makes the trenching considerably more expensive)!

In those days this equipment would probably cost (in bulk purchase) about $50,000 for the 565 PDH terminals and $30,000 for the 140 Mb/s terminals or about 7 * $50,000 plus 8 * 30,000 = $590,000, and labour, management and overheads would have brought this up to about $800,000 per regenerator / terminal site for this project.

The Batteries and Air Conditioning and Alarms and Floor Space and Rack Mechanics etc. were all there at literally nil expense as these buildings also housed by the telephone exchange equipment (and the previous generation Cable repeater/terminal equipment). *Competitive Economics (as mindlessly trumpeted by the ACCC / PC etc.) totally avoids mentioning the massive savings and minimised overheads that comes with "Economy of Scale" that is totally obliterated by having competiting infrastructure businesses.*

With a ball park cost from above of say $800,000 ($0.8 M) per regenerator/terminal equipment; that is $13.6 M, leaving the SMOF and trenching to be nominally about $44.5 M – $13.6 M = $30.9 M for nominally 940 km.

In other words the cable and trenching (all done in bulk with big economy of scale savings) was about $30,900,000 / 940 = $32,900 per km. Now the fun begins!

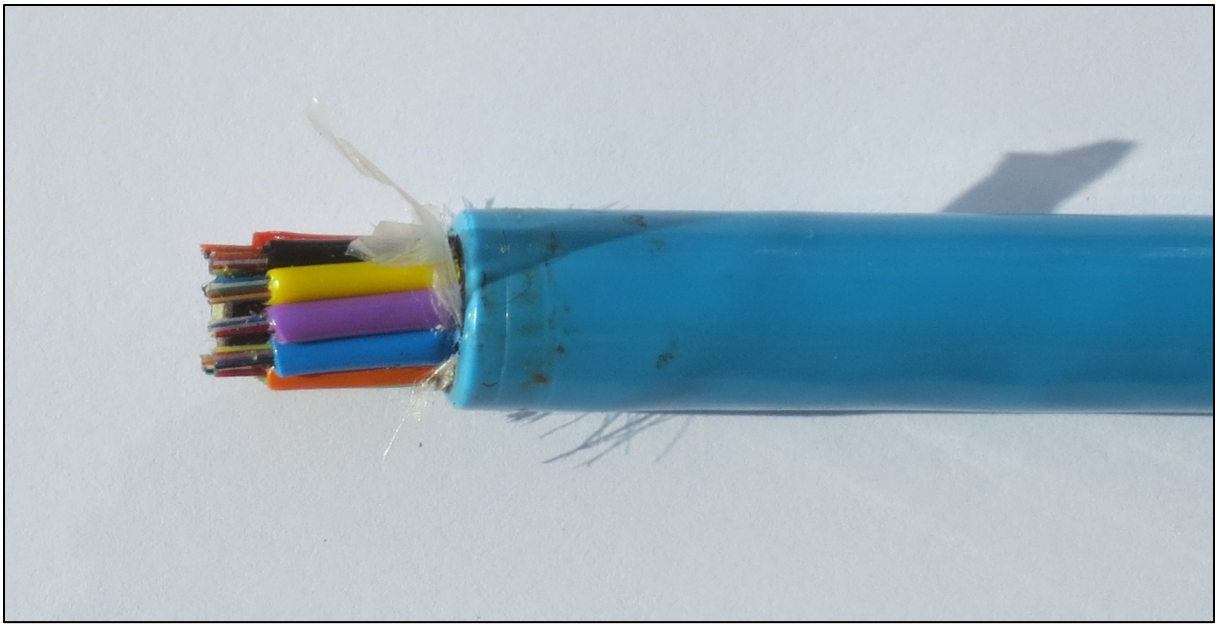
The big cost with SMOF cable is not the fibres but the sheath that holds and supports the fibres (so the fibres do not get crushed)!

If we very generously allowed the SMOF cable to cost $4/metre ($4,000 per km) because this was then a new technology, the then (1986) trenching costs would have been in the vicinity of $28,900 per km. (That is very close to reality for then!)

Circa (1990 - 1993) when the thin (nominally 6 strand, occasionally 12 strand) inland network of SMOF cable was rolled out and trenched in beyond the metropolitan State Capital Cities into the Regional / Remote areas; it was done with a sincere austerity mindset; *Telstra had also just paid out very dearly (about $450 M) for the inland DRCS technology over the previous decade, had also just paid out for the MEL-SYD SMOF high capacity network (for its time) plus a raft of metropolitan SMOF cables and inter major urban SMOF cables and the engineering design of SMOF cables (and trenching them) was also in their infancy, and Mobile Phones were pressing for substantial funding in the metropolitan areas - and there was the Pay TV debacle.*

The SMOF cable is now far less expensive (approaching $2.50 per metre for 96 fibre cable) and the trenching costs for the past decade are nominally about $35,000 per km. One of the big costs for this type of work is diesel fuel used by very expensive large mechanical aid equipment (that is also very high maintenance).

My past three years studies in non-urban Fibre to the Homestead (FTTH) in Regional Rural areas has shown that with the SMOF network highly distributed there is very little need for a 144 strand fibre cable as the main core and that a 96 fibre SMOF would be the absolute maximum requirement – where up to 24 fibres in that same cable could be used for Access. (*The 96 fibre cable is a smaller outside diameter cable structure than the 144 strand fibre cable, with a reduced cost per distance and the same sized drum can hold a longer length cable.*)



The above is a picture of a 144 strand SMOF cable that can be direct buried.

> *The (unseen) white rod in the centre of the cable is a poly/glass-fibre strain relief that looks and feels like a thick knitting needle!*
>
> *Note the thick (soft) polypropylene tubes, each carrying 12 polyester coated fibres (and each silica strand is about as thick as human hair). The thin polyester coating is coloured for fibre identification and fibre protection.*
>
> *Around the soft polypropylene tubes is a thick and hard polyethylene cable support and over this cable support is an outer (blue in this case) nylon sheath that prevents ants from eating the cable.*

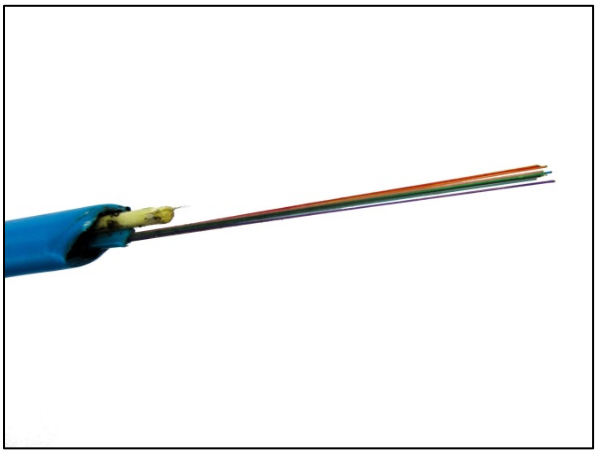
The fundamental problem with point-to-point radio (compared to that of SMOF) is the limited available Broadband Bandwidth over distance (and reliability) and the fact that one rather thin SMOF cable (8.5 mm sheath outside diameter) can carry 12 fibres; and each pair is the transmission medium for at least 1 Gb/s for distances over at least 60 km. Thus one pair of fibres far exceeds the transmission transport capability of a single point-to-point high capacity Radio system, and SMOF is far more reliable.

We really have to rethink Australia's inland telecommunications network as a large, highly distributed integrated net and not spurs from urban centres.

In the same mindset, the standard "drop" cable (*the term "drop" historically comes from connecting from a telephone pole to "drop" down to the home premises eave*); that (as far as I am aware) can be direct buried, and has nominally two strands in a soft polypropylene sheath which has an outside diameter of about 8.5 mm.

With innovation, this type of cable construction can have 6 or 12 fibres in it instead of two fibres for very little incremental cost and really lends itself to more Remote areas to have highly economic shared CAN and Core / Backhaul Network infrastructures.

The picture on the right shows 12 fibres in a "Drop Cable" sheath that usually carries only two fibres (including the ivory coloured "strainer").



Innovations like this that can very inexpensively provide a substantial portion of Australia's Regional Rural and Remote areas with reliable and expansive Broadband back-connectivity with the Core Network infrastructure and with re-engineered DRCS / HCRC Broadband (IP) point-to-point radio.

Similarly, recent developments in optical fibre cable technology have come up with an inexpensive very thin aerial fibre cable that can be strung as far as 140 metres (between power poles) without the need of a support wire. This very lightweight cable is also capable of having 12 fibres in it, opening a wealth of Regional / Remote opportunities for long distance Access Broadband connectivity never before possible.

Why We Have Deep Buried Cables

Australia's Post Master General's Department (PMG) was a virtual copy of the well-entrenched British model – so the CCITT (now renamed the ITU) recommendations that were standard in the UK (and virtually all Europe) primed the practices that were seamlessly rolled out in Australia without question and with very little local reasoning nor argument (and it worked – most of the time).

Cable technology was particularly expensive and used only where necessary – under seas between countries and under rivers. As cable technology improved and became necessary because of space taken by beside footpaths (telegraph poles / cross-arms / wires) trenched cables became common in Australia through the 1950s.

From the 1930s, Australia's PMG Telecom Research Laboratory (TRL) in Melbourne did a lot of research and development work to facilitate a range of private companies to manufacture telecomms equipment (including cables) in Australia. This Australian manufacturing mindset headed by TRL built practical and theoretical expertise that highly stimulated the Australian economy for several decades.

The prime reason for deep burying (conductive) cables is to minimise lightning damage. When bolt lightning strikes, it results in very high (direct / induced) currents through the soil and if there is a conductive cable then it takes the bulk of the current!

The deeper the (conductive) cable the far less likely is the lightning current damage, especially if the soil is "wet"! This explains why conductive cables are deep buried!

Because much of the UK (and Europe) has thick topsoil (typically 600 mm) and the climate is predominantly wet – hence they plough fields to overturn and dry the soil before planting – it naturally followed that very expensive telecoms cables should therefore be maximally protected by being trenched in as deep as practicable.

Between urban centres (i.e. between towns and cities, alongside the roads), the nominal cable was buried at a depth about the shoulder height of an average person which was about 4 to 5 foot or about 1200 to 1500 mm.

The then Post Master Generals (PMG) Dept. in Australia directly followed the standard UK process of burying inter-urban telecoms cables at nominally 4 to 5 foot (1200 mm to 1500 mm) below the ground surface.

SMOF cable is non-conductive and has no conductive armour coating (except under sea / water / rivers etc. – where the metal armour itself is very highly conductive) so **<u>there is no valid reason to deep bury SMOF cable against lightning</u>**!

In Australia the ground is generally much drier/ rocky and harder than in Europe, making deep trenching in Australia extremely slow and requiring very powerful trenching machinery; making this process very expensive. Typically the cutting and backfilling of a continuous trench for laying telecoms cable at 1200 to 1500 mm deep is nominally about $35,000 per km (plus the very minor cost of the SMOF cable).

Considering the Australian soil is typically dry, clay / rocky and has a very thin topsoil layer (typically 50 to 100 mm) – it makes a tremendous amount of economical and practical sense (to me) to bury telecoms non-conductive SMOF cables between non-urban centres at no deeper than 600 mm under the ground surface.

There will be very occasional “back-hoe fade” but in most cases the cables will be nowhere near where most deep soil cutting / ploughing is done. *In the past 20 years farming practices have dramatically changed with ploughs being used far more rarely than ever and plough depths are rarely deeper than 100 mm.*

With this mindset, not only is much less powerful ripping and trenching machinery required, but the trenching / laying / backfilling process would be significantly faster and I would expect the cable ploughing process to be $10,000 to $12,000 per km depending on the terrain and not nominally $35,000 per km.

Re-thinking the whole SMOF trenching process is a practical engineering issue for Australia – particularly in RRR areas that will be radically less expensive and a far rollout faster process. This makes the prospect of inland “light” trenched SMOF cable highly practical and very economic and is highly worthy of general acceptance.

In direct comparison with a DRCS rollout: the DRCS / HCRC mast and equipment would have conservatively cost about $500,000 each. Consider 10 hops at 45 km each; this is 11 masts and equipment, with a ballpark price of $5.5 M.

With SMOF cable over the same 45 km * 10 distance (450 km), the 1500 mm deep trenching cost (including 6 strand SMOF at say $1,200 per km) would be in the order of $35,000 + $1,200 = $36,200 per km or about $16.3 M.

With SMOF cable over the same 45 km * 10 distance (450 km), the 600 mm deep trenching cost (including 6 strand SMOF at say $1,200 per km) would be in the order of $10,000 + $1,200 = $11,200 per km or about $5.0 M. Clearly the "light" trenched SMOF cable is about the same cost, far more reliable, and a far greater bandwidth.

Thinking “Broadband”, with the DRCS equipment updated (see “Re-engineering the DRCS for RRR Australia"), the 1.5 GHz "L band" can very comfortably transceive 650 Mb/s bi-directional. Two strands of SMOF can transceive 1000 Mb/s (1 Gb/s).

One of the really big problems with point-to-point radio is fading due to (daily) temperature changes where the radiated signal bends up/down (like a banana) and misses the receiving dish. This is the same visual effect as a mirage on a hot day. SMOF does not have this problem – making SMOF the ideal transport medium for long-haul, massive bandwidth, transmission.

If the same (long-haul) 450 km cable structure was upped to say 12 fibres then the cable cost would be about $1,400 per km, total cost including "light" trenching would still be about $5.1 M and this is now capable of transporting 6 * 1 Gb/s or about 9 times that of the single 650 Mb/s “reengineered Broadband DRCS” link.

Thinking slightly more laterally, the 12 fibre cable is nominally about 8.5 mm outside diameter (OD). A slightly different cable construction can support eight 12 fibre tubes (i.e. 96 fibres) and is nominally only 12.5 mm OD.

96 strand SMOF at say $3.00 per metre = $3,000 per km. Include the “light” trenching at say $10,000 per km plus the cable = $13,000 per km. So for a distance of 450 km this is about $5.85 M. With industry standard 1 Gb/s IP technology per pair, this cable is capable of 48 Gb/s!

There is no economic reason to even trial any new “Voiceband” (Broadband with VoIP) Homestead connection trial if the Access Network structure for that area cannot be economically back-connected into the Core Network and similarly the Core Network in at area must have plenty of through connectivity – to cope with a growing economy. This situation comes back to being indigenous with all of Australia’s telecommunications network infrastructure – not just parts of the Access Network.

Increasing Regional Points of Interconnect

Currently there are 121 Points of Interconnect (POIs) directly connecting with the Telstra Core Network, geographically distributed about Australia for the NBN Corp and other Carriage Service Providers (CSPs) to back-connect their Customer Access Network (CAN) infrastructure into. These 121 POIs are provisioned (by Telstra) to currently connect with 8,814,000 Broadband connections, which is effectively every Family and Business Premises in Australia, and not counting for population growth.

Of the 121 POIs, 86 are in Metropolitan areas and these potentially connect to 5,817,000 premises. The meaning of “Metropolitan” is the State Capital Cities and suburbs of: Brisbane/Gold Coast, Sydney, Melbourne, Hobart, Adelaide, and Perth. The rest (35 POIs) is assumed to be “Regional” and accounts for 2,931,000 non-metropolitan end users / premises.

Currently there are few Regional POIs that are not coastal-located and this is a critical concern as this “blindfolded” POI rollout was the result of a very reluctant situation (from Telstra) where the Australia’s inland Core Network is extremely thin as most of the Core Network is Metropolitan and/or Costal-based.

My understanding is that Telstra executives did everything they could to covertly derail the NBN Corp. infrastructure by minimising the POI count to about 6 to make the Broadband rollout impractical. With the realisation that NBN Corp. were prepared to install very long “tails” that literally paralleled and bypassed existing Telstra long-haul infrastructure; a compromise of 121 POIs was agreed on and the majority of these POIs are still metropolitan / coastal and high population density based.

The only inland POIs are at: Dubbo, Queanbeyan, Civic, Tamworth and Wagga (for NSW/ACT); Toowoomba (for Queensland); Ballarat, Bendigo, Shepparton, Traralgon (for Victoria); Katanning (for WA). This is a grand total of only 11 inland POIs, and these are barely “inland” and anywhere near the bulk of the HCRC/DRCS sites.

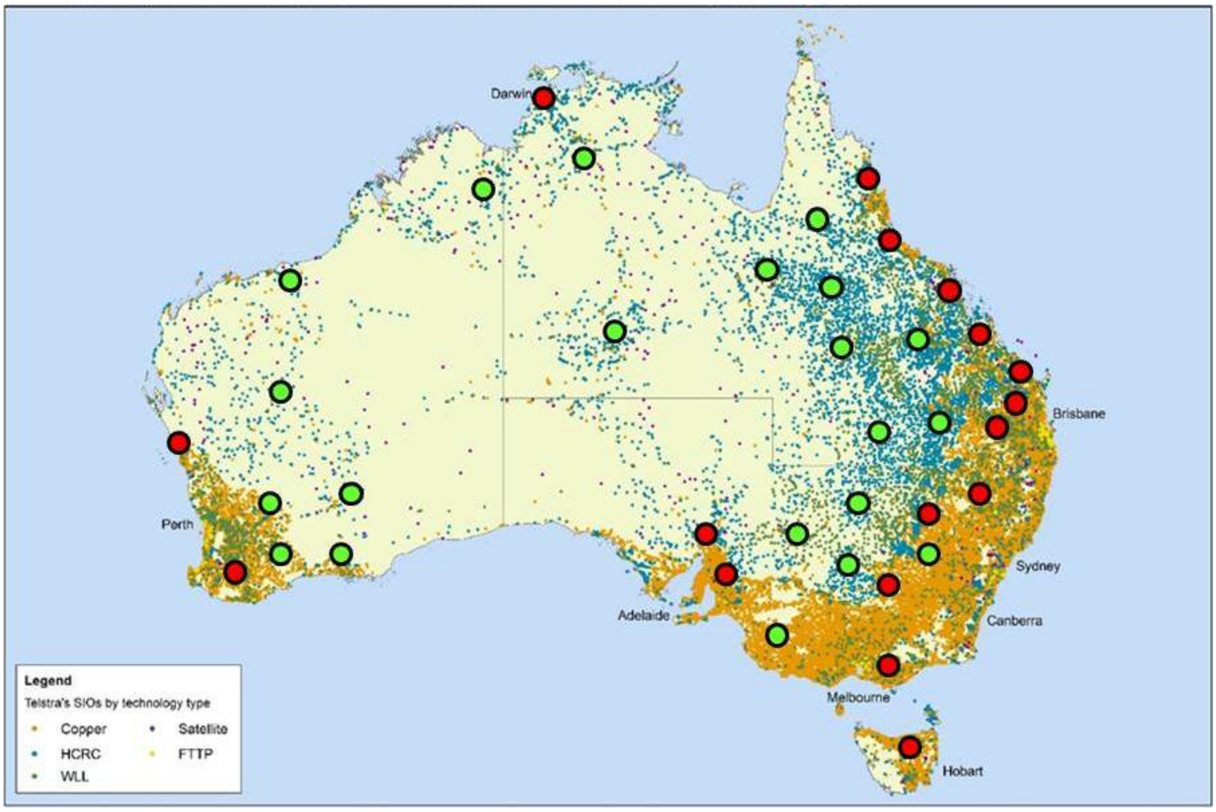
The bulk HCRC / DRCS population is in inland Central Queensland and North-West NSW as shown in the Discussion Paper map on page 5, and shown below. The remainder of the DRCS / HCRC population is in the Northern Territory, Western Australia and South Australia.

In these cases, the only (inland) POI in Queensland that is anywhere near a reasonable HCRC / DRCS population is (considerably) west of Toowoomba in Queensland's south east – and Queensland has by far the largest HCRC / DRCS population! The POIs at Nambour and along the Queensland coast have some HCRC / DRCS end users but this is coastal and very hilly where fibre back-connected point-to-point radio could provide low-latency Broadband to provide inexpensive and reliable "Voiceband" connectivity. (More on that later)

In NSW, the only inland POIs near any HCRC / DRCS population are Dubbo and that population is west of Dubbo and west of Wagga Wagga. In SA, Port Augusta has a surround of HCRC / DRCS end users and Stirling is almost in Adelaide but has some connection to HCRC / DRCS end users. Apart from Darwin, the NT is virtually devoid of POIs (where they are also needed).

