www.satpty.com

Efficient Site Design

By: Dale Stacey

dale@satpty.com

Synopsis

The greatest spend in establishing new mobile radio/telecommunication sites is invariably in the real estate, the access, civil works, and establishment of tower/building structures and power. Experience shows that this can equate to >90% of the capital cost. So why is this part of the project so often poorly considered in our build of radio infrastructure projects ? This presentation deals with some lessons learned, oversights and pitfalls in establishing sites and some future strategies and building checklists to capture fundamentals of what we need.

- regulations governing site builds
- concept of right sizing
- number of sites growing
- concept of the value of a site and tower in real estate terms
- remoteness multiplier
- building site and tower structural survey databases
- practical trumps theoretical
- impact of increasing regulation (tickets, inductions, grinding pegs off, fencing)
- increasing environmentalism (managing aesthetics, radiation to public)
- checklist for site surveys

www.satpty.com

Disclaimer

These are my views,
all care no responsibility !
no one can be an expert on everything !

www.satpty.com

Inherent Value of a Site / Tower

a) It is Commercial Real Estate with an inherent commercial value (Value = x times the annualised RoR after costs), typically x will be 5.

b) Value function of Captive market, location, (High Density to Remote bit like ACMA rates).

c) Exclusivity (ie is there only one site available).

d) Supply/Demand.

e) Coverage Profile.

f) Access.

g) Amenity (suitability for what you are trying to achieve). (Is it easy Landlord to deal with etc)

h) Facility (Is the tower suitable with capacity, is the equipment room suitable, is the Power supply and HVAC suitable with capacity)

i) Trade off between Lease rather than own and operate

SAT have built a database valuing sites to aid carriers when assessing the value of a site (Value a+b+c+d+e+f+g+h+i), (done this twice.)

(MAIN) Regulations governing site builds

WIND LOADING / STRUCTURAL DESIGN

-AS 1170 Code upgraded in 2011, again in 2021

-2011 the windloading parameters became more stringent from previous

-2021, (new wind region maps, region B and C have increased in size), (C cyclonic and D extreme cyclonic)

This theme is likely to continue with recent Global events.

STEEL DESIGN

-AS 3995- Design of steel lattice towers and masts

CONCRETE DESIGN

-AS 3600: 2018 Concrete Structures, Steel & Tendons

ELECTRICAL DESIGN

-AS/NZ 3000 - The Wiring rules

-AS 3010.1 Generating Sets.

-AS 45091 Australian Skills Qualification

GUIDELINES

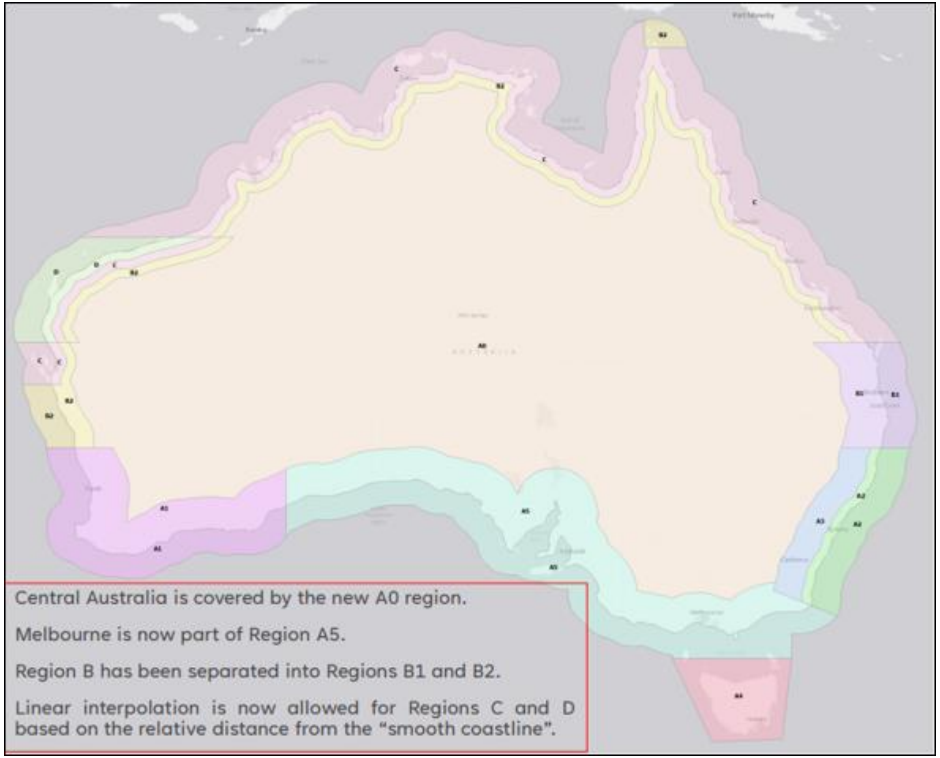
-issued by Clients. (Optus, Telstra, State Governments)

-Sustainability requirements (Power, disaster withstanding/ recovery)

MANDATORY OHS

Climbing, Safety, Fencing, increasing Public awareness, ARPANZA

WIND REGIONS AUSTRALIA



General Concept of Optimising / right sizing / Minimisation / Value Engineering.

Sizing the tower height - (polynomial cost as a function of height), LOS, coverage delimited, consider reducing height, access, alternate tower type

Sizing the power can easily have quadruple to 10 fold ripple effect cost (6-10 dB cost in radio speak)

Earthing, lightning protection considerations

Power, Critical point at which uneconomic to connect to grid, definition of a solar site

Access and serviceability costs (track)

Capex versus lease.

