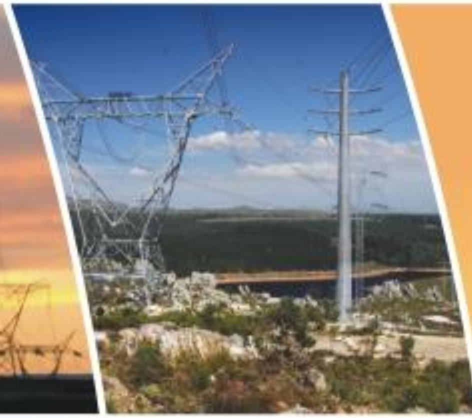


POWER LINE® SYSTEMS · INC ·

TRANS-AFRICA PROJECTS

3rd Generation Chainette Towers & Other Tower Optimisation Concepts

Pierre Marais

2015 PLS-CADD Advanced Training & User Group Meeting

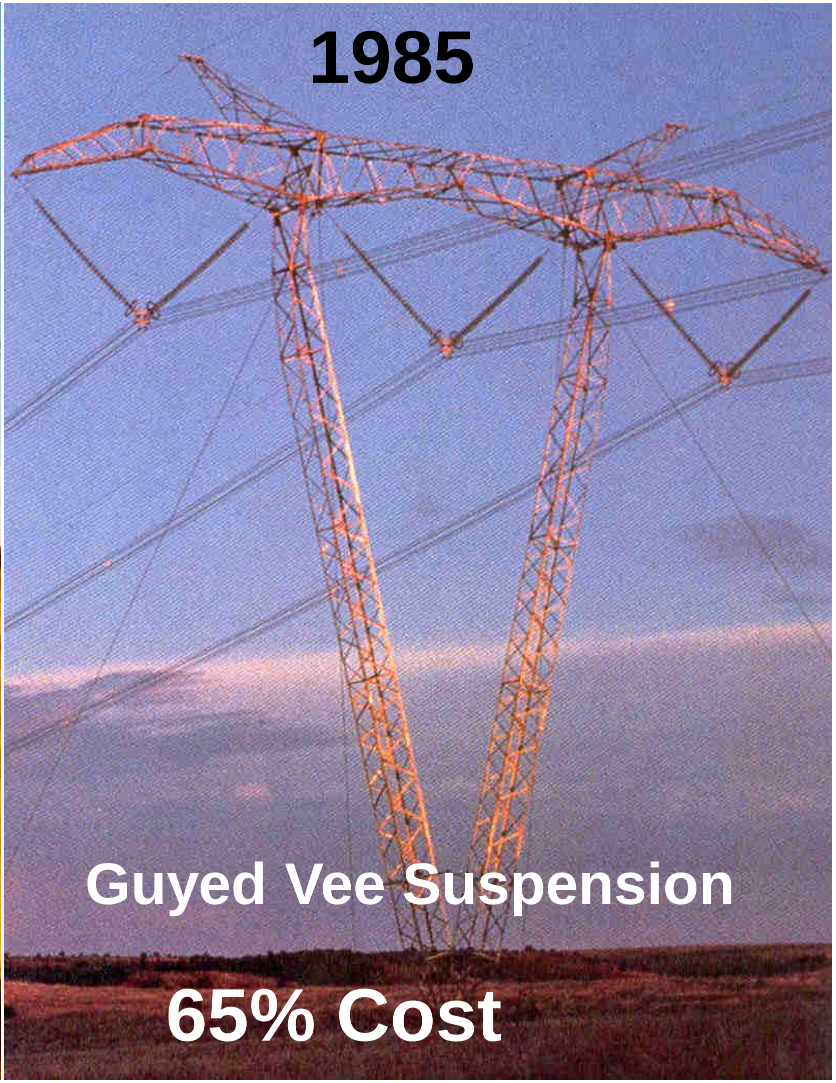
Overview

<u>Optimisation of chainette towers</u>

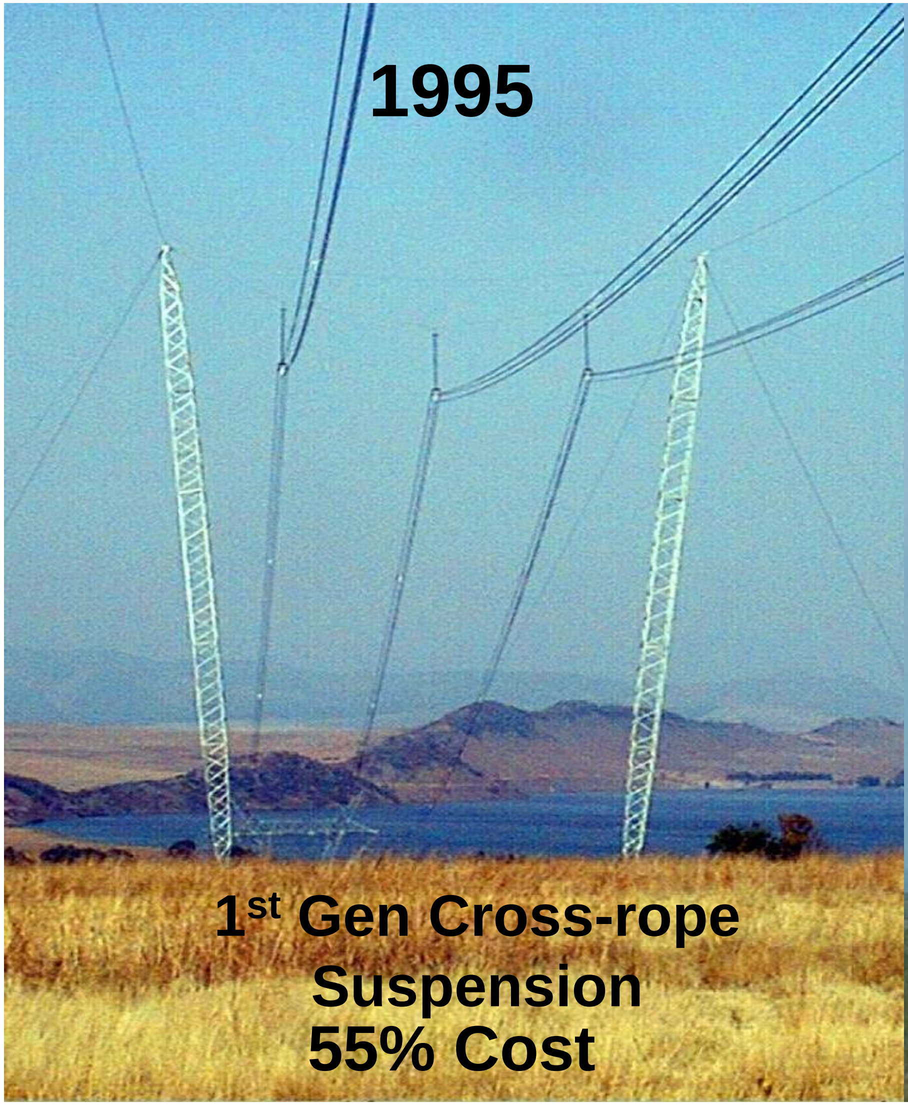
- Evolution of 400kV crossrope structures in South Africa
- Chainette Tower Variants
- Understanding the performance
- Modelling in Tower
    - 1st & 2nd generation Chainette towers
- Further potential efficiencies
    - 3rd generation ideas

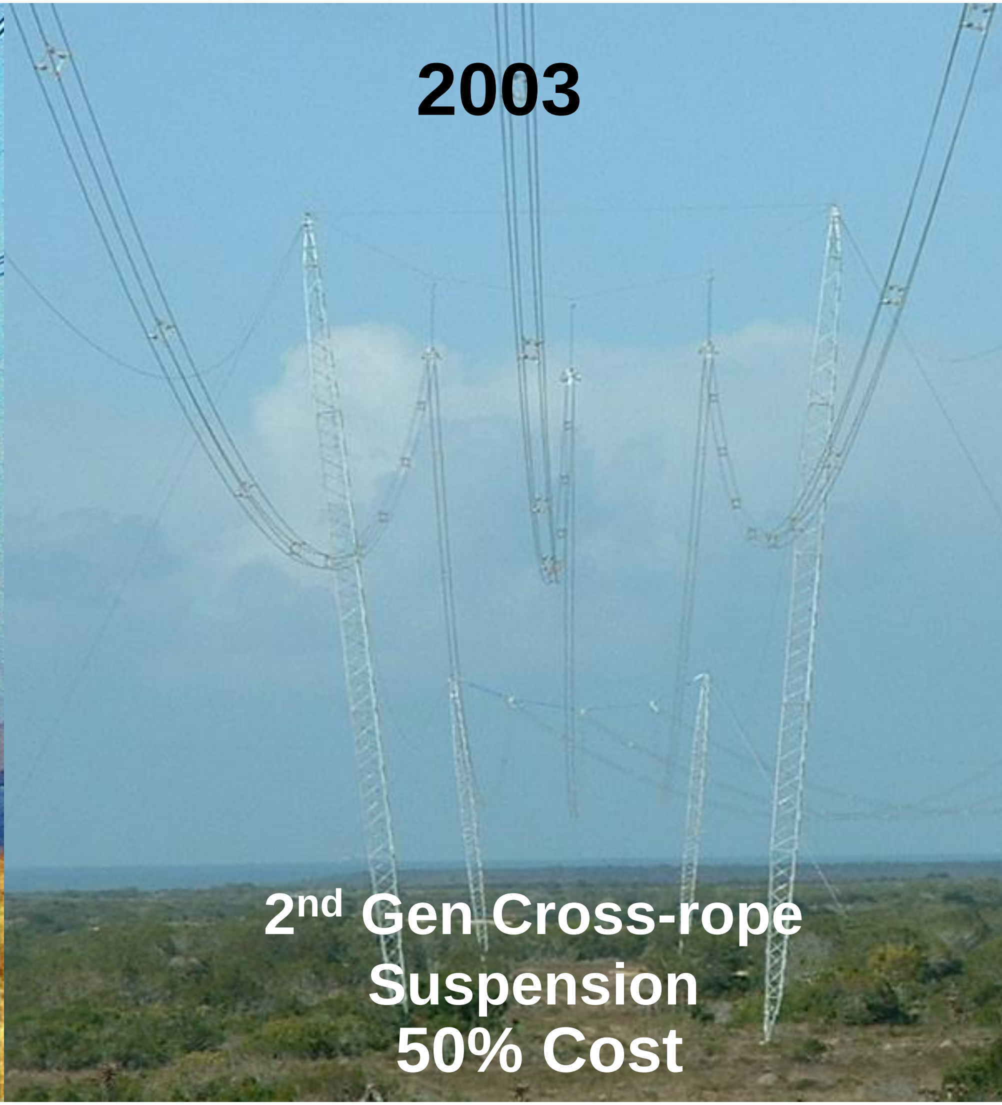
<u>Optimisation of a narrow base 132kV lattice tower</u>