If low-latency Broadband back-connectivity (for these trials and beyond) is to be taken seriously, then the Regional / Remote Areas need several more very inexpensive (smaller) POIs to be placed in appropriate Regional / Remote locations.

The map (from the Discussion Paper) as shown below includes 20 potential inland POI locations (green filled circles) that do not exist. These (much smaller) POIs would far more inexpensively pick up the vast majority of HCRC / DRCS "Voiceband" customers and provide them with low-latency high-reliability "Broadband" (VoIP). The red filled circles are the very few pre-existing POI (mainly inland) locations where POIs where DRCS / HCRC technology is prevalent.



For ease of reading most of the Regional coastal POIs are not shown.

Of the 35 "Regional" POIs, many of these are coastal and far from DRCS / HCRC equipment but there are seven in Queensland, three in NSW, one in Vic, two in SA, two in WA, one in NT and one in Tasmania (red filled circles) totalling 17 that have POIs that are relatively near potential useful testing sites.

Economically, it would be far less expensive and a far better network utilisation of available SMOF cable and long-haul transmission systems to have appropriately located inland POIs (as alluded to in the above map shown by 21 green filled circles) installed in these regional areas, and back-connected to major the Metropolitan pairs of Main Switch / Routers.

In a theoretical sense, the total count of Broadband connections to POIs remains constant as these extra POIs would have their count taken from the Satellite and other POIs. In any case, this would leave room for future population growth!

In a practical sense, any spare fibres in the new SMOF cables back-connecting these POIs will provide Australia with a degree of future-proofing the Core Network infrastructure making Australia's Core Network far more robust and therefore far more capable of supporting new and expanding inland industries.

Note in this map a virtual line of green filled circles extending north of Victoria through the western side of NSW and in through the centre to the North of Queensland. These POIs almost exactly follow the alignment where Australia must have a (48 Fibre) high capacity long-haul Single Mode Optical Fibre (SMOF) cable-based transmission network to link the inland and provide alternate high capacity paths towards coastal cities along the way.

Practical Remote Broadband Connectivity

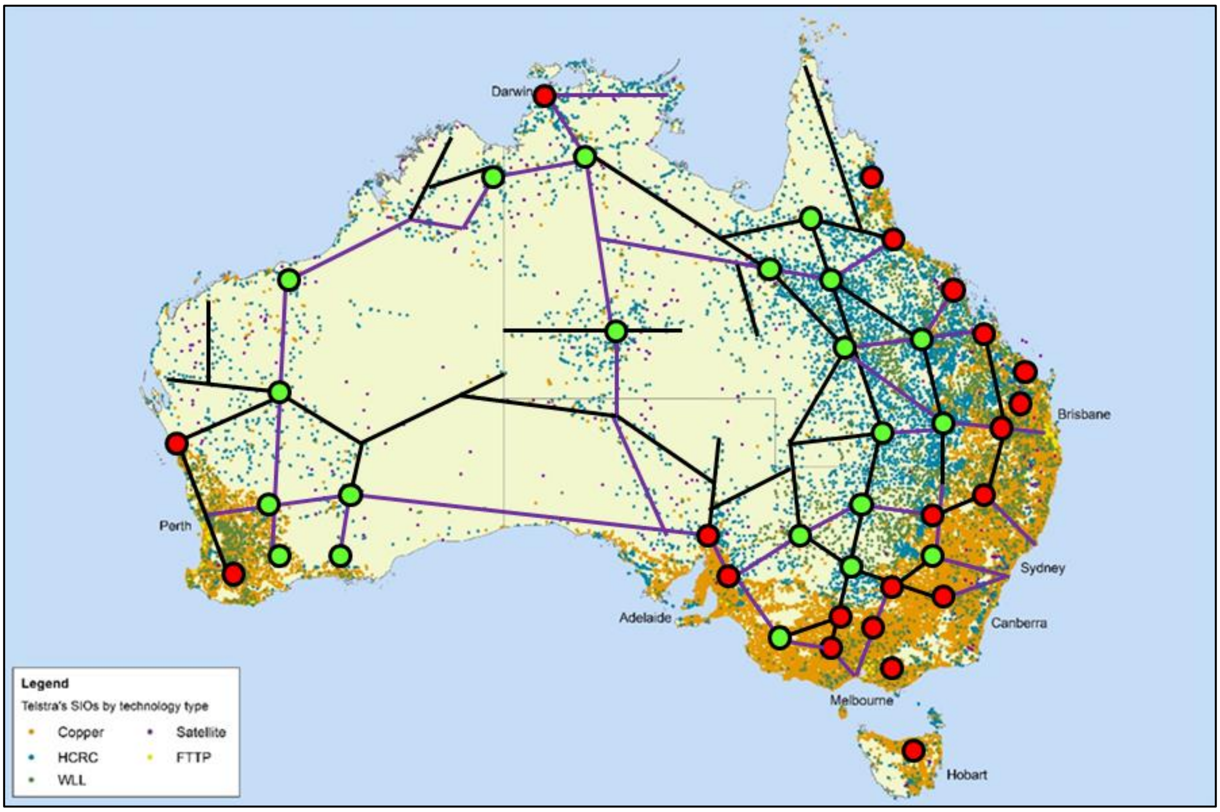
In my Submission dated 25-Mar-2008 (12 years ago) to the Expert Committee on Telecommunications about the proposed NBN build; I included an itemised and detailed breakdown of an inland high capacity SMOF backbone running through north western Victoria – western NSW – inland Queensland then through to Darwin with many spurs to Australia's east coastal cities.

This economic high capacity network would have provided all the network infrastructure to back-connect most of the inland DRCS / HCRC technology in the eastern half of Australia and negated the cost of very expensive high-maintenance low-performance Satellite such as "SkyMuster" (that has proved an engineering and financial disaster for the Australian economy.)

The map below shows some of the pre-existing long-haul SMOF routes as purple lines, and the black lines show the concept of the loose inland grid that I am very strongly suggesting must be put in place to synergetically back-connect hundreds of inland Regional / Remote DRCS / HCRC locations to provide low cost highly reliable low-latency and high capacity Broadband to tens of thousands RRR customers.

Instead of the main long-haul SMOF routes being Capital City (State) centric, these inland routes form a <u>highly robust inland grid that really suits IP routing and minimises the opportunity of a catastrophic network failure throughout Australia</u>.

This grid will provide considerable alternate high capacity Broadband Internet paths for high density IP traffic between metropolitan centres, and provide the imperative telecommunications framework for Australia's economy (and future industries) to comfortably grow and expand well beyond the limited metropolitan areas.



This inland backbone / grid SMOF network will also provide ample Broadband Core Network capacity to very inexpensively interconnect thousands of inland Rural / Remote Localities, Villages and Towns (and Country Cities) to build Australia's economic future for the next 50 years (at least).

There have been a few optical cable failures where big earth movements have snapped main arterial SMOF cables – resulting in parts Australia being in a temporary "Internet Blackout" – because there is virtually no alternate paths between major cities and most inland cities have literally only one core network connection – to the State Capital City – with no alternate paths.

The inclusion of this inland grid will provide a very strong defensive robustness that other highly populated countries take for granted.

The problem is that most of these existing Regional POIs (red filled circles) are geographically distant from the vast majority of the DRCS / HCRC end users to potentially be upgraded, which means that the tails from these clusters of DRCS / HCRC telecoms equipment will be very long (several hundred km) and follow common physical paths.

The 17 green filled circles are my first round suggestion for new non-metropolitan Regional POIs to be predominately located near more highly populated DRCS / HCRC areas and when totalled account for about 1,497,000 end users; or about 17% of the total Australian POI count; or about 53% of the total Regional POI count. These Regional POIs will significantly reduce the overall cost of back-connecting virtually all Remote Homesteads to reliable, low-latency and fast Broadband.

For practical purposes, the POI must have adequate bandwidth back-connecting to at least Sydney / Melbourne / Brisbane / Perth (preferably all four) plus be minimum-latency. This connectivity may sound impractical but inland Australia is not geographically "near" any of these, and combination back-connected POIs are advantageous.

It is imperative that the current DRCS transceiver units be re-engineered as a matter of urgency and the new version that "talks" IP will provide nominally 350 Mb/s to several localities. The inland IP based SMOF cable transmission systems that exist can then directly back-connect these re-engineered DRCS transceivers.

This re-engineering DRCS units process is not at all expensive. Assume there are nominally 2000 radio hops, that is 4000 re-engineered DRCS units at say $4,000 each totalling about $16 M in equipment.

With this re-engineered DRCS equipment in place it should be very straightforward to remove all the old NEC line concentrator telephony equipment, install ADSL2+ / VDSL / point-to-multipoint and point-to-point radio for those in the Small Town / Village / Locality and point-to-point radio for those further out (all connections using IP as the common transmission / communications / signalling protocol).

Jumping forward to IP connectivity - assume the re-engineered DRCS is capable of (bidirectional) 650 Mb/s and the maximum premises count is 660, so 650 Mb/s / 660 = 0.985 Mb/s per end user. Assume the Internet (maximum) route occupancy is 0.02 (i.e. 2% of the time your computer time is fully using the Internet - and same for everybody else on this re-engineered DRCS), then the nominal premises data speed would be nominally 0.985 / 0.02 = 49 Mb/s.

With a VoIP call the actual (Core Network) occupancy rate is at maximum half what it is for an Analogue telephone call, (because (most) people do not talk while the other person is talking)! Even then, the actual data occupancy is about half that again (because of the data saving when using VoIP as only active signal is sent - and there are breaks between the words) so the route occupancy is nominally between about 0.25 E and .50 E a VoIP connected telephone call.

Being very generous, allow 1 E for a VoIP telephone call - and do the simple maths for 660 concurrent telephone calls assuming the standard 64 kb/s (0.064 Mb/s) on the nominal 650 Mb/s "Backhaul" connection to the Core Network!

Now - consider everybody concurrently using VoIP at 0.064 Mb/s (64 kb/s); the "effective" data rate is far more like 0.064 Mb/s * 1.00 E * 660 = 42.24 Mb/s out of 650 Mb/s. So this leaves at least 608 Mb/s as Broadband for 660 Homesteads.

Assume 608 Mb/s for 660 Homesteads and an occupancy of 0.02 E. The average data rate will be in the order of 608 Mb/s / 660 / 0.02 = 46 Mb/s. This is as good as many metropolitan consumer premises using VDSL in their Access Network.

Now, this is a fully loaded "re-engineered" DRCS, and looking back at the Australian map of the DRCS systems in place - on average most DRCSs in remote areas have about five serial masts (and a spur or two with a couple of masts on these. Being generous and say 10 masts / repeaters and being only 50% Access Network connected, this comes up with about 330 Homesteads per re-engineered DRCS.

Accounting for VoIP traffic: 0.064 Mb/s * 1.00 E * 330 = 21.12 Mb/s out of 650 Mb/s. So this leaves at least 629 Mb/s as Broadband for 330 Homesteads. So the average busy hour data rate should be in the order of 629 Mb/s / 330 / 0.02 = 95 Mb/s.

So the available data speed to the localised Access Networks (commonly called "Exchange Switching Areas" (ESAs) in these situations is highly dependent on the time of day / night (i.e. "busy hour") and the total number of Homesteads in the ESA connected per re-engineered DRCS site.

If the data usage becomes intense (e.g. inter-site computer gaming, video conferencing, movie downloading, Homestead-based active Website / highly repetitive Farming / Grazing Data Reporting/Storage etc.) then the traffic density (Erlang) will be considerably higher and the connectivity speeds will be impacted.

The structural problem is that the current DRCS physical network structure is a series of STARs, with long fingers. What is really required for more optimised IP transport is a slight restructure so that the lengths of these fingers are shortened / broadened - or made onto large loops - by network connecting at / near both ends.

There are several cases where the top of a mast on one DRCS is in visual sight (<50 km) of another mast from another DRCS, but these are separate systems. IP Re-engineered DRCS can optimise this connectivity, and so can "light" trenched SMOF cable (see the next section) - and also inexpensively do this.

By including another cross-connecting p-p IP radio link, not only is the network made far more reliable / robust but the available bandwidth is dramatically increased; because the "Backhaul" connection can come from either / both sides to the re-engineered DRCS.

With "looped" re-engineered DRCS running IP at nominally 650 Mb/s this really means that the connectivity (for those near an "end") can be almost doubled; the reliability is dramatically improved and the connection speed should approach / exceed the magic "1,000 Mb/s" (1 Gb/s).

Put this another way - by having the re-engineered DRCS link of say 10 masts connected at both ends - not at one end only; the bandwidth capability near the middle is almost doubled to 650 Mb/s * 2 > 1,000 Mb/s and the reliability is doubled too. So the ability to provide consistent Broadband is far greater than before.

One networking (apparent) problem comes when people stream TV or video conferencing at say 5 Mb/s. Assume many of the 660 Homesteads watch the streamed ABC News at 17:00 pm for an hour. The maximum number of premises watching streaming TV in this instance is 650 Mb/s / 5 Mb/s = 130 Homesteads.

With a double ended back-connection arrangement the maximum number of premises able to concurrently watch streaming TV is 130 * 2 = 260. Most Homesteads in Remote areas would be using a Satellite for watching Broadcast TV!

So with a re-engineered inexpensive DRCS base unit to "talk IP" this really opens the door to facilitate low-latency, highly reliable Broadband connectivity to a large majority of inland / Regional Remote Australia - and this Broadband service can easily and inexpensively provide "Voiceband" telephony at Remote premises!

Appendix 3 – Broadband Access in the Bush

Connecting to Homesteads and Remote Villages

Until about 20 years ago (circa 2000) virtually all Farming and Grazing business was done by (“Voiceband”) Telephone and Fax. Not any more – almost all Farming and Grazing business is done by Websites / Emails / Mobile Devices “**Broadband**”.

When anybody uses the Plain Old Telephone Service (POTS) as soon as the Backhaul network connects into the Core Network that connection is by VoIP (see Appendix 1).

What is not widely known is that the signalling for VoIP (i.e. SIP) goes to a common control area, but the VoIP path can be / is far more direct, meaning that Local - Local calls using VoIP certainly do not trombone to the State Capital City or Regional Switch and back again as they used to do with a POTS connection based on telephone "channels" and the Inter-Exchange / Backhaul Network - thus the centre of the Core Network is usually almost VoIP "free" as most calls are generally local!

In Appendix 2 "**Practical Remote Broadband Connectivity**", this area gave a rather simplified overview of the RRR Backhaul Network infrastructure. Also in Appendix 2 "**Reengineering the DRCS**" also showed that reengineered DRCS transceivers to "talk Broadband IP" will be a very inexpensive and economic strategy that would provide the necessary long-haul transmission necessary for back-connection into the POIs of Australia's Core Network and very inexpensively provide ample Broadband connectivity throughout Remote inland Australia.

It is imperative that this re-engineered Broadband Backhaul / Core IP network infrastructure is synergistically provided to connect with the large majority of Access Network infrastructures the Regional Remote Homesteads / Villages / Towns etc..

In this process, the use of PDH technology would be substantially reduced - freeing up a considerable proportion of strands in SMOF cable used for Backhaul and make this SMOF cable and IP Routers etc. part of the unified IP Core Network infrastructure. The immense economic savings from this opportunity cost technology transfer must not be underestimated.

In Appendix 4 there is a topic "Serious Lack of ADSL Facilities Rural Areas" that broadly shows that Villages (with relative short pair copper access lines were denied ADSLx infrastructure. One prime reason why these Remote / Rural Villages were denied ADSL was that there was/is not nearly enough IP Broadband connectivity available in the Backhaul that services (connects to) these SCAX huts.

As shown in Appendix 2 "**Re-Engineering the DRCS for RRR Australia**" a Router / Switch (like this above) can very inexpensively interface between the reengineered DRCS units (that would have SMOF tails on them from the mast-mounted transceivers - connecting through one of the four SFP module slots on the left, and provide Broadband IP connectivity to a range of Access Network equipment through the 12 RJ45 ports (centre).

Technology advances in the past 30 years have introduced a range of IP-based Access Network infrastructures.

What has to be clearly understood is that all these IP based Access Network technologies provide Broadband at the premises and this premises Broadband will facilitate VoIP telephone connectivity through an ATA interface at the premises / mobile device, and the Broadband will facilitate a Wi-Fi connection at the premises - which can directly communicate with Mobile Devices (Phones) - in/near say 50 metres of the premises Wi-Fi head.

Here is a very brief outline in point form of Broadband Access Network technologies that could be applied in this case (and some considerations about initial cost and ongoing maintenance (which must not be ignored):

ADSL2+ on Pair Copper to the Premises

- Is Synergetic with the Backhaul / Core Network
- Uses the pre-existing (low maintenance) pair copper telephone cables
- Most cables in RRR areas are plastic insulated / sheathed, low maintenance
- Provides a maximum of 24 Mb/s downstream up to about 1 km
- Urban concept limit about 4 km
- Very Inexpensive to Install and Manage / Maintenance / Operate
- Non-Urban can connect to about 11 km (bonded pairs)

VDSL on Pair Copper to the Premises

- Is Synergetic with the Backhaul / Core Network
- Uses the pre-existing (low maintenance) pair copper telephone cables
- Most cables in RRR areas are plastic insulated / sheathed, low maintenance
- Provides a maximum of 50 Mb/s downstream up to 500 metres
- Very Much Urban Limited Concept about 500 metres
- Very Inexpensive to Install and Manage / Maintenance / Operate

Point-to-Multipoint Fixed Wireless / 3GSM / 4GSM

- Is Synergetic with the Backhaul / Core Network
- Needs a geographic High Point for the Radio Base Station
- Must Have Line of Sight for Good Connectivity
- Can be Affected by Bad Weather / Smoke etc.
- Has a Nominal Range of about 5000 metres
- 3 GSM limited to about 7 Mb/s
- 4GSM limited to about 100 Mb/s (throttled at 50 Mb/s)
- 3.5 GHz Nominally Limited to About 50 Mb/s
- Very Inexpensive to Install / Manage / Operate
- Fundamentally Urban (Local) Limited

Point-to-Point Radio

- Is Synergetic with the Backhaul / Core Network
- Needs a geographic High Point for the Radio Base Station
- Has a nominal maximum (Line of Sight) range of about 40 km
- Ideal for less than 10 km and greater than 3 km
- Technology optimised for Non-Urban (beyond towns / villages)
- Limited to about 100 Mb/s (throttled at 50 Mb/s)

Geostationary Orbiting Satellite

- Not at all Synergetic with Australia's Backhaul / Core Network
- Technology optimised for Non-Urban (beyond towns / villages)
- Unreliable because of Weather / Fire / Smoke / Storms
- Construction / Launch / Management is all foreign Debit
- Needs Expensive Earth Stations to continually manage the Satellite Positions
- Long Latency totally Unsuitable for Telephony Use

Low Orbit Multiple Satellites

- Not at all Synergetic with Australia's Backhaul / Core Network
- Technology optimised for Non-Urban (beyond towns / villages)
- Unreliable because of Weather / Fire / Smoke / Storms
- Needs Very Expensive Earth Stations to continually manage Satellite Positions
- Construction / Launch / Management is all Massive Foreign Debit
- Short Latency is Suitable for Telephony Use

Passive Optical Network to the Premises (PON - FTTP)

- Is Synergetic with the Backhaul / Core Network
- Line of Sight is not a Transmission Issue
- Very Reliable Transmission - Unaffected by Weather Conditions
- Has a nominal maximum range of about 10 km
- Technology optimised for Urban (cities)
- Limited to about 100 Mb/s (throttled at 50 Mb/s)
- Fundamentally Urban Limited / Engineered
- Requires laying / trenching of Single Mode Optical Fibre
- Short Latency totally Suitable for Telephony Use

Active Optical Network to the Premises (AON - FTTP)

- Is Very Synergetic with the Backhaul / Core Network
- Line of Sight is not a Transmission Issue
- Very Reliable Transmission - Unaffected by Weather Conditions
- Has a nominal maximum range of about 60 km
- Highly Distributed Network Technology optimised for Non-Urban Rural Farms

- Limited to about 1,000 Mb/s (throttled at 100 Mb/s)
- Fundamentally Non-Urban Limited / Engineered
- Requires laying / trenching of Single Mode Optical Fibre
- Usual to Share the one Cable for Core and Access Connectivity
- Short Latency totally Suitable for Telephony Use
- Bi-Directional Speeds are Ideal for Rural / Remote Business

These dot-pointed Broadband Access Technologies are ALL the available range of choices to connect Premises so as to provide Voiceband (telephony) services once the NEC 30 Line 2 Mb/s PDH equipment is removed. Because this Request for Comments is focussed on Regional Remote telephone connectivity (i.e. Voiceband), it may be practical to provide a select mix of technologies at various locations to service a range of Homesteads / and Urban Premises.