Dissipating heat

Optimising indoor/outdoor mix of equipment (move to outdoor) (example 5G technology)

Getting rid of PIM

Serviceability

Reliability Calc

TOTAL COST OF OWNERSHIP MODEL/ANALYSIS.

www.satpty.com

Electrical Design

The Ripple Effect -Example

Adding 6 extra channels could add

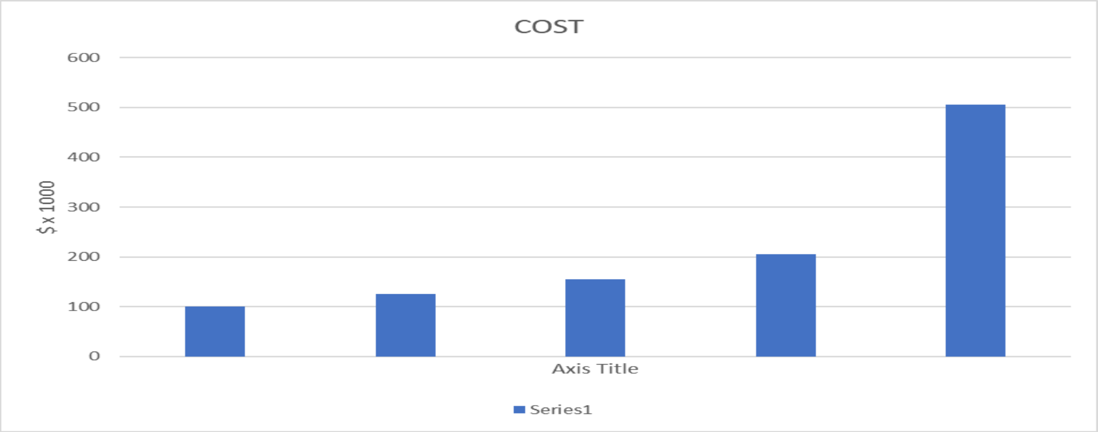
~2 KW peak load onto the Power system ⇒ requiring addition Battery capacity ⇒ Power AC to DC Power upgrades ⇒ heightened max demand ⇒ additional cooling ⇒ Transformer upgrade ⇒ Transmission Line upgrade

In limit 5 x the Peak Load capacity (note doesn’t account for site autonomous Power systems which can be much greater cost)

Equipment Load	AC/ DC Power Supply upgrades	Equipment Room Cooling upgrades	Max Demand upgrades add 10 kVA	**Transformer upgrades**	**LV or HV Line upgrade**
~Peak 2 kVA ~Steady State around 1500 kVA Power consumption typically 400-500W per channel 2kW for 6 channels + peripherals (router, microwave) 	Add charging ability 60A at 48V=~3kVA 	Add Max~5kVA Steady State ~2kVA Main 16 hrs, second summer 8 hrs day, DC fan 8 hrs winter less (30 KWhr) EER (high 3’s) 		415/11,000V Upgrade by 10kVA	Maybe needs upgraded 

www.satpty.com

Real Cost of Power System Provision



Equip	$100K	$100K	$100K	$100K	$100K
DC Power Supply upgrades		$25K	$25K	$25K	$25K
Cooling upgrades			$15K+$15K	$15K+$15K	$15K+$15K
Transformer Upgrades				$50K	$50K
Power Line upgrades (example 2Km’s)					$300K
running total	**$100K**	**$125K**	**$155K**	**$205K**	**$505K**

www.satpty.com

Operating Expenditure (Opex)

2kVA load equates to 2.2 x 24 x 365 kWhr/year = 19,272 kWhr or $3854.40 per year (as 20c a kWhr) RAW LOAD

Max Load ~10kVA

~ADMD load is more like 4kVA ~ $7708.80 per year (as 20c a kWhr) aggregate system

(typically 2-10 times a domestic bill) - Not insignificant, not environmental.

Load Minimisation

www.satpty.com

How can we reduce the electrical load at a site.

-strip out whats not required (lights, auxiliaries, overkill Hot Standby - Duality)

-Smart management of devices (turn on and off, pick charging times)

-Optimise with duty cycles / batteries /(solar)

-Build to demand not excess. (modular if necessary)

-Optimise and minimise cooling cycles, fans not A/C etc

-Location of equipment out of the sun with passive cooling skins/double skins

-Move Loads outside (growing theme with 3G/4G/5G and link ODU, all outdoor)

Winter / Alpine Climates

-As lots of sites are top of mountain

-trickle heat (maybe use the residual heat from the equipment)

-retain passive heat

-minimise airflow

www.satpty.com

Break even point between grid power and off site

Define ‘off grid’

Cost where TCI over x years is better than cost of connect plus kWhr expectation

-typically a 10 year TCI analysis +/-

-Derive a table of kWhr total cost versus off site and minimise as per previous steps

- $200-300k not going to buy much… or unusual

- ¾ of a Kilometre is a benchmark of sorts (cost of extending a 11 KV line in Victoria 300k in todays costs)

On Grid Cost		**Off Grid Cost**
Cost to connect	<	Capex of ‘Solar’ System
Opex cost of electricity bill (increment with CPI+)		