Evolution of EHV Structures in Eskom

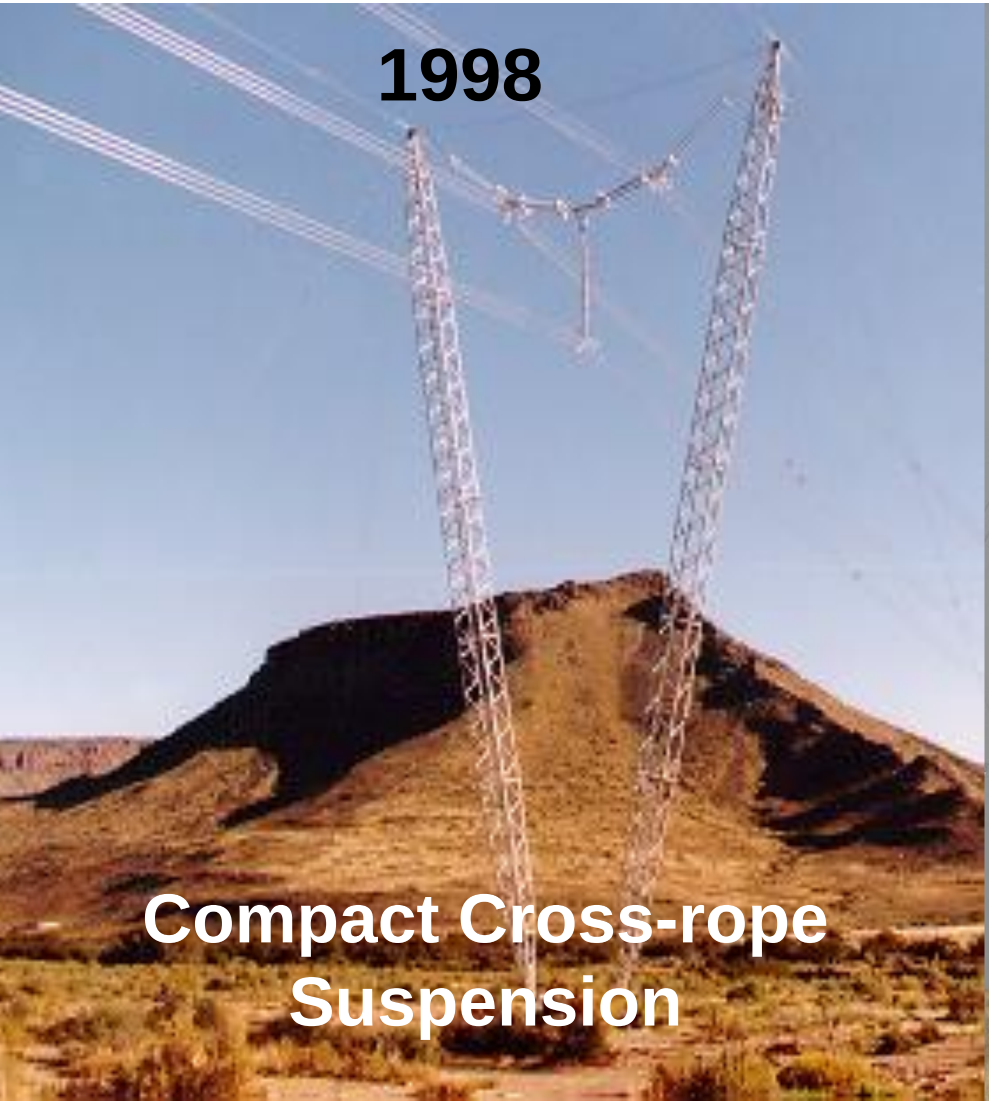


Evolution of EHV Structures in Eskom

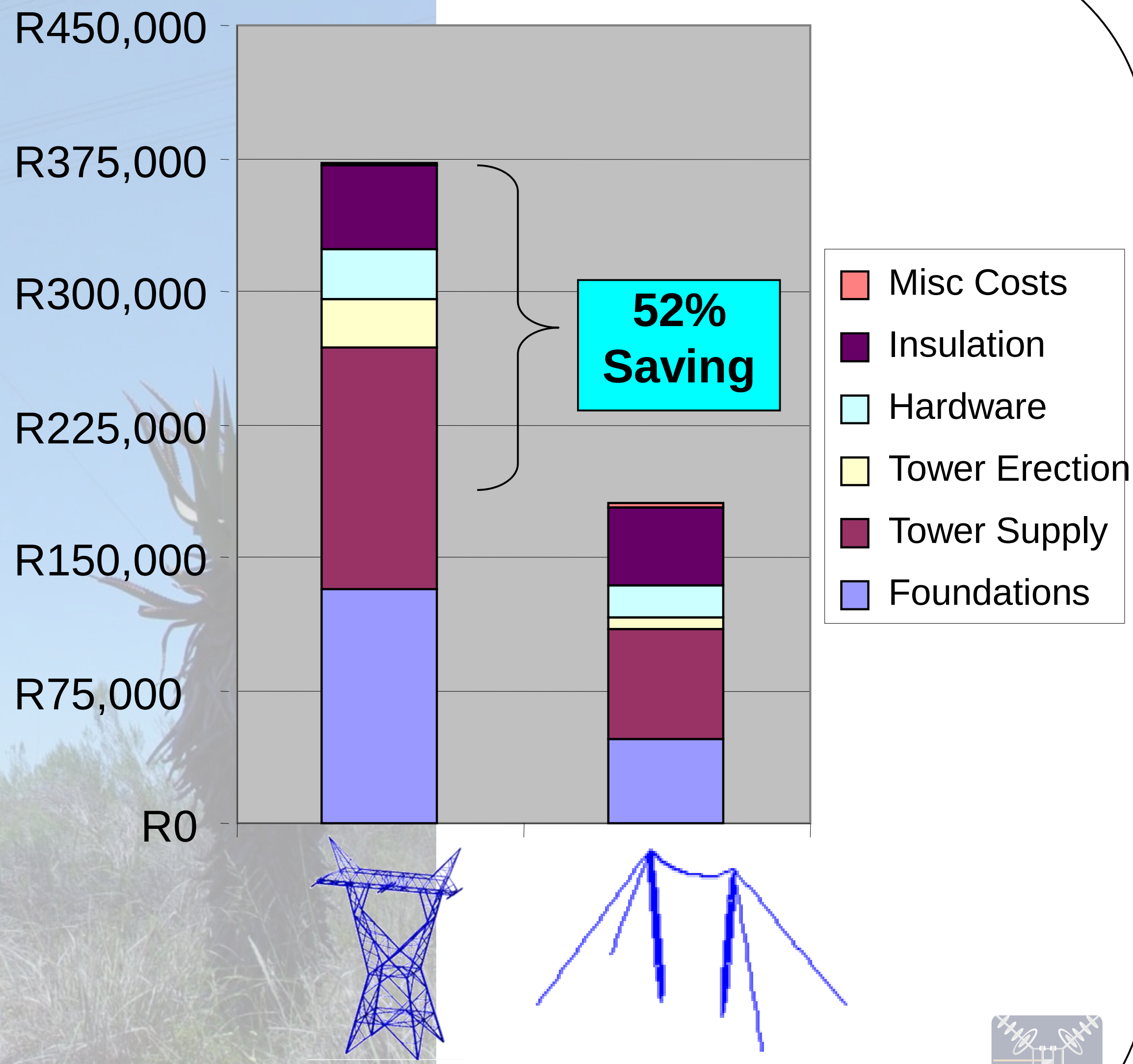




Chainette Tower Variants



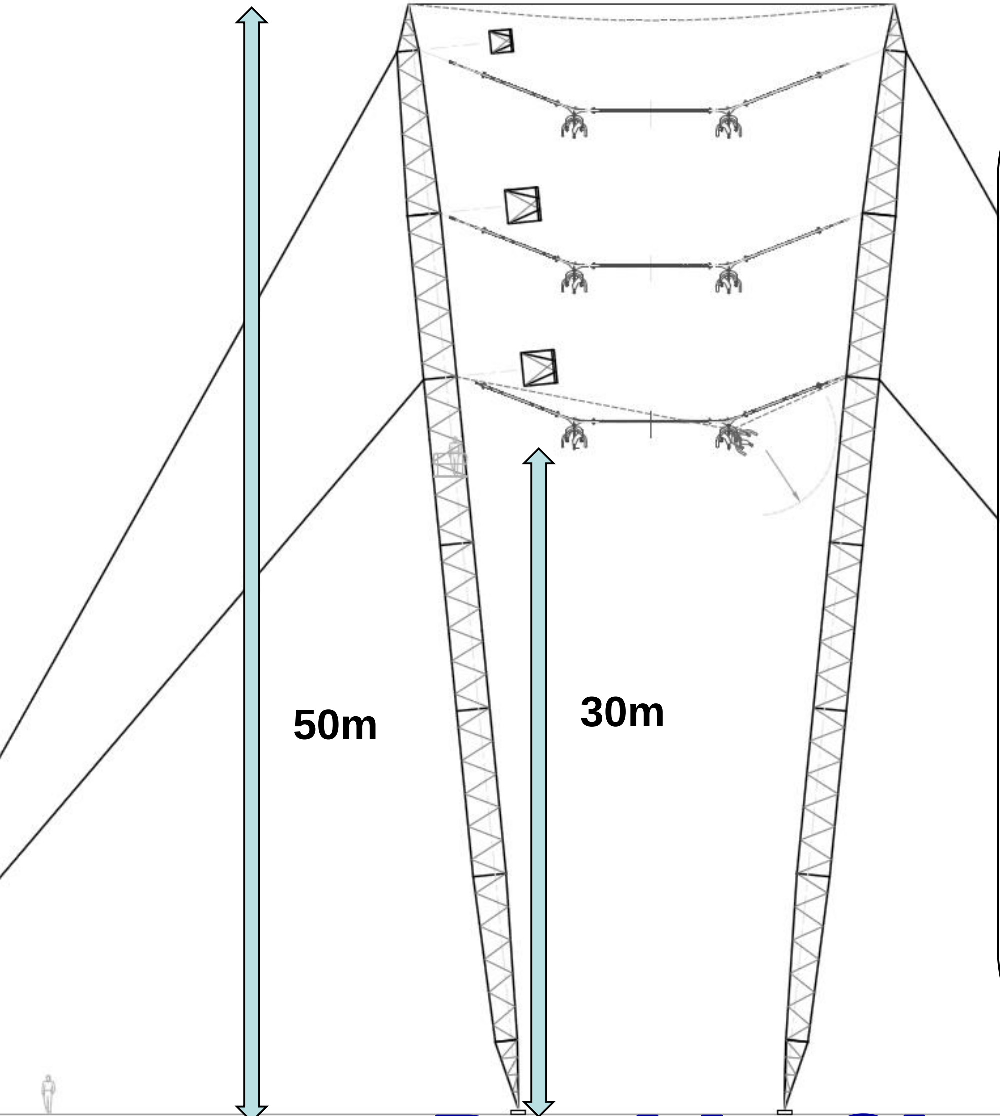
Chainette Tower Variants