Starting the elimination tree, Geostationary Satellite is out because it is extremely expensive (to Australia as all the construction and launch costs are "import costs") - and these costs are immense, and the ongoing maintenance is very expensive - and the infrastructure replacement life is short - typically less than 10 years. Also the reliability (compared to terrestrial services) is poor - and the latency is far too long for telephony "Voiceband" services.

The other nagging issue is that Australia has a lot is sunk telecommunications capital in the Remote inland area with the external plant (masts etc.) of the legacy DRCS infrastructure (including over $6 Bn to Telstra for minimum maintenance). Also there is a lot of SMOF cable in these areas that can be used to very inexpensively back-connect much (if not all) of this legacy Remote telecoms infrastructure. Further - most of this Remote inland external plant infrastructure is in good physical condition.

The Better Internet for Regional Rural and Remote (BIRRR) Facebook / Website[2] is ample proof that the Geostationary Satellite strategy was and still is an extraordinarily bad decision that was most probably driven by compromised / bribed politicians / executives and/or by (academic) telecomms engineers who had virtually no comprehension of Australia's inland Backhaul / Core network infrastructure.

In my professional opinion, the department would be extremely foolish to recommend / fund the use Geostationary Satellites and waste this useful inland Remote telecomms infrastructure - for a proven unsatisfactory and temporary result.

Next on the elimination tree is the Low Orbit Satellite and it is also out - because this too is also extremely expensive and all "import costs" and offers no advantages over the geostationary orbit satellite technology other than the latency may be considerably shorter than for geostationary satellite technology.

In my professional opinion, the department would be equally extremely foolish to recommend / fund the use Low Orbit Satellites and waste this highly useful inland Remote telecomms infrastructure - for a rather temporary and very expensive result.

Having for several years been heavily involved with telecommunications equipment specifications for the construction of Tenders - and for many years been in the evaluation of Bids from such Tenders; and also having

[2] https://birrraus.com/

specifically worked for over two years in a major international telecoms equipment manufacturing corporation as a Team Bid Manager (the other side) to "win" many Tenders - I would be totally unsurprised for (large) Corporations vying to win Satellite deals to provide very lavish (expensive) Dinners and tickets at major Sports events (Corporate Invitations) and major Artistic events / Travel for Executives / Directors / Ministers / Senior Department etc. in the process of formalised bribery / corruption to "stitch up" their winning of a Satellite-based telecommunications Tender.

Next on the elimination tree <u>could be</u> ADSL / VSDL technologies, which although the Digital Service Line Access Multiplexers are now quite inexpensive, would be using pair copper cables. The problem is that this Exchange Switching Area (i.e. the wiring in the villages) may be in a poor state of repair.

Generally most Regional Remote localities are arid and the pair copper cable is usually polyethylene insulated (with a nylon sheath) - so the chances of internally wet cables in these localities is usually rather low. (Internally wet cable has the effect of making that cable appear to be much longer than it physically is.)

This is a picture of a typical inexpensive Digital Line Services Access Multiplexer (DSLAM) that would be installed in a small SCAX hut in place of the aged NEC 30 line 2 Mb/s Line Concentrator. This is only 2RU (88 mm) high taking a minimum of racking space.

Each of the four horizontal modules most probably connects 50 lines - so this fully configured DSLAM would connect 200 premises - which is a good sized Village!

The problem with ADSL / VDSL is that the (downstream) speed is very much limited by the length of the pair copper cable from the SCAX hut to the Premises modem. In this Appendix 3 there is a chapter titled "**Physically Bonded Pair Copper for Long Distance ADSL**" that describes the distance limits of DSL technology, (and how this distance can be significantly increased).

On the top left of this picture is a row of RJ45 connectors that "talk IP" and one of these would be directly wired to the Router (in the same SCAX hut) like as shown near the start of this chapter.

Next worth serious consideration (and possible elimination) is GPON / BPON (Gigabit Passive Optical Network) technology, which although is very much urban based could have a real application in Regional Remote Villages and some "isolated" homesteads that have a SMOF cable running nearby.

In this Appendix 3 there is a topic "**Gigabit Passive Optical Network (GPON)**", that gives a basic overview of how this works and how it can be applied to in Regional Rural and Remote areas. It needs to be stressed that GPON (like all these access network technologies) rely on a low-latency IP-talking back-connection into the Core Network.

The advantage of GPON is that unlike point-to-point radio there is no necessity for line of sight for a connection - but cable has to be laid and really - it is excellent for Consumers but not good enough for Small / Medium Businesses that need a higher occupancy and equal upstream and downstream speed.

The next technology worthy of inclusion is Active Optical Network (AON) - particularly in Regional Rural areas and particularly with Homesteads.

In this Appendix 3 there is a topic "**AON Fibre to Rural Homesteads**", that gives a basic overview of how this technology works and how it can be applied to in Regional Rural and Remote areas. It needs to be stressed that AON (like all these access network technologies) rely on a low-latency IP-talking back-connection into the Core Network.

The prime advantage of AON technology over GPON technology is that AON delivers fast, reliable, bi-directional Broadband and this is exactly what Rural / Remote Homesteads into the future really need right now.

Because non-urban AON technology is highly distributed it can be configured to be highly reliable because its parent "Backhaul" network connections are usually from more than one geographically different source.

This technology will certainly have its place in low-latency Broadband connecting Rural Homesteads as the SMOF cable is almost always a shared Backhaul / Access arrangement that has massive economies of scale efficiencies that have been totally neglected in Australia for well over a century.

The next technology worth of inclusion is Point-to-Multipoint Radio - particularly in Regional Remote areas where line of sight is practicable.

The NBN Corp., which is already charged to provide Broadband access technology in and near urban areas - is now using 3.5 GHz Fixed Wireless surrounding Regional Cities and larger Towns instead of the highly troubled and extremely expensive SkyMuster satellite technology.

In Appendix 3 there is a topic titled "**NBN Corp and Fixed Wireless Broadband**" that outlines this technology and its application - and how it could be actively and economically used in and around several Regional Remote Towns / Villages - if the re-engineered DRCS units are rolled out to provide Backhaul connectivity that "talks IP" and not PDH!

In the past decade, the technology involved with Wi-Fi has gone through a rebirth where very inexpensive transceivers / antennae are now available that can connect an entire nearby village from a (DRCS) mast-mounted antenna. This is very similar to the technology used by the NBN Corp. where they use 3.4 GHz ad Wi-Fi is nominally 5 GHz for this purpose. Each premises would have a small parabolic dish or flat plane directional antenna to make line-of-sight connection.

In a similar mindset, the CSIRO researched and (I believe very partially) developed the Ngara point-to-multipoint Broadband[3] radio technology (circa 2011) - specifically for Regional Remote Australia. In Appendix 3 there is a topic titled "**CSIRO's Ngara Remote Broadband Project**" that outlines this technology and its application. It seems the department is blissfully unaware of this world-leading research (and early-stages of development).

This is a tragedy of circumstances where Australian Government Departments / Commissions / Organisations are working totally independently of each other and seemingly clueless of the synergies to be gained by these world leading innovations being actively developed, manufactured and used in Australia for Australia.

Another of the politically caused tragedies is the use of **3GSM / 4GSM** in non-urban Regional Rural / Remote areas. It is now taken for granted that people carry mobile devices wherever they go and whatever they do - especially people in the cities!

Radio Black Spots is a natural phenomenon caused by having radio base stations (RBSs) spaced out too far and/or having no back-connection into the District switch that is in turn back-connected into the Core Network.

This problem can be very inexpensively resolved by looking at the problem from the Farmers and Graziers view and not from the Corporate Urban Cities mindset.

Frankly, safety comes first and having 3GSM / 4GSM radio connectivity on a Farm is the first priority - which means that the whole spectrum auctioning process is a political mess that is very easily fixed for Regional Rural / Remote areas as described in Appendix 3 "**4GSM Base Stations for all Homesteads**". This problem was caused by compromised politicians and can be very inexpensively / easily fixed by politicians who put Australia before themselves!

Providing Low-Latency Broadband IP

Before 2010, “Voiceband” (as VoIP/SIP) had become a firm subset of “Broadband IP” and as such the Rural / Remote telecommunications network connectivity testing must therefore be entirely based around low-latency “Broadband” telecoms transmission and routing equipment technologies (and certainly not “Voiceband”).

With this updated low-latency “Broadband” mindset in place, not only is the design of the testing radically changed from “Voiceband” (telephony), but the engineering design of the network structure can be radically simplified / unified to provide low-latency “Broadband” at the Regional / Rural / Remote customer premises.

In other words, the test should be straightforward and simple – like calling the Telstra Speed test Website at: https://speedtest.telstra.com/ as this test will find the nearest main switch and back connect the nearest speed testing website, perform a downstream and upstream data speed test and measure the response latency – and show these on the screen.

These simple results can be recorded, stored, analysed and the resultant information used to determine the relative effectiveness of the Broadband connection and its appropriateness for the customer.

[3] https://csiropedia.csiro.au/ngara/

Homesteads are a special case where these are the Farm Management and Business Office, the Family Home, the Education Centre, and the Social Entertainment Centre.

These days Farm Management requires 100 Mb/s bi-directional Broadband, Education requires 50 Mb/s bi-directional Broadband, Social Entertainment requires 50 Mb/s Broadband and the Telephone is connected to the Broadband via an ATA (Analogue Telephone Adaptor) that is usually in the Router / Switch / Wi-Fi Head – in the Homestead premises – connected to the Customer Access Broadband Network.

There should be nothing wrong with setting up an active Website (or a Radio Station streaming source) out of the metropolitan areas – but these require very fast upload speeds and a virtually direct link to at least one or more Main Switches in the Metropolitan areas, and can have a traffic approaching 1 E at say 100 Mb/s.

With a basic understanding of the above area, it stands to reason that Broadband can come in several technologies and that optimally, the technologies need to best suit the customer premises.

Working down from the top, it should be obvious that all (non-urban) Homesteads and all major urban Business Offices should be directly connected with Single Mode Optical Fibre (SMOF), and have bi-directional data speeds at or exceeding 100 Mb/s.

If this access network component cannot be SMOF, then Homesteads / Businesses should be a direct and clear line of sight point-to-point digital radio capable of more than 100 Mb/s bi-directional over the necessary distance, the shorter the better.

The second tier is urban Business Premises Offices (in small Regional / Remote Towns and Villages). If there is no SMOF but there is pair copper cable and it is good condition, and shorter than 500 metres in total length, then VDSL is an economic and practical solution. This will provide in excess of 50 Mb/s and it is reliable and low-latency.

If good pair copper is not available then the second consideration should be point-to-point digital radio from a central high point to connect at 50 Mb/s or faster.

The third tier is the general Urban Consumers in (in small Regional / Remote Towns and Villages). If there is SMOF, then this is the optimum choice - but failing that; if there is pair copper cable, and it is good condition, and shorter than 500 metres total length, then VDSL is an economic and practical solution. This will provide in excess of 50 Mb/s and it is reliable and low-latency.

If good pair copper is not available then the next consideration should be point-to-multipoint digital radio from a central high point to connect at 50 Mb/s or faster.

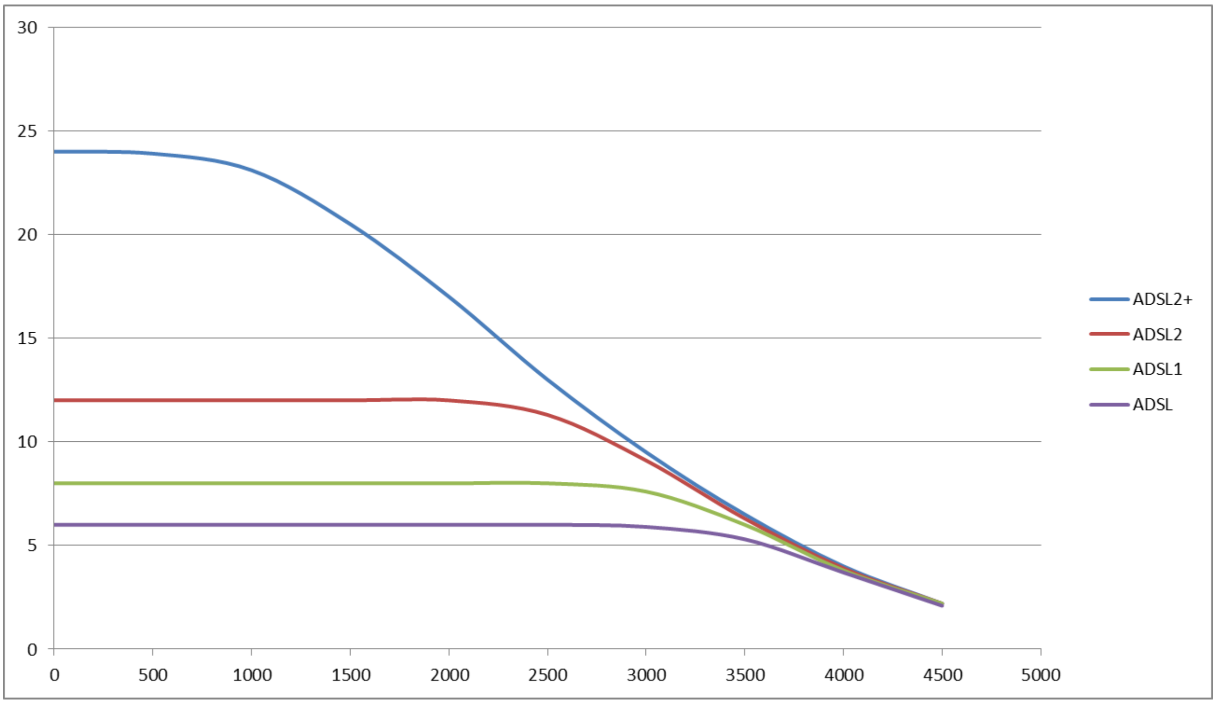
With the basic ground rules set, the next problem (which is much bigger) - is how to back-connect all these Towns, Villages and Homesteads with fast and reliable Broadband – considering the distances can often exceed 50 km between sites.

Physically Bonded Long Distance ADSL

The practical technology of ADSL emerged circa 1995 because of inexpensive Large Scale (analogue) Integrated (LSI) silicon chips that could do on a postage stamp, what previously would take a whole rack (and then some) of telecomms equipment.

Fundamentally ADSL uses the unused bandwidth on "Voiceband" telephone lines (engineered for 50 kHz maximum) from about 24 kHz to about 2,200 kHz. The upstream frequency band is about 24 kHz to 384 kHz and the downstream frequency band is about 384 kHz to 2,200 kHz. I often think of this as the analogy of racing F1 cars on dirt farm paddocks. It's ugly and it "sort of" works!

The nagging problem with DSL technologies is data speed - which its primarily determined by the length-dependent and frequency-dependent line attenuation - both of which have a monotonic relationship. So - the longer the cable the greater the attenuation. The higher the frequency the greater the attenuation!



With typical 0.4 mm diameter urban pair copper cable the ADSL2+ downstream speed of 24 Mb/s is noticeably not affected with cable lengths up to about 900 metres - see the blue line in the above chart. Beyond this nominal distance (on the X axis) the uppermost (downstream) frequencies are attenuated so much that they are received (at the premises modem) in/under the noise floor so the uppermost frequencies (i.e. 2.2 MHz and slightly below) in this bank of receiving sub-modems in the ADSL modem cannot work.

As the line length is increased, so too is the frequency-dependent attenuation also increased, so more of the upper frequencies are below the noise floor resulting in the downstream speed being significantly reduced.

With ADSL2 - see the red line above - (which has a maximum downstream speed of 12 Mb/s with a zero length line); its smaller bank of downstream sub-modems that extends to about 1,700 kHz. So ADSL2 keeps working at near full downstream speed of 12 Mb/s up to about 2500 metres before the upper frequency line attenuation is too great.

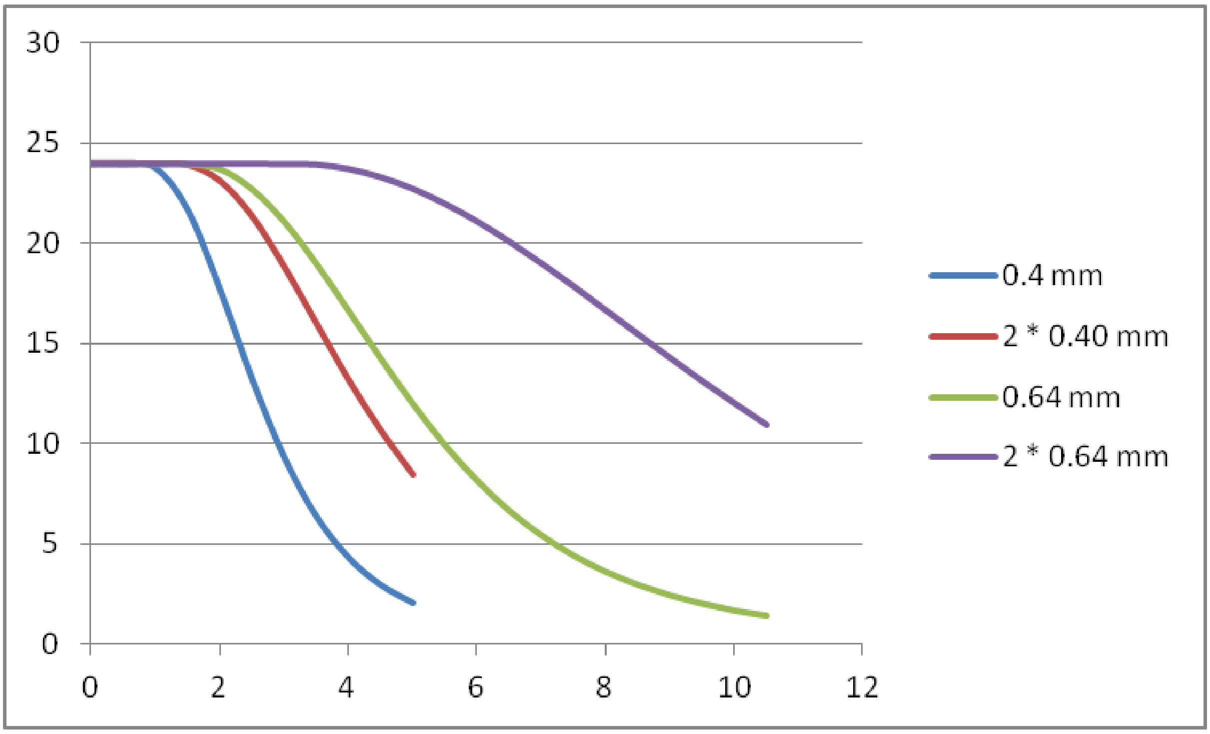
In Regional areas it was quite common to install 0.64 mm pair copper cable instead of 0.40 mm pair copper cable because the larger diameter cable wires have a much lower "loop" resistance, meaning that these 0.64 mm pair copper could be installed over a much longer distance (i.e. 10.5 km), where the urban 0.40 mm pair copper was limited to 4.1 km. This distance limit was initially set for telephone loop signalling purposes - not "Voiceband" transmission specifications!