Earthing and Lightning Protection

www.satpty.com

Protects People and Equipment

To define the nature of a LPS

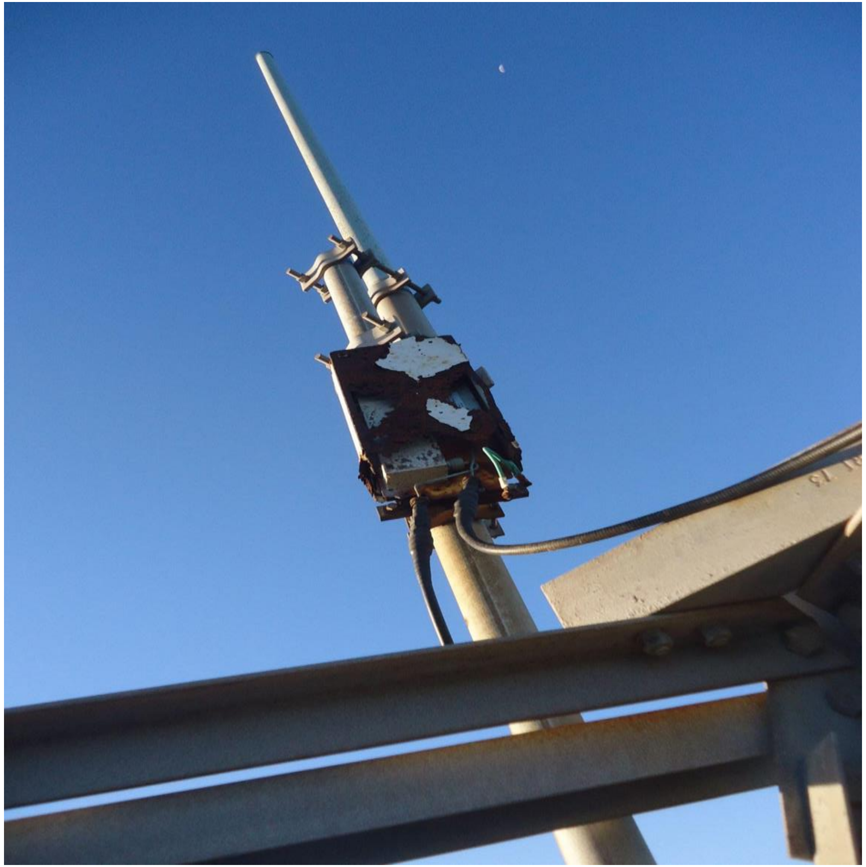
-IEC 62305 risk assessment

-Soil resistivity

-Good Housekeeping, Earthing kits applied

top bottom, bends and into equip room (plus 10m intervals)

-No loops bond. Separate Comms and Electrical Earths



Equipment Room Design

www.satpty.com

Continuing the Example from above. Where do we put all this ‘stuff’

Our Outdoor half size 19’ equipment rack (600 x 600 x 1100) Include plinth 1000 x 1000 x 200	FOOTPRINT 1 m^2 VOLUMETRICALLY = 0.596 m^3
½ x 19’ rack for Mobile Radio Base station (600 x 600 x 1100) 1 x 19’rack for Power Supply System and batteries (600 x 600 x 1100) = equipment room, minimum 2400 x 2400 x 2400 (for erganomics) -concrete plinth to support equipment room (3000 x 3000 x 200) Outdoor area for mounting 2 split air conditioners (typically 600 x 600 x 300 each)	FOOTPRINT 9m^2 VOLUMETRICALLY = 14.4 m^3

Ie Footprint increase ~900%, Volume increase ~2300%

Real Estate

www.satpty.com

Lattice Tower Installation

www.satpty.com

www.satpty.com

Spun Concrete Pole Build

www.satpty.com

Tower Modelling

-SpaceGas

-SAP

-Atena

-Tekla

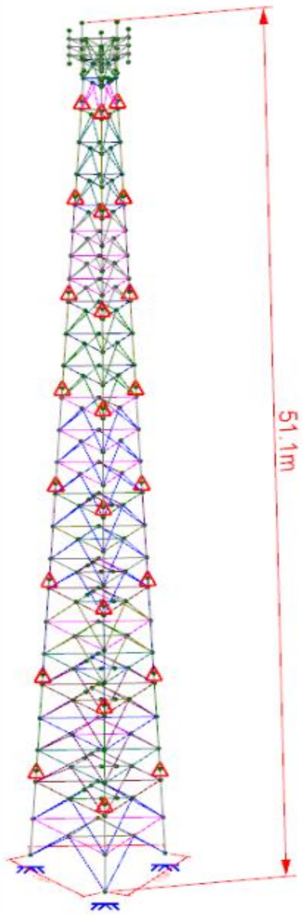
-Bentley

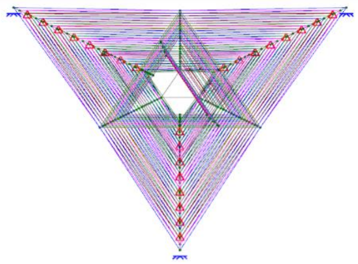
-CheckPole

-RocPole

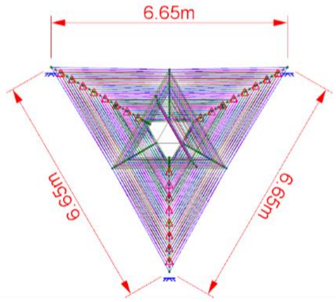
-Finite analysis/Calculus based.