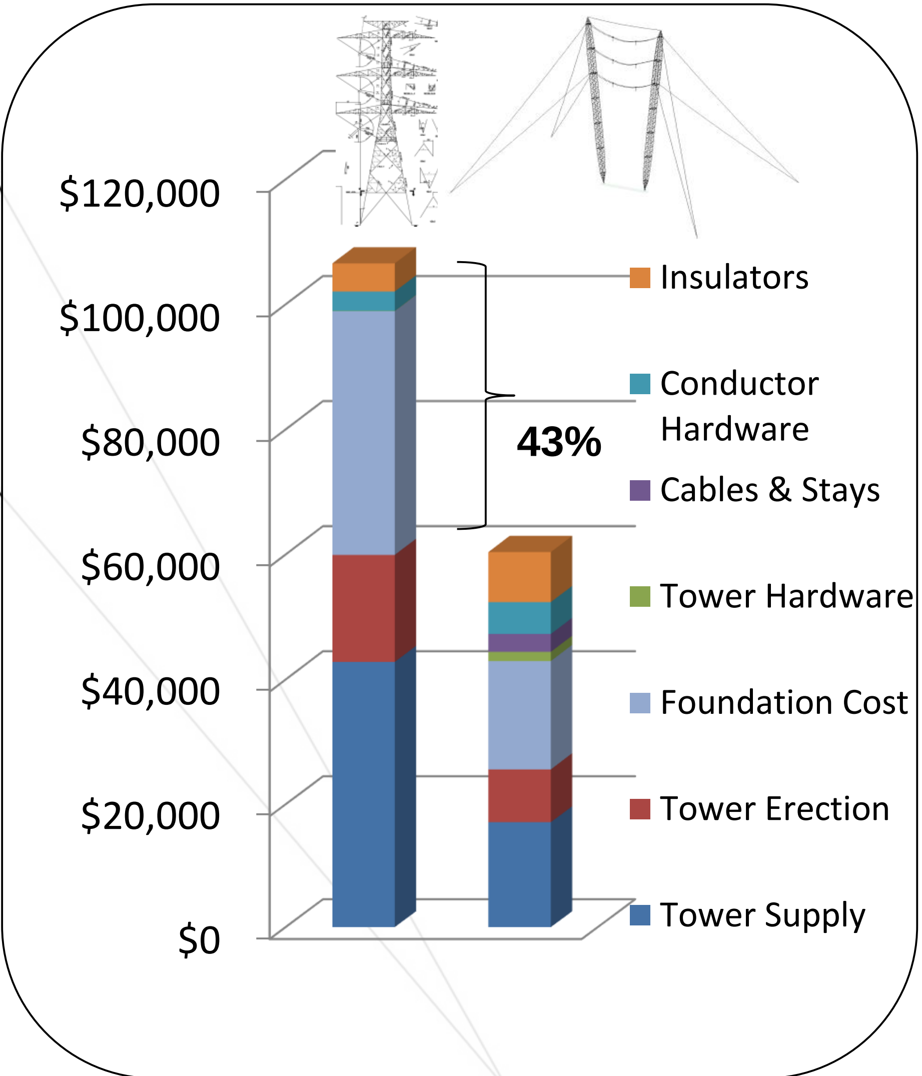


0-15 degree structures

- 0-15 Degree guyed strain

Chainette Tower Variants





Double Circuit 380kV

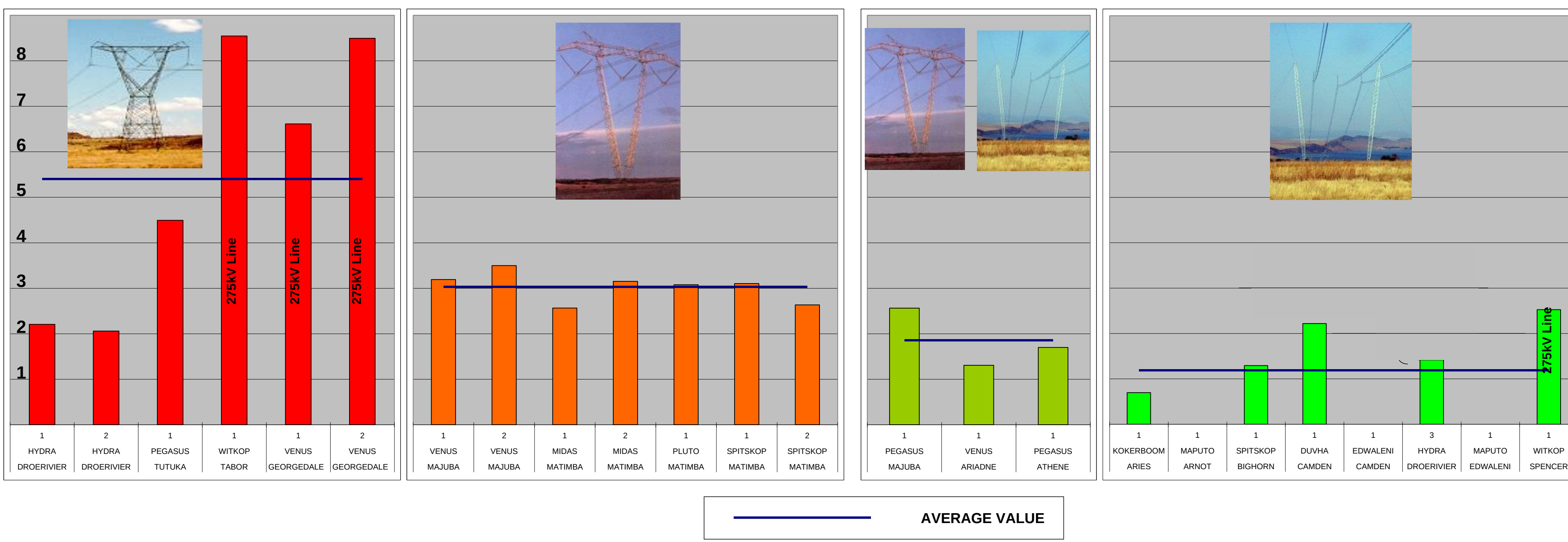
Chainette Tower Variants

970km 350kV DC line 2007

Crossrope towers perform better...

