ARCIA

ARCIA PROFESSIONAL DEVELOPMENT TRAINING PROGRAM

AUSTRALIAN RADIO COMMUNICATIONS INDUSTRY ASSOCIATION

ARCIA

FUNDAMENTALS OF PRIVATE MOBILE NETWORKS (4G/5G)

HALF-DAY SESSION

About today……

- Around 3-4 hours in duration – depends on the questions !
  - 9:00 – 12:30
  - Morning tea 11-11:30
- Course aims:
  - To sound knowledgeable around friends and colleagues when discussing 4G & 5G.
  - Help you start thinking about to use private mobile networks in the industry.
  - Enable you to tell when salespeople are lying to you.
  - Appreciate the steps & considerations for deploying a network – either your own use or for a customer.
  - Encourage discussion.
- The course is not highly technical
  - Is designed for people in the radio/telecoms/communications industry however.
  - But we can go down any technical ‘rabbit hole’ you like !
  - Hopefully provides a ‘philosophical framework’.

ARCIA

VOCUS

LCN challenge

Agenda

- Background intros
- What is LTE ?
  - 14 key ‘concepts’
- 5G – An Introduction
- How to build your own

ARCIA

VOCUS

LTN challenge

Background to Presenter & Participants

Background to Challenge Networks

- A systems integrator that specifically builds ‘Carrier networks’ - PSTN, data & mobile
- Has partnerships with the Tier 1 telecom vendors and several of the Tier 2.
- Focuses on smaller networks (less than 1-2 million subscribers).
- Has built ‘turn-key’ mobile networks in multiple countries around the world.
- The CN strategy is to develop ‘best for customer’ solutions rather than restricting to any single vendor product portfolio.
- Now has taken our expertise in carrier network design/build/support to include private/industrial LTE networks.
- In April 2023 was purchased by Vocus, now the ‘Wireless group’ within them.

ARCIA

VOCUS

CN challenge networks

Vocus at a glance

- Connecting 2/3 of the ASX 200 and more than 200 govt agencies
- 25,000km national fibre network
- Networks and technology solutions provider
- Providing international connectivity via Australia Singapore Cable
- Leading provider to space and satellite industry
- $1b investment in network over the next five years
- Owned by a consortium of Macquarie Asset Management and Aware Super

VOCUS

CN – Private LTE Networks

- First integrator in world to build a private LTE network.
- First to build private LTE network using Nokia RAN.
- First to deploy Private LTE network in Peru.
- Deployed first network into Gold mining and first into oil & gas.
- First in Australia to use Band1 (2100MHz) for LTE.
- First to deploy with CATM1 as integrated mine LTE/IoT solution.
- First to deploy ‘greenfield’ mine site with only MCPTT-LTE voice solution rather than legacy UHF/VHF.
- Now has 25 + private LTE network deployments (both above and below ground).
- Solutions deployed in Europe, South America & Australia.

ARCIA

VOCUS

CN challenge

Why care about LTE ?

Why the interest in private LTE ?

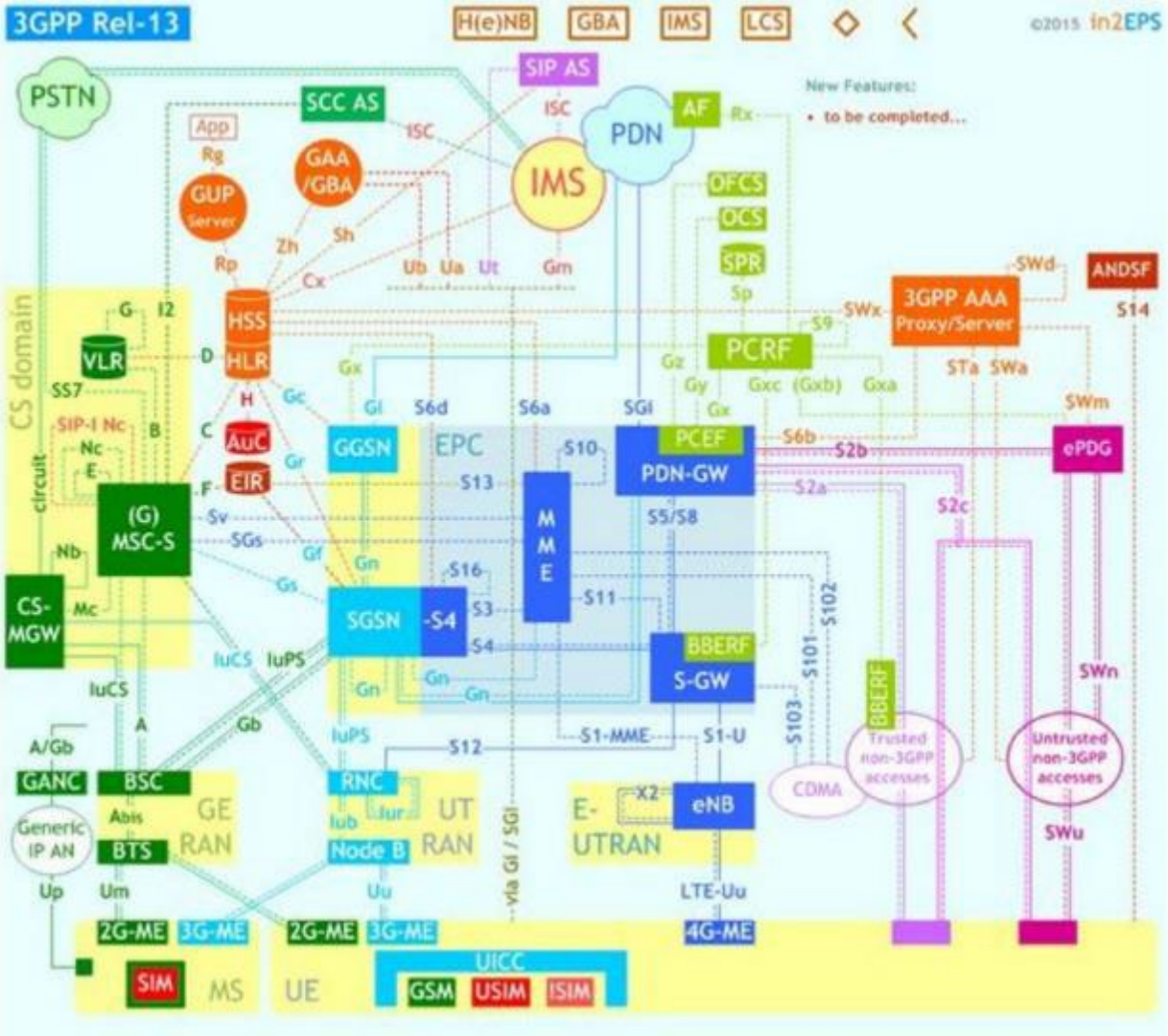
- Greater connectivity (both fixed and wireless) considered to be a key enabler for future technology
- Data needs & user numbers continue to rise
- WiMAX is (very) dead
- Wi-Fi often seen to have reached it's technical limits
- P25/TETRA/DMR reaching capability & maybe EOL
- LTE becoming cheaper
- Pressure for efficiency & safety improvement
- Uncertain future for some vendors/industry segments
- LTE often seen as 'killing' other wireless technologies

ARCIA

VOCUS

LTN challenge

So what is LTE ?



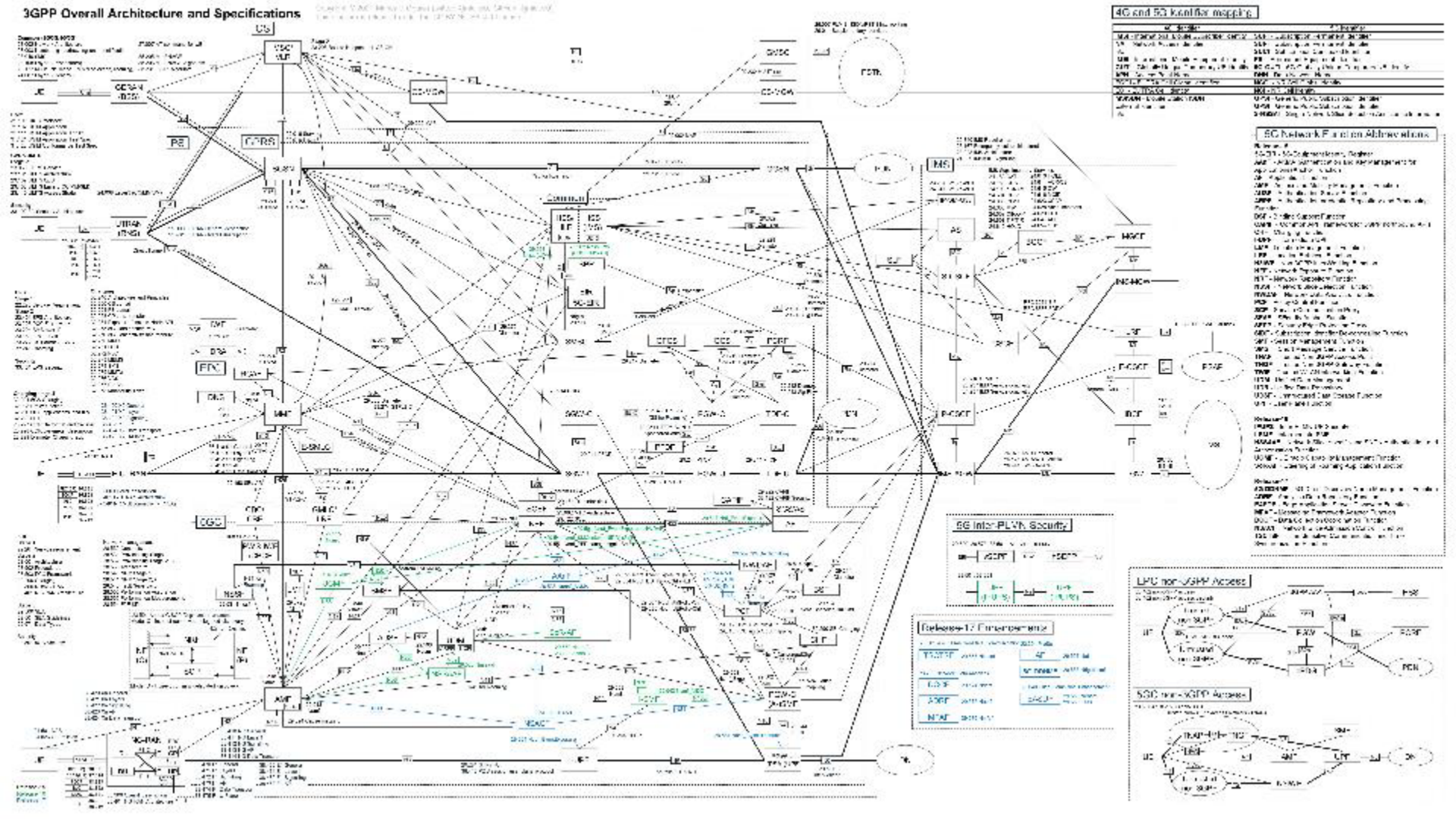
The ‘boxes’

- Tight definition over the ‘box’ interconnects
- Tight definition over the functions of each box
- Loose definition over how each box works

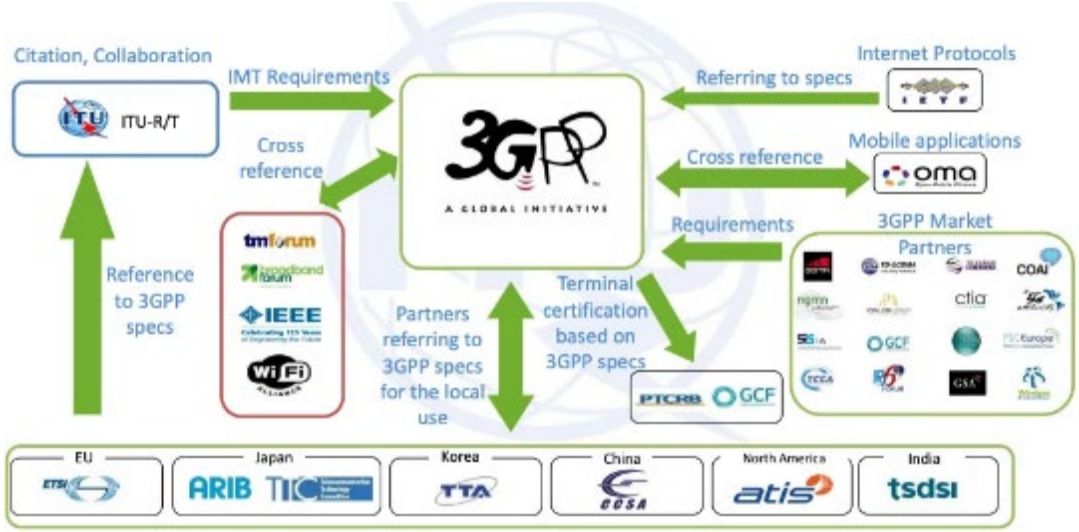
3GPP
A GLOBAL INITIATIVE

Source: in2EPS

VOCUS
LTN challenge


3GPP Overall Architecture and Specifications
4G and 5G identifier mapping
5G Network Function Abbreviations
5G Inter-PLMN Security
Release-17 Enhancements
LPLC non-3GPP Access
5GC non-3GPP Access

Concept #1, #2 & #3



- LTE is “unknowable”
- LTE is a ‘standard’ – not a technology
- Multi-vendor solutions are to be encouraged
  - Or at least not suggested as being impossible.
  - ‘Open RAN’ is a new example of this

Back to the beginning of the universe……
Evolution of Mobile

1G	2G	3G	4G	5G
TACS, AMPS, NMT	D-AMPS, GSM cdmaOne	CDMA2000, WCDMA HSPA,UMTS	LTE, LTE-A	LTE+ xx

Mobile 3GPP versions

Releases are made approximately every 6-18 months

- Release 9
- Release 10
- Release 11
- Release 12
- Release 13
- Release 14
- Release 15
- Release 16
- Release 17
- Release 18
- Release 19
- Release 20
- Release 21

Release when ‘LTE’ was first defined and ‘3G’ stopped

Was Frozen in Q1 2016

This is where ‘5G’ was being added

Most deployments are at these levels

Release 18 being ‘Stage 2 Frozen’ in March 2024.