Pre loaded codes and antenna systems





Plan view with dimensions



Dimensioning a Tower

www.satpty.com

-Height requirement

-Strength and loading requirement

(Antenna Matrix)

-Locating

-Foundation Design

-Installation

-Feeders

(ancillaries Hut, Power, Fence..)

www.satpty.com

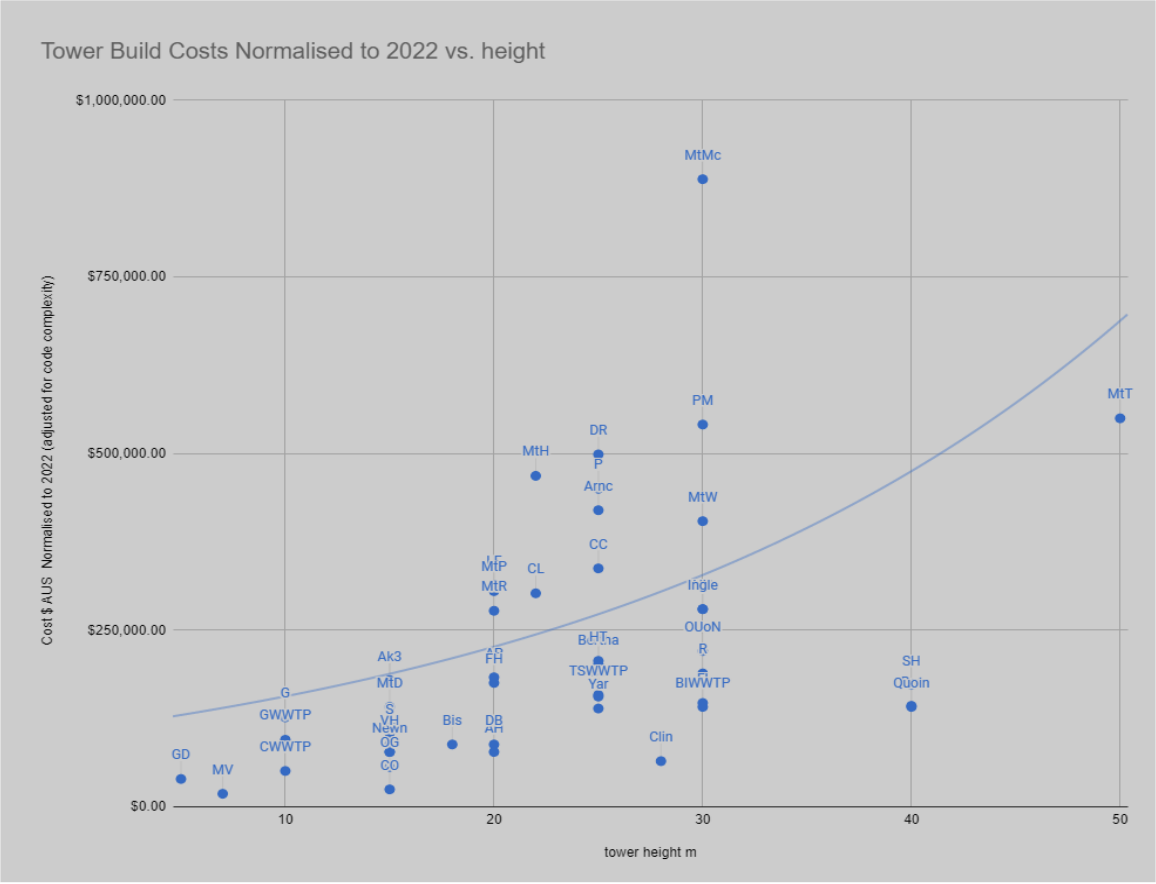
BENCHMARKING COSTS
(Experience of 60 previous Tower builds)