- Crossrope / chainette towers have the lowest fault rate of any tower type on the Eskom grid

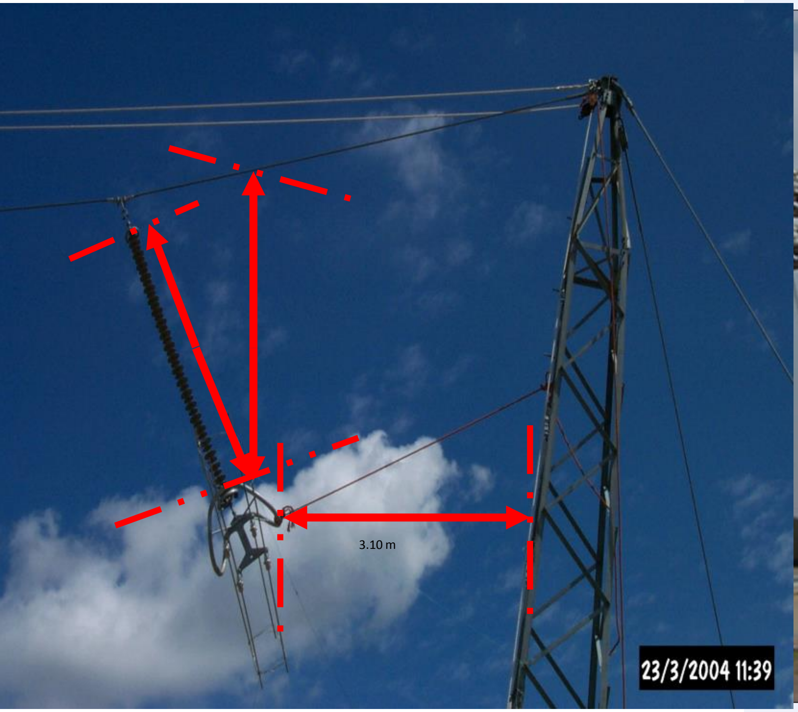
SELF SUPPORTING	GUYED VEE	MIX	CROSSROPE



5.4 FAULTS/100KM/YEAR	3.0 FAULTS/100KM/YEAR	2.8 FAULTS/100KM/YEAR	1.2 FAULTS/100KM/YEAR

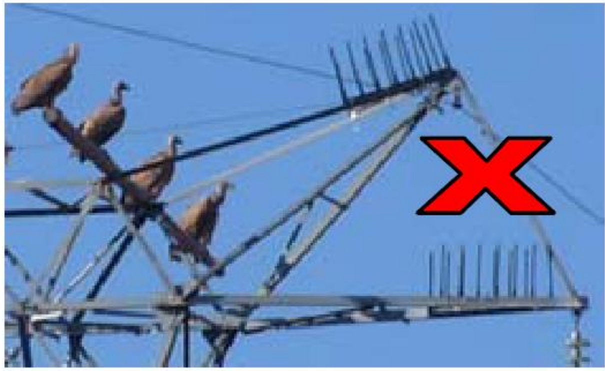
Understanding the performance

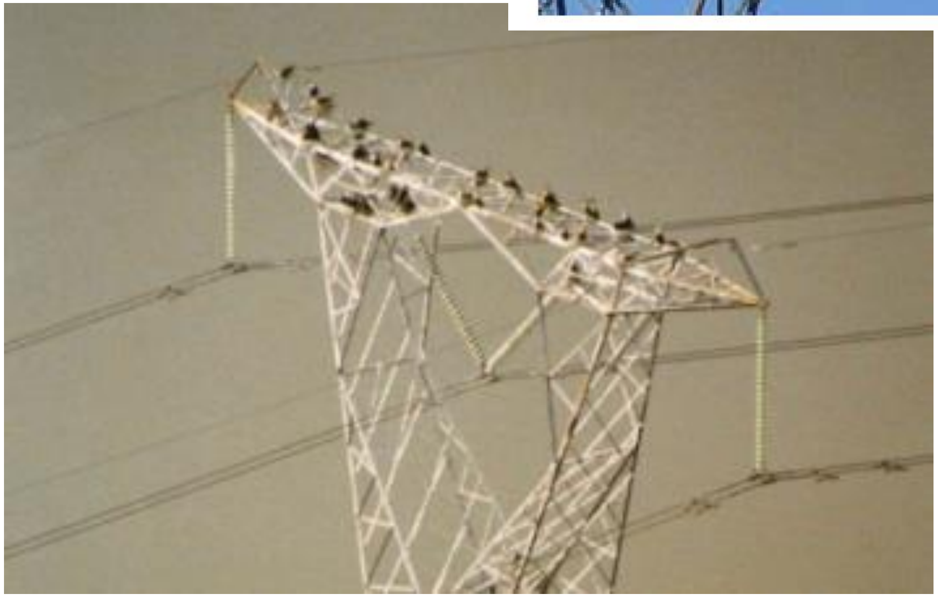
- A naturally high electric strength
  - ➢HV Impulse tests confirm a higher electrical strength compared to conventional towers



Understanding the performance

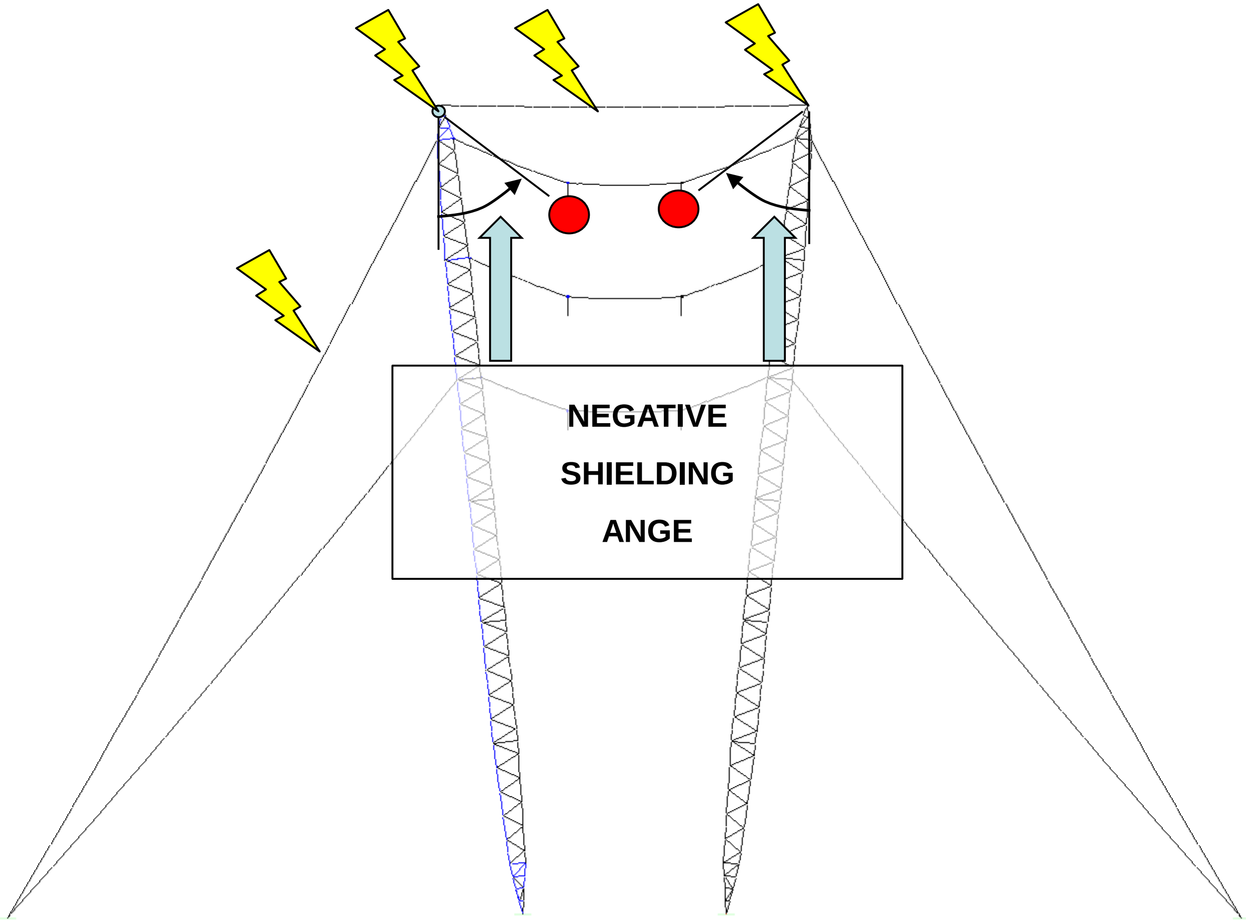
- Bird pollution flashovers virtually eliminated
  - ➢Birds do not perch on crossrope
  - ➢No possibility of nesting
  - ➢No bird pollution on insulators