Currently being defined

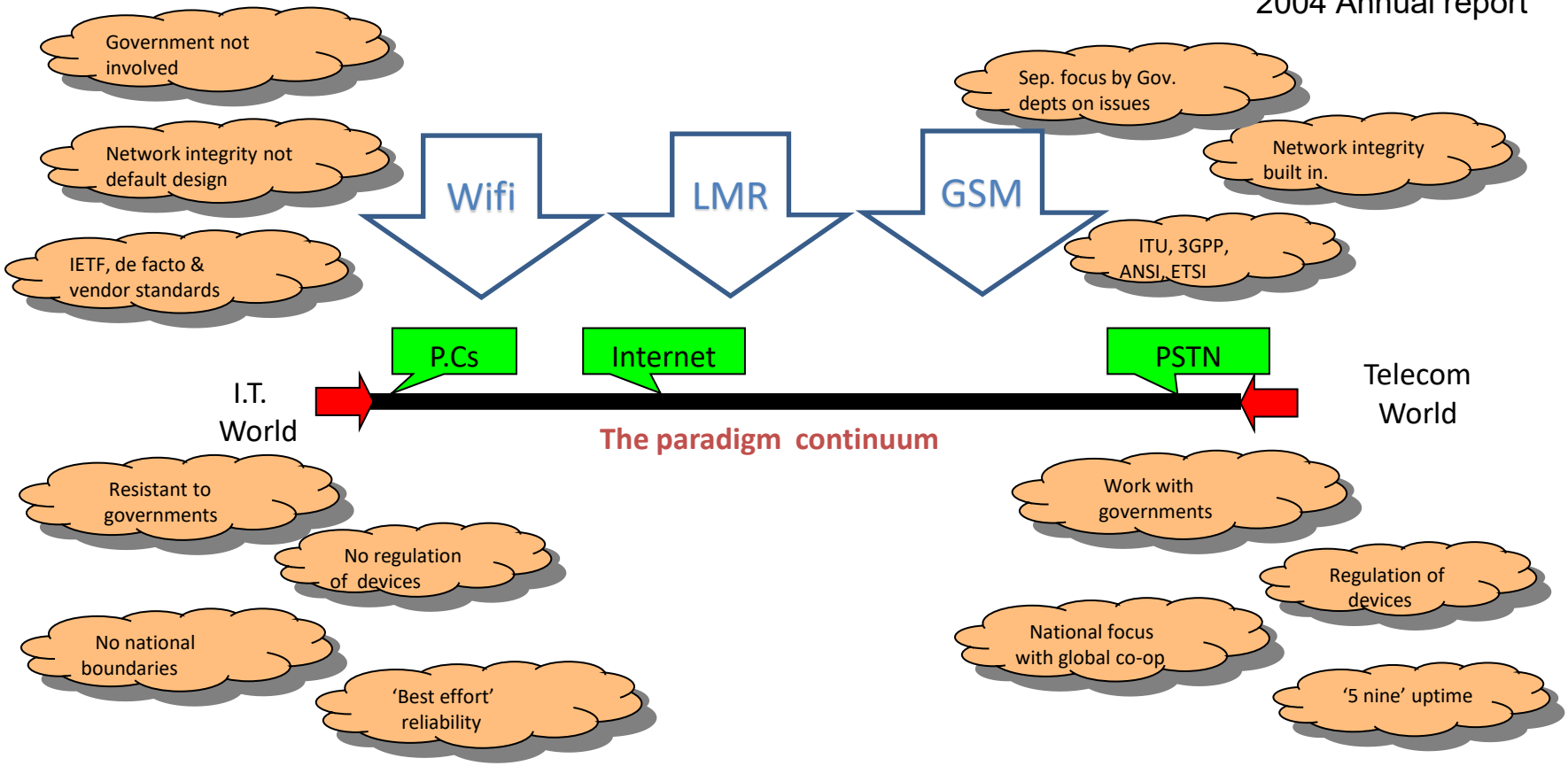
Please note: This is a basic representation of the releases to demonstrate the general flow of development.

Concepts #4 & #5

- LTE is a journey not a destination
  - Unlikely to be ever ‘complete’.
  - Is an ecosystem.
  - It’s generally backward compatible.
  - ‘5G’ is really just yet another new 3GPP Release (marketing term not a technical one) {Will talk about 5G latter}
- You don’t have to test your solution against the 3GPP specifications !
  - unless perhaps you buy a solution from some questionable Tier 2-3 vendor….
  - You want to employ lots of people.
  - Just test for unusual use cases & integration.

‘The clash of cultures’ – Internet verses Telecom

Source: ACMA Vision 2020
2004 Annual report



Concept #6

- This convergence of cultures is not to be underestimated
  - See it in ‘IT team’ vs ‘OT team’ clashes.
  - Different technology paths.
  - Potentially ‘blood on floor’ between teams during deployments.
  - Typically the number 1 reason why your LTE network may fail in your business.

Why private LTE ?

It is generally accepted that for industrial enterprises private LTE (and 5G) networks are the logical migration path from legacy wireless (Wi-Fi, UHF, VHF, mesh) solutions

- **Supports demands of industry requirements:**
  - ✓ More data
  - ✓ More devices
  - ✓ More connectivity
- **Communication convergence:**
  - ✓ One infrastructure, many applications
- **Economic efficiency:**
  - ✓ Reduction in costs
- **Roadmap:**
  - ✓ Replaces TETRA/P25
  - ✓ Long term future
- **Value add:**
  - ✓ Typically - 3% to 10% increase to mine efficiency
- **Technology advantages:**
  - ✓ Distance
  - ✓ Speed
  - ✓ QoS

ARCIA

VOCUS

LTN challenge

Why not just use existing consumer network ?

There are significant differences….

Consumer Mobile networks	Mining/Industrial Networks
Consumer focus	Machine/Operations focus
Urban focus	Typically Isolated location
Large number of low value subscribers	Small number of high value subscribers
‘Reasonable’ reliability	‘Mission critical’ reliability
No variable Quality of Service	Full Quality of service to individual users
Low level of network security	High level of network security

ARCIA

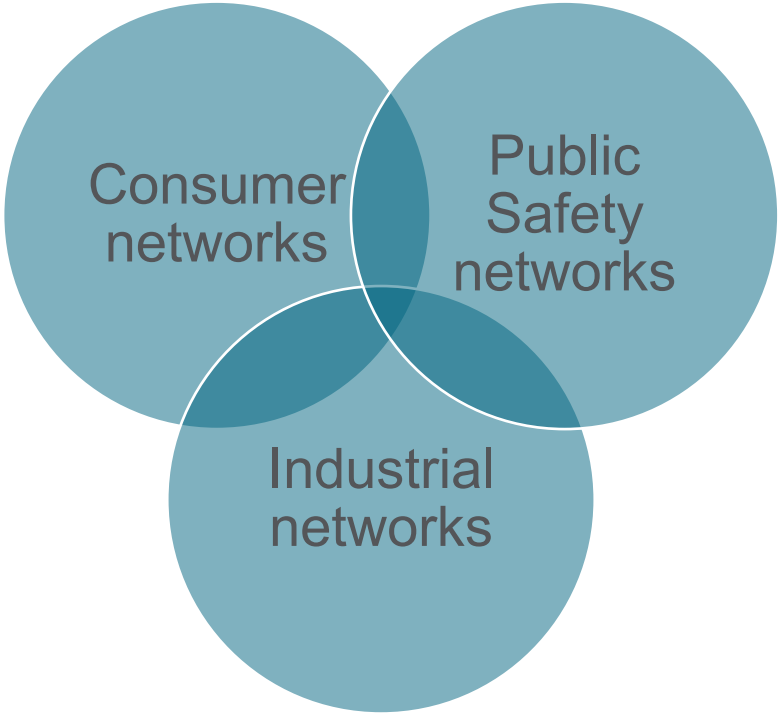
VOCUS

LCN challenge

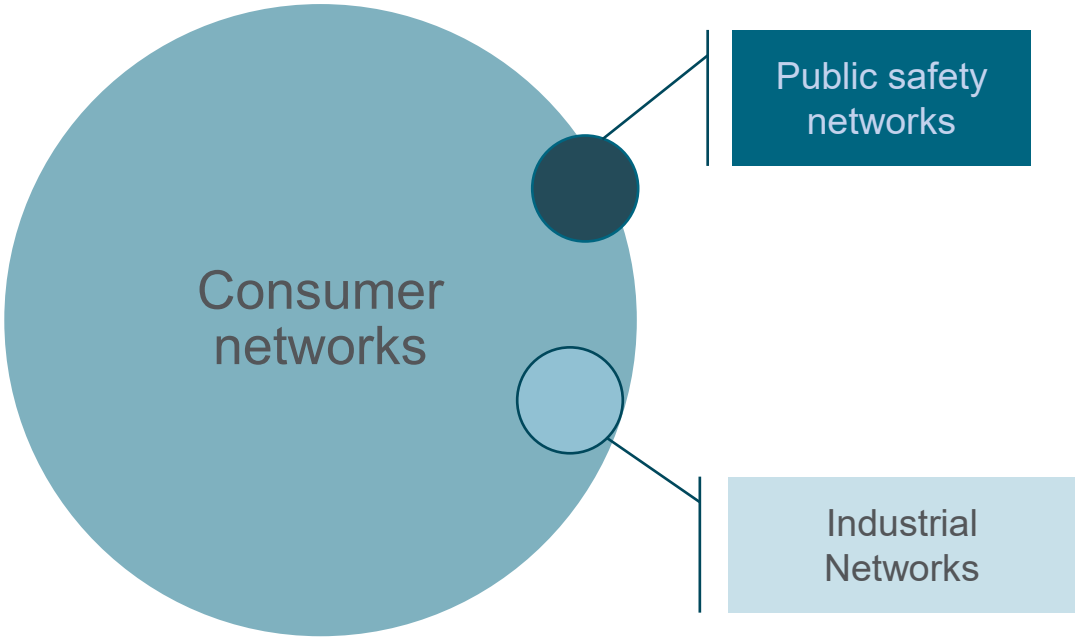
Concept #7

- Private LTE ≠ Public/Consumer LTE
  - Based on same technology but implemented completely differently
  - Performance characteristics completely different
  - Like comparing a Commodore to a Land Rover Discovery: Both based on the same base technology but very different implementations

Three key market segments of LTE - Logical



Three key market segments of LTE – Market Share



Concept #8

- Don’t confuse the market segments
  - Some are more mature than others
  - They have very different challenges
  - The LTE implementations of these segments are different to each other
  - A consumer network is very different to an industrial network which is very different to a public safety network……

ARCIA

VOCUS

LTN challenge

Concept #9

- “Those who have the gold make the rules”
  - Standards driven more by the large carriers & vendors
  - Why the needs of the ‘little guys’ (Industrial & public safety) delayed

ARCIA

VOCUS

LTN challenge

What are the Key LTE Connectivity Advantages:

- **LTE Coverage Capability at Distance (1-30km)**
  - ✓ Lower number of sites than legacy technologies for same coverage.
  - ✓ Able to cost effectively provide broader coverage to whole mine site.
  - ✓ A open cut mine of 20km x 10km would nominally require 5-10 LTE macro sites for complete mine coverage (compared to 200+ sites with Wi-Fi)
- **RF Interface**
  - ✓ QOS. Able to run multiple services on different devices with guaranteed performance
  - ✓ Handover. Devices can move around the mine site with no performance impact to another.
  - ✓ Continuous device throughputs of 1-50 Mbps depending on device & application.
  - ✓ Multiple 'Networks' can be run on the one single infrastructure network.
- **Fully Scalable**
  - ✓ Network capacity and coverage can be expanded to mine user requirements.
- **User Devices**
  - ✓ A global ecosystem of modems, tablets, handsets, developed for a worldwide user base.
- **Lower Cost of Ownership (both CAPEX and OPEX)**
  - ✓ Greater economies of scale on expansion compared to alternative technologies.
  - ✓ Much lower maintenance costs than Wi-Fi

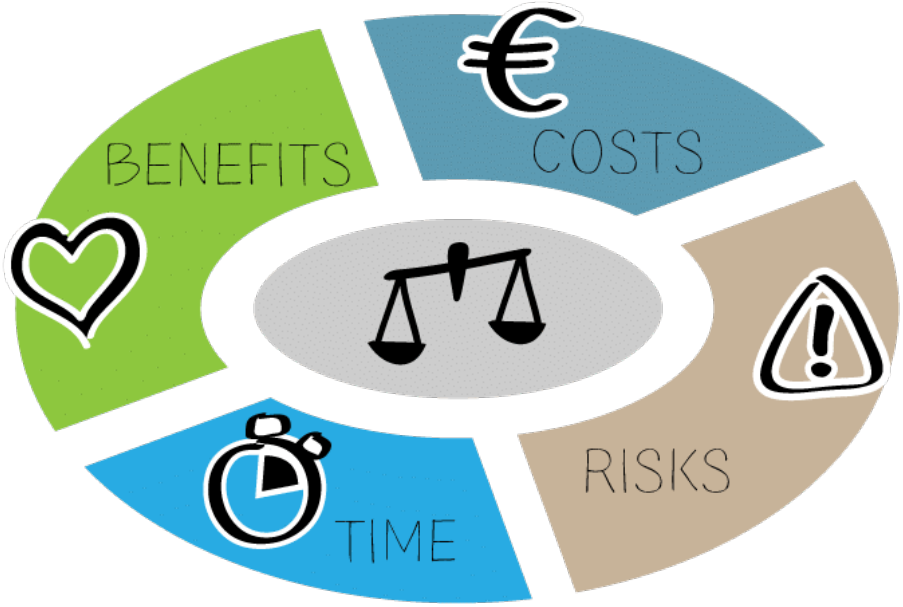
ARCIA

VOCUS

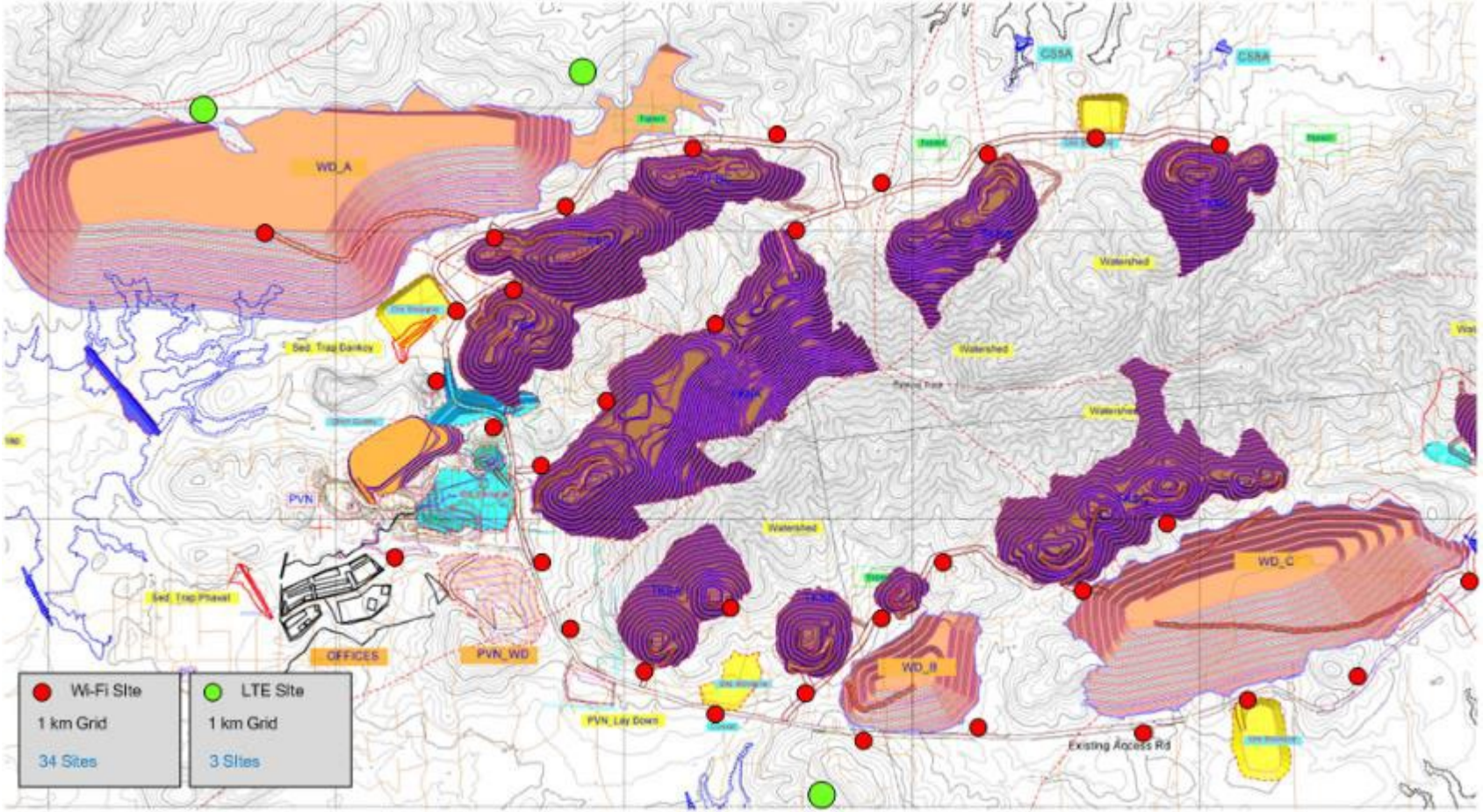
LTN challenge

Concept #10

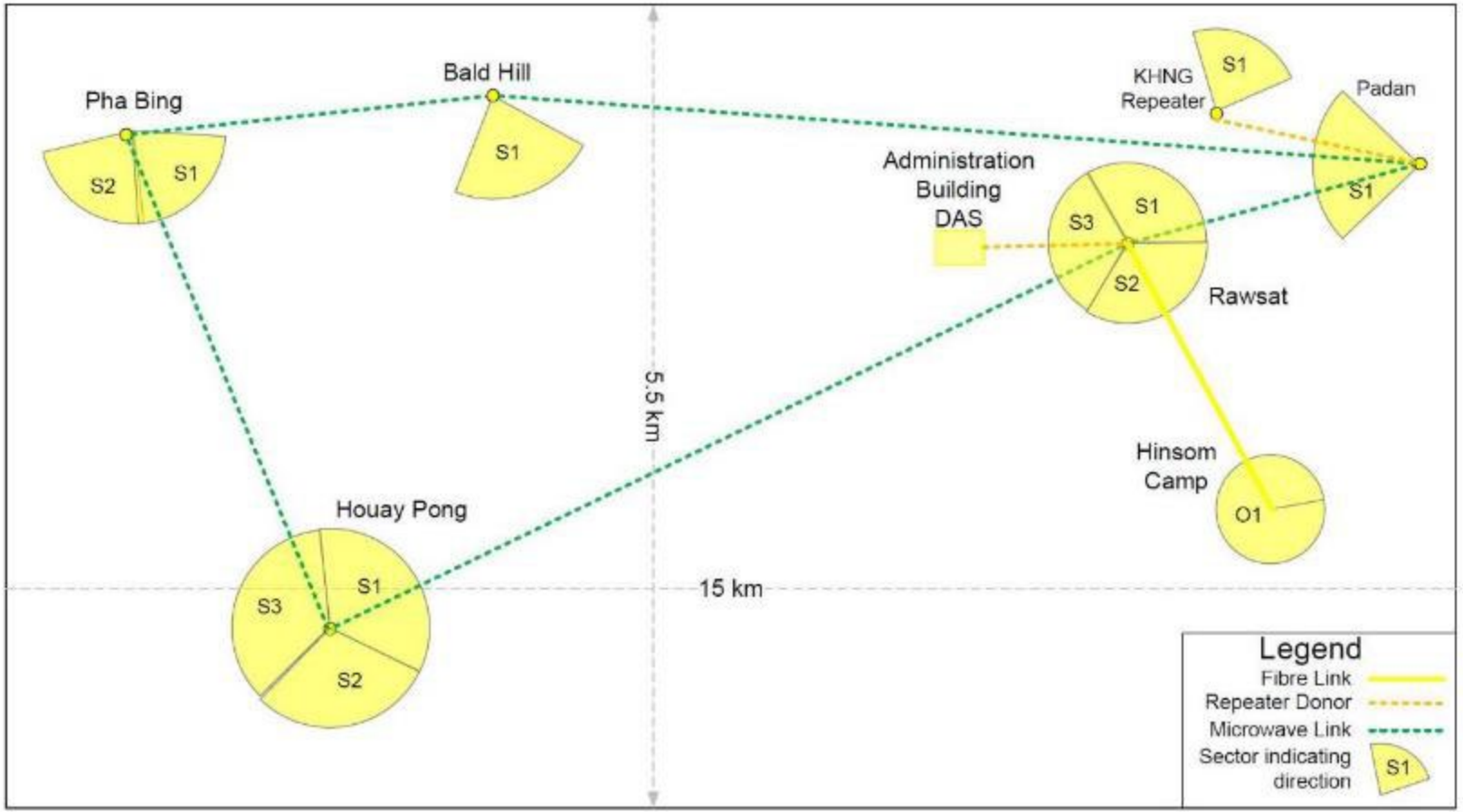
- The previous slide is all you need to know technically to develop an LTE business case !



Wi-Fi Vs LTE – number of sites

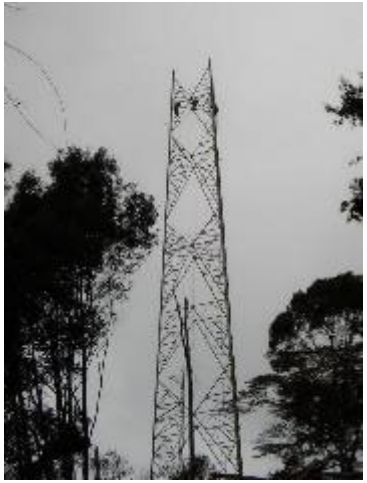


Final design



Concept #11

- Height (Trigonometry) is your friend
- The most expensive things in an LTE network are….
  - Power
  - Concrete & steel
  - Site access
  - Backhaul (for remote locations)

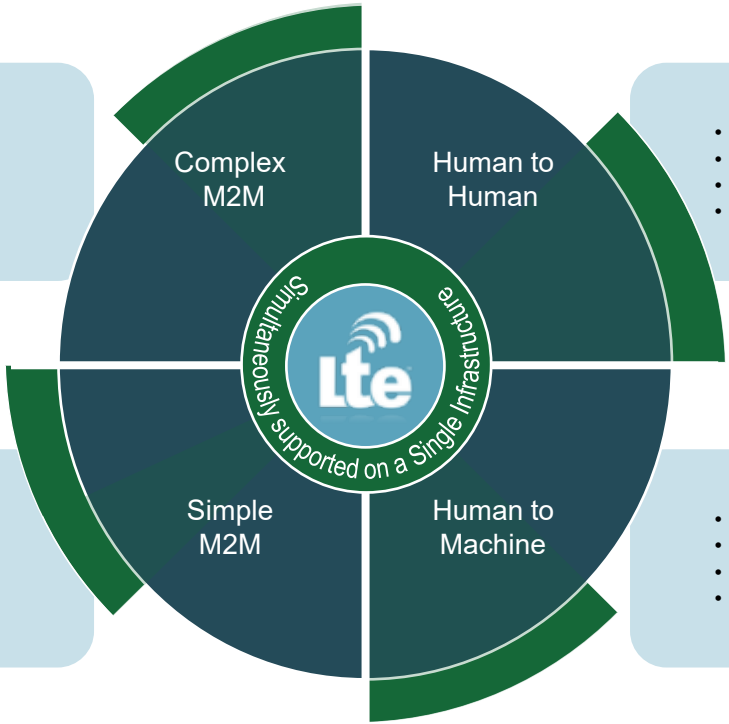


ARCIA

VOCUS

Common Use-Cases

- Vehicle Autonomy
- Machine Autonomy
- Remote Control
- Drone Telematics



- Voice & Video
- Messaging
- LMR Migration
- Remote Expertise

- Video Surveillance
- Site-wide Telemetry
- Fleet Management
- Pump / Light Control

- Internet Access
- Knowledge Bases
- Augmented Working
- Remote Diagnostics

ARCIA

VOCUS

LTN challenge

Concept #13

- LTE ≠ Wi-Fi ++
  - Remember the differences – QOS, Distance, scale
  - Not ‘Wi-fi on steroids’
  - Wi-Fi 6 has some new features however

The ‘Achilles heel’ of LTE - Regulatory & Spectrum

Regulatory

- In Australia, fully private LTE networks are supported by the Government Regulator (ACMA).
- In some countries, private networks are ONLY allowed to be ‘owned’ by the ‘mobile carriers’.
- These restrictions have limited growth in some countries (Sweden, much of South America, etc) to the mobile operators who have limited expertise.