One of my earlier theoretical studies (July 2015) was based around “physically bonded” pair copper for ADSL to get a far longer distance than otherwise considered.

In these situations where the Homestead is further than 4 km from the local exchange it was common practice to use 0.64 mm pair copper (instead of 0.40 mm diameter insulated pair copper) to keep the phone line’s series resistance component minimised (and be within signalling range).

One way to dramatically reduce line attenuation is to physically bond two pairs of wires in the same cable to form a single pair. The overall series resistance should be nominally halved per unit distance, providing substantially less insertion loss over the same distance. One of the intricacies of electrical transmission is that as the frequency is increased (above the "Voiceband" frequencies) the "skin effect" comes into play where most of the current flow in near the wire's surface. So, having a thick wire (with a relatively thin surface area compared to the overall cross sectional area) is not necessarily optimum for higher frequency transmission!

With a physically bonded pair, not only is the cross-section area doubled, but the wires' skin area is also doubled – and this is the wires surface that is used by ADSL frequencies (up to 2.2 MHz).



The chart above shows the theoretical downstream data rate for four different pair copper structures with a DSLAM2+ (24 Mb/s max) technology at the exchange / Node, connecting to the Premises ADSL2+ modem. On this chart; distance is shown on the X coordinate (in km) and the downstream data rate is shown on the Y co-ordinate (Mb/s)

In these examples, the pair copper is initially taken to be purely 0.40 mm pair copper (for urban up to 4,100 m) as the cobalt blue line or purely 0.64 mm pair copper for non-urban as the lime green line to a maximum of nominally 10,500 m.

The cobalt blue trace shows the typical 0.40 mm pair copper using ADSL2+ which is the urban standard curve.

The maroon trace shows the expected downstream data rate with two physically bonded 0.40 mm pair copper lines. The length is about 2,700 m before the downstream data rate falls to 20 Mb/s. (Un-bonded the 20 Mb/s distance limit is about 1,700 m.) By 4,600 m (way past the urban 4,100 m limit) the bonded downstream data rate is about 10 Mb/s. (Un-bonded the 10 Mb/s distance limit is about 2,900 m.) So – theoretically - pair bonding these 0.40 mm pair copper lines almost doubles the distance / speed ratio!

The next trace (lime green) is with 0.64 mm pair copper (common in non-urban areas), and it is slightly better than pair-bonded 0.40 mm pair copper)! The 10 Mb/s downstream distance limit is about 5,400 m.

With pair-bonded 0.64 mm pair cable (purple trace); by 4,500 m (i.e. beyond urban distance limits) the downstream data rate is still almost 24 Mb/s and by 8,500 m the downstream data rate is over 15 Mb/s. By 11,000 m the data rate is 10 Mb/s.

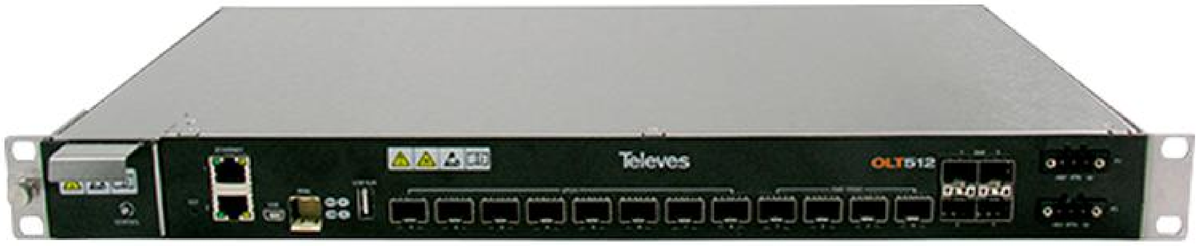
In theory this is fantastic, because this means that distant (up to say 11 km) Homesteads could have “excellent” Broadband (>10 Mb/s). One main problem is that because of privatisation, Telstra (seeking short-term profits) discarded/scuttled a very high percentage of their highly skilled field staff who could manage this variation with line jointing. So – in practice this cannot be done - unless the field staff are trained to have the skills to optimise customer service connectivity!

Fact is that many Homesteads have a spare pair of wires connecting right to the premises going totally unused, and I would be very unsurprised if many Regional / Rural / Remote situations have spare cable pairs all the way from the Main Distribution Frame (MDF) at the SCAX hut to the premises!

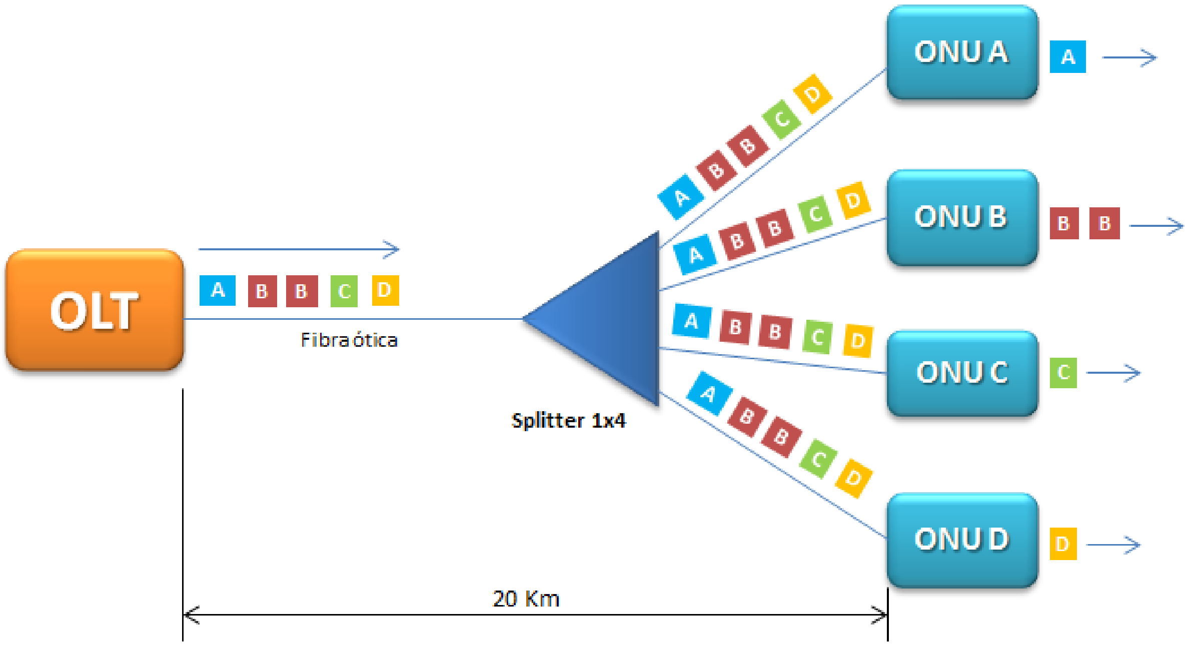
If the spare pair was physically bonded at the line side of the MDF, and at the terminating block in the Customer Premises, then this "spare" wire pair would be very gainfully used to provide a highly significant reduction in transmission attenuation which would in most cases relate as a significant increase in ADSL speeds.

Gigabit Passive Optical Network (GPON)

This (below) is a typical OLT unit that could be useful in Regional Remote Villages.



The technology of a Passive Optical Network (PON) is where there is an Optical Line Termination unit (OLT) is installed at the Local Exchange site (SCAX hut) and this OLT sequentially timeshares both the send and receive optical packets to a distant "Passive" Optical Splitter that is placed near a group of (urban) premises, and connects these premises with Broadband - as depicted in the diagram below.



The above diagram shows the common sequence of optical packets being sequentially transmitted from the OLT to the Passive Splitter (1:4 in this case) connecting to four premises. The sequential upstream path (from the premises to the OLT) is virtually identical but done at a different "colour" (wavelength). Usually the downstream wavelength is 1510 nm and the upstream wavelength is 1350 nm and this makes the optical separation rather easy.

The Optical Splitter (line the one shown on the right) splits the downstream light signal into 32 different paths to connect by fibre to 32 separate home units. It also combines the 32 upstream light paths into one stream that connects with the OLT (through a long SMOF cable).

This way the number of fibres connecting from the Node (SCAX hut) to the Optical Splitter is reduced from 32 to one.

The prime reasons why PON is used is that (compared to Active Optical Networks (AON)) the amount of racking space (and power) is minimised, and PON optimally / maximally uses the available bandwidth and time on the fibre cable.

Consider the OLT above has 8 SFP connections (centre of the front panel) and each of these SFPs connects through a long SMOF cable to a fully used 1:32 Passive Optical Splitter that then connects 8 * 32 = 256 nearby premises. This OLT uses only 1 RU (44.45 mm) in rack height! In other words, one of these OLTs could comfortably connect to a Village of up to say 256 premises.

Considering the power consumption at say 2.5 W per SFP = 5 W at the SCAX hut for the OLT heads! This is totally negligible.

The usual urban strategy is to have a 1:32 passive Optical Splitter near the premises clusters, but in Regional Remote situations this may be impractical as there may be a "cluster" making a Village of say four to eight premises.

In this case a 1:4 Optical Splitter will connect up to four premises and have much less attenuation meaning that the Village can be nominally 20 km away and still connect perfectly well.

The serious consideration is for localities that have poor quality pair copper cables and there is a Broadband availability (either by reengineered DRCS or by SMOF cable - talking IP) then - especially if line of sight is a problem - then PON technology should be very seriously considered and accepted.

GPON technology has a 1 Gb/s maximum downstream (in the main cable and the (32) premises would typically get better than 1/8 (over 100 Mb/s) on a shared basis.

In 2014 I considered the concept of utilising non-urban PON FTTP through the using existing SMOF spare fibres in IEN cabling that passes by / through farms and is near homesteads. That paper showed that the nominal 10 km limit (as provided in the Cost Benefit Analysis by McKinsey's) was really based on tight urban northern hemisphere demographics and really did not suit non-metropolitan Australia at all.

The fundamental problem in Australia is that when optical fibre was rolled out in the RRR areas this engineering was done in an austerity mode where SMOF cable with a minimum number of strands was trenched in – even though trenching was by far the most expensive part of the process (and the SMOF cable cost about 10% of the total project cost – and 90% of the cable cost was the cable sheath – not the fibres)!

Still, (1990 – 1993) was early development times with SMOF technology and 6 fibres seemed as an overkill even then. These days I would rarely consider anything less than 24 fibres (even 48 fibres) where the current 6-fibre cable now goes!

My theoretical consideration was that by reducing the optical splitter ratio from a close urban 1:32 to a lesser of down to 1:16, 1:8, 1:4, then distances of up to 40 km: e.g. from a Town located OLT to a remote SCAX hut in a village of say 16 or 8 urban premises can be connected at virtually nil cost by re-purposing the SMOF cable and making the SCAX hut a passive Splitter location.

Consider the situation of a SCAX hut in a village of 40 premises, 35 km from a town with OLTs in the local exchange site. Assume the optical attenuation is 0.43 dB/km and the optical budget is 24 dB.

At 35 km the SMOF attenuation is nominally 15 dB so the optical splitters will have to be 1:4 (6 dB attenuation) if this is to be done passively. This means there would have to be at least 10 fibres in the cable connecting the OLT in the local exchange to the SCAX hut. This is impractical - but a small OLT could be located at the Village SCAX hut and be back connected by two fibres (running nominally 1 Gb/s) and the 40 Village premises could be easily managed by four 1:16 passive splitters .

For a village connected through a SCAX hut at nominally say 20 km the SMOF attenuation would be about 9 dB. Using 1:8 splitters (9 dB attenuation) could be used providing 8 premises per fibre.

If the cable has a limit of 6 fibres, then the maximum village size would be about 48 premises and this would cover most small SCAX situations with no spare fibres. Again positioning an OLT at the village provides the facility to inexpensively provision PON technology.

The strategies considered here theoretically provided a rather inexpensive way to provide full Consumer Broadband connectivity to a large number of urban / Village premises located near SCAX huts in rural Australia.

These theoretical strategies involve the use of passive splitters with a much less splitting ratio than 1:32 down to 1:2 and no active components.

With a few farm homesteads in the way – it may be possible to extract an unused fibre from a nearby cable and insert a passive splitter (say 1:4) and from there connect four Homesteads. In theory this sounds plausible - but it is not practical as the number of spare fibres in the RRR cables is critically low!

With this understanding it became obvious that PON in non-urban areas is most likely impractical in Australia – primarily because there is not nearly enough spare SMOF cables in the ground in RRR areas, and certainly not near most Homesteads!

In any case - because SMOF is so inexpensive it would be bad planning to rollout a minimum fibre cable with no growth potential and almost all non-urban Homesteads will be requiring high upload speeds (as well as high downstream speeds) – so this really means that Active Optical Network (AON) technology is the way to go for the now and future - particularly for Regional Rural non-urban Homesteads.

AON Fibre to Rural Homesteads

When it comes to Farming and Grazing practices, the productive shift has vastly moved towards (live) electronic accounting and reporting. The value of this data is extremely high as this data can be analysed to pre-determine market trends and the performance of various crops / stock as they grow – not just at the saleyards, but for crop growths, seed trades and associated farming equipment sales / service.

Recent detailed Engineering studies (that I have done for the past three years) have definitively shown that Urban-based (centric) telecommunications Customer Access Network design templates and network structures that are universally used for telecoms network planning / deigning **have no place in non-urban RRR Australia**.

My detailed non-urban studies clearly showed that highly distributed networks are far more economic than centric (urban) structures. PON technology has its place in Urban situations because the premises clusters are very close and the Optical Headends are centralised, and the vast majority of the end users are Consumers.

The Active Optical Network (AON) is a very comfortable technology fit for non-urban Regional / Rural areas – especially where the Homestead spacing are less than 5 km apart. This topographic includes most of the “copper wired” non-urban areas in Australia, but can well extend into the Regional – Remote areas.

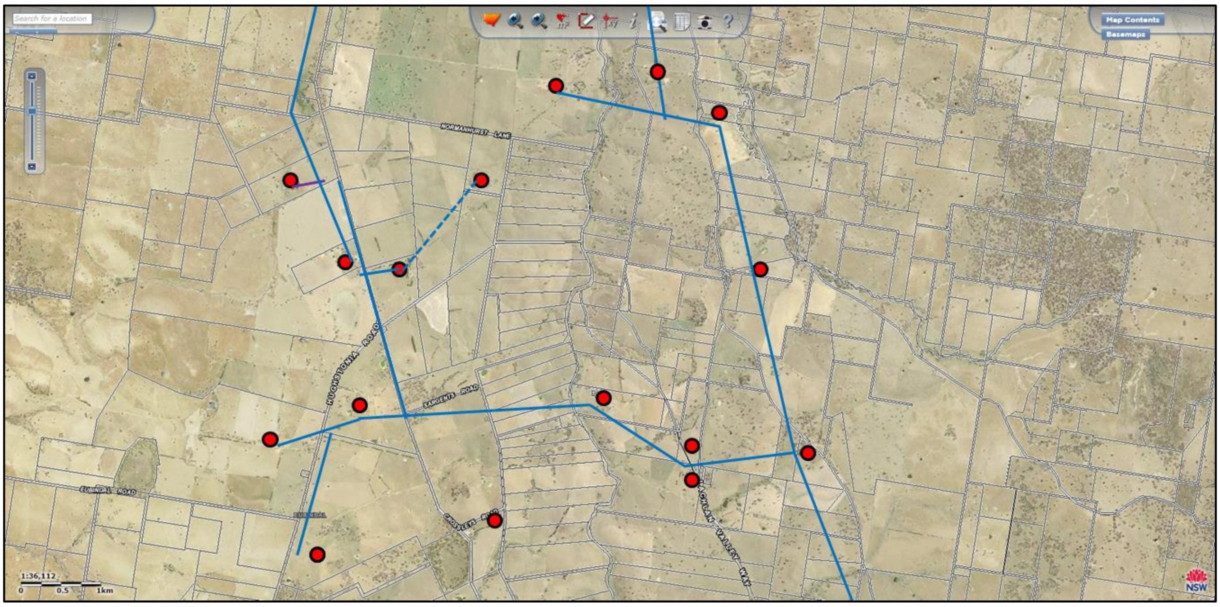
Basically AON technology uses a Small Form Profile (SFP) module at each end of the fibre and usually the SFP includes an optical splitter – so the one fibre has bi-directional transmission, and the transmission range is typically limited to about 20 km – which really suits distributed network structures, and keeps the cable fibre count down.

Like most well-engineered metropolitan networks, the non-urban aggregation network layer is a series of rather large intersecting loops that provides alternate routing to minimise network congestion and maximise reliability. My conception of the Australian non-urban AON based fibre network structure is unique and it took several months to optimise over several different non-urban rural areas.

These studies have included the non-urban areas involving several thousand Homesteads surrounding the areas near Boorowa, Young, Yass, Harden, Wangaratta / King Valley, high detail about the semi-rural area of Wamboin / Sutton / Bywong, non-urban King Island plus some more Regional Remote areas where the Homestead spacing really would benefit with point-to-point Broadband Radio connections – and/or connect on shared SMOF cable passing by the Homesteads.

Further, these studies have shown that a very considerable economy of scale can be gained in Regional / Rural areas (*because trenching is by far the most expensive network installation process*) by sharing the one Single Mode Optical Fibre (SMOF) cable (sheath) for both Core and Access Network transmission purposes for much of this SMOF infrastructure.

This partial map shows a Fibre to the Homestead (FTTH) network sub-structure that literally bypasses urban areas and picks up the Homesteads with (at least) 100 Mb/s bi-directional low-latency Broadband connectivity. Generally the SMOF cable would follow near a fence lines. Detail of the equipment is not included – but it should be rather obvious that the structure is certainly not the standard spoke-like star network that is all too common with industry-standard urban network structures.



For Regional / Remote areas where Homesteads are nominally spaced more than 5 km apart (to upwards of 70 km apart) these Engineering studies showed that point-to-point (Broadband) terrestrial Radio can far more economically provide highly reliable, low-latency Broadband connectivity over these longer distances.

The problem is that all too often the urban centric network designs are assumed without consideration that distances are great and separate Access Network and Core / Backhaul Network is a very poor economic consideration.

For over a century, the standard telecommunications design templates have physically separated the Access Network from the Core / Transit / Inter-Exchange / Backhaul Network – to be on separate poles, separate cables and in country areas to be even in different trenches. Yes, in metropolitan / urban areas it is common to have shared conduits – but separate cables.

After several decades in a very wide range of career paths in Australia's telecoms industry; it makes absolutely zero economic sense to me to have separate SMOF cables for Core network and Access Networks in non-urban areas.

During this three-year study of non-urban Broadband network infrastructure design; what started out with centralised nodes with many end users (as per standard in urban network structures) quickly showed itself to be very expensive in cable usage even though there was an efficiency of scale by having the Broadband equipment was centralised. Also, the network was not all that robust because when the central Node has a problem – everything as a problem!

Slightly distributing the Broadband Nodes to be smaller and with fewer end users significantly increased the Node count, and dramatically reduces the SMOF cable length and this necessarily brought with it significant economies. This did not really significantly improve the network robustness as the Nodes were still "too big"!

With the realisation that Homesteads are basically co-linear and (unlike that in Canada, UK, Europe and USA) set back from the roads, caused a radical change in cabling strategy with further significant economies, and then further distributing the Node structures resulted in a highly distributed and robust network structure that is effectively void of Villages and Towns – which could be connected as spurs from the main routes. This network structure is totally reversed to that in urban areas!

It is this type of Broadband SMOF (shared Access and Core) Network structure that needs to be rolled out in the Regional / Rural / Remote areas of Australia and capitalise / share the already in-place HCRC / DRCS infrastructure in place – if the masts, coax cable and antennae are in good enough physical condition.

The picture on the right is an inexpensive Optical Modem (as would / could be used an a Homestead).

The front panel shows an SFP slot (hole) for an SFP to plug into. The front panel also includes five RJ45 connections with the (blue outlined) socket being the WAN connection, the grey and orange outlets are the LAN connections. The Orange RJ45 socket includes Power On Ethernet (POE).