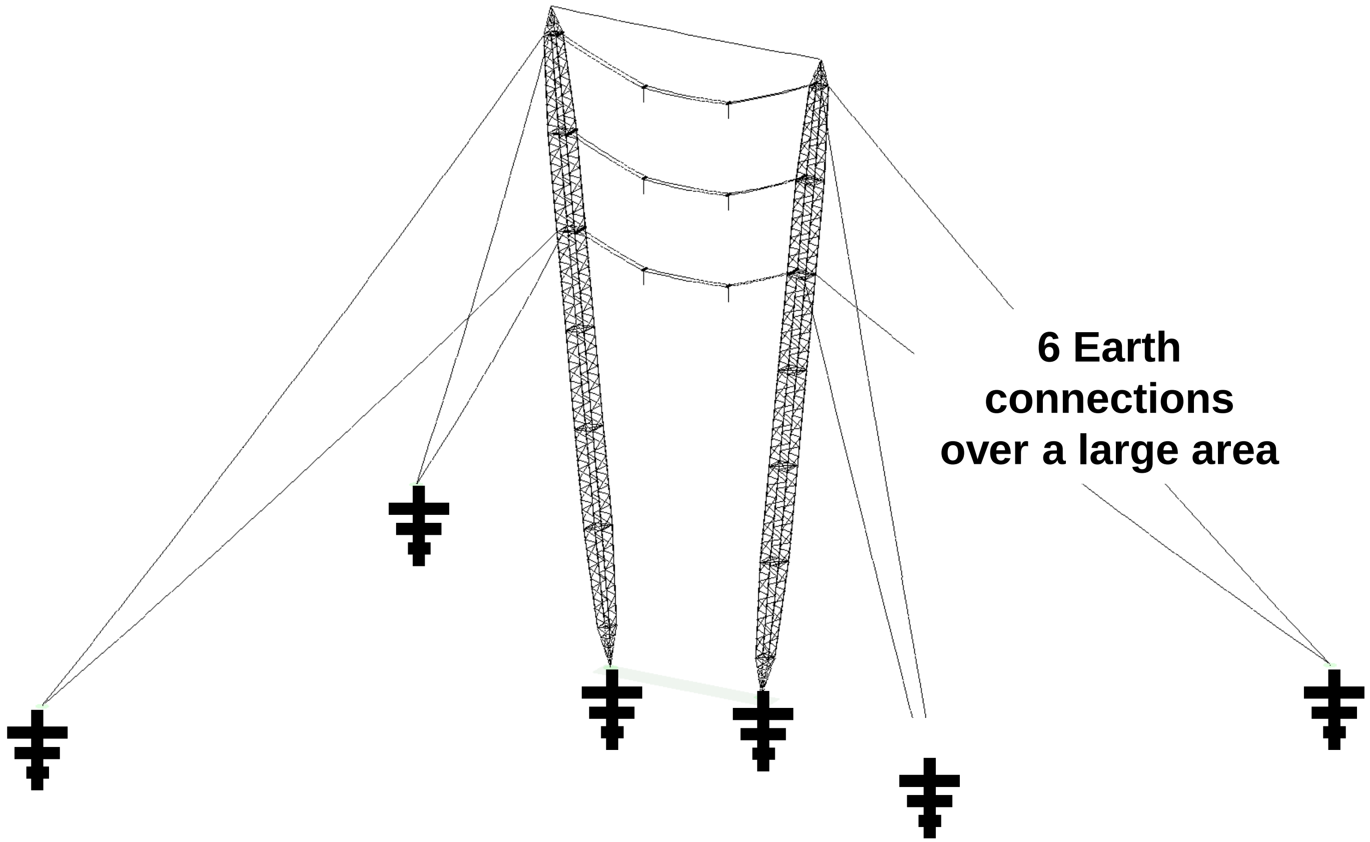
Understanding the performance

- Excellent shielding from Lightning Strikes
  - Phases well protected against lightning strikes



Understanding the performance

- Multiple earth contacts produce lower superior connection to earth
  - ➢Reduced back-flashover rate

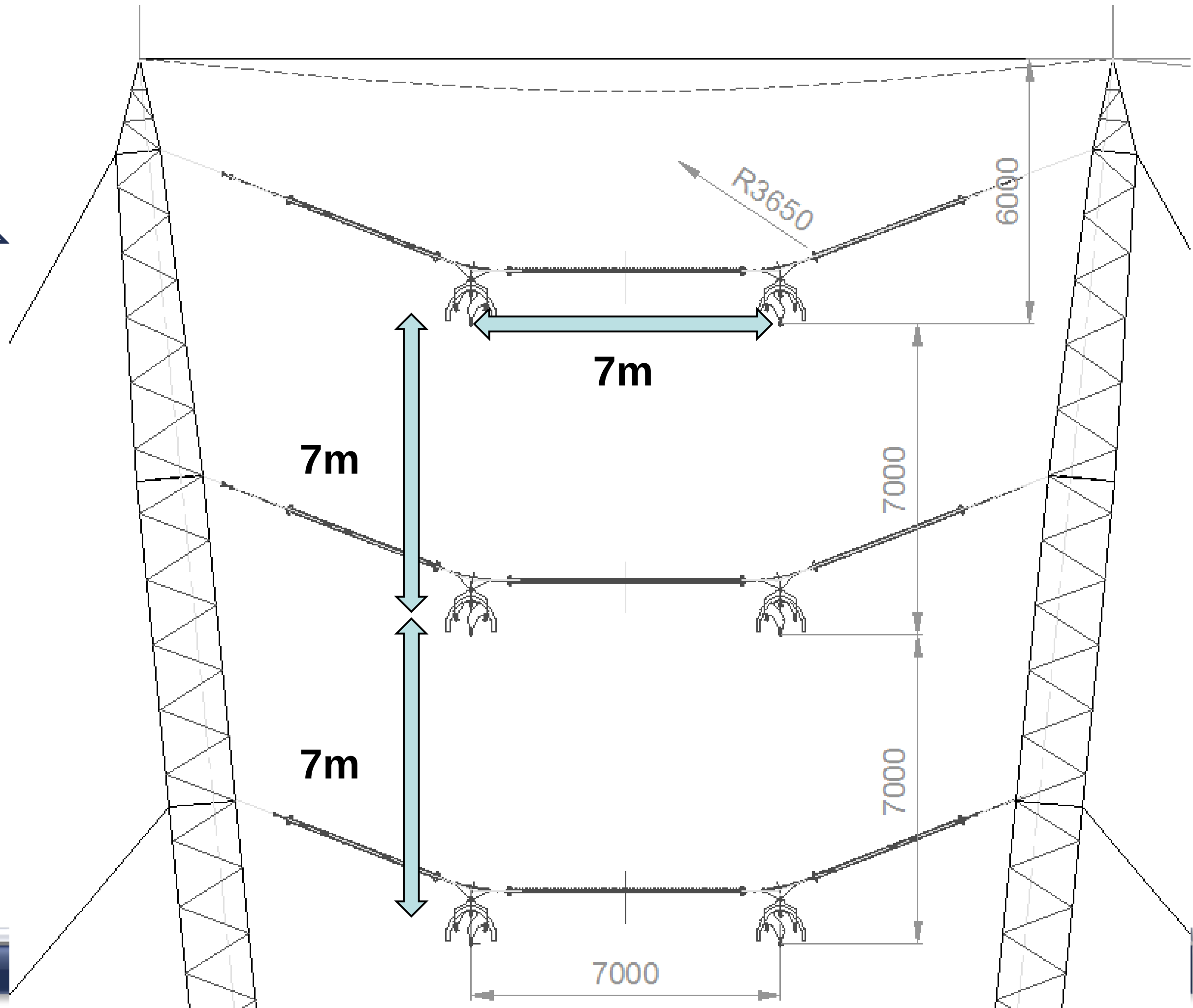


Understanding the performance

- Low weight
  - ➢Rapid re-construction

Understanding the performance

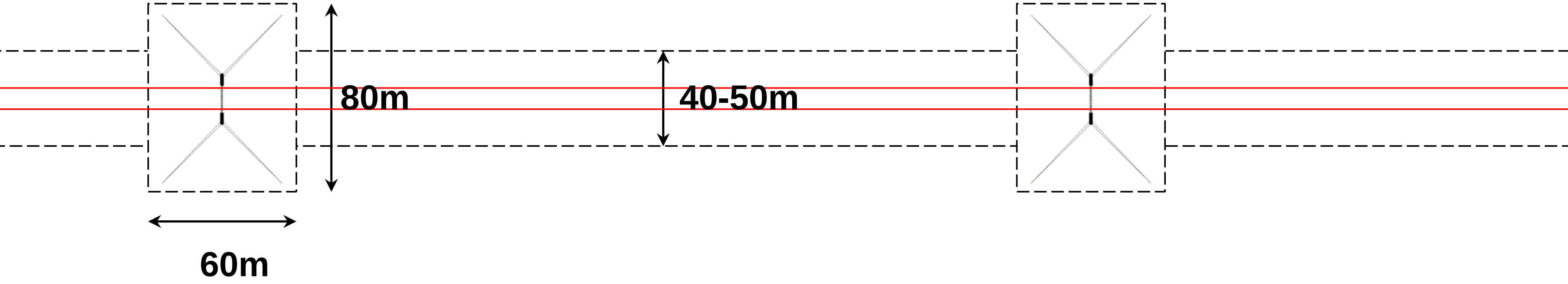
- Compact phase spacing is electrically efficient
  - ➢Capacitance ⇧
  - ➢Inductance ⇩
  - ➢Lower losses



Less Steel to Steal!