Spectrum

- In Australia, generally LTE spectrum is available in regional & remote areas.
- Currently the legacy mobile carriers have an effective monopoly on spectrum in urban areas of Australia.
- Some countries (e.g. Germany & Japan) have had spectrum allocated nationally to private networks.
- Uncertain future for urban spectrum allocations in Australia regarding private networks

ARCIA

VOCUS

Some current areas of hot industry debate ?

- Are traditional mobile operators able to build private LTE networks for industry ?
- Will regulators make provisions for this evolving technology – especially for spectrum in urban environments ?
- Will spectrum for Public safety use be made available for private LTE ?
- When/if will TETRA/P25 be replaced by LTE ?
- Role of UHF/VHF ?
- Will OpenRAN cause disruption to traditional vendors ?
- Impact of Wi-Fi 6 on 4G/5G ?
- Are there new ways of revenue generation for consumer network operators?

ARCIA

VOCUS

LTE challenge

Concept #14

- LTE is not perfect !
  - Remember the differences – QOS, Distance, scale
  - Not always an option in some locations – spectrum & regulatory

The Take away message…..

- These 14 concepts will give you a framework for understanding everything else in LTE
  - If you hear something that conflicts with one of these concepts…. It's probably wrong.

Questions & Break ?

LTE Solutions specifics

Industrial Use Cases – Typical scenarios

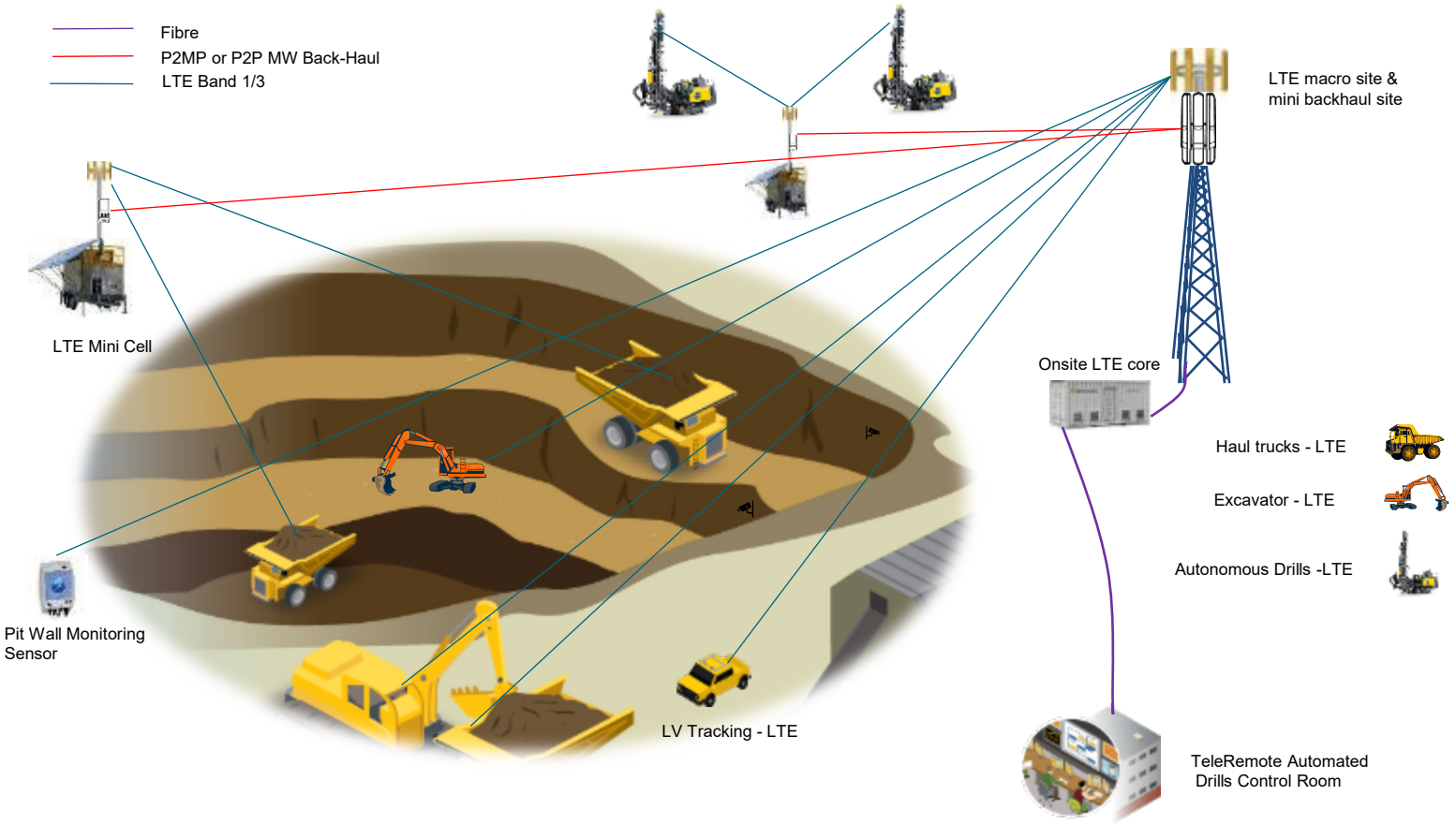
- **Use cases:**
  - Smart collaboration (Text, Voice, Video), PTT
  - Automated Guided Vehicles (Latency <50ms)
  - Surveillance Cameras (Latency <50ms)
  - Human Machine Interface (Latency <50ms)
  - Remote Expert (Latency <50ms)
  - Augmented Reality (Latency <50ms)
  - Sensors, Actuators (Latency >100ms) – CATM1 & NB-IoT
- **Coverage: 100s m^2 – 100 km^2s**
  - Indoors and/or outdoors
  - Above and/or below ground
- **Number of UE: 10s-10,000s**
- **Bandwidth per UE:**
  - Low: < 200 kbps
  - Medium < 1Mbps
  - High: > 20Mbps