4GSM Base Stations at all Homesteads

In the RRR areas the radio spectrum usage and application is almost diametrically opposite to that in the metropolitan cities. All country cities and most large Towns have an urban-based Mobile device radio spectrum coverage, with a line of sight radial distance of up to about 10 km (typically much shorter and prone to a high number of “Radio Black Spots”.

All major highways and a high proportion of minor highways also have “along the highway” Mobile device coverage by the use of highly directional antennae.

From all aspects this RRR in particular Mobile Device spectrum rollout and usage is a really ugly arrangement as nothing “fits” comfortably – and it certainly does not fit the large majority of those in Farms / Stations in RRR areas!

It is essential that the Farmers and Graziers (small / medium businesses) that have the large land holdings (compared to the urban home sections) have 4GSM base stations at / near their Homesteads and not pay “rent” to the ACMA for spectrum usage.

This is a radical departure from the FCC driven "auction" mantra that the ACMA seems to have followed in blind political hypnotism (Refer to Appendix 4: "**Privatisation and the ACMA Debacle**"

The basic strategy is that most (Regional Rural) Homesteads will in due course be back-connected by Active Optical Network (AON) technology so that have a nominal 100 Mb/s bi-directional link with the commercial world.

Why? Because Farming and Grazing is becoming more and more driven be the Internet of Things (IoT) and this means that stock and crops (and the ground water etc.) will be tracked on a continuous basis - and communications will move from the "Voiceband" telephone to Hi-Res Video Conferencing - with group conversations. Also because the Homestead is no longer just a paper office and home but also an education centre, an entertainment centre and a electronic processing centre.

The Farm "Voiceband" Telephone will become a VoIP phone that is one step away from being part of an IP-PABX - which is another step away from having Wi-Fi IP Extensions and Wi-Fi connected Mobile Phones as extensions in and very near the Homestead / Woolshed / Garage etc.

By having Mobile phone as 4GSM extensions of the Homestead IP-PABX this means a Homestead located low-power (in most cases) 4GSM Radio Base Station / Antenna will provide 4GSM coverage over the Farm as the first instance and over the surrounding Roads in the second instance.

People "driving by" have Mobiles that are foreign to the IP-PABX. These Phones would be automatically through-connected via the IP-PABX and AON infrastructure to the POI and the call can connect as per any other Mobile connection!

This simple and straightforward non-urban 4GSM strategy totally transfers the funding of the “Radio Black Spot” Programme to financially assist non-urban Farmers / Graziers to have localised 4GSM Radio Base Stations and associated equipment at their Homesteads – who actually need and would use it as part of their everyday safety and work productivity / infrastructure!

4GSM Connectivity in Remote Australia

In a virtually identical mindset - with my proposed Reengineered DRCS transceiver units to connect and "talk IP" it is a very straightforward process to connect 4GSM Radio Base Stations and have these back-connected at the DRCS masts.

Currently the SCAX hut / Radio Repeaters at / near the base of these DRCS masts has either pair copper wired connection to the Homesteads – if within about 4 km, or analogue radio (usually with a non-directional dipole antennae mounted at the top of the DRCS radio mast) up to about 15 km. Either way, this seriously outdated telecoms equipment provides very basic “Voiceband” telephony connectivity.

Taking this mindset one step further; in Appendix 2 “**Re-engineering the DRCS**” shows that it is a very inexpensive option to provide a minimum of 350 Mb/s bi-directional IP connection linked by multiple DRCS towers as part of a (looped) backbone connection to the Core Network.

With a bit of rather innovative engineering (as demonstrated by the CSIRO several years ago in their Ngara backhaul[4] project - and there is precious nothing on the Internet about it) this part of the electromagnetic spectrum could be far better utilised to get in excess of 1 Gb/s (1,000 Mb/s) over 50 km distance (radio hops) and very inexpensively provide the imperative IP-based backhaul connectivity.

At the DRCS masts it would then be inexpensive to include a 1 Gb/s Router/Switch and connect by Fibre to the Homestead (FTTH), or (digital IP) Radio to the Homestead (RTTH) – either point to point or point to multipoint – and through this provide low-latency and reliable Broadband and have VoIP (telephony) and Wi-Fi connectivity in the Homestead for Mobile Devices.

Most Homesteads in Remote areas include a Radio Mast. The inclusion of a low-power 4GSM (somewhat) directional antenna and integral base station would provide Remote Stations with 4GSM coverage for up to 5 km around the Homestead.

In Towns and Villages, the large majority of premises are Consumers that require basic Broadband connectivity (nominally a minimum of 25 Mb/s, preferably 50 Mb/s).

Most urban businesses require nominally 50 Mb/s but some businesses that require large and fast file transfers (e.g. for artwork, 3D printing, data analysis, film and sound editing) may require much faster sustained speeds of 100 Mb/s (and more).

They need this data transfer to be bi-directional too – but this is not 24/7! Traffic density on Internet, Roads, Highways, Stockyards, Shopping Malls, Train Lines, Call Centres, Fire Escapes etc,. all use the same applied maths based on the Erlang (which is the normalised traffic route density), and (usually) the busiest period in the 24 hours is used as the base to work from.

[4] https://csiropedia.csiro.au/ngara/

NBN Corp and Fixed Wireless Broadband

In the past year, executives in NBN Corp. have finally bowed to incredible customer pressure in that the geostationary Satellite Service for Broadband delivery in Australia was an absolute and utter failure with gigantic internal costs and even bigger external costs to the Australian economy. (NBN Corp. would not see or be negatively affected by these external costs of a failing Australian economy partially caused because they are a sub-Government Corporation and not a sub-Government Commission). *Which idiots set NBN as a Corporation instead of a Commission?*

When NBN Corp. started with its politically locked-in Satellite rollout, this 3.4 GHz point-to-point radio "Fixed Wireless" technology was in its evolution stages, and recently (by about 2018) it really matured.

NBN Corp. engineers had long recognised the necessity of Fixed Wireless Broadband where pair copper is far too long for VDSL (500 metres), a more Remote FTTC Node is not economic, and the politically driven / locked-in SkyMuster Satellite infrastructure was already far too congested, far too expensive, and far too unreliable. Also the high latency of geostationary satellite technology made SkyMuster totally unsatisfactory for "Voiceband " telephony.

Engineers in NBN Corp. knew full well that 3.4 GHz Fixed Wireless would have been a far better strategy than Satellite, but the NBN Corp. was already well entrenched into using Geostationary Satellite, and they could not pull out of this contract.

The NBN Corp. are now using 3.4 GHz for fixed Wireless connectivity in a similar manner as analogue radio connects from DRCS masts (to directly connect Homestead premises in Regional Rural areas.

The NBN Corp. 3.4 GHz equipment has a typical maximum range of 10 km and can be pushed as far as 14 km (but the data rate will be rather limited – because of the limited Signal to Noise Ratio (SNR)).

NBN Corp. are actively rolling out 3.5 GHz Fixed Wireless based around Regional Cities and Towns to Homesteads with a roof / gutter line of sight to the central NBN Masts / Antennae.

This Fixed Wireless technology that is now connecting a large majority of Homesteads within 10 km of most Regional Rural Cities and Large Towns will take a significant traffic (congestion) load off the high-latency SkyMuster geostationary Satellite service.

The standard (NBN Corp.) practice is that the Homestead has a roof-mounted 3.4 GHz plate Antenna / Transceiver (directly facing line of sight with the Radio Base Station). The Transceiver is externally powered from the wall-mounted Connection Box that includes a Router Switch (with four RJ45 ports). It is usual to connect a LAN Router/Switch/Wi-Fi/ATA Unit with a short Cat5 cable and connect the standard analogue telephone to the ATA port.

> *Note that (as stated before): Homesteads are a special case where these are the Farm Management and Business Office, the Family Home, the Education Centre, and the Social Entertainment Centre. These days Farm Management requires 100 Mb/s bi-directional Broadband, Education*

requires 50 Mb/s bi-directional Broadband, Social Entertainment requires 50 Mb/s Broadband and the Telephone services too.

With consideration that the now very aged DRCS equipment is reengineered to "talk IP" it would be very straightforward for the NBN Corp. to continue through the inland Remote areas and install Fixed Wireless technology using the DRCS masts for the Fixed Wireless base station antennae in place of the telecommunications equipment to minimise the cost of this technology rollout.

CSIRO's Ngara Remote Broadband Project

Circa 2012, the CSIRO explored an ambitious project (called Ngara) to provide Broadband connectivity to the Regional Remote areas of Australia (providing there is line of sight).

My very limited understanding of this project was that it uses the UHF TV band about 700 MHz as antennae are readily available and with frequencies in this range it can be quite directional and distance is virtually limited by the horizon (which is about 50 km in the Regional Remote areas).

Without being limited to TV channel widths (nominally 7 MHz only in Australia) the send and receive bandwidth could be quite wide and by using recently developed Phase Amplitude Modulation (PAM) techniques provide upwards of 50 Mb/s and by another in-house time sharing process be bi-directional too.

This picture[5] shows the prototype of the radio base (with a ring of vertically-oriented dipoles. Basically these transceivers included co-ordinated phase shifting so that the beam from/to the ring can be automatically focussed to several homesteads in many different locations and in this process provide optimum signal connectivity for every

[5] https://www.engadget.com/2010/12/20/csiros-ngara-internet-transmission-project-begins-in-tasmania/

homestead and minimum signal connectivity to areas where there is no Homestead Ngara equipment - and the maximum range is about 50 km.

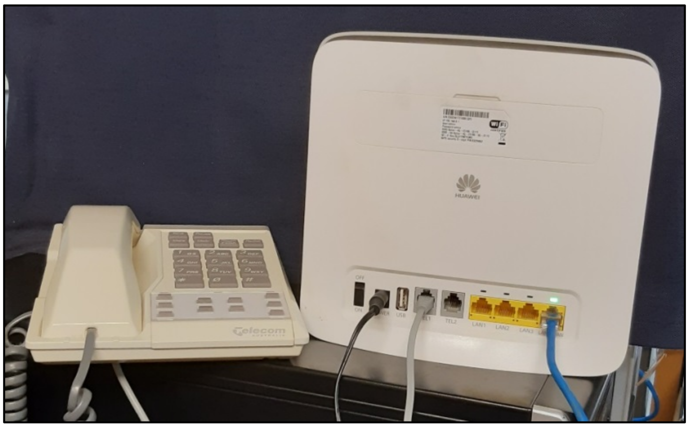
At the Homestead, the equipment is a basic UHF TV antenna and associated radio / Broadband equipment (as per any point-to-point Wireless / Modem) - and the Local Area Network (LAN) connects behind that. So - yes - you could connect an ATA to the LAN and have a "Voiceband" fixed access low-latency Telephone connection, and with Wi-Fi on the LAN you can use your 4GSM devices!

My understanding was that this Ngara prototype was trialled in Smithton in the north-west of Tasmania and worked very well - then everything went very quiet...

A few years later I heard from another person that they (CSIRO Ngara team) were pushing to roll out this Ngara technology in the Kimberley area but were stifled because (apparently) Telstra had no spare fibres on its Darwin - Perth cable. It seemed that Telstra were very uncooperative - which to me was no surprise - because this technology could have meant the death knell of the USO "Gravy Train" (see Appendix 4 "**Business, Politics and Gravy Trains**").

Broadband VoIP at the Homestead

In the early 2010s, not only were businesses fast changing over to IP-PABXs and Mobile Phones and Laptops, but home premises had ADSL (or Cable Internet) and a reasonable proportion of these home premises had an ADSL Modem with an ATA (Analogue Telephone Adaptor) included in the (Modem) Router / Switch / Wi-Fi head – see below left.



The above left is a typical “Optus” ADSL2+ Modem / Router / Switch / Wi-Fi and ATA (Analogue Telephone Adaptor) – and a USB connection!

In this case the blue Cat5 cable (from the premises modem) is connected to the Wide Area Network (WAN) port, leaving three other Local Area Network (LAN) ports for other connections e.g. Printer / TV / Computer etc. and the grey RJ12 connector is the ATA interface connecting to the T200 analogue phone on the left.

3GSM/4GSM Mobile Phones in range of this Wi-Fi head can connect to the Wi-Fi (with the password) and can be used as a standard Mobile Phone – without having to be in the range of the 3GSM / 4GSM Radio Base Station’s reception area.

This concept of premises Wi-Fi connectivity to a mobile phone radically mind-shifts the problem of being in a “Radio Black Spot” area – providing the broadband connectivity is low-latency and reliable!

For ADSL / Cable / Radio / Wireless / Fibre Modems that do not include an ATA interface for the analogue “Voiceband “ telephone, there is a special ATA Adaptor (above right) connected to their Local Area Network (LAN) – as shown with the Cat5 blue cable and their plain old “Voiceband” telephone connected directly to the ATA via the RJ12 connector and Grey cable!

The Broadband / VoIP “Voiceband” interface is in the ATA Unit.

The other “Killer Application” was that of PABXs, where the VoIP/SIP is routed in the IP-PABX (directly from the Broadband connection to the Local Exchange Broadband interface).

The Extension Phones all have the SIP/VoIP interface and the user uses the extension phone as though they would any wired phone (and this extension phone has a screen and looks / feels like any other PABX / Commander phone)!

Instead of the PABX being a whole rack or more of telephone line interfacing and switching equipment, the PABX is a (very) small Personal Computer (PC) with a Power On Ethernet (POE) Internet Switch on it that externally powers the IP extension phones! It is really that simple.

This picture outlines the minimum “Voiceband” communications for Homesteads. On the left is the Broadband Modem / Router / Switch – which would (with Cat5 cable) be connected to the 16 port Power on Ethernet (POE) Switch so that several IP extension phones (like the one on the right) can be located about the Homestead.

The little board in the middle is a Raspberry Pi (micro-computer) which can be programmed to be a complete IP-PABX so any extension can call any extension – and call out and receive calls from beyond the Farm.

Further, because the Modem has a Wi-Fi head, so that 4GSM Mobile Phones when in Wi-Fi range (or Homestead 4GSM range) can also directly connect with the rest of the world, and they too can be made to be part of the IP-PABX extensions and make “internal” calls.

With an ATA interface then there is nothing stopping the old pre-existing analogue “Voiceband” phone from having phone from also being used!

For business, education and social purposes this Broadband facility would enable high quality low-latency Video Conferencing, fast Video Streaming, TV reception via Broadband Streaming, Radio Reception via Broadband Streaming and the liberal use of Secure / Shared data resources and Storage backup.

A high percentage of home premises use multiple “hands free” extension phones like those pictured on the right.

The base station is a standard analogue Telephone interface – so it can plug in directly to the standard phone line or plug into an ATA interface (as is standard practice with the NBN Corp removal of the Analogue Telephone “Voiceband” line and replacing that with a Broadband connection into the premises).

These “hands free” phones connect to the Base Station using 2.4 MHz Wi-Fi technology (just like your Laptop).

The picture on the right is Telstra’s LH1000 Router / Switch / Wi-Fi, ATA Broadband interface Unit.

The Broadband connection comes from the Modem (Fibre / Cable / VDSL / Fixed Wireless etc.) through the red RJ45 cable and connects via the Home / Office Local Area Network through both the Yellow Cat 5 cable and Wi-Fi to: Computers, Tablets, Mobile Devices, Printers, TVs, Data Storage, Point of Sale, Cameras, Security, Farm and Grazing Process Recording Devices, etc.

Note the fawn cable at the bottom right is the RJ12 ATA interface connection to the telephone (like the ones above). Just above that connection is a small plastic cover that hides a plate that secures a miniature SSD memory card – just like in your Mobile Device – that associates the Phone Number to the Broadband device (in this case the ATA interface in this Broadband interface unit).

With (so to speak) “the writing on the wall” several years ago from the 3GSM rollout, the entire (fixed access) telephony infrastructure was, by at least 2010, back-connected by “VoIP / SIP” interfaces at the Local / District exchange sites – including the now very out-dated DRCS / HCRC infrastructure!

So – the 2 Mb/s PDH DRCS / HCRC technology is a brilliant though extremely outdated technology and the analogue (“Voiceband”) telephone connection is to all intents and purposes well and truly a firm subset of “Broadband”!

In line with this telecommunications technology transfer towards unified IP – with the rollout of the (Internet-based) Access Network infrastructure by the NBN Corp. in major urban areas and other Carriage Service Providers (CSPs); the premises-located Analogue Telephone Adaptor (ATA) has become part of the premises interface equipment to interface the “Voiceband” telephone to “Broadband”.

Providing “Voiceband” is very out-dated and totally inapplicable in today’s telecommunications environment (and was since before 2010). That said; it is imperative that as much of the existing telecommunications DRCS / HCRC infrastructure that is in good physical condition should be innovatively re-utilised to minimise the projected costs, maximise the service coverage and be re-utilised as a prime long-haul Broadband connector for the Regional Remote areas in Australia.

The technology that I am proposing here is particularly versatile because the Broadband signal connecting the Transceiver / Antennae is via SMOF cable and therefore very rugged, and can be trenched in for several km if necessary, and can connect to a variety of topographic situations:

- For a Homestead this can be a direct fibre straight into Fibre Modem – Router switch as shown above.
- For a Small Village / Homestead this could be an Active Optical Network (AON) with the Optical Switch somewhat centrally located.
- In a similar mindset, an out-posted Homestead (up to about 10 km) could be point-to-point Broadband Radio (optical back-connected at each end).
- For a Small Village / Homestead Cluster this could be the direct fibre into a small FTTC VDSL arrangement (if the pair copper is in good condition) – this is not recommended.

With the massive advances in telecommunications and electronics since the late 1970s when the concept of DRCS was seriously considered (including the now very widespread use of Single Mode Optical Fibre (SMOF) from the late 1980s in almost every telecommunications situation; the innovative and synergetic combination of these two technologies can now provide very inexpensive Broadband connectivity in Rural and Remote areas far more less expensively than ever before considered.

Appendix 4 - Business, Politics and Gravy Trains

Davidson's USO Gravy Train

In 1969, Chile had immense telephony costs because the then Bell Telecoms owned about 80% of the Chilean telecommunications infrastructure and because telecommunications is an essential (not discretionary) service; Bell overcharged as much as they wanted to. The Chilean Government moved to significantly reduce the end user costs of telephone / telecommunications infrastructure by nationalising this “Utility” (as very euphemistically termed in the USA to discreetly soften the critical meaning of “Essential Product/Service” to make it appear as "Discretionary").

Bell executives contacted USA President Nixon who wasted no time in engaging the CIA, who in retribution stopped Chilean international trade, grossly devalued their Peso causing rampant inflation that wrecked the Chilean economy and installed the CIA's puppet President Pinochet to let Chile sink.

The USA being in an extremely powerful world position, then instructed the IMF, WTO etc. that all western economies will privatise their infrastructures or face the same economic scuttling / trade isolation as was given to Chile - leaving it destitute.

Over the next 20 years all western economy countries quietly and carefully moved to privatise all their infrastructures - but the race was on with telecoms infrastructures.

The Commonwealth of Australia was set up as a **common wealth of national infrastructures** and this external / international policy went directly against the prime directive of the Commonwealth’s prime initiative in building Australia’s economy.

In Australia, the Post Master General’s (PMG) Department was the holder of several portfolios including telecommunications. In 1975, the PMG was split up and made into several Commissions. (*In my opinion was an excellent move as many of the bigger business decisions (e.g. land transactions, contracts etc.) no longer had to be Acts of Parliament that would take several months, if not years, to be passed.*)

From here, the private sector corporate greed could not be contained and moves were made to discreetly privatise parts (if not all) of Telecom Australia Commission – at immense expense and damage to the Australian economy. (QED the NBN cost.)

The problem was that at that time Telecom Australia Commission was world-wide revered as having one of the best telecoms infrastructures on a large land mass.

In 1980, the Davidson Inquiry was specifically set up to introduce a telecoms sector on the Australian Stock Exchange (ASX) so that substantial financial investments (e.g. superannuation / personal wealth) could be spread into this new sector.