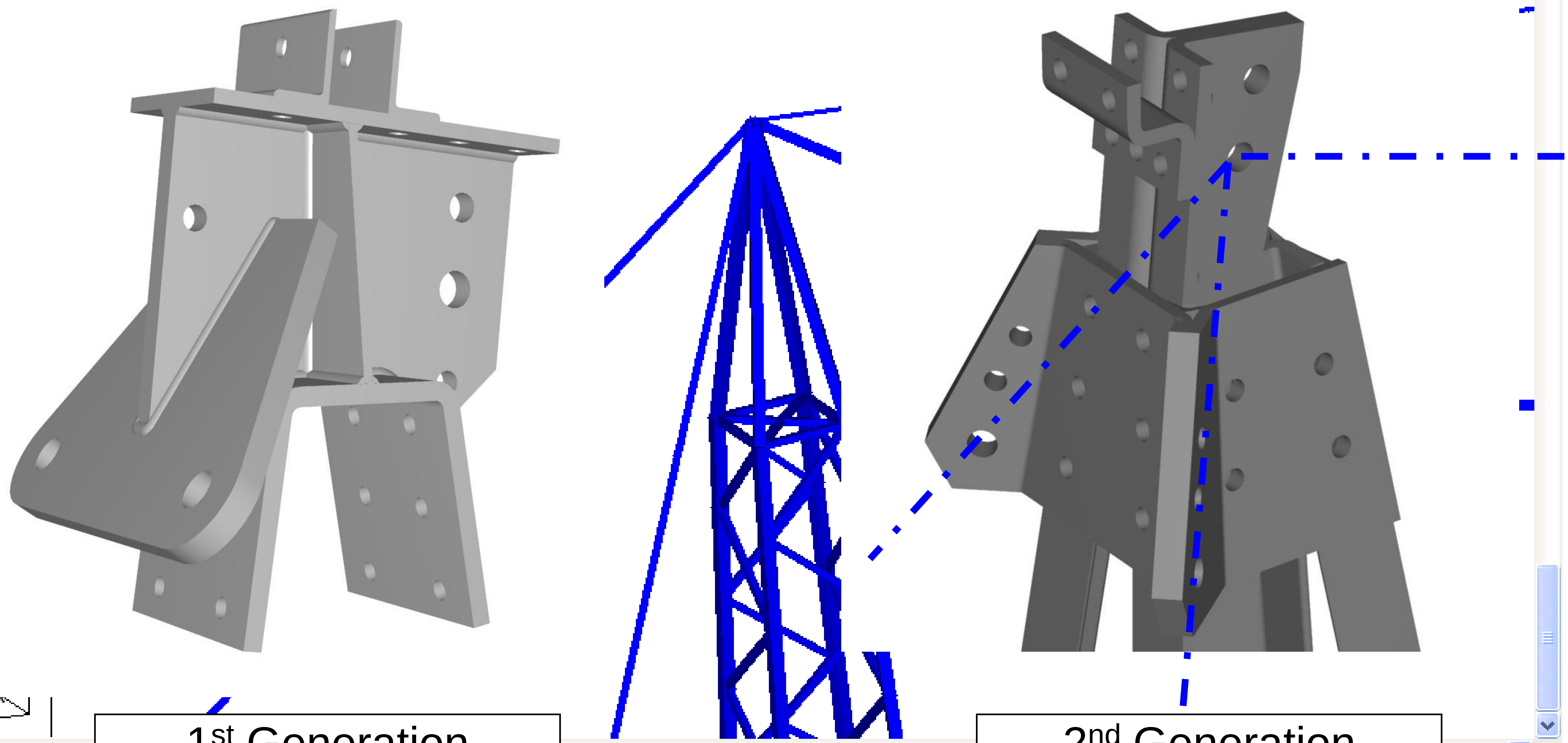
Tower footprint size and right of way implications

- Solution to wide tower footprint:
  - ➢Standard right of way required for line (40-50m)
  - ➢80x60m building restriction around every tower site



Peak Design

- ➢ **Welding Eliminated**
- ➢ **Be careful to avoid eccentricities**
  - ➢ **Replicate the original Tower FEM model as far as possible**

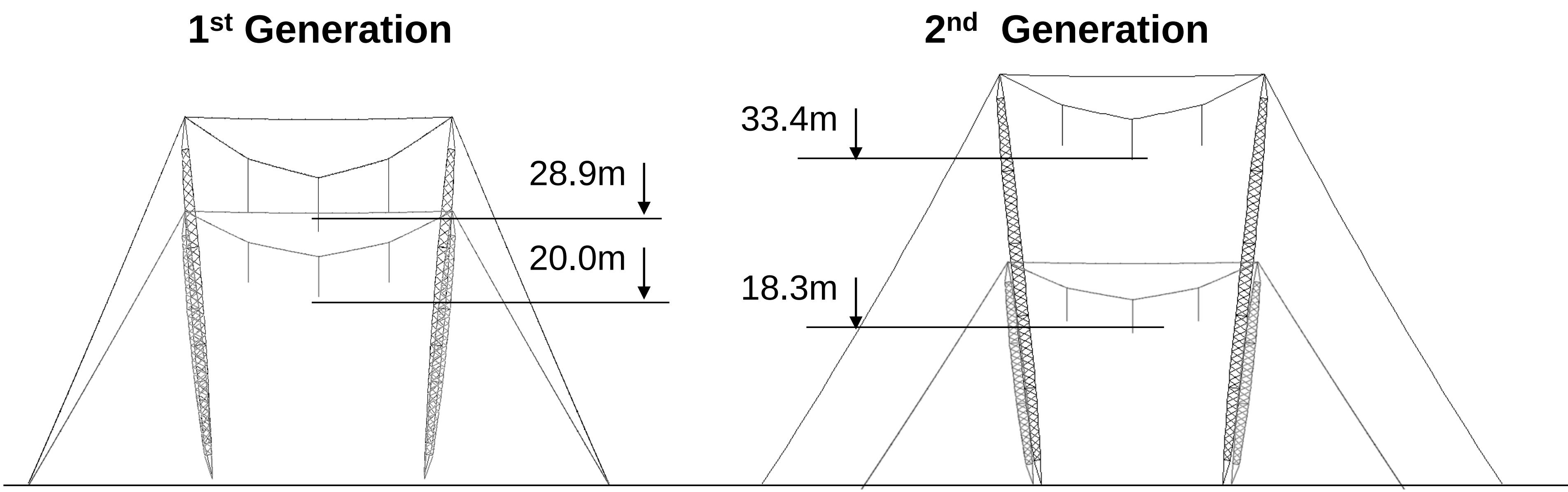


1st Generation

2nd Generation

Modelling in Tower

- What is the optimal attachment height?
- Possibly taller than you think (Unless you have flat terrain)
  - Taller suspensions can eliminate in line strain structures
  - Optimum spotting will reveal the optimal height

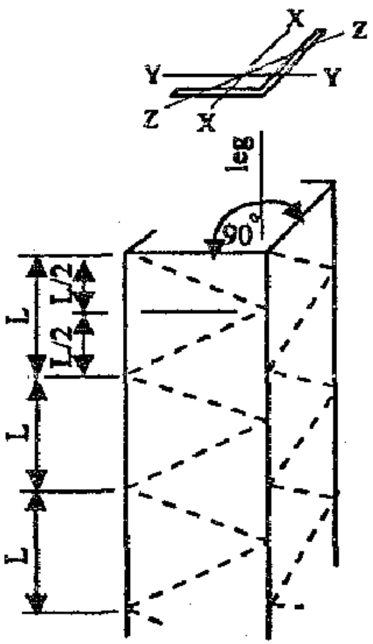


Optimal height for flat terrain

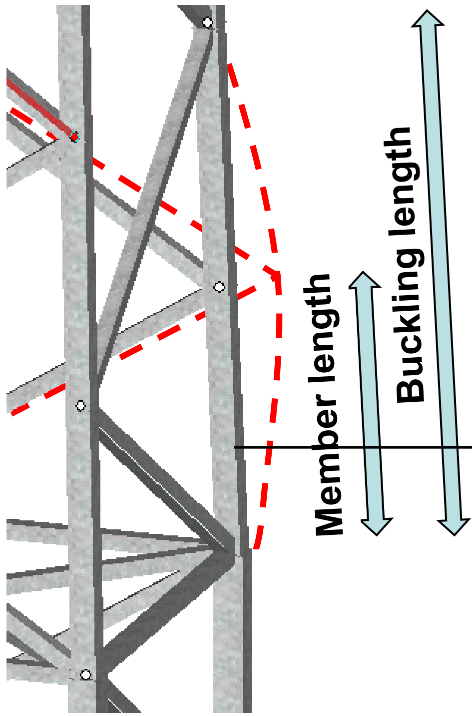
Optimal height for "normal" terrain

Modelling in Tower

- Staggered bracing shown to be the most effective bracing pattern
- Take note of RLX ratio (see also ex5.tow)