ARCIA

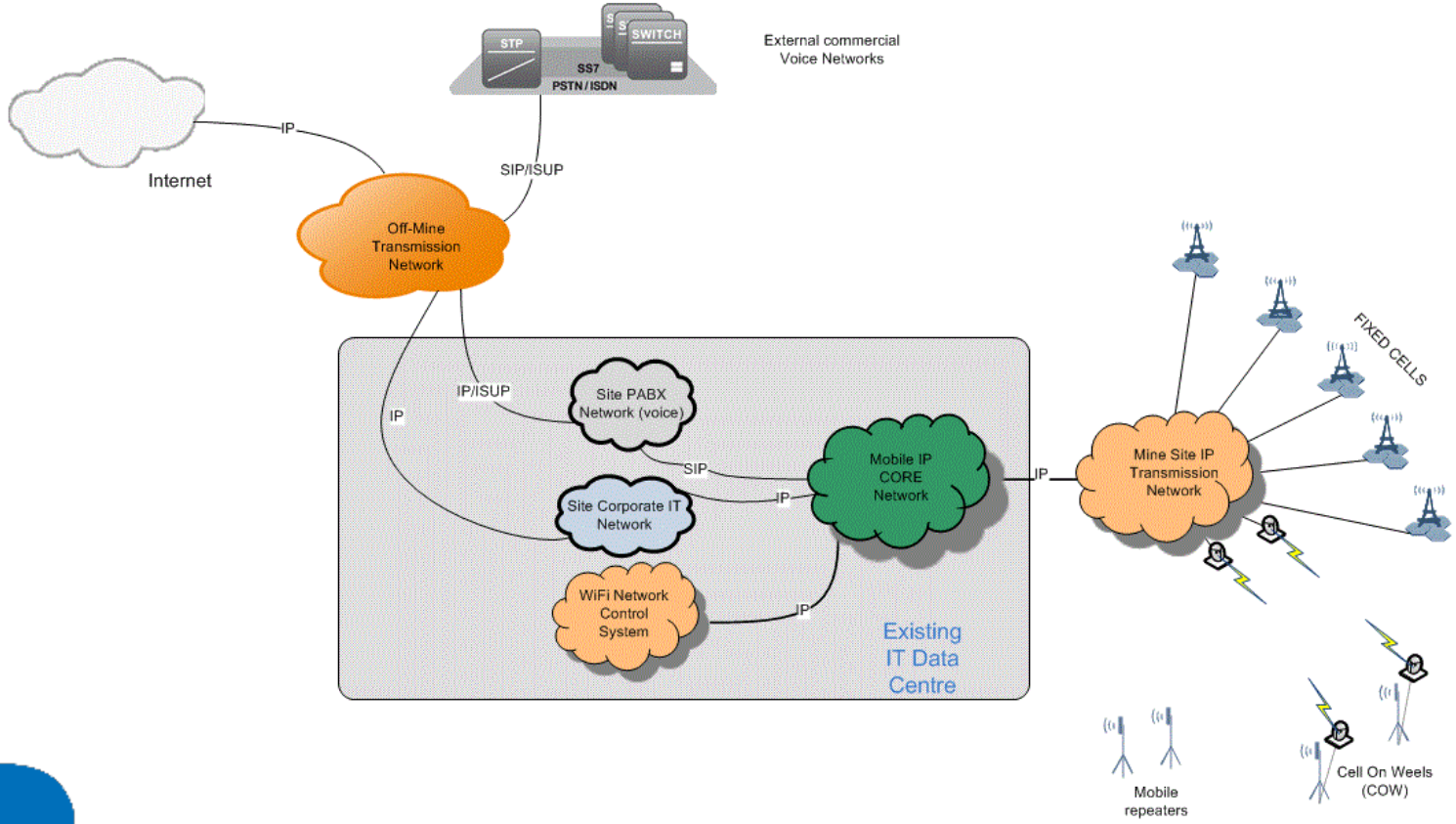
VOCUS

LCN challenge

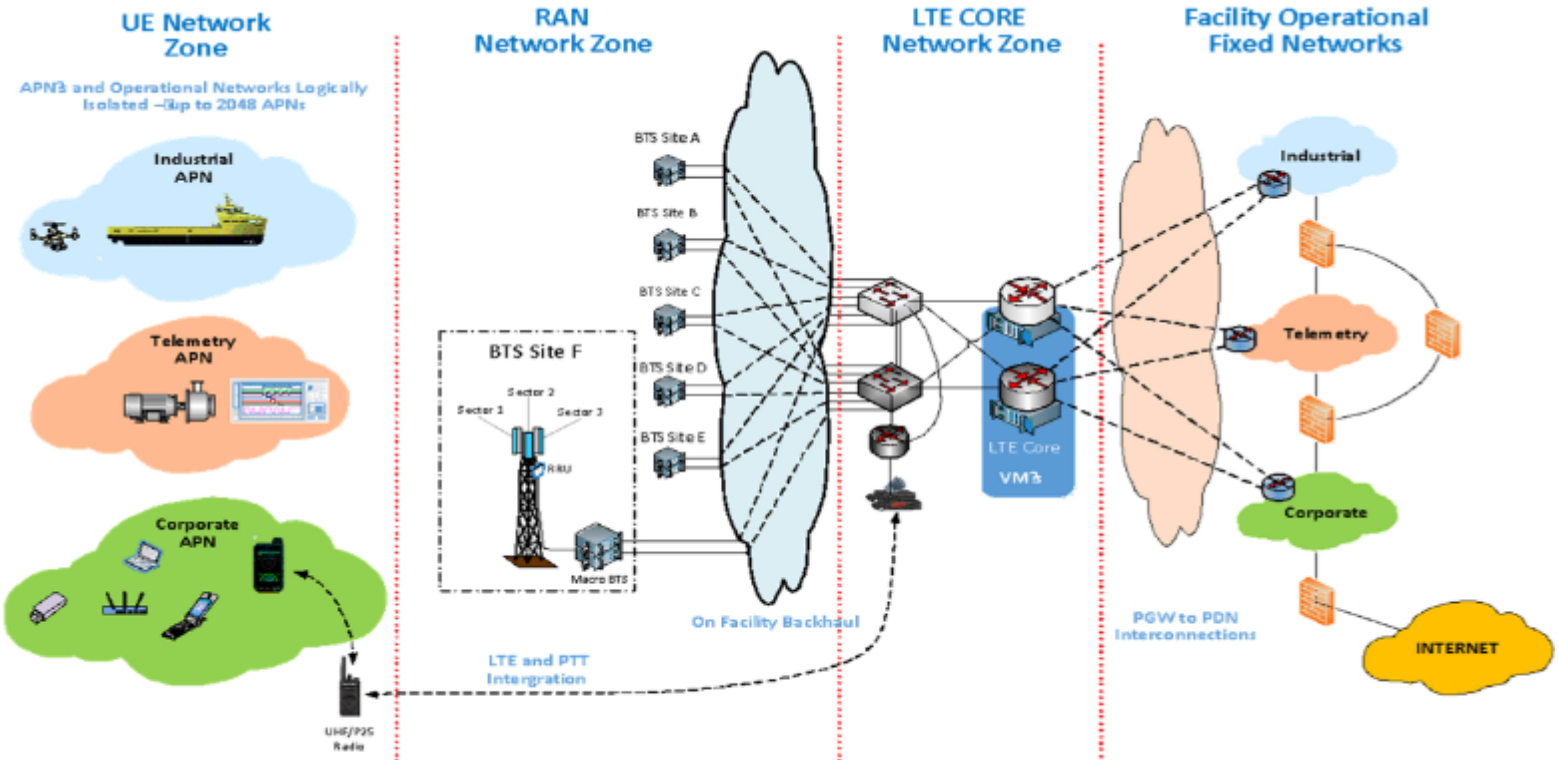
Typical private LTE network in a pit mine



Typical private LTE Network Overview



LTE Network more detailed



End to End – Quality of Service (QoS)

- ‘Tunnels’ of data, each with own priority and guaranteed bit-rate
- End to end QOS – from UE to application servers

FMS – Vehicle command and control

Video

PTT - voice

Telemetry

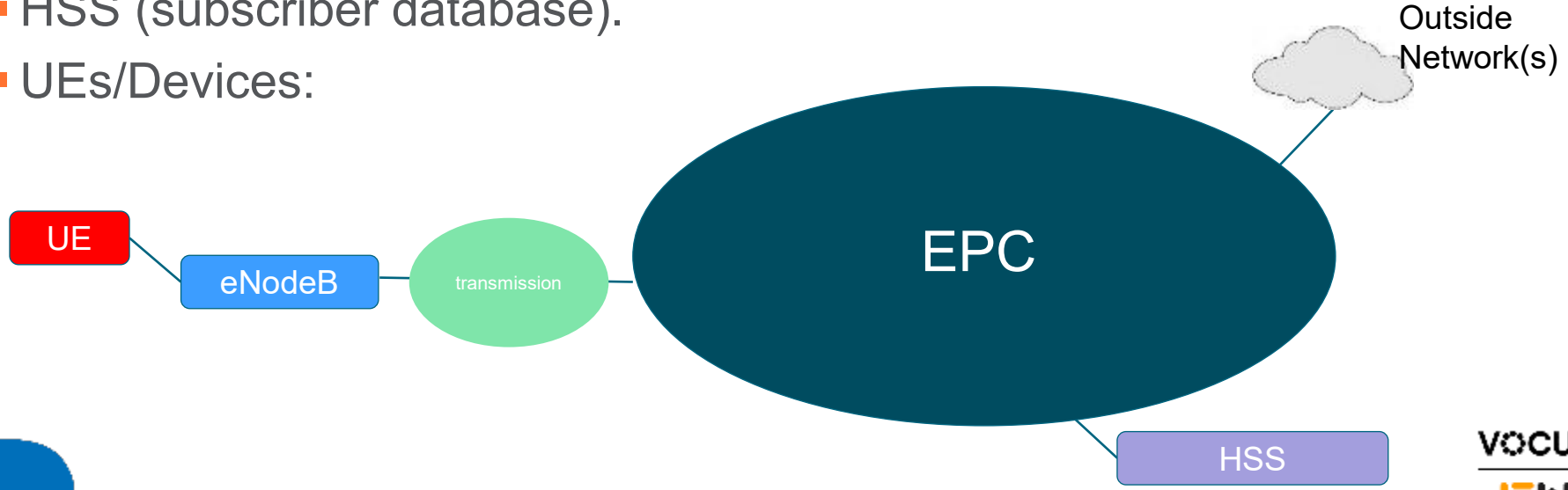
EPC/LTE core

LTE router

Network Router

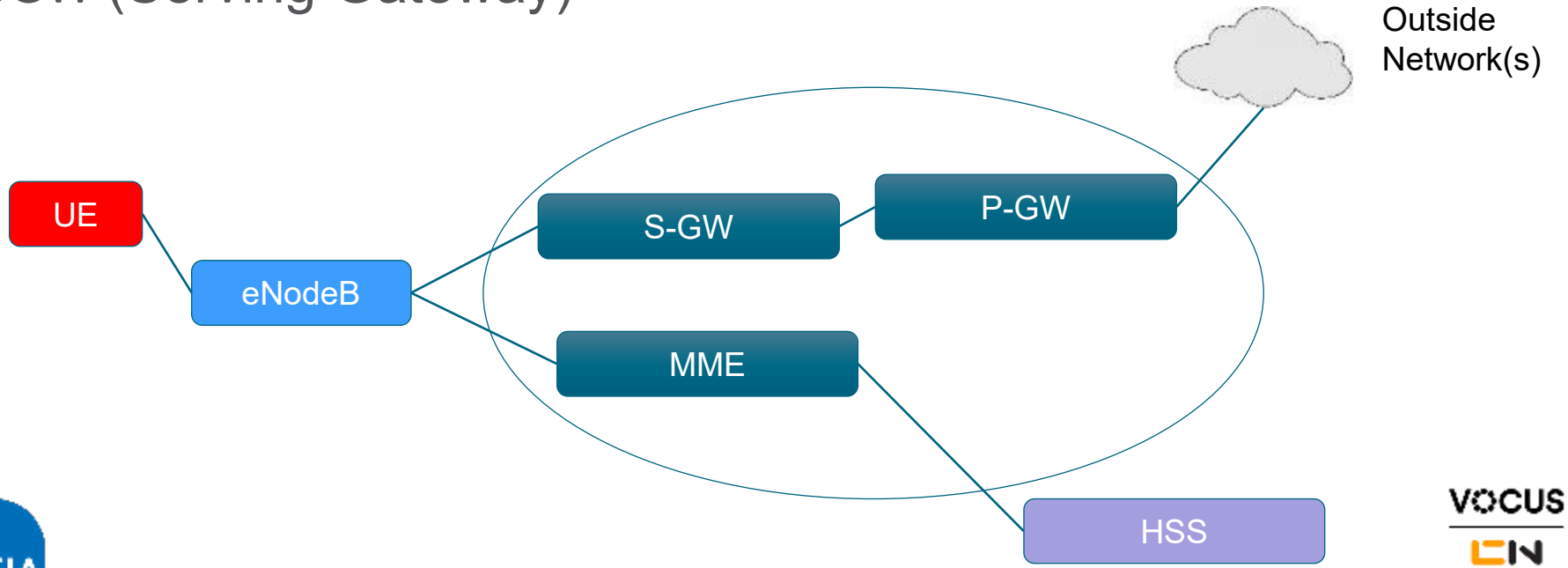
Components in a LTE Network

- Radio (eNodeB).
- Transmission network (fibre & MW):
- EPC (Mobile Core).
- HSS (subscriber database).
- UEs/Devices:

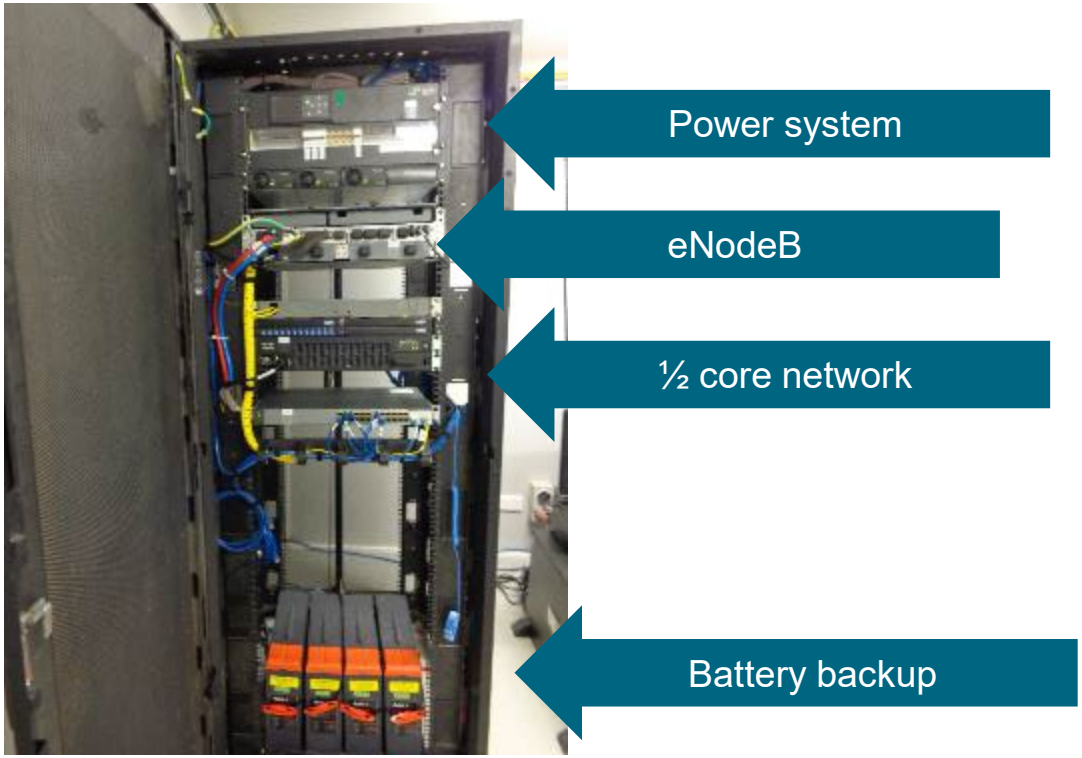


Components within the EPC

- MME(Mobility Management Entity)
- PGW (Packet Data Network Gateway)
- SGW (Serving Gateway)



Example of a real core network



Different Base station types

- Fixed large Mobile base station (eNodeB) [Macro site]
  - Used to provide permanent, long distance, high capacity coverage
  - Expensive due to civil works components (power, tower, etc)
  - High power consumption (1000w)

- Fixed small Mobile base station (eNodeB) [Mini site]
  - Used to provide small area coverage (1-2km)
  - Typically used in camps, buildings, etc
  - Quick & easy installation, 240v or 12v power

- Mobile ‘COW’ Cell On Wheels [Trailer]
  - To provide medium term & short distance coverage
  - Takes a day to move/setup
  - Medium power consumption. Can be solar/wind powered

VOCUS

Field deployment example of trailer/COW

Small(5w) eNodeB can often replace existing legacy Wi-Fi infrastructure

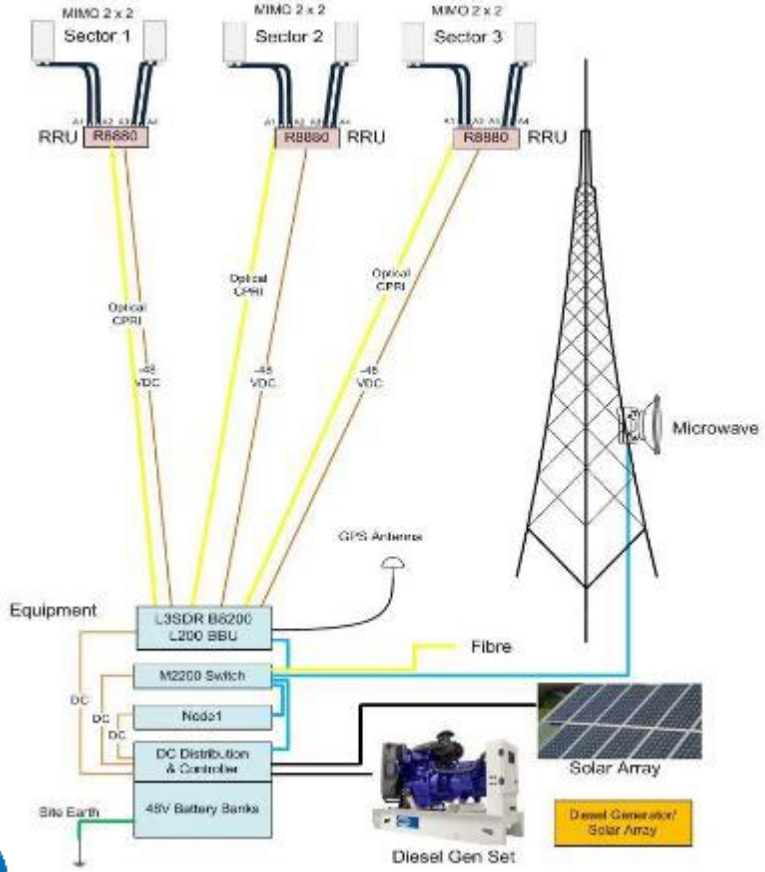
Rapid deployment Mini eNodeB on 10m tower

ARCIA

VOCUS

LTN challenge

Macro eNodeB



Questions & Break ?