To do this, the then Australian Telecommunications Commission would have to be deliberately broken up (and lose its massive economy of scale efficiencies), leaving pieces be privatised, an opposition telecommunications infrastructure would be established (Optus) - using a large chunk of the then PMG infrastructure - and allowed other telecommunications corporations to “compete” for telecoms services inside Australia - at expense to Australia's economy.

> *There is a fundamental economics irregularity here (check with Adam Smith) in that Economic Competition only works with Discretionary Products and Services. When it comes to Essential Services there is no*

limit to what the population will pay for Essential Services and this is why there is extortion and war until death to have Essential Services (Utilities).

This is why Essential Services must never be in the hands of the Private Sector – and why the Australian Commonwealth was specifically set up as sub-Government infrastructures and not in the private sector. This is why Australia's economy is slowly dying because the excessive end user costs of these privatised infrastructures (electricity, water, roads, telecomms, etc.) are killing Australian industry / manufacturing and innovation.

At this time (1980-1982), the technology of long distance Digital Radio Concentrator System (DRCS) - Voiceband telephony was being trialled as "proof-of-concept" in the Regional Rural Remote (RRR) areas with excellent progress. Telecom Research Labs had also been working for several years on the "pipe-dream" concept of Single Mode Optical Fibre (SMOF) technology - but without any success.

In the Davidson Report (1982), the term “Telecommunication” was interchangeably used with “Telephone” because by far the prime telecommunications product was analogue "Voiceband" telephony with fixed access services. Mobile phones were in their infancy and telegraphs / data were largely replaced by Fax technology - using the analogue "Voiceband" telephony circuits - as did Dial-Up modems for connecting through to "Bulletin Boards" - the predecessor of Websites! Management hierarchy was almost entirely built around the number of Telephone services being “managed”.

The (1982) Davidson Report:

- Bemoaned the “tyranny of distance” as being a killer for privatisation.
- Made no mention that a considerable proportion of the telecoms revenue would be diverted from building new infrastructure to go into shareholder dividends at massive expense of the Australian economy.
- Welcomed the situation that new Digital (telephone) Switching technology was starting to show signs of proving to be extremely reliable (and required virtually zero maintenance costs).
- Recognised the considerably Marketing efficiencies (i.e. new products) will be gained by using Digital Switching and electronic (not manual) processing.
- Identified that the current (telephone-based) transmission network was almost entirely structured around relatively high maintenance analogue (telephone) transmission technology.
- Welcomed that Digital (telephone) Transmission (based on Plesiochronous Digital Hierarchy (PDH)) was also in its baby steps and was looking extremely promising and be very low (zero) maintenance.
- Saw that virtually all business (commercial profits) were then based around Fixed Access Plain Old Telephone Services (POTS).
- Recognised there was a very small Sales Portfolio based around the POTS.
- Visioned that a possible future Mobile Phone service that may parallel POTS as another product range.
- Recognised that DRCS / HCRC and Satellite telecommunications infrastructure was very expensive – but had to be funded because of previous legal telecommunications agreement to service RRR areas and Islands etc.

- Pressed for the inclusion of the “Universal Services Obligation” (USO) annual payment (starting at $170 M) from the Federal Government to more than cover the costs of the established legal telecommunications agreement.
- Identified that there were other markets (e.g. Pay TV, Mobile Phones, Data Services etc.) that "competitive" telecoms could move into.

This Inquiry / Report was (in my professional opinion and lived-experience) a highly fraudulent and deliberately deceptive treasonous tool with the sole intent of facilitating the privatisation of Telecom Australia Commission – so that “rivers of gold” that flow through the financial channels for infrastructure rebuilding processes could be diverted into Shareholder Dividends and to obscenely overpaid executives – at the expense of Australian Productivity and Australia’s Economy.

Following the letter of the law - not the spirit of the wording in the Report; the term “Telephone” was taken literally and the Universal Services Obligation (USO) funding was focussed at funding the Rural / Regional / Remote (RRR) “Telephone” (not “Telecommunications”) service operational costs – with the assurance that the USO figure must always exceed the RRR "Telephone" service overheads (to keep the **$170+ M pa “Gravy Train”** rolling into Telecom Australia Corporation / Telstra).

The word "maintenance" in infrastructure business terms means "proactively maintain and upgrade" but in competitive business terms "maintenance" means "reactively repair" (i.e. do as little as possible and avoid any responsibility).

This “Gravy Train” would justify privatising the Telecom Australia Commission, so that this infrastructure could be put on the Australian Stock Exchange as a prime Telecom Sector security, and run highly profitably without any major complaints or further high level Inquiries)! Well that was the very short-term thinking!

Also, circa 1981, internal plant operational (wages) maintenance costs then far exceeded the cost of the electromechanical switching equipment: using Step-by-Step and Crossbar switch technologies. The cost of analogue long-haul transmission equipment using transistors and thermionic valves in Frequency Division Multiplex (FDM) although large, was small in comparison to the full-time maintenance required to keep this equipment operational.

From the late 1950s, the inclusion of polyethylene insulate pair copper wire in the Access and Inter-Exchange network dramatically reduced maintenance requirements but the earlier paper-insulated lead sheathed cable still required skilled maintenance.

Telecom Australia already experienced very low maintenance overhead costs with Plesiochronous Digital Hierarchy (PDH) transmission through the DRCS programme that started in 1978 and the 2 Mb/s "Megalink" / ISDN was fast becoming a very popular business connection technology with Indial circuits for PABXs (and for Bulletin Boards). At the remote Village sites, the DRCS uses an NEC 30 (telephone) line to 2 Mb/s PDH interface - which was also virtually zero maintenance.

In 1980, Telecom struck a massive contract with LM Ericsson to manufacture the Ericsson AXE PDH-based digital switches to replace millions of Step-by-Step and Crossbar electromechanical switches that interfaced with analogue telephone line circuits in many hundreds of Local Exchange sites. This technology had its teething problems but after that was virtually zero maintenance.

The Davidson Report drew a very long bow to foresee the pipe-dream technology of Optical Fibre (if realised), may significantly reduce the cost of long-distance transmission. This Report simply did not foresee was that the technology of Single Mode Optical Fibre (SMOF) would have an astoundingly low attenuation per unit length compared to all other comparable transmission mediums - and far less expensive to manufacture. Appendix 2 "**Optical Fibre is Very Economic**" covers considerably more on this topic.

It was not until early-1986 (when SMOF started to be mass manufactured in Australia) that the synergy of SMOF and PDH (for inexpensive and reliable long-haul transmission) and AXE - and Nortel DMS100 (for telephone circuit / channel switching) that resulted in the cost of telephone calls becoming far less expensive.

From 1978 to 1990 Telecom Australia had invested about $407M into the DRCS / HCRC technology of the long-Backhaul transmission telephone network in Australia's Regional Remote areas. Almost all these sunk costs were in very high radio masts, necessary for point-to-point radio transmission at nominally 1.5 GHz (the "L Band) over 45 to 60 km radio hops.

By 1989 the private sector was in for their kill to privatise Telecom Australia Commission!

When the new Telecom Australia Corporation was founded in 1989 this discreet $170 M pa USO “Gravy Train” was implemented and this lopsided Federal funding gave a deliberately false (higher) value of TLS on the ASX at the continuing expense of the Federal Government (and at the expense of the Australian economy).

It seems the department who is responsible for checks and balances of the USO "Gravy Train" never really addressed this issue for over 30 years.

In the meantime, it seems to me that the department (of Communications and the Arts) executives have sat there for decades like stool pigeons in a carnival sideshow; totally asleep at the wheel while there have been at least 14 Select Senate Inquiries, the massive “Networking the Nation” multiple project funding fiasco, at least three (totally useless) Regional Telecommunications Reports, at least three totally failed “Rural ADSL” Initiatives, at least three ACCC Inquiries about ADSL not working in competitive hands and at least one PC inquiry on ADSL marketing issues, a departmental Inquiry about Broadband that fizzled, a gutless and misguided decision to not separate Telstra, and four massively expensive NBN rollouts to hide and pay for the gigantic economic mess caused by privatising Telecom Australia Commission.

The department does not have to look at all far (e.g. Networking the Nation, ACCAN, Farmers Federation, BIRRR, CWA, and a plethora of Senate Inquiries, some ACCC Reports and PC Reports, Regional Telecommunications Reviews, etc.) to realise that since about 1993 Australia’s terrestrial inland Regional Rural and Remote (RRR) telecoms infrastructure has not advanced to integrate Broadband technologies that elsewhere have very economically replaced analogue "Voiceband " with VoIP/SIP.

From my several decades of practical and professional experience with Australia’s telecommunications infrastructure it is painfully obvious to me (and others like me) that the problems of Voiceband communications were resolved before 1996.

Technology has moved on and all end users demand low-latency High Speed Broadband and because Australia’s telecommunications infrastructure was privatised for corporate greed, the big losers were the “Cost Centres” i.e. Regional, Rural and Remote areas. Much of this is outlined in this Appendix.

Had the Davidson Report included External Accounting to show the massive GDP income from Farmers and Graziers then the true value of non-metropolitan customers would have been recognised and there is no way that Telecom Australia Commission’s infrastructure would have been privatised (but the retail sales and marketing part would nevertheless have been privatised - but for a far lesser sum).

The way I now read this “Voiceband trials for DRCS / HCRC customers” tells me that the department is (at least) way out of its depth with virtually zero in-house telecom experienced engineers – and the department has been told (by the Treasury?) that the USO “Gravy Train” will be stopping. Now, the department has conceived Farmers and Graziers need a better Telephone service? That was 1975…

It is now 2020 and RRR Farmers and Graziers desperately need low-latency, fast and reliable Broadband (which they are not getting from the satellite fiasco).

My gut feeling is that Telstra wants the dying “USO” Gravy Train to keep rolling in but is desperately looking to jump ship to the “Radio Black Spots” Gravy Train ASAP.

Australia's Privatisation Mess

After the stooge Davidson Report (1982) that “facilitated” the Telecom Australia Commission to be (force) privatised in 1989; Australia was also stripped of its very high Economy of Scale network infrastructure.

Australia also lost a huge amount of productivity and Gross Domestic Product, and Innovation, Manufacturing and Export Sales, and lost collateral business efficiencies (particularly in the Regional, Rural and Remote areas) through enforcing (telecommunications) infrastructure competition - and then some after that.

> *You will not read about this in (western) economics because it flies in the face of the “Competition is good – greater Competition is better” mantra – which only works if you are the arms (equipment) suppliers (with all the money).*
>
> *To add insult to injury to the Australian Economy; the Productivity Commission (PC) and the Australian Consumer Competition Commission (ACCC) were also set up as “Right Wing Economic Police” to enforce increased competition outside the Adam Smith defined “Discretionary” goods and services – into the “Essential” goods and services; resulting in our Australian economy being crippled by “Infrastructure Competition” and its highly uneconomic overheads – to make the privatisation of infrastructures “look efficient” for the financial greed of a very few!*

There is an absolute avalanche of readily available evidence in the form of telecommunications discussion papers (like this one) / inquiries / reports that are like child’s pantomimes; where the on stage policeman is continually looking the other direction and cannot (will not) see the villain. In every case, a major problem is finally noticed and cannot be avoided, so the curtain as again drawn…

Here are some of many examples: Networking the Nation (circa 1999), more than 14 Select Senate Inquiries into Telecommunications (1999 – 2015), 3+ Regional

Telecoms Inquiries, multiple Productivity Commission (PC) Inquiries into Telecommunications, multiple ACCC Inquiries into unsatisfactory ADSLx performance and marketing. NBN Version 1, 2, 3, 4, 5. There are many more.

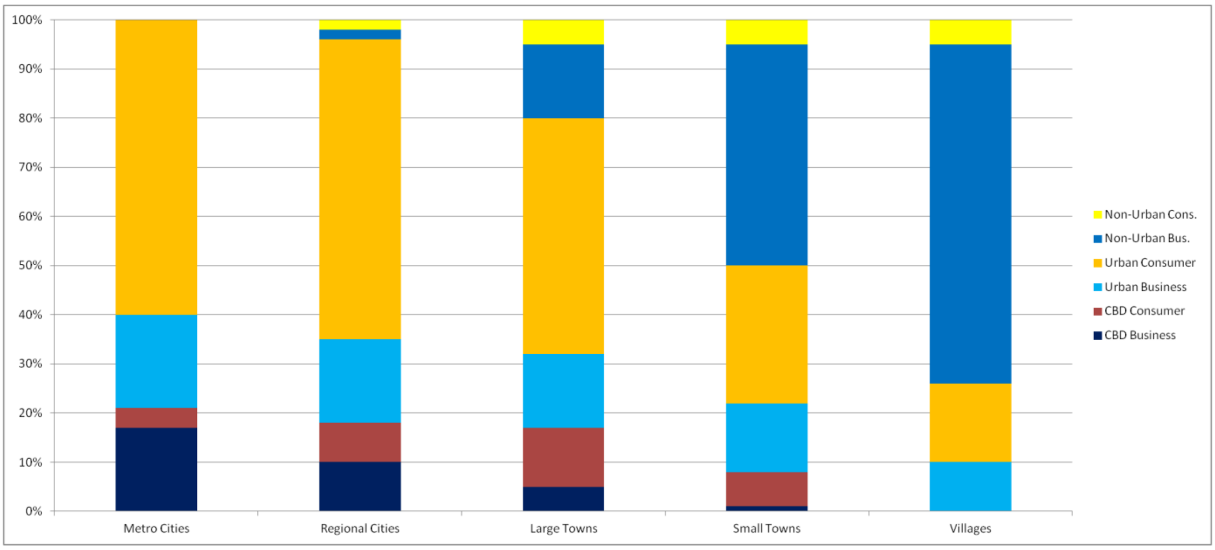
Competing telecommunications companies certainly do not have the economy of scale for purchasing (so the same equipment costs Australia considerable more) and cannot have themselves at the front of an equipment manufacturing production programme (so the equipment supply is considerably delayed) and also cannot have the level of engineering support that (so they get the engineering trainees without years of invaluable experience and in-house knowledge, and “fixes” come weeks ,if not months, late) compared to the massive telecoms infrastructures.

> *How do I know this? Because after 30 years in Telecom Australia / Telstra as a Technical Officer and later as a Transmission / Network Specialist Engineer with a very wide knowledge and expertise about most of the transmission and switching equipment infrastructure in Australia – and I became the National Voiceband Transmission Specialist (before being made redundant in 1996/7) primarily because our senior executives didn't know what Broadband was!*
>
> *I then worked in Nortel Networks 1997 – 1999 for two years as the Bid Manager in the Alternate Operators area, but I associated with the Telstra and Optus Engineering / Sales and Marketing teams. This personal lived-experience gave me an incredibly large knowledge-base on how Competitive Business mindsets in infrastructures totally wreck very well-structured and highly efficient Infrastructure Businesses.*

The fundamental (politically caused) economic problem is that Telstra Corp. is a Private sector corporation, and the NBN Corp. is also a corporation - so naturally, these two corporations are fighting against each other - not co-operatively working with each other - and the outcome is that Australia's economy is being shredded!

Wrong Non-Metropolitan Business Model

While doing another theoretical study in 2015, I came to realise the painfully obvious mistake in that **<u>Telstra, Optus, NBN etc. (even “the department”) all have the wrong non-urban business model</u> – where they have the metropolitan / urban areas earmarked for high priority investment and the non-urban areas marked as really low telecommunications priority investment. "Cost Centres"!**



This chart above shows my well-considered estimations of the relative population of telecoms customer types per topographic area (including the surrounding area), where these areas are grouped in columns.

When you look at a metropolitan city – most of the working people are employees on contracts / wages to larger / businesses – and the number of large (corporate) businesses is relatively small compared to the overall metropolitan population. A low percentage of the overall Consumers live in the CBD area, most Consumers live in the suburbs and the suburban centres / industrial areas are the places where the urban businesses are located.

With Regional cities the amount of CBD (corporate) business is considerably less proportion of that population, but proportionally more people (than in Metro areas) live very close to the Regional CBD areas. Urban industry is there - but not as proportionally as large as in Metro areas. What is interesting is that there is a small percentage of the Regional City population that is on farms - and these are small / medium sized businesses.

With Large Regional Towns the size of the corporate area is small but the number of people that live near the CBD is relatively high compared to the percentage in Regional Cities. The big telling point is the greater percentage of Farmers / Graziers / Miners in these community areas as small / medium businesses than in Regional Cities.

With Regional Small Towns, the size of the corporate area is almost zero but the number of people that live near the CBD is relatively high compare to the percentage in Regional Large Towns. The big telling point is the again greater percentage of Farmers / Graziers / Miners in these community areas as small / medium businesses than in Regional Large Towns.

When it comes to Regional Villages, there is no Corporate area, the CBD really does not exist, the few shops / garage make the "business centre" and consumer houses surround this. Beyond the urban Village most (virtually all) are Small / Medium Businesses as Farms / Mining in non-urban environments.

Before the age of Broadband (and because of the very high cost of long-distance ("trunk") telephone calls) most Farmers and Graziers (and their families) rarely used the phone - apart from business to arrange a stock or crop sale or purchase (usually worth more than most people would earn in a year or two). The use of Homestead phones stopped at 8:30 pm because that is when Farmers and Graziers go to bed - and be onsite working by 5:30 am!

It was this very low telephone call rate usage that was directly related with the farming community plus the maintenance of these considerably longer non-urban telephone lines that set the private sector commercial mindset to (with only "internal accounting" as the biblical yardstick) to see all non-urban telephony a "Cost Centres".

With the imminent ceasing of the USO "Gravy Train", it seems that Telstra executives are more than willing to totally discard their inherited responsibilities that "justified" the privatisation of the Australian Telecommunications Commission through the Davidson Inquiry (1980) / Report (1982) as the HCRC was never upgraded to IP.

By 2000, (some 20 years later) the use of Broadband was already becoming extensive and frankly the USO should have been thoroughly reviewed by the department before then. At that time I very seriously doubt the department had any in-house telecommunications engineering expertise. Consequently a USO review by the department would have been much like a child's pantomime by looking in all the wrong places at all the wrong times and would have found absolutely nothing.

This "Request for Comments" from the department smacks of exactly the same (child's pantomime) situation where the USO is ticketed for termination; the department is apparently looking to replace "Voiceband" (analogue telephony); and the large majority of the network infrastructure is unified IP with Voiceband being provided by VoIP/SIP as a well-entrenched subset of IP. That is - the department is looking at the wrong technology - the correct technology that the department must be looking at and actively actioning is Broadband using the IP suite through the HCRC!

Unlike non-urban analogue telephony (as still on Farms), the big telecommunications use is Broadband. The Farming and Grazing (and Mining) communities use Broadband far more extensively than "Voiceband" telephony.

In the last 40 years, a high degree of robotic mechanisation has been introduced to manufacturing through the use of solid-state electronics. Australia was world-first in mechanically grading apples - and labelling them. Most production lines are now robotic and these manufacturing production techniques are filtering through Australian Farming and Grazing (and Mining).

The concept of the Internet of Things (IoT) has been emerging for about a decade and implicitly it must have fast and reliable Broadband connectivity connecting with and through Farms and Remote Stations - with Homesteads as the Data Centres.

For convenience, people generally use their mobile devices far more than a fixed access telephone, and we all expect to have low-latency on telephone calls (even international telephone calls)!

Full Services Competitive Fiasco

Circa 1992/3 both Telstra and Optus were both in fierce competition; rolling out their very highly duplicated “Full Services” access network (using a Hybrid structure of Fibre and Coaxial Cable (HFC)) for the carriage of competing Pay TV services in the metropolitan areas only.

Anybody that has done project management knows that to shorten the project time by say 10% literally increases the total project costs by at least 20%. A 20% speed-up will cost at least 40% more etc.

The people on these fiercely competing projects were working six full days per week, plenty of overtime every day and equipment was being rush manufactured and priority flown into Australia (at great expense). Spies were on the lookout on both sides and the engineering structure was continually being changed to cover / duplicate each-others streets.

On top of this there was very extensive and costly advertising from both sides vying for market connection – by “houses passed” not “houses able to connect” – a very subtle marketing lie because of engineering changes resulting in amplifiers being omitted or incorrectly placed for short term partial street connectivity – leaving most battle axe blocks isolated.