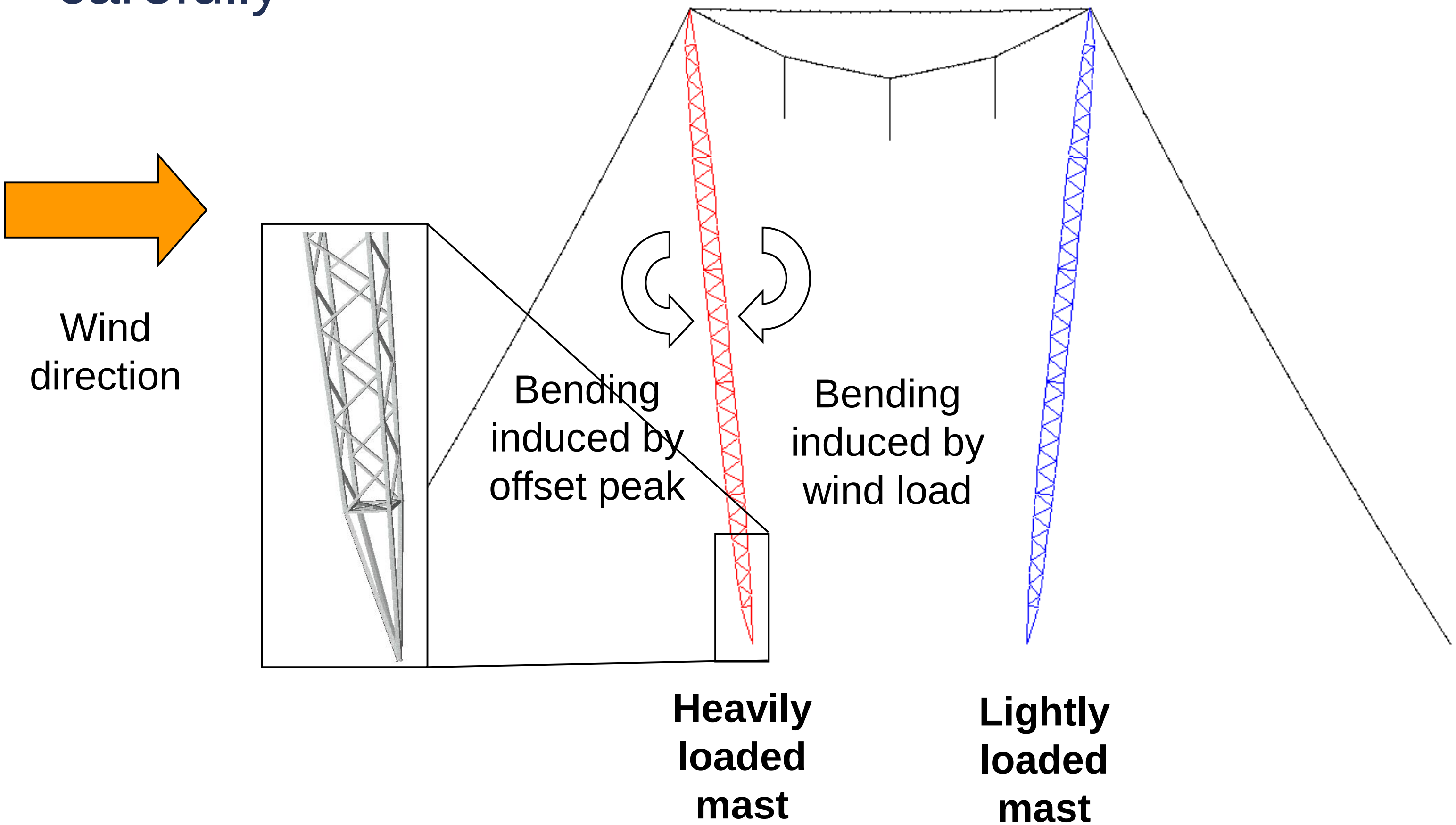
(c) Leg Controlled by (1.2L)/r_{xx}



Ecc. Code	Rest. Code	Ratio RLX	Ratio RLY	Ratio RLZ
1	4	2.4	2.4	1.33

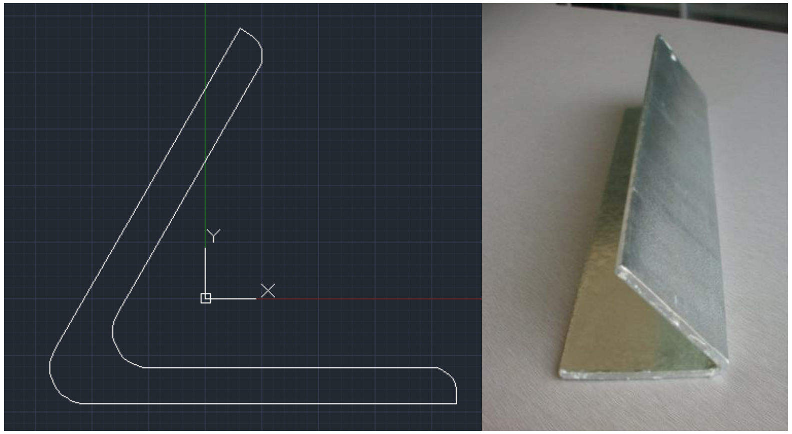
Modelling in Tower

- Offset peaks can provide some structural efficiency
  - But also can induce torsional loads – choose extent carefully

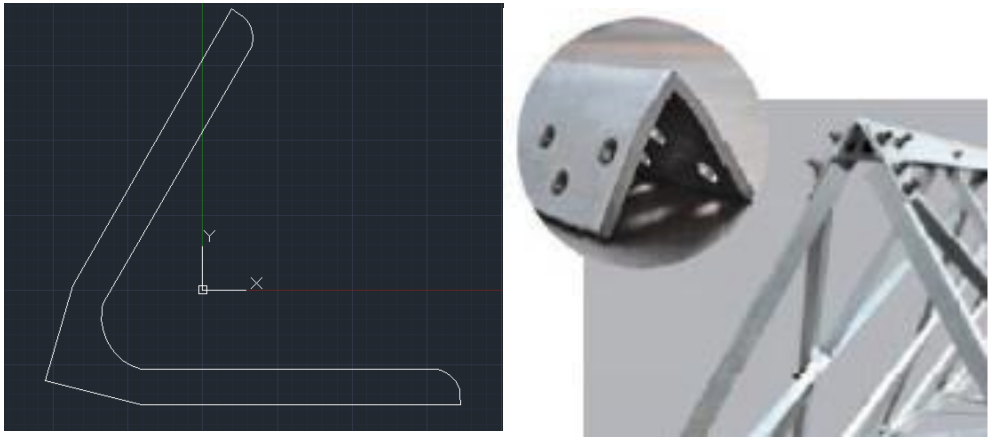


Further potential efficiencies

- Hot rolled 60 degree angles



Hot rolled 60º angle

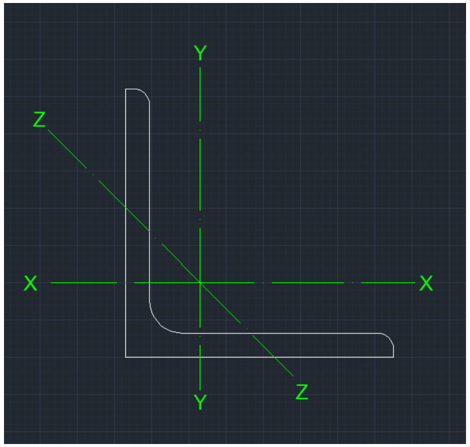


"Schifflerized" 60º angle

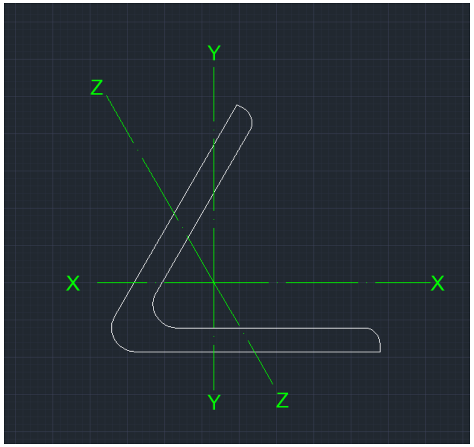
- Potentially more cost effective material cost
- Lower drag coefficient
  - ➢ SAPS wind used to benchmark current (square) design with proposed (triangular) mast

60º vs. 90º Angles

- Compared to 90 degree angles of the same size:



90º angle



60º angle

SECTION PROPERTIES OF COMPLEX SHAPES CAN BE DETERMINED IN AUTOCAD USING "REGION" AND "MASSPROP" FUNCTIONS

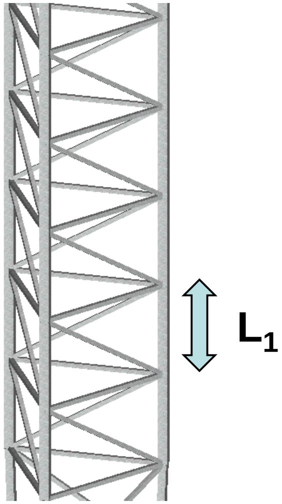
	90º ANGLE	60º ANGLE	% change
rx	21.3	19.1	-10%
rz	13.7	16.8	22%