ARCIA

VOCUS

LCN challenge

Public safety discussion

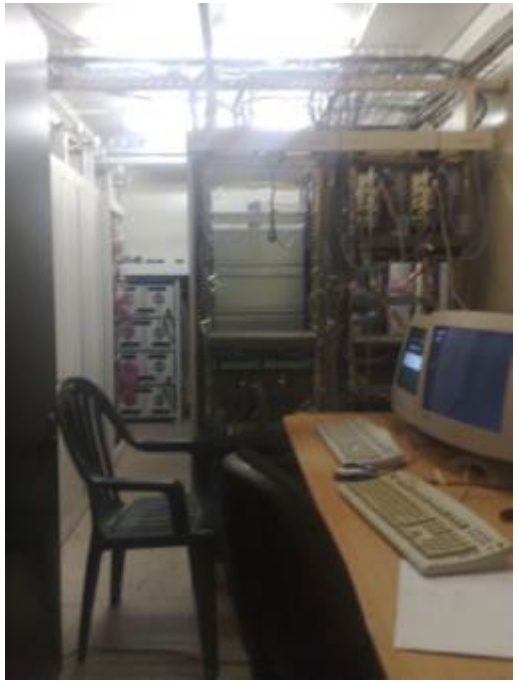
The technology is the easy bit….

Traditional mobile DR solutions

- COW [Cell on Wheels]

Traditional mobile DR solutions

- Total exchange replacement



Traditional mobile DR solutions

- Major exchange replacement

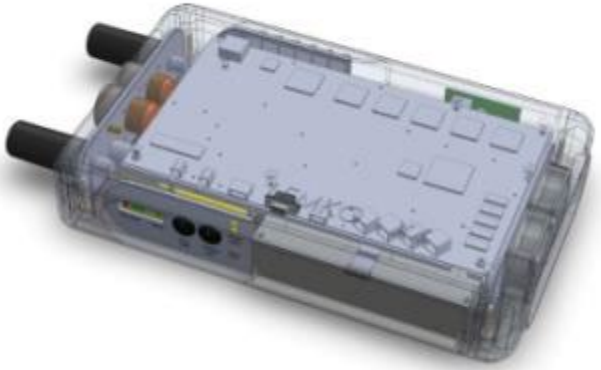
ARCIA

VOCUS

LCN challenge

Traditional mobile DR solutions

- Small replacement network



ARCIA

VOCUS

LTN challenge

Complexities…. Non-Deterministic

- Public Safety (Disaster Recovery) networks are completely different to consumer networks.
- Critical to understand that the technical communications architecture required for a Public safety network should be completely different to that of a consumer network.
- The reason for the above is that in public safety:
- Can have key infrastructure destroyed (burnt, blown up, etc)
- You don't know 'where the plane will crash' so coverage requirements are unknown.
- You don't know 'how many people involved' so capacity requirements are also unknown,

ARCIA

VOCUS

LTN challenge

Complexities….

- Consumer network owners see it all as a revenue opportunity.
- Consumer networks owners don’t understand the requirements.
- Getting everyone aligned is hard
- Spectrum – unless Public safety agencies have their own spectrum - it’s hard
- Vendor misalignment.
- Politics – between everyone
- Technology is the easy part !

ARCIA

VOCUS

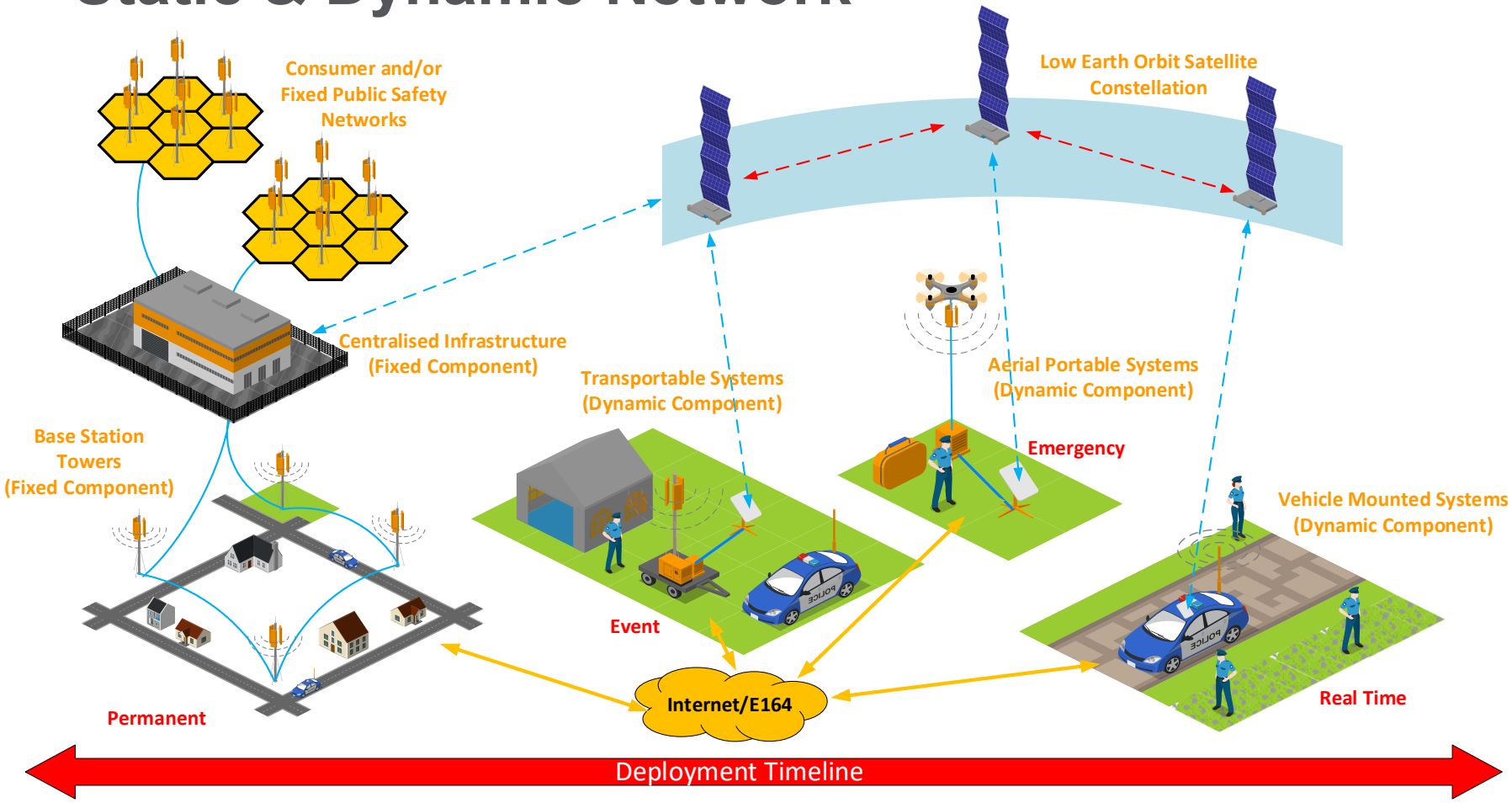
Breaking down the problem of the architecture….

- We see dividing the network problem into two domains

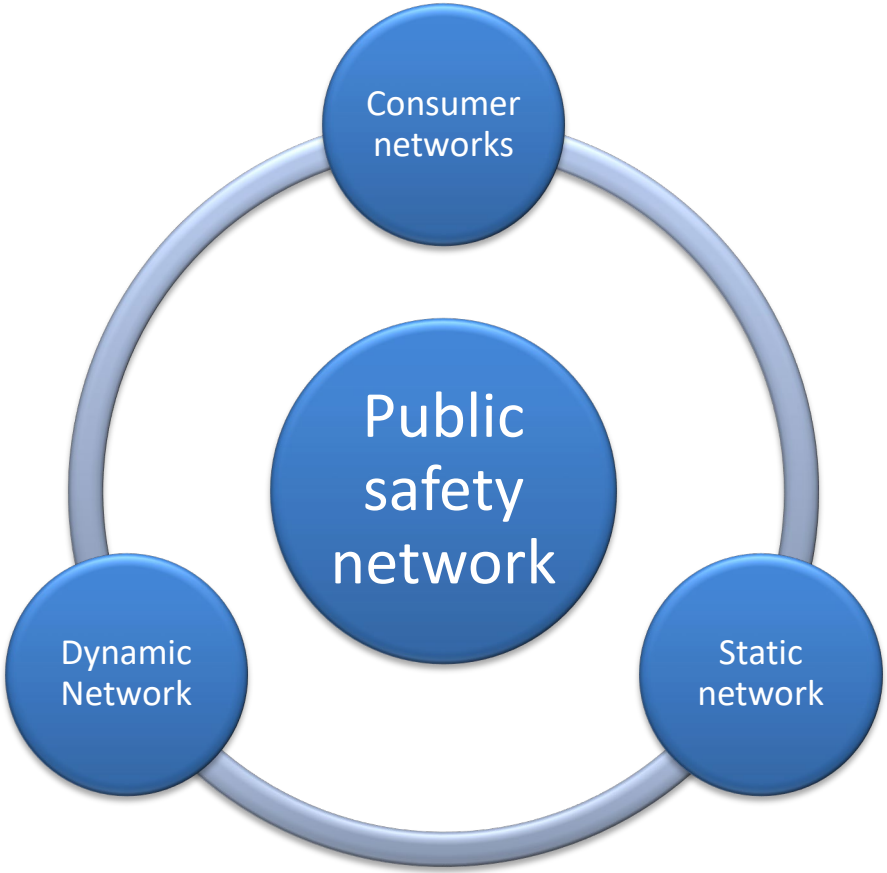
- Static
- Dynamic

- Then integration with existing consumer network(s)