Extract from

SAT Database

60 Sites with

detailed build cost



www.satpty.com

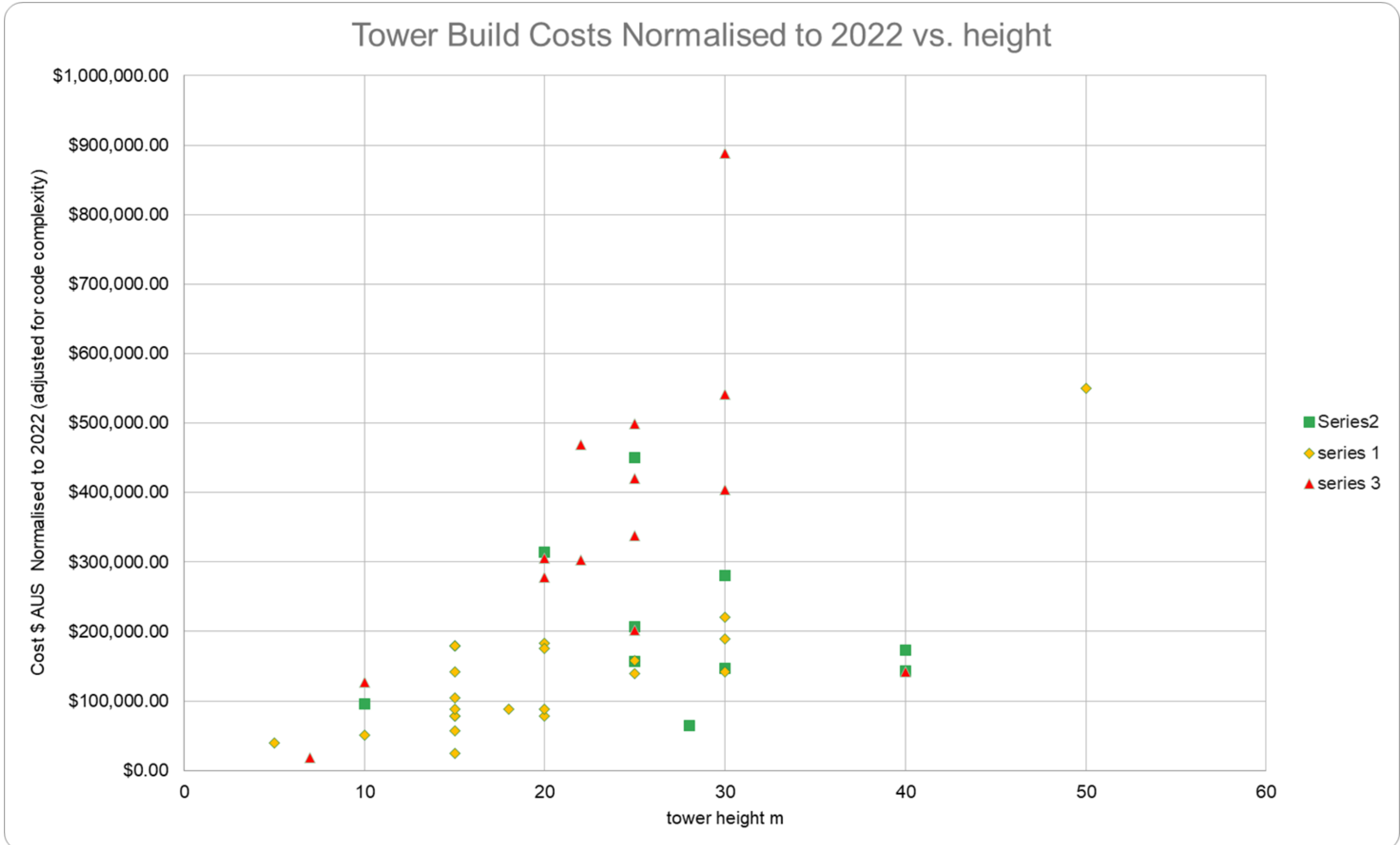
Mix Easy / Medium / Hard / Extreme

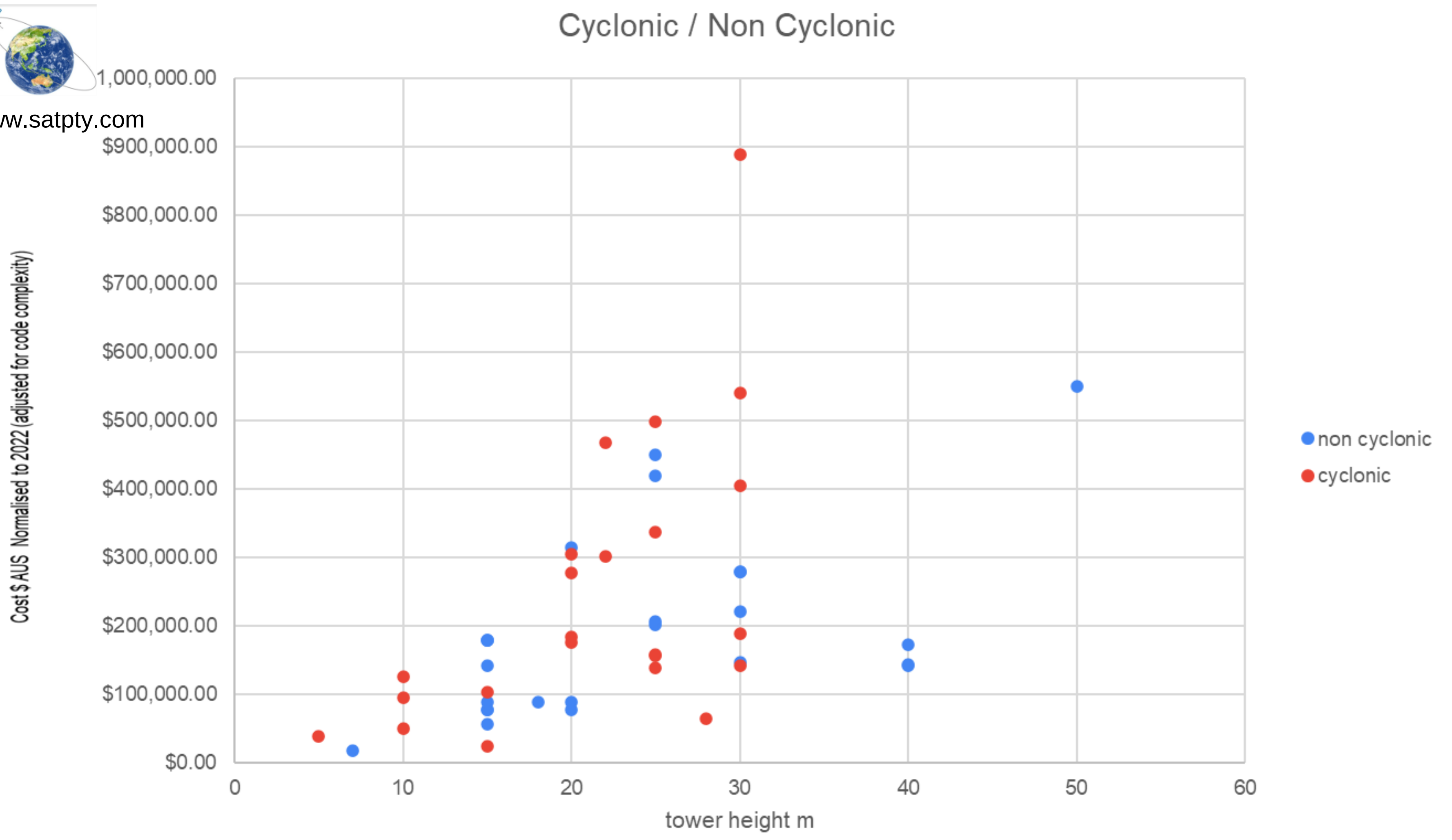
Extract from

SAT Database

60 Sites with

detailed build cost





www.satpty.com

Bands pre 2011, 2011-2019, Post 2019

www.satpty.com

Normalised

Extract from SAT Database

60 Sites with detailed build cost

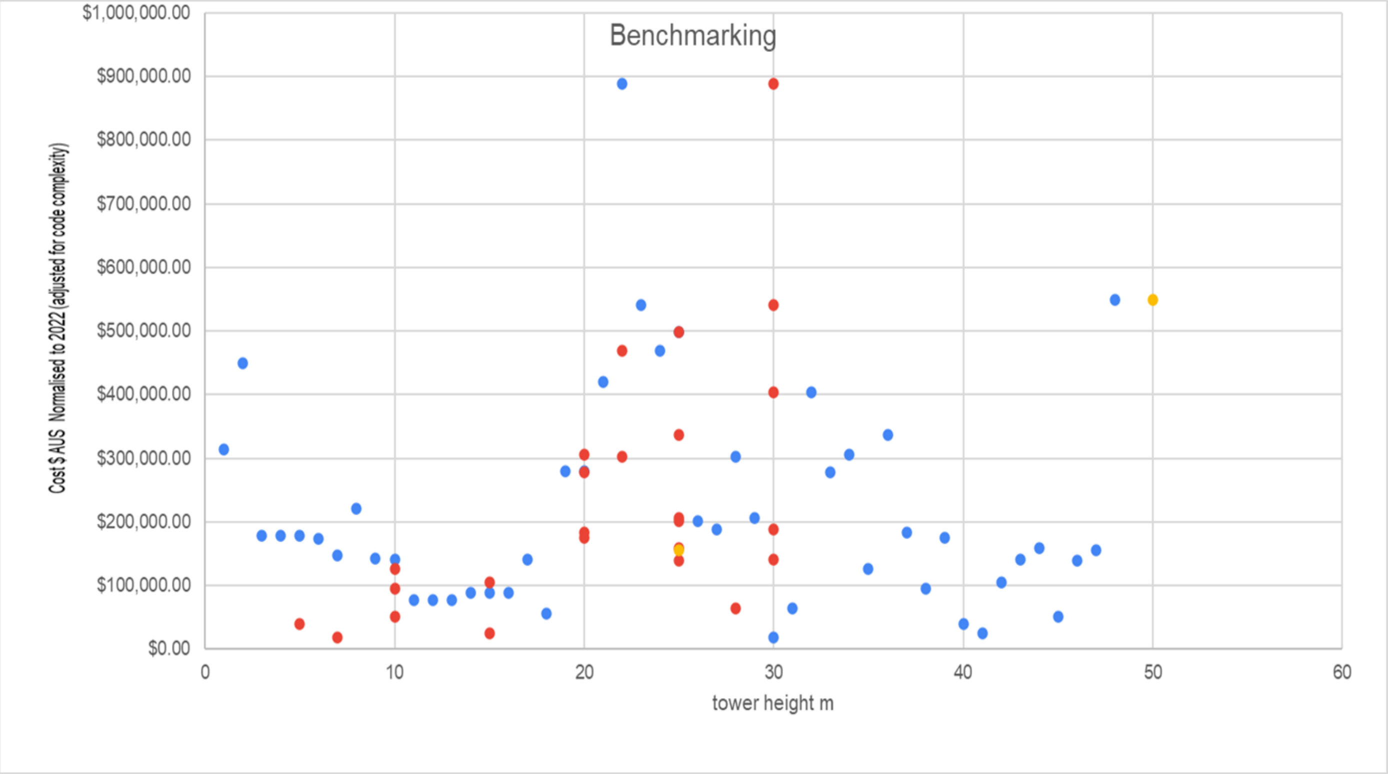
-CPI multiplier applied

-Normalising Multiplier of 2.11

applied pre 2011

-Normalising multiplier of 1.09

applied 2011-2021.



Breakdown of foundation / installation / tower hare ware costs

www.satpty.com

Height	Name	Foundations	Installation/Services	Tower Hardware	Tot Cost
25	HT	26.79%	29.56%	43.65%	$ 201,588.00
25	R	20.31%	67.41%	12.28%	$ 206,797.34
30	AP	26.34%	71.18%	2.48%	$ 888,360.00
30	CL	16.63%	76.17%	7.21%	$ 541,200.00
22	PM	30.31%	64.98%	4.71%	$ 468,600.00
25	TSWWTP	18.02%	77.08%	4.90%	$ 498,960.00
30	Yar	6.68%	87.58%	5.74%	$ 404,481.00
20	MtR	38.19%	45.93%	15.89%	$ 277,585.00
20	MtP	43.22%	42.37%	14.41%	$ 305,406.95
10	MtH	60.95%	18.53%	20.52%	$ 126,896.00
25	Bertha	23.27%	65.41%	11.32%	$ 337,634.00
20	CWWTP	7.87%	84.23%	7.89%	$ 183,546.00
10	ST	46.23%	20.14%	33.62%	$ 95,172.00
20	GD	5.61%	93.02%	1.37%	$ 175,615.00