- Ix, rx decreases
- Iz, rz increases

- This impacts the relative efficiency of different bracing patterns

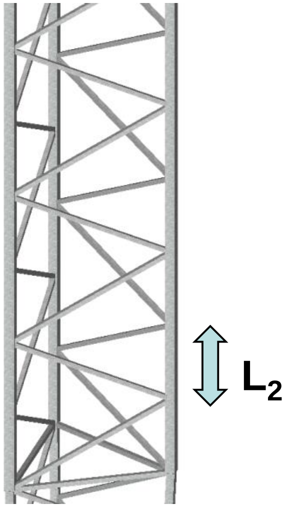
Further potential efficiencies

- 2 different bracing patterns investigated



Symmetrical bracing

(1.2L/rz controls)



Staggered bracing

(2.4L/rx controls)

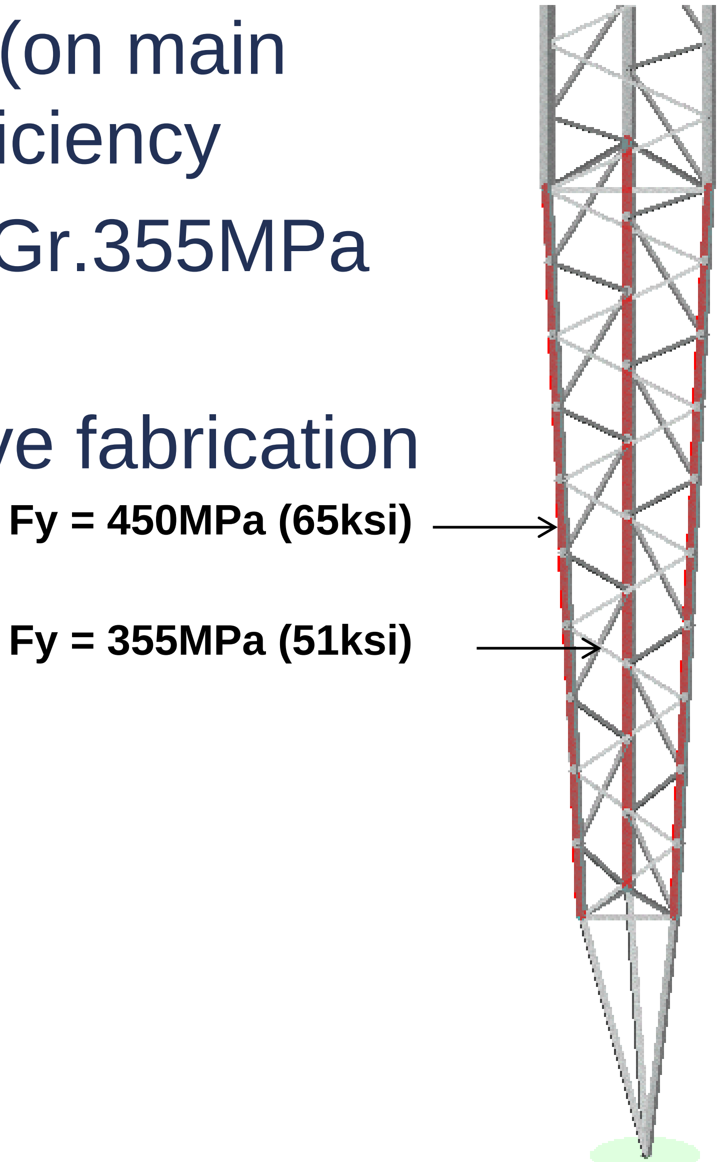
10% Lighter

(L_1 can = $1.75L_2$ for same main leg size)

- Staggered bracing still more efficient than Symmetrical bracing

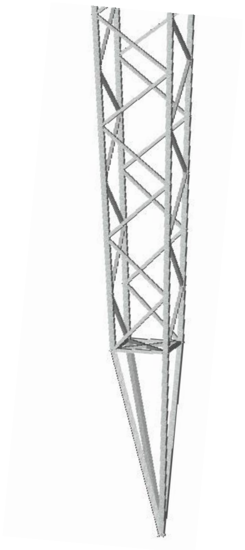
Further potential efficiencies

- Utilising higher steel grades (on main legs) can produce further efficiency
- Gr. 450MPa compared with Gr.355MPa steel
- Viability dependant on relative fabrication costs



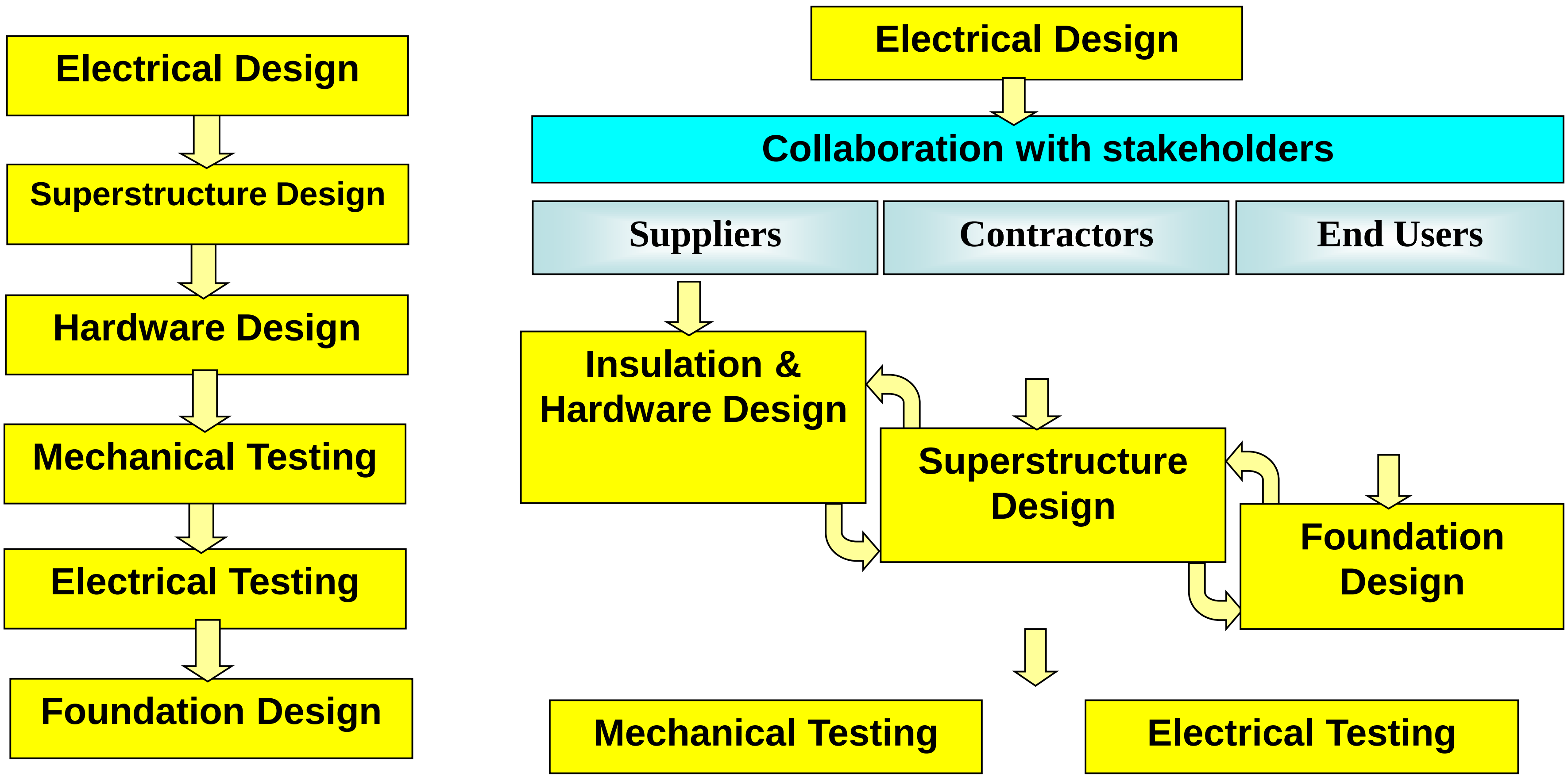
Further potential efficiencies

- Combination of steel grade and 60º hot rolled angles produce a 15% reduction in weight
- Alternatively structural efficiency can be translated into increased strength
- Viability dependant on fabrication cost implications



Structural optimization of a narrow base 132kV lattice tower using PLS Tower

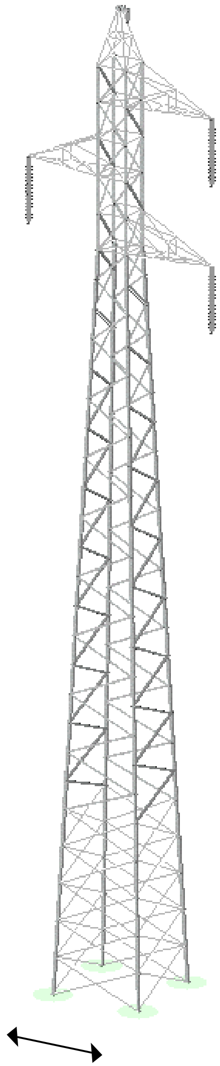
Conventional vs Integrated Optimization