Static & Dynamic Network



Public Safety Network – the building blocks



Height Illustration

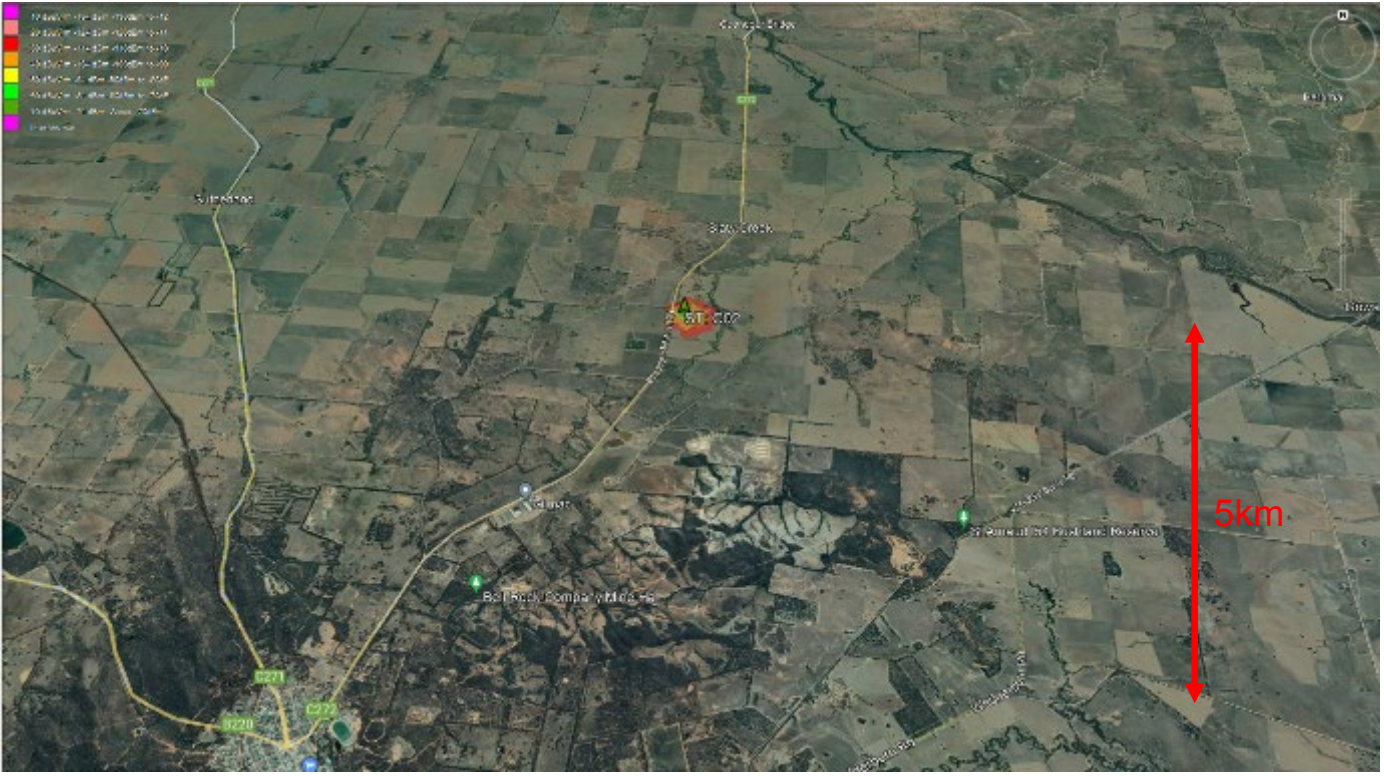
Typical disaster recovery solution
Antenna height – 5m

ARCIA

VOCUS

LCN challenge

Rapid Deployment – Height matters
Antenna height – 5m

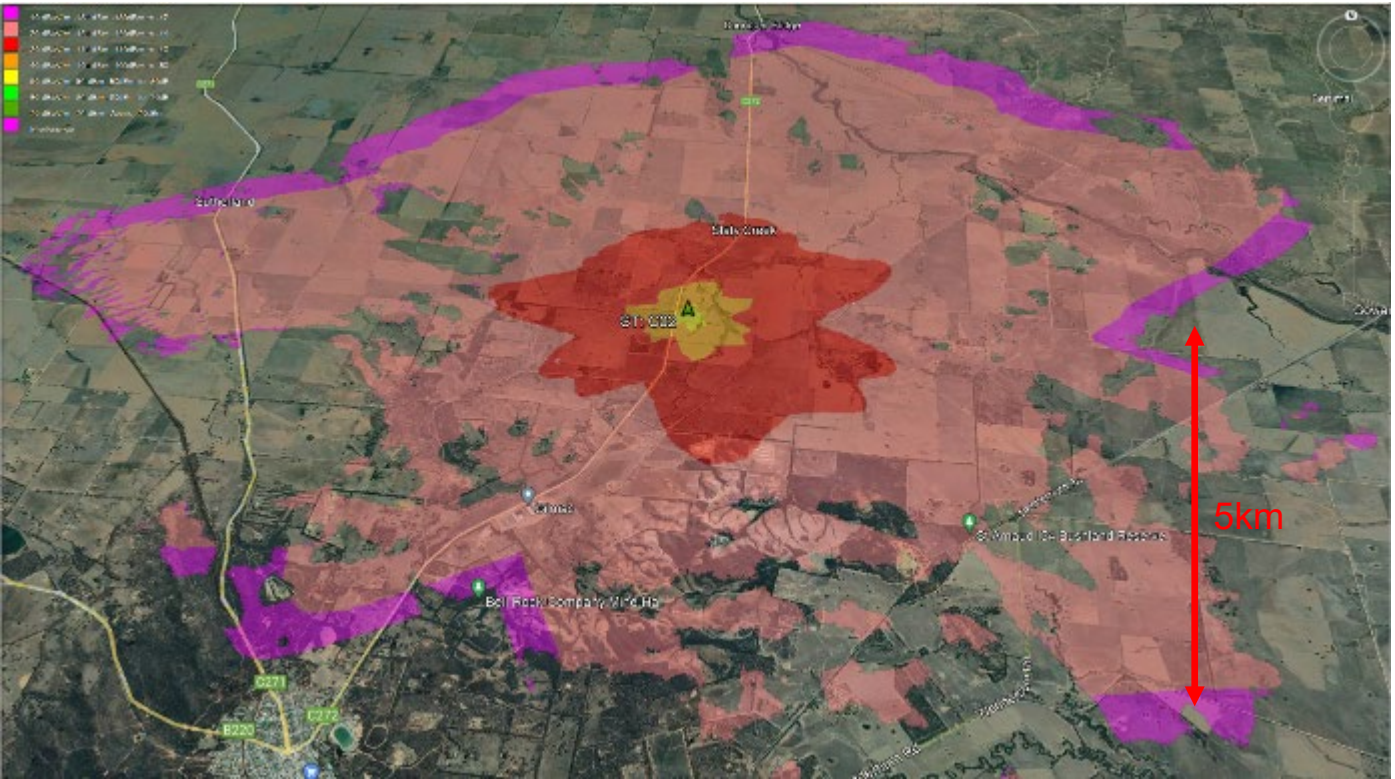


- 5w 2T2R eNodeB
- Victorian undulating
- Coverage width 500m

Rapid Deployment – Height matters
Antenna height – 20m

- 5w 2T2R eNodeB
- Victorian undulating farmland
- Coverage width 4km

Rapid Deployment – Height matters
Antenna height – 100m



- 5w 2T2R eNodeB
- Victorian undulating farmland
- Coverage width 12km

5G Discussion & IoT

In the news – Capacity & Speed

- *"5G specs announced: 20 Gbps download, 1ms latency, 1M devices per square km"* – Technica Feb 17
- *"5G will be the key enabler of a new era that will affect every end user, the economy, and the society as a whole. It will make the probable possible by connecting everyone and every thing efficiently."* – Nokia insight magazine.
- *"Telstra boss predicts 5G to be faster than NBN fibre"* – The West Australian 11 Jan 2018
- *"Going massive with MIMO"* – Jan 26 2018 Ericsson
- *"Samsung hits 1.7Gbps in 5G tests on a moving train"* – Fossbytes Dec 2017
- *"Did the 5G rollout in Wuhan damage the innate cellular defense cells of the population, putting the people at risk of complications and death from coronavirus?" - Natural News April 21*

5G

VOCUS

Key Messages – 5G generally

- There is a lot of ‘hype’ in the market about 5G.
  - Sadly, it will not create world peace or end starvation.
  - Unfortunately much of the hype has to do with vendors (who are marketing to create new revenue streams) trying to encourage consumer demand (consume more data).
- 5G is just a small evolutionary step from 4G/LTE.
  - In contrast 3G/UMTS to 4G/LTE which was a large change in technology platform.
  - However the further push to standardisation and ‘open’ platforms means further multi vendor solutions and new vendor players.
  - RAN changes (standardisation of CPRI interface) potentially will disrupt the market commercially.
  - For the traditional mobile only vendors (Ericsson, Nokia, Huawei) a number of new vendor entrants (Microsoft, Amazon, etc) are now enabled to compete.
- The laws of physics still remain valid.
  - To achieve the ‘advertised’ high bandwidth of 5G, lots of spectrum is required. (Due to physics)
  - To access ‘lots of spectrum’ this is generally in the ‘higher frequency bands’. (Due to economics & physics)
  - The ‘higher frequency bands’ means limited (typically 10-500 metres) cell site range (Due to physics)
  - Don’t let the ‘under test conditions’ results from vendors misguide you !

ARCIA

VOCUS

Key Messages – 5G

- ‘5G’ is really a marketing term not a technical one. It is simply an arbitrary ‘stake in the sand’ of a set of continually developing standards.
- ‘4G’ & ‘5G’ are really evolutions of the ONE standard (3GPP).
- One does not replace the other, they are simply expansions to an established ecosystem that is constantly expanding.
- Backward compatibility is a fundamental characteristic – if you sent your Samsung S20 back in time 15 years – it would still work on the legacy mobile network of the time.
- 5G (and 4G) is a standard not a technology.

Key Messages – 5G Private Networks (specifically)

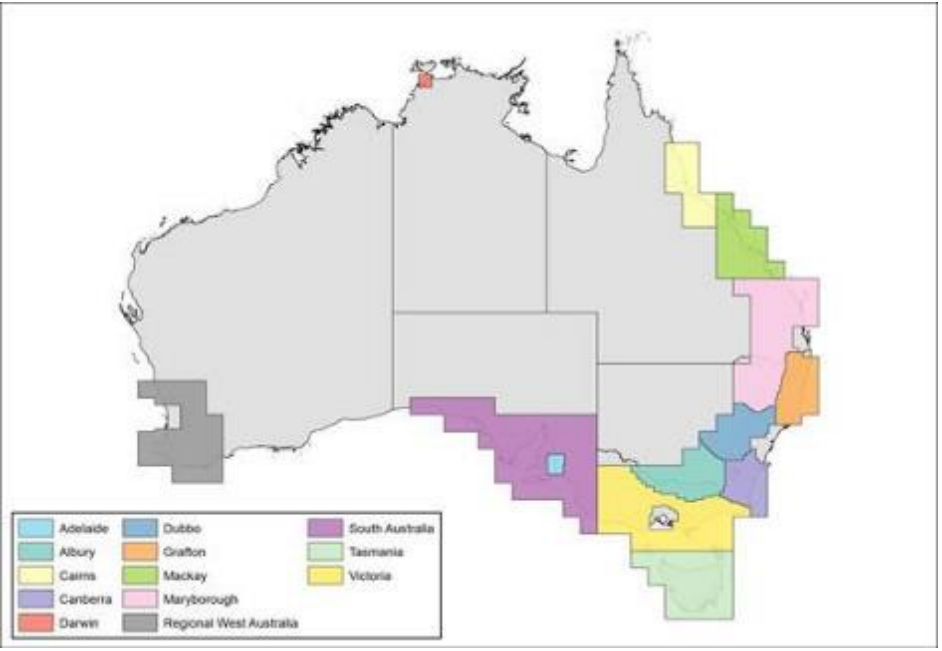
- If you already have a 4G/LTE network your investment is secure.
  - It's not about to become 'obsolete'
  - You can readily expand your existing LTE network with 5G base stations (called '5G-NR').
- The 5G use case is primarily around high bandwidth applications (high speed video, equipment autonomy, etc).
  - Potentially 3-4x speeds of 4G/LTE
  - HOWEVER these speeds are generally limited to 100-500 metres from the 5G base station (due to allowable operating frequency).
- The 'low latency' feature often highlighted in 5G is not highly relevant/applicable in private networks – as the low latency is already achievable (as the core network is onsite).
  - Remember that the speed of light cannot be increased by sales teams.
- Expect to see 5G base stations being 'added' to existing 4G/LTE private networks in 2022 and beyond. This will provide high speed 'spot coverage' zones.
- Current limitations within industrial networks include availability of suitable modems and other end user devices.

ARCIA

VOCUS

Regulatory & Spectrum – Australian context

Site location determine what options (if any) are available for private mobile networks.

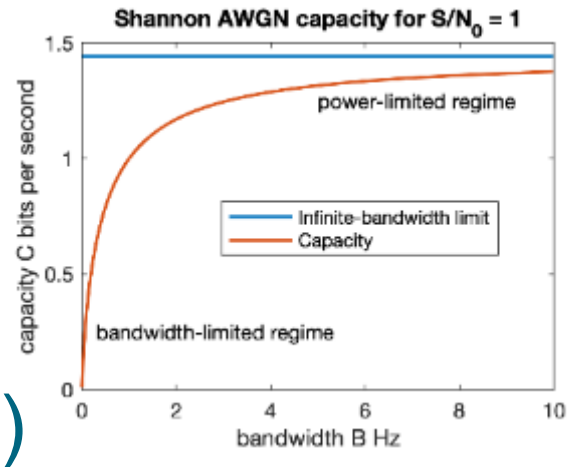


- In Australia for private networks, 5G is identical to that of 4G from a regulatory perspective.
- With some limited exceptions, private 4G/LTE is limited to Band 1 (2100 MHz) and Band 3 (1800 MHz).
  - These are ‘Apparatus licences’ which cover a geographical circle of 50km diameter.
  - They are FDD bands – 10 MHz + 10MHz is the typical size (with a max of 20 MHz + 20 MHz).
- For 5G, there are two spectrum groups.
  - The so called ‘cm wave’ band - Band 78 (3600 MHz).
  - Also the ‘mm wave’ bands – n257 (26 GHz) and N261 (28GHz)
- The key reason that 5G has potentially higher speed than 4G is that these new spectrum bands have larger bandwidths (60-200 MHz rather than 20-40 MHz).
- It appears that some spectrum will be made available nation-wide for industrial use.