Breakdown of foundation / installation / tower hare ware costs

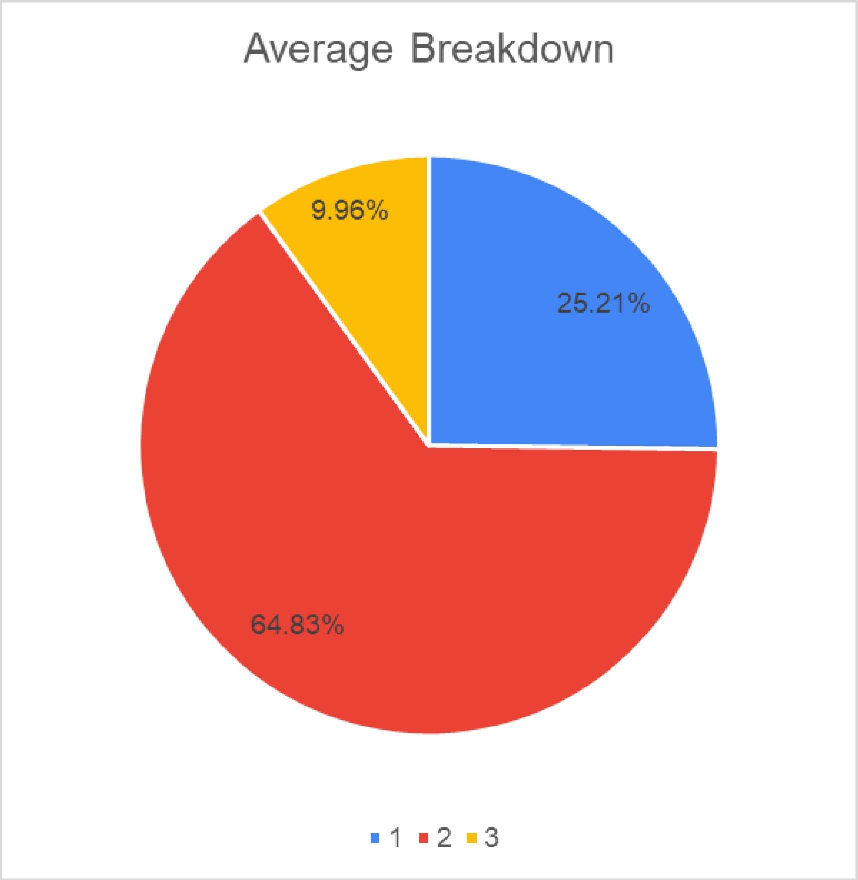
www.satpty.com

Yellow = Tower Hardware
$32,319

Blue = Foundation
$81,772

Red = Installation
$210,275

60 tower average
Medium tower height 21m
Average cost = $324,367



www.satpty.com

Aesthetics

Increasing environmentalism (managing aesthetics, radiation to public)

Checklist for site surveys

www.satpty.com

- regulations governing site builds
- concept of right sizing.
- number of sites growing.
- concept of the value of a site and tower in real estate terms.
- building site and tower structural survey databases.
- practical trumps theoretical.
- impact of increasing regulation (tickets, inductions, grinding pegs off, fencing)
- increasing environmentalism (managing aesthetics, radiation to public,)
- checklist for site surveys

www.satpty.com

Technology Improvements on Tower Loading
E.g. Microwave

OLD		NEW	
10%	⌀3.7m antenna or above		
10%	⌀3m antenna	5%	⌀2.4m antenna or above
20%	⌀2.4m antenna	20%	⌀1.2m antenna
20%	⌀1.8m antenna	25%	⌀0.9m antenna
20%	⌀1.2m antenna	25%	⌀0.6m antenna
20%	⌀0.6m antenna	25%	⌀0.3m antenna

-Note benchmark for windloading of 3.0m antenna in australia in region a 3m = 20 kN (old AS 1170.2 code)
Use area ratio to adjust this up and down
-Similar improvement in capacity (2 Mbps gone to ~400 Mbps, 200 fold, reliability up, LSI up)

www.satpty.com

Collecting information at site survey

Developing Template

SITE SURVEY FORM www.satpty.com

Summary

SITE NAME:		ACMA ID or RFSNA ID
Date		
By		
Track General Condition	Access Track suitable for 4WD/2WD/Flatbed Truck/Crane/Concrete	Permissions / Keys required

Site Location

GPS LOG	Lat	Long	Comment
Tower Centre			
Compound Gate			
Access Waypoint 1 ( )			
Access Waypoint 2 ( )			
Access Gate			

detailed GPS access log taken

Structure Details

Structure type	☐ Building	Pole ☐			Tower ☐	
		wood ☐	Steel ☐	spun concrete☐	Lattice ☐	Guyed ☐
					3 leg☐	4 leg☐
Manufacturer			Model		☐ photograph nameplate	
Structure height	[..............................] (taken with a laser)					
Access / Ladder fitted	Access:				Ladder Yes ☐No ☐	
Fall arrest fitted	Yes ☐ No ☐ Manufacturer ....Model .... Rating ....kN. Last inspected .... Current Yes/no					

Notes

Amenity:
Expectation on Loading:
Suitability for new antennas:
Condition of Tower / general Maintenance:

Cable run:

www.satpty.com

Documentation and Photos / Videos

Documents to Attain	Site Plan: Site Access Plan: Compound Plan: Compound Layout Foundation As built: Tower As built: Tower Structural Details: Structural Survey: Tower Shop Drawings: Equipment Room Fixation: Equipment Room Layout: Electrical Schematic: Earthing Diagram: Antenna Schedule: Feeder Schedule: Power Feed drawings: Solar Drawings: Generator Drawing: Geotechnical Assessment:	
Foundations / Guy Anchors inspected & Photographed		Completed ☐ Photograph any defects Comments:…………………………………………………… …………………………………………………………… ……………………………………………………………
Climb structure & record all defects In a separate report		Photograph defects & label locations on tower elevation dwg Use Highest Resolution Practical Completed ☐ Comments:…………………………………………………… …………………………………………………………… ……………………………………………………………
Check condition of galvanizing		new/ just off colour / tarnished and weathered/surface rust/severe rust
Check a sample of bolts for tightness		Check 5 random bolts on each face for tightness Completed ☐ Comments:……………………………………………………
Check antenna locations against drawings		Completed ☐ Update tower elevations ☐ (each antenna's to be shown only once on the elevations) Comments:…………………………………………………… …………………………………………………………… …………………………………………………………… .
Check Antenna /Feeders for defects/damage		Completed ☐ (bent missing elements/corroded mounts/ torn radome covers/ODU earthing) Photograph any defects ☐ Comments:……………………………………………………

www.satpty.com

Capture all available antenna details		Photograph Antenna nameplate ☐ (align antenna schedule & elevation dwgs) Update Antenna Schedule ☐
Check antenna against RCSMB		Provide updated info for RCSMB corrections (on the existing RCSMB document) Completed ☐
Inspect lightning protection		Grounding kits fitted at top & bottom of all RF feeders ☐ Surge arrestors fitted at gland plate ☐ Gland Plate grounded to site earth ☐ Highest point is a DC grounded Antenna or a lightning finial ☐ Comments:... ....
Inspect Structure earthing connections		No corrosion/ mechanical damage/bolts are tight Completed ☐ Comments:...
Conduct a Site Earthing test		As per Site earth test method provided (3 pole 62% method) Indicative reading (A) (Ohms) .... (current probe at 20m & 50m from site boundary, voltage probe at 62% of current probe distance) If (A) is greater than 30 Ohms conduct a full test (10 tests out to 100m from site boundary) Final test result (Ohms) .... Record tests on provided spreadsheet ☐
Photograph each tower face and tower leg		Via Drone (typ 3-5 photos progressing up the face including photos showing the complete face to allow scaling of antenna heights) Completed ☐
Photograph the overall site layout		Via Drone (at least 2 photo's taken directly above the structure center, encompassing the complete site) Completed ☐
Photograph the cable ladder		Completed ☐ Type of cable support fitted [...]
Photograph the gland plate		Completed ☐
All RF feeders are labelled at the gland plate & antenna connection		Yes ☐ No ☐ Comments:... ....
Is there a Geotechnical assessment		Yes ☐ No ☐
Review latest Structural assessment		Are all antenna included in the Structural assessment? Comments:... ....
Tower Signage		Photograph all fitted signs ☐

www.satpty.com

Vegetation obstruction		Any antenna obstructed by nearby trees Yes ☐ (photograph) No ☐ Measure the vegetation heights for the closest trees in each cardinal direction N……………………E……………………S……………………W……………………
Aviation warning lights fitted. Power Feed:		Yes ☐ No ☐ Comments:……………………………………………………………………………

POWER SYSTEMS

AC FEED TO SITE	1P / 3 Ph Meter Details: Photograph	11 KV Transformer spotted Photograph
SOLAR PANELS	Type: Qty: Array Size: Regulator Details: (Photograph all)	
GENERATOR	Type: Details: Mtce records: Photograph: Last Started: Photograph	
BATTERIES	Type: Strings: Total number: Date into service: Tested: Photograph	
OTHER (Wind, Fuel Cells, Water)		

www.satpty.com

Notes / Sketches

Conclusions

www.satpty.com

- Consider Value engineering, right sizing, conservatism costs, lack of considering the full Engineering design can be costly particularly with regard to the Access, Power and Structural costs. easily able to blow out to typically 10x the Radio Network costs. This usually dominates the cost expectations for a network rollout

POWER ON SITE

- Reduce equipment dimensioning (functionality (trunking example), Erlang capacity calculations, consumption, cooling requirement), think about scalable upgrades when you need
- How can we reduce Power footprints (passive cooling, double skins, out of the sun external placement, external heat sink, minimising kVA's of cooling, smart approach to Battery charging or generator operation)
- Strip back unnecessary equipment loads (lights, cold standby)
- With Solar systems equate the Total Lifecycle Cost (x years), in terms of expectation of kWHr

TOWER LOADING

- Reducing antenna footprints and size with technology
- Dropping height where possible, using logical locations for access
- Leasing space rather than Own and operate

TOWER BUILDING

- Survey site and confirm important parameters, (access, height required, antenna table to enable tower specification), use template
- Understand Geology (Geotech report), site layout restrictions (Parks, Heritage, boundary, footprint)

REAL ESTATE FOOTPRINT AND LOADING

- Reducing real estate footprints and volume
- Consider the lease model rather than site/tower own and operate

PROPERLY SURVEY THE SITE AND CAPTURE ALL THE RISKS, CAVEATS, PARAMETERS