My understanding is that these HFC infrastructures were 85% duplicated, and covered 80% of the metropolitan premises. It cost the then Telstra about $2.5 Bn and Optus about $2.2 Bn, totalling $4.7 Bn – and it was a failure as the customer take-up was not nearly as high as expected.

Without competition, a single HFC infrastructure covering 100% of the Metropolitan area, and put in the pre-existing under-footpath conduits instead of hanging under the power lines; would have provided 100% premises connectivity for barely $1.0 Bn and would not need extensive and expensive rebuilding as the NBN Corp. executives are now finding out.

Infrastructure Competition is so wasteful, particularly when all the infrastructure components are not manufactured in Australia but all imported!

Restructured Telecom Australia

Since the splitting up of the Post Master General’s Department in 1975, the offshoot of Telecom Australia Commission had remained substantially the same. The Headquarters was fundamentally Telecom Research Labs (TRL) and national purchasing base – located in Melbourne, and focussed on providing engineering support to Australian telecommunications manufacturing companies and building Australian manufacturing / innovation and business expertise – and was really behind building the Australian economy.

Beyond the Headquarters, all Operations were under State Management control and the Regional / Rural Remote (RRR) Inter-Exchange Network was fundamentally a tiered-Star structure (like the spokes on a bicycle wheel) centred from each of the State Capital Cities. This Australian telecommunications infrastructure was then recognised as being one of the best telecoms infrastructures in the developed world!

Before Corporatisation in 1989 there were massive improvements in telecommunication technologies that plummeted the overhead operational costs: with the introduction of the low maintenance DRCS / HCRC technology from Telecom

Research Labs in the late 1970s; Digital Switching (circa 1980 onwards) that required virtually zero maintenance and Digital Transmission (circa 1980 onwards) and very inexpensive Single Mode Optical Fibre (SMOF) (circa 1986 onwards) that also required virtually zero maintenance.

> *With the rollout of (Ericsson AXE) digital switches from 1980 onwards, these switches primarily had 2 Mb/s (30 "Voiceband" / ISDN channels) as this Inter-Exchange Network interface, and the (Metropolitan) Step-by-Step and Crossbar Switches that were being replaced, were mesh-network interconnected (in each "metropolitan" capital city) with thick (0.64 mm) pair copper cables.*
>
> *These "Transit Network" cables could be used for 2 Mb/s transmission but because of a massive manufacturing mistake in the USA; the silicon chips in the second version of these 2 Mb/s regenerators (required at 1830 metre spacing) was fundamentally flawed – causing 2 Mb/s links of 30 PCM channels to intermittently drop out everywhere in metropolitan areas – resulting in severe customer frustration / complaints.*
>
> *Literally in the nick of time the technology of SMOF cable became practical in early 1986 and this cable was rush manufactured in Australia to replace the now continually failing pair copper based metropolitan Transit Network (part of the IEN) with 2 Mb/s (0.002 Gb/s) using pairs in SMOF cable.*
>
> *I believe that Telecom wasted no time in pulling out the thick pair copper transit network cables and selling the copper to fund their State country (RRR) SMOF long-haul Inter-Exchange infrastructures (1988 – 1993).*
>
> *As this RRR long-haul Inter-Exchange Network rebuild was basically funded from the sale of copper from the capital city transit networks; it is now plain to see why large States with small Capital cities have rather limited inland SMOF connectivity – and why small States with large Capital cities have very extensive inland SMOF connectivity!*

Because of massive productivity gains made through this first generation digital transformation, Telstra was at risk of losing the $170+ M pa USO "Gravy Train", so Telstra re-organised itself into Business Units and combined all the previously State-managed Inter-Exchange Network infrastructure into one "National Network Engineering" Business Unit and placed all the high overhead Access Network infrastructure in few Business Units relating to their expected profitability.

The "Country Wide" Business Unit that catered exclusively for the Access Networks in the RRR areas (including the very expensive but fast becoming low overhead DRCS / HCRC technology). These areas were fully expected to run at a massive loss and was neatly placed to continually accept (and use) the USO "Gravy Train".

Because the State boundaries were now eliminated, the new country "Regions" far more comfortably fitted the large geographic areas with reasonably common Access Network equipment within each Region. Where technicians were previously readily available from local exchange sites to attend to maintanencing local telephone issues this quickly became no longer the case because too many of these technical and lines staff were made redundant.

To address this problem one (at least) one Regional General Manager set up Shop Fronts (as he had earlier done as a District Manager) in some of the larger country towns / cities.

These Shop Fronts provided a practical customer interface and included proactive marketing. This simple and inexpensive marketing strategy had remarkable results with producing a profit that had Telstra senior executive directors mortified because this Region was a Country Area and a profit there really threatened the at least $170 M pa USO Gravy Train!

My understanding was that the Regional General Manager was "made redundant" (and replaced by a person that severely lacked management skills) – the general management team scuttled, and these country city Shop Fronts were quickly shut down. Ensuring continuing financial losses in Country areas, and the USO "Gravy Train" of $170 M+ pa kept rolling in.

Telstra's Structural Separation Threat

In late 2004, the Federal Government threatened Telstra that if it could not prove Broadband capability then it (Telstra) would be structurally separated. Telstra went into defensive mode and internally restructured itself – ready for the decree, and quite prepared for the decision to separate along its own pre-determined strategy.

Part of Telstra's strategic plan was to rebuild its Cable Internet – which uses the HFC infrastructure from centralised metropolitan locations to approx. 1 M customers.

These single geographically centralised Exchange locations in each State Capital City had so many Broadband Routers (to provide Broadband over HFC) in these Exchange sites that they had all reached physical limits – and Cable Internet was certainly not being advertised!

By sheer chance coincidences I was employed at Silcar (Thiess Services) in Sydney on January 2005 as an Admin Officer where I soon radically simplified the Health, Safety, Environment & Quality reporting process, created a staff database to facilitate proactive scheduled staff training.

While in this role I was asked to be across a phone call from Telstra to Silcar regarding the rebuilding of Telstra's HFC Internet infrastructure. Silcar won the contract. I became Silcar's Sydney Supervising Engineer.

Broadband Router equipment from the bulging Homebush Exchange site was re-installed and commissioned with new optical headends into 124 Local Exchange sites in the Sydney Basin (400 nationally) – in 10 months.

Each site had a comprehensive rack-mounted remote testing facility plus the wired-up racking space to install six Broadband Routers. All these Sydney Local Exchange sites were back-connected with a dual star cable network of about 2,500 km of SMOF strands (in the Sydney Basin) to two new geographically separate main Internet Switch/Routers. Nationally, this was a $2.5 Bn project and gave me an excellent engineering insight.

It was obvious to me that the Broadband Routers had almost hit their use-by date and were difficult to repair, the HFC street infrastructure was in a pitiful condition (Optus HFC was worse) and that this whole infrastructure would need a major (expensive) rebuild if it was to provide Broadband connectivity to the "proposed" 6 M premises in the Metropolitan area.

Words about the Structural Separation of Telstra soon disappeared and it became obvious that the Federal Government ("the department") had been totally fooled (or bought out) into considering that this Broadband Internet partial restructure would have been capable of providing 6 million metropolitan premises with Broadband.

The Radio Black Spots Gravy Train

As Fixed Access Telephone services are now becoming technically obsolete, questioning the validity of the USO "Gravy Train" as Mobile Access Devices (i.e. 3GSM / 4GSM / 5GSM devices) are effectively replacing Fixed Access Telephone services but not in RRR areas - because of "Radio Black Spots"!

The concept of "Radio Black Spots" came about in metropolitan areas with the rollout of 2GSM / 3GSM networks that were basically structured with Radio Base Stations (with antennae mast) located on the high spots to get maximum ground area coverage – with an absolute minimum of Radio Base Stations . The problem was that because of the hilly terrain in most metropolitan areas (State Capital Cities and their suburbs), there were hill sides and valleys that simply did not have line of sight to the Radio Base Stations – and/or the Radio Base Station transfer locations suffered instant congestion - resulting in call dropout.

The fix was to install small Radio Base Stations in / near these "Radio Black Spot" locations to carry the mobile phone active connection through and prevent these Radio Black Spots from resulting in calls dropping out.

As mobile phone coverage extended outside the metropolitan and urban city / town areas; the concept of "Radio Black Spots" became a political voting tool, as another form of political corruption to shore up votes on the "promise" of Radio Base Stations.

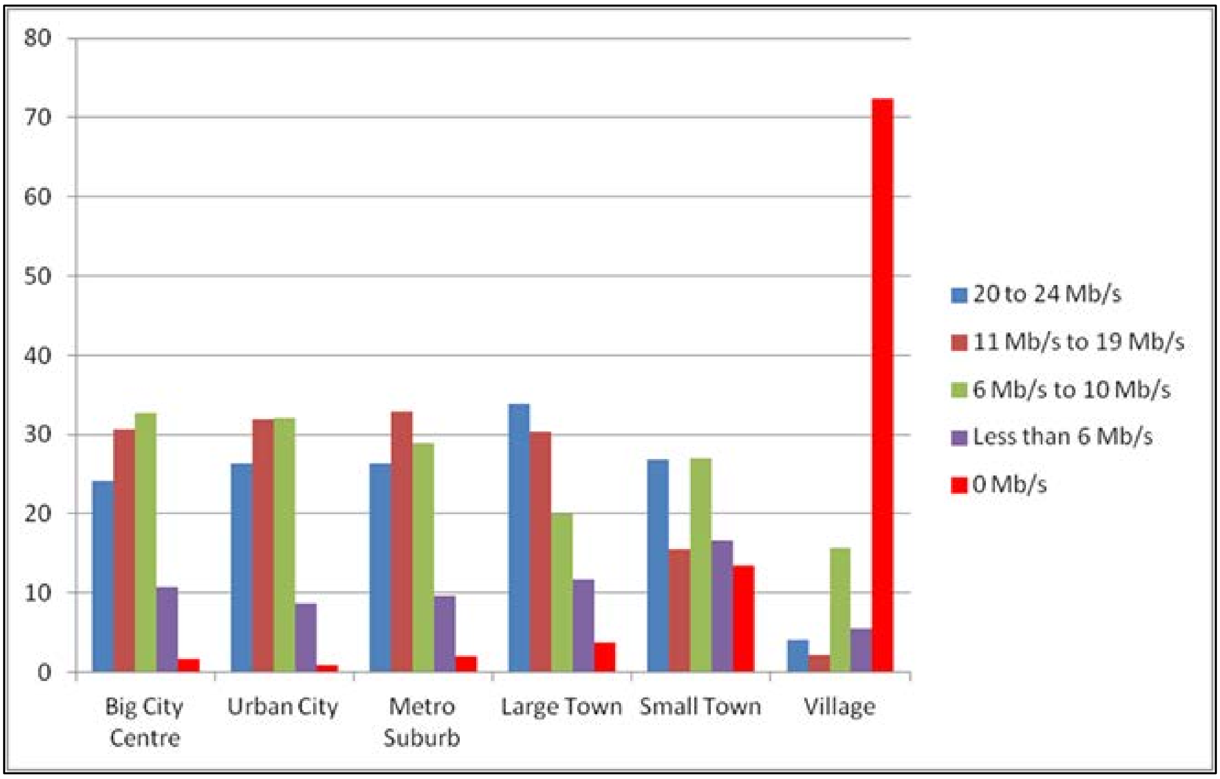
It therefore comes as absolutely zero surprise that Telstra (and other "competing" telecommunications infrastructure providers – (get the irony) – have moved their focus to strip funding from the department; from the unbelievable "Universal Services Obligation" (Gravy Train) to the even more unbelievable "Radio Black Spots" (Gravy Train) and keep the Federal Government money rolling in for what they were privatised to do – without any funding!

The Davidson Inquiry / Report pressed all the buttons to privatise the then apparently highly inefficient Australian Telecommunications Commission. If privatisation was in any way inefficient (in the competitive business) there would be no need for a Gravy Train, and no ensuing "inquiries". It is painfully obvious that the Department of Communications and the Arts had this infrastructure stolen from it – and there is no way the corporate sector is going to let go of this infrastructure Cash Cow.

Serious Lack of ADSL Facilities Rural Areas

When ADSL was initially rolled out circa 1998-1999 the Local Exchange located Digital Services Line Access Multiplexers (DSLAMs) were ADSL1 vintage (8 Mb/s max downstream), and many premises in the metropolitan areas that got ADSL1 had this at nominally 8 Mb/s (or a little bit slower). This was much faster than Dial-Up internet and nobody complained – except those in the more major urban RRR areas where ADSL was not rolled out into these (semi-urban) areas.

When the second rollout of ADSL2+ technology happened, a lot of the older (much slower) ADSL1 DSLAMs were retrofitted into Regional Rural Remote (RRR) areas. A simple analysis of the DataCube data (circa 2016 - courtesy "the department") threw up a very interesting chart (as shown above). This chart is the grouped ADSLx downstream speeds in terms of various urban topographies.



This charted set of data is in percentages of downstream speed blocks and are shown vertically. Unlike the ACCC meaningless "Measuring Broadband Australia" report, this chart includes a breakdown of urban areas in topographic groups relating to the urban (and physical size) by the line count. Village =< 250 lines, Small Towns 250 – 1500 lines, Large Towns 1500 – 7000 lines. Metro City, Urban City and Big City Centre have much the same line count but are slightly differentiated by home unit, house and garden premises, and shop / industrial land areas.

The Metro City and Urban City topographies are of little consequence in this submission as these are not Regional; but the Big City Centre is Regional and it (as expected) closely aligns with the metropolitan counterparts.

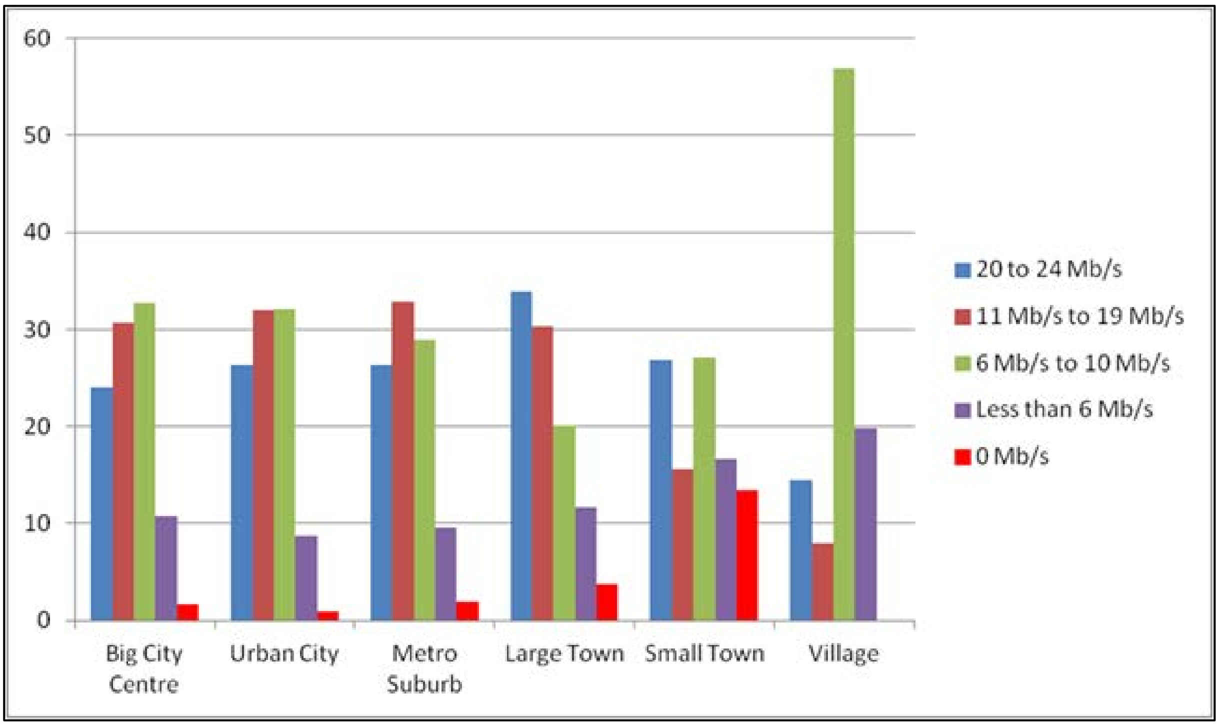
It is however, surprising / interesting that the Large Town topography has a proportionally higher ADSL2+ optimisation than the Small Town and Village (where these Small Town should have been 100% 24 Mb/s) and it is obvious that a high proportion of the Town ADSL1 (8 Mb/s) equipment was relocated from the Metropolitan areas (where many of these DSLAMS were on lines longer than about

3300 metres that could not exceed 8 Mb/s even after being retrofitted with ADSL2+ DSLAM exchange equipment (capable of 24 Mb/s on lines shorter than 900 metres)!

What is startling is the red columns (representing no ADSL connectivity by percentage of telephone lines in that topographical grouping). It is really painfully obvious that a very high percentage of the Village SCAX huts have zero ADSL Broadband equipment and these would include considerable DRCS installations.

These Village SCAX huts connect with our Farmers and Graziers that build Australia's incredibly large food supply – and being crippled by privatised Australian telecoms infrastructure; putting shareholders before building Australia's economy.

When we take out the 0 Mb/s for the Villages this second chart above shows another interesting problem in that even though a high proportion of Villages have almost all the premises within a 750 metre radius (that would easily be capable of 24 Mb/s with ADSL2+) the ADSL downstream speed is limited to (much) less than 10 Mb/s!



One prime reason why these Remote / Rural Villages were denied ADSL was that there was/is not nearly enough IP Broadband connectivity available in the Backhaul that services (connects to) these SCAX huts.

Why ADSL was such a Competitive Disaster

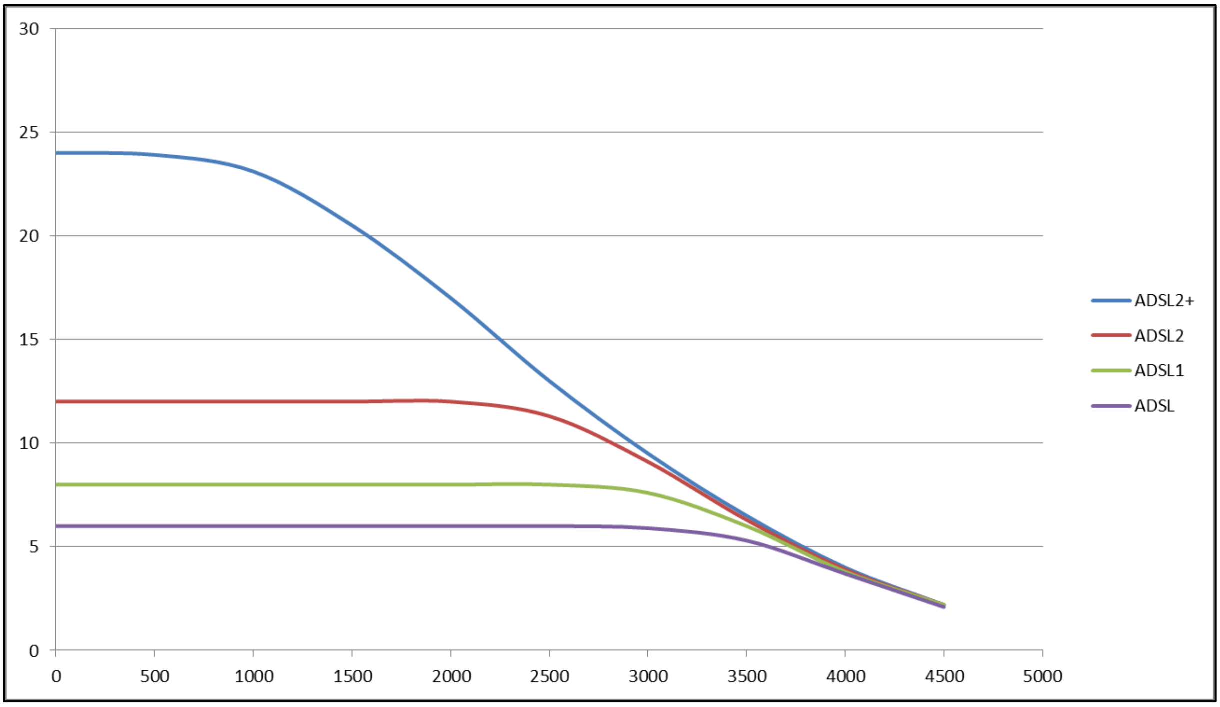
When ADSLx technology was rolled out by Telstra from the late 1990s onwards, it did so with maximised internally accounted profit (greed) as the leading guide.