ARCIA

VOCUS

Maths beat marketing



Shannon's law:

$$C \approx w.n.\log_2 (1+SNR)$$

- Capacity
- Bandwidth
- Num. of antennas
- RF Noise

So fundamentally, 'speed' is determined by:

1) How much spectrum you have (bandwidth)
2) Number of antennas
3) Noise levels
4) 'Load' on network
5) Technology encoding (which is improving but has limits)

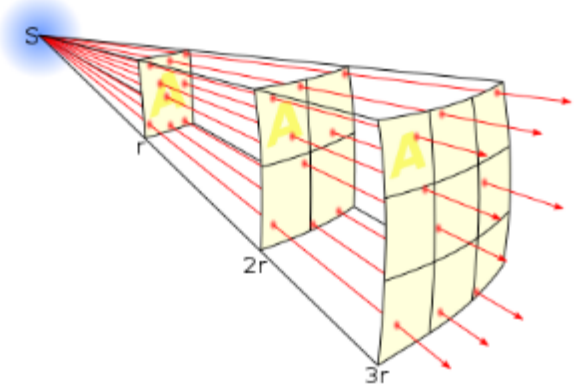
ARCIA

VOCUS

LIN challenge

What frequency you use & distance matters !

$$\text{Free Space Path Loss} = \left(\frac{4\pi df}{c}\right)^2$$



So key points :

1) Higher frequencies don't travel so far
2) Distance matters

ARCIA

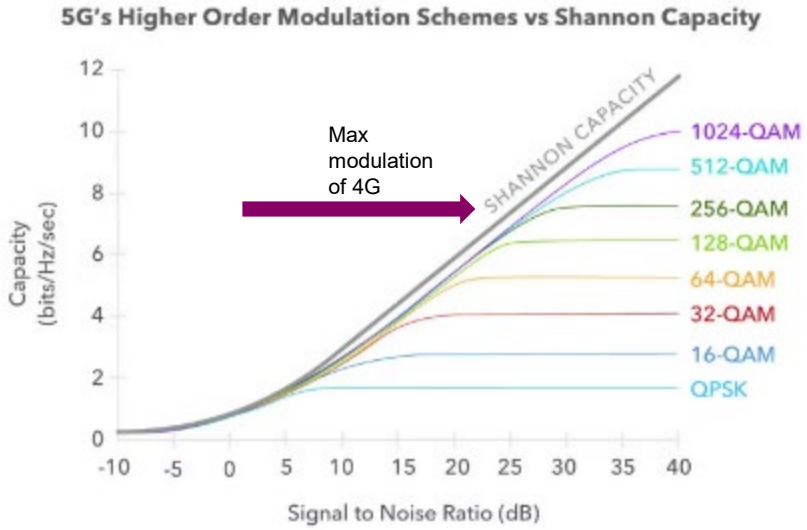
VOCUS

LTN challenge

So is 5G fundamentally faster ?

Well yes but not always as much as the sales people would like you to believe…

1) Physics (and the maths around it) finally wins….
2) In terms of bits/Hz/sec – it mainly has an impact with high SNR (see graph on right)
3) So while theoretically (based on encoding schemes available in 5G vs 4G) 5G has a higher efficiency, this is often difficult to achieve outside of near perfect (high SNR) environments.
4) In practical, real world terms:
   - When all else is equal (Bandwidth, # antennas, SNR)
   - The advantage of 5G encoding vs 4G is minimal (<10%)
4) Is primarily the bandwidth that makes the higher speeds.



Now there are other considerations in LTE that reduce efficiency compared to 5G such as 1MHz guard bands, max 20 MHz channels, etc, but these are issues that only come into consideration with larger bandwidth allocations. As with all things in engineering 'it depends' !

VOCUS

Slide adapted from a Cisco presentation

Typical Radio Access Hierarchy 4G, 5G, Wi-Fi

	Common Terms	Typical Coverage (inter-site-dist.)	Typical spectrum (per network)	Typical DL (~user rate)	Optimal Service
mmWave unlicensed 60 GHz	WiFi, WiGig. 802.11ad/ay	50 m	7GHz shared (2GHz channel)	5,000 Mbps	Point to point. Indoor.
mmWave 24-50 GHz	Millimeter Wave	50-200 m	800MHz channel	2,300 Mbps	Hot-spot data, Point to multi-point NR-IIoT/URLLC
Unlicensed 5-6 GHz	Wi-Fi 802.11ac/ax. LTE-U, NR-U	100 m	500MHz shared (80MHz channel)	300 Mbps	Hot-spot data, indoor, mesh
Upper mid bands 3-4 GHz	C-Band, sub 6Ghz, TDD, CBRS (US)	500 m	100MHz	290 Mbps	Supplementary data capacity
Lower mid bands 1-3 GHz	1800/2600MHz, FDD or TDD	5,000 m	80MHz (3x20MHz ch)	120 Mbps	Urban Voice, data capacity.
Low bands sub 1GHz	700-900MHz FDD. UHF, Digital Dividend	10,000 m	40MHz (2x20MHz ch)	80 Mbps	Voice, Data coverage. LTE-M (IoT).
Low bands sub 800MHz	600-700MHz FDD. 2nd Digital Dividend	10,000 m	20MHz	50 Mbps	Voice over NR. NR-IoT

* Depends on environment, site design, RF features (e.g. MIMO schemes)

* Depends on country specific regulatory allocation and number of operators

* Depends on # users, load, interference, etc. Not peak rate.

What does 5G bring for IIoT and when?

- Today 5G largely “bolts” on to 4G/LTE to Gbps Bandwidth
- Mainly “mid-band” 3.5 GHz, with some “mmWave” 25-28 GHz

		Enhancements coming 2020+
Private 5G network	• Unique network ID • Integrated and independent architectures • Seamless fallback to public networks	Slicing and access control
Spectrum	With NR-U, 5G NR will support: • Licensed spectrum • Shared spectrum • Unlicensed spectrum	More aggregated bandwidth
URLLC	• Low latency • Ultra-reliability • CoMP multi-TRP • Service multiplexing • Enhanced mobility	Radio & NW enhancements for lower latency below 10ms to 1ms
TSN	• Ethernet over 5G • Deterministic networking • Device time synch.	Providing “Wireline” responsiveness
Positioning	• Network & device based • Industrial IoT requirements	Location tracking to sub 1m at up to 160km/h

Key Messages – 5G evolution from 4G

- There are essentially two paths open:
- Phase1 – 5G NSA (Non Stand alone)
  - This is the path that almost all consumer network carriers have taken around the world.
  - The 5G RAN (called NR – New Radio) connects back to the existing LTE core.
  - The 4G RAN (eNodeB) provide signalling as a radio overlay to the 5G NR units.

- Phase2 - 5G SA (Stand Alone)
  - As of today in service around the world there are only a handful of such deployments in the consumer network space.
  - There is a new separate 5G core network and a new 5G RAN (same as the phase 1 RAN).
  - In this scenario there is no mixture of 4G/LTE and 5G Radios in the network.
  - There are currently very few private networks also.

ARCIA

VOCUS

Where would a 5G SA network be used in private networks – next 1-2 years ?

- In small sites (less than circa 1-2km2) where the site can have lots of small base stations.
- Where spectrum is limited to only the 5G cmW and mmW bands (so urban environments).
- Where there is a need for high bandwidth, high density applications.
- UEs options are a key determinant

ARCIA

VOCUS

Why are some vendors banned from 5G activities in some countries ?

- Consumer 1/2/3/4 G are all ‘centralised’ networks
  - These are easy(ish) to protect
  - So called ‘Walled garden’ security
- 5G networks are potentially ‘decentralised’ networks
  - Harder to protect using historical approaches
- Many vendors have their support outside of Australia
- Less of an issue for private LTE networks

ARCIA

VOCUS

CN challenge

Questions & Break ?

ARCIA

VOCUS

LCN challenge

Steps to building your own…

Generally no single solution

Side adopted from a cisco presentation

There are many types of wireless technologies applicable to IoT

Industry and use-case driven technology selection criteria

1. Where is the network ?
2. What are the applications requirements?
3. How 'big' is the network (physically & number of users)?
4. What are the potential technology options?
5. What are the CapEx and OpEx Implication?

Industrial LTE implementation models

Which to use varies on:

- Country specific regulatory environment
- Access to spectrum in area

Private LTE

- Licensed or unlicensed spectrum
- Build & operate own network infrastructure
  - Core
  - Base Stations

Shared

- Sub-licence spectrum from a mobile network operator
- Build & operate part/all the network infrastructure

Public LTE

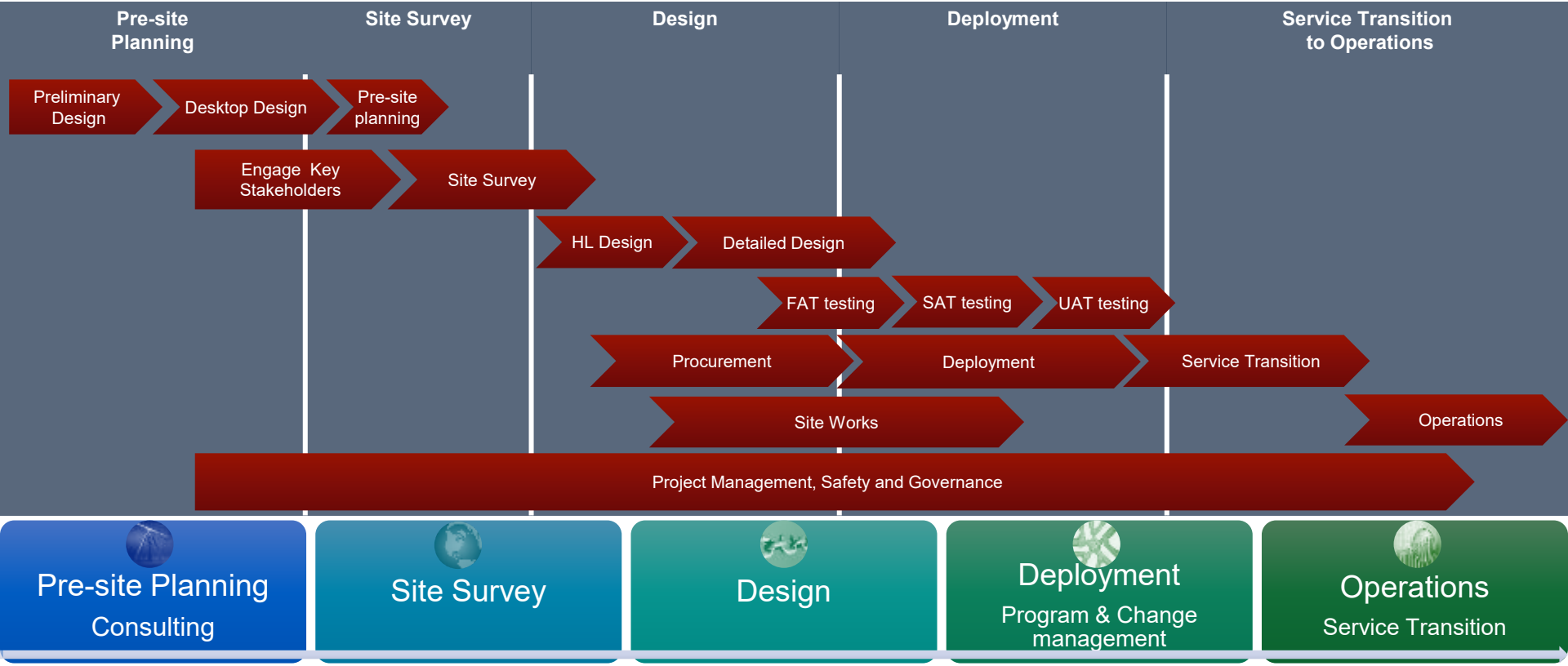
- Partner with a mobile network operator
- Extension of consumer network
- Alternatively ‘network slice’ to create a ‘virtual’ private network

ARCIA

VOCUS

Phased Deployment Approach

What does a wireless project look like?



WE HOPE YOU ENJOYED THIS SESSION

If you have any questions that haven't been answered, please email them to us at info@arcia.org.au with the email heading 'PDT program question' and we will respond.