Telstra perceived that the highest profits would come from customers on the big city metropolitan exchanges (because these exchange sites had many businesses attached), so Telstra very preferentially rolled out ADSL1 (8 Mb/s max) Digital Services Line Access Multiplexers (DSLAMs) at these exchanges.

The chart below is not generally understood my most people (even in the telecommunications industry)! If you follow the green line for ADSL1 (8 Mb/s maximum (with a very short customer access pair copper line) this chart shows that the downstream speeds literally stays constant (at 8 Mb/s) up to about 2700 metres, (as shown on the X Axis) and beyond there the downstream speed gradually falls away. By about 4100 metres (the maximum length line for an urban telephone), the downstream speed is nominally 4.0 Mb/s

This basically means that if a DSLAM 1 (8 Mb/s max) is installed in the Local Exchange then all (urban) Village, Small Town, Large Town and at least 50% of a Large Country City or a Metropolitan suburb should have 8 Mb/s – because these telephone lines are shorter than 2700 metres.

Basically about 50% of Large Country Cities' premises and 50% of all Metropolitan Suburban premises will have telephone lines longer than 2700 metres and these end users will have lower than 8 Mb/s - but at least 4 Mb/s downstream!



From here Telstra worked their way out to the other metropolitan exchanges, then country cities then country towns – and last of all, some SCAX hut sites (often referred as "Cost Centres" by senior executives, acutely aware of the Davidson Report's "Gravy Train") – and desperate to not make these RRR areas profitable!

The next rollout (circa 2005 onwards) used ADSL2+ technology DSLAMs.

Going back to the above chart for ADSL2+, the blue line shows that the downstream speed should remain at nominally 24 Mb/s up to about 1000 metres line length and from there; as the telephones Customer Access line length is increased, then so too does the available downstream speed decreases to about 8 Mb/s at 3300 metres.

Frankly, there is no advantage in having an ADSL2+ DSLAM on lines longer than 3300 metres – these end users may as well stay on an 8 Mb/s max DSLAM1 exchange based technology!

Basically this would have meant that all Villages, all Small Towns, all Large Towns should have had 24 Mb/s as most of these pair copper lines are shorter than 1000 metres and the longest urban lines are about 1500 metres (i.e. about 20 Mb/s downstream for the Large Town outskirts)!

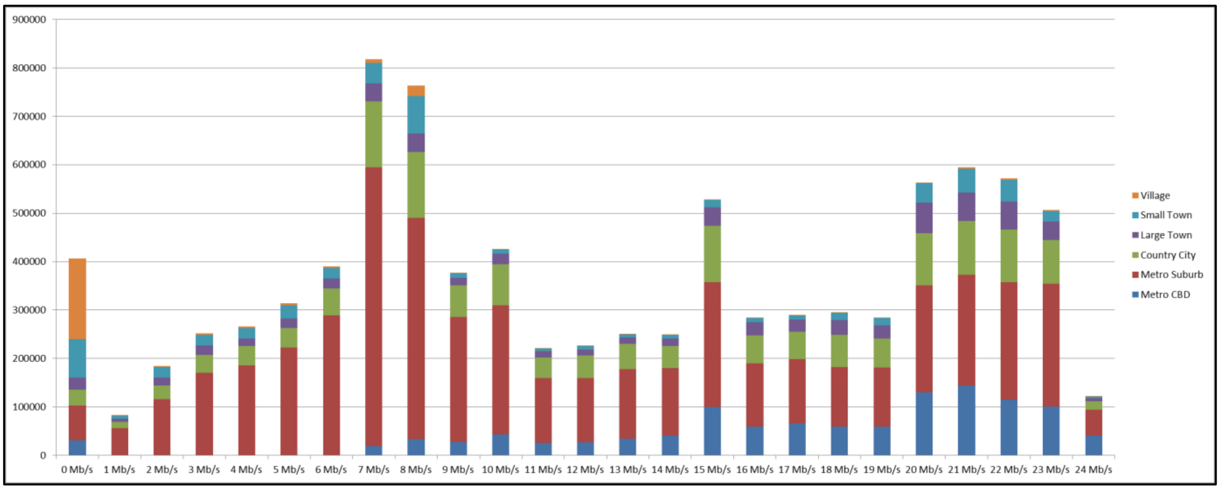
With Country Cities and Metropolitan suburbs, the average maximum length is about 3700 metres (about 5 Mb/s) and the average length is about 2300 metres (about 15 Mb/s) – meaning that at least half of the end users will on ADSL2+ services connecting at be below 15 Mb/s for an advertised 24 Mb/s service.

In engineering terms this is a pretty straightforward base to work from and the sales rules should have been put in place – but they were not and the ensuing dog fight for owning customer's Broadband services was an absolute competitive disaster.

My analysis of the ADSL Data Cube (2016) highlighted a raft of issues negatively affecting metropolitan and Regional / Rural / Remote (RRR) ADSLx end users.

- To minimise outlay costs a large proportion of ADSL1 (8 Mb/s) DSLAMs were retrofitted into non-metropolitan (RRR) local exchanges, and ADSL2+ (24 Mb/s DSLAMs installed in metropolitan local exchanges.
- Although the pair copper access lines in these Towns & Cities was generally much shorter than the Metropolitan lines, the downstream speed is limited by retrofitted DSLAM1 technology (8 Mb/s max) where most of these Town and Country City services could have been provided with 24 Mb/s DSLAMs.
- Because of fierce competition, "new" (metropolitan) customers were connected ADSL2+ (24 Mb/s) technology DSLAMs irrespective of their too long access line length – so their Downstream speed remained at 8 Mb/s or less.
- A high proportion of Customers on short lines were left on DSLAM1 (8 Mb/s) exchange equipment – even though their lines were capable of over 15 Mb/s.
- A considerable proportion of metropolitan ADSL services operated at lower than 4 Mb/s strongly indicated their Main Cables paper insulation (near the exchange sites) was wet and extremely poorly maintained. (Caused by "privatisation"!)
- Many of the RRR country towns and villages had a range of much slower downstream speeds that is highly attributable to different DSLAM technologies – but far more attributable to very slow back-connections where the country Core Network is operating in a virtual congestion mode most of the time.

The chart below is a simple graphical analysis of the Data Cube data for the total Australian ADSL downstream services in 2016 by Mb/s "buckets" and by urban topographic grouping. Co-incidentally, the "buckets" represent similar size premises count based on common sized land for urban premises, so the columns should be highly consistent for each topographic grouping.



The very tall columns for 7 Mb/s and 8 Mb/s are almost entirely caused by competition business interfering with infrastructure business resulting in short lines capable of 24 Mb/s but serviced with 8 Mb/s DSLAMs at the Local Exchanges.

The columns for 1, 2, and 3 Mb/s are almost entirely the result of competitive mindsets wiping preventative maintenance / line testing / specification practices.

The low columns for 11, 12, 13, 14, 16, 17, 18, 19, Mb/s would be 60% to 80% higher but for competitive mindsets wiping preventative maintenance practices that are standard processes in Infrastructure Business to maximise short term profits.

The peaks at 15 Mb/s and 10 Mb/s are functions of standard cable drum lengths for constructing the pair copper access network's exchange switching area.

The ACCC and PC had more than a few Inquiries but could not understand this why their competitive business practices (in an infrastructure business world) had wrecked the rollout of this simple Broadband technology (as they are not Engineers but Lawyers) and they would not accept that this woeful situation was entirely caused by them introducing / enforcing competition without having the basic infrastructure-based engineering rules in place to prevent this downstream discrepancy fiasco.

In this same fiasco, Telstra executives saw that providing good Broadband into country (Regional / Rural / Remote) areas was an internal "Cost Centre" that indirectly threatened losing the $170 M pa USO "Gravy Train", when in fact, providing Broadband to Farmers was a massive external accounted profit for Australia because (after mining) the Farmers and Graziers are the prime GDP earners.

The Moving Network Demarcation Points

Technology changes and competitive business forces have caused the goalposts that define where the demarcation between the CAN and the Inter-Exchange / Backhaul / Core Network is and how it has moved.

Had these goalposts not moved, virtually all of the DRCS / HCRC equipment would have been under-laid / and back-connected) with an inland grid network of SMOF cable systems (and to a large degree would have been largely replaced by very high capacity SMOF technologies that would have been synergetic in building Australia's defensive inland telecommunications infrastructure).

With Fixed Access Telephony the demarcation point between the Customer Access Network (CAN) and the Inter-Exchange Network (IEN) was for many decades determined as being the speech bridge in the Manual Operators Sylvester Switchboard. One cord connected to the Customer line and the associated cord connected to the Transit Network line!

Why the speech bridge? Well, on the CAN side this signalling was Ring Down / Loop Disconnect (to talk with the telephone) and on the other side of the speech bridge the signalling was Channel Associated Signalling (CAS) – to talk with the switching.

With Electromechanical Automatic (Step-by-Step and Crossbar) technologies the speech bridge performed virtually the same isolation of signalling functions and this too was the demarcation point between the CAN and the Inter-Exchange Network (IEN).

With most early version Pair Gain Systems (PGS) the Ring Down / Loop Disconnect signalling is transferred through the amplifier / channel equipment so with these PGS's, this is all part of the Access Network!

With Electronic Line interfacing (as in DRCS / HCRC, AXE, System 12 technologies, Remote Integrated Multiplexers (RIMs), Loop Multiplexers etc.), the Line Interface Circuit (LIC) performed the signalling isolation functions (around the transmission hybrid) and this too was/is the signalling demarcation point between the CAN and the Inter-Exchange Network (IEN).

The AXE 104 was specifically engineered by TRL and Ericsson as a small country digital exchange for use in thousands of SCAX huts - with 2 Mb/s back connections - just like the HCRC - but is was considered to be part of the Backhaul Network and it was primarily rolled out in Regional Rural areas of Australia. And so the tug-of war continued between Telstra Business Units. . .

The Inter-Exchange Network (IEN) referred to the "Voiceband" channel structured long haul transmission matrix and associated hierarchical level long-held switching infrastructure – between the CAN infrastructures at each end of a connected circuit.

> *The USA term "Backhaul" is virtually synonymous with "Inter-Exchange", and the Inter-Exchange Network also carried Radio Programmes, TV Channels, Data etc., in much wider channels than allowed for with Voiceband. The big change came with unifying the Inter-Exchange / Backhaul Network to be entirely IP connected and all connections virtually switched through Routers instead of physical / electronic switches.*
>
> *With the later change to a unified IP Core fabric, the "Inter-Exchange / Backhaul Network" name changed to be the "Core Network". It is not uncommon for the back-connection from some Broadband / CAN interface equipment in confusion to incorrectly be called the "Backhaul Network"!*

With ADSL / VDSL (which is a Broadband CAN/Core Network interface), the CAN / Core Network demarcation point is in the middle of the DSLAM. The modem banks in the DSLAM are almost part of the CAN and the DSLAM is back-connected into the "Edge Router" which is the Broadband entry/exit point to the Core Network!

So again we have situations like the Remote Fibre to the Curb (FTTC) VDSL "Node" (which is really a locally-powered DSLAM located deep into the CAN (where the pair copper Customer Access Network cable to the premises VDSL modem is nominally shorter than 500 metres) and the FTTC VDSL Node is back-connected by SMOF to the "Edge Router" in the Local / District Exchange site; which is the Broadband entry/exit point to the Core Network! This fibre DSLAM etc. is actually all part of the Customer Access Network (CAN)!

With Cable Internet, the Broadband Router talks IP on the Core Network side and this directly connects to the Edge Router. On the other side of the Broadband Router, this talks "TV Channels" and listens on the "Maintenance channels" and this connects to the Optical Headend. So – all past the Edge Router (i.e. the Broadband Router etc.) is all CAN!

How and Why the DRCS/HCRC was "Lost"

Most of the DRCS / HCRC is part of the Inter-Exchange Network that should have come under Telstra's then National Network Engineering Business Unit.

> *Circa 1995, I was in a meeting in Melbourne that was relaying from Headquarters as to the new decisions about where the Demarcation Lines between the Inter-Exchange / (Backhaul) Network (IEN) and the Customer Access Network (CAN) were going to be changed.*
>
> *For me, this was rather important as I was the "National Voiceband Specialist" and to me it was rather clear-cut in an Engineering sense as to as to where the Demarcation Lines were – and why it was at the change of signalling systems between the CAN and the IEN infrastructures!*
>
> *The non-integrated Pair Gain Systems (PGS) remained as part of the CAN – no surprises there these PGSs were always part of the CAN. The DCRS / HCRC was/is effectively an integrated Pair Gain System. Because virtually all this equipment was well in the Regional / Remote areas, and virtually directly connected with Customers it was deemed to not be under the National Network Engineering (NNE) Business Unit jurisdiction for maintenance, spares etc. and be part of Country Wide Business Unit.*
>
> *In hindsight I saw the logical business sense for this decision as almost all of this equipment was well into the (Inland) Customer Access Network as most of this DRCS radio transmission equipment was virtually structured as a physical Backhaul "Party Line" on (PDH) digital radio – connecting to a "District" Exchange switch, and the available service techs / field staff were basically working on CAN equipment - which was the NEC 30 line concentrators - (and the DRCS radio equipment too)!*
>
> *The political side was "interesting" because the overhead costs must have been rather high – and this cost would have greatly assisted in "justifying" the spending of the annual USO of at least $170 M pa.*
>
> *The irony was that after I was made redundant from Telstra in 1996/7 the Country Wide Business Unit was again substantially re-structured and I understand was that all the CAN equipment (including the DRCS / HCRC) came back into the Technology Business Unit – which also included the National Network Engineering Business Unit! Back to square one!*

The above is my understanding as to why the DRCS/HCRC equipment somehow snuck in under as CAN infrastructure as an apparent un-integrated Pair Gain System – but the 1.5 GHz Radio part is integrated with the Inter-Exchange Network as this is 2 Mb/s PDH in and out – and directly connects into the Local/District switch – just like Remote Integrated Multiplexers (RIMS)! Most of the Line Interface Cards (LIC) in the NEC concentrator in the DRCS / HCRC is part of the CAN and the rest is IEN; as the LIC is central to this Line Concentrator equipment!

So – back to the DRCS / HCRC debacle. To all intents and purposes – the Digital Radio part of the DRCS / HCRC is really part of the Inter-Exchange / Backhaul / Core Network and has multiple (up to 22) 2 Mb/s PDH circuits as its IEN connection.

Simply replacing any small part of the DRCS is not a viable strategy and a much larger scope has to be visualised to utilise Broadband instead of Voiceband and totally rethink the entire Australian inland (RRR) telecommunications infrastructure – and do it properly.

Even 20 years ago, the prime deliverable for Regional / Remote areas in Australia should **not** have been "Voiceband" (Telephony) but should have been "Broadband" that is low-latency, highly reliable and nominally 100 Mb/s bi-directional. One of the prime reasons why this did not happen was because of a lack of Core Network infrastructure in the RRR areas.

My underlying concern is that for over 20 years (i.e. since after 1997) the rollout of Broadband (Access Network) connectivity has been very much piecemeal with short term internally accounted (only) profit (i.e. private sector corporate greed) as the prime reason to install / operate Broadband connectivity.

With External Accounting included, the priorities would have been reversed with low-latency, low jitter, high speed Broadband being rolled out in the Regional Rural Remote areas to the Homesteads in particular as these small / medium Farming and Grazing businesses (after Mining) are the core of Australia's GDP.

No surprise the rollouts of Broadband technologies was and still is extremely metropolitan centred – at the expense of Australia's RRR (Regional, Rural and Remote) economy (which is the missing the Broadband external accountability to build Australia's productivity and innovation), and that really concerns me.

In the past 30 years the entire business world has dramatically changed from "Pen / Paper / Postal / Telephone / Meeting / Transaction" to "Text / Mobile / Website / Email / Video (Conference) / Meeting / Transaction".

Where a Fixed Access Telephone was central in virtually all businesses in Rural / Regional / Remote (RRR) areas in Australia the Fixed Access Telephone is now almost a forgotten item (except in Farm / Station Homesteads where the GSM coverage is too weak (or non-existent) and the Broadband connection (by Satellite) is unreliable and has an unacceptably long latency.

This situation raises a rather interesting and concerning point in that the Davidson Report (1982) instigated what I would call a "Gravy Train" of at least $170 M pa as the Universal Services Obligation (USO) to be paid by the Federal Government to Telstra for keeping the RRR areas Fixed Access Telephone services in operation, and essentially do nothing about emerging Broadband technologies being rolled out basically beyond the metropolitan areas. (This is mentioned in Appendix 4)

My understanding is that from 1989 this "Gravy Train" started and as it is now 2020, this is 31 years or at least $5.27 Bn paid into Telstra – and to do effectively nothing about improving this DRCS / HCRC infrastructure to become excellent Broadband!

Again – with the setting up of the NBN Corp. (with the again blinkered and "greed mindset" that privatised infrastructures are more "efficient" than a well operated sub-Government Commission) – has proven to be yet another massive economic mistake. The call for papers such as this is living proof of the enormity of this economic ignorance about the immense value of Infrastructure Businesses being privatised that is slowly and surely killing Australia's economy.

The ACMA's Spectrum Auctioning Debacle

The privatisation and breaking up of Telecom Australia Commission (circa 1989) has resulted in a radical change in focus from providing appropriate telecommunications for all (especially the inland) into providing totally unnecessary and expensive multiple / competing / duplicated telecoms infrastructures in metropolitan areas to maximise shareholder profits. This resultant very lopsided topographical distribution of telecoms infrastructure was an horrendously poor national economic strategy.

The immediate privatisation consequence is that in non-metropolitan areas (where internally accounted profits are low) there is a serious lack of appropriate telecoms infrastructure. Consequently this lack of appropriate telecoms infrastructure has negatively impacted on the non-metropolitan business profitability and the very existence of Australia’s Regional, Rural, Remote non-urban Farming and Grazing Small / Medium businesses (and all at the expense of the Australian economy).

In a similar mindset, it is the Farmers and Graziers that must have 4GSM “Mobile device connectivity” based at their Homesteads as this is a prime workplace safety issue and an essential tool for communicating while Farming / Grazing – especially when it comes to non-urban computer assisted Farming / Grazing etc. processes.

> *In the USA, the frustrating decision to auction off the electromagnetic spectrum (which is prime infrastructure) was caused by their political hard right “small Government” mentality – that makes the Commissions managing these infrastructures (essential products and services) very easy to manipulate / control by business private sector; and maximise short term profits at the expense of the USA economy. No wonder the USA is in perpetual and immense and rising debit.*
>
> *The direct consequence was that the USA’s Federal Communications Commission (FCC) was literally driven broke by very severe lack of Government funding. In desperation to have cash flow and pay their staff, the FCC were manipulated/forced to auction off electromagnetic spectrum to the highest (big business only) bidders to keep their monopolies.*
>
> *In Australia the ACMA is equivalent to the FCC in the USA. Either the ANZUS treaty forced the ACMA to auction off Australia’s electromagnetic spectrum, or our brainless (and well-overpaid) idiots in Canberra blindly followed suit with the FCC and auctioned off Australia’s electromagnetic spectrum in total ignorance of the massive negative implications.*

Because of multi-duplicated / competing mobile carrier licences in the metropolitan areas the allocated electromagnetic spectrum ran out – requiring UHF spectrum from the TV broadcast band to be sliced off and provided to the multi-duplicated mobile device service providers. This totally unnecessary and wasteful competition caused fiasco was very creatively / deceptively called the “Digital Dividend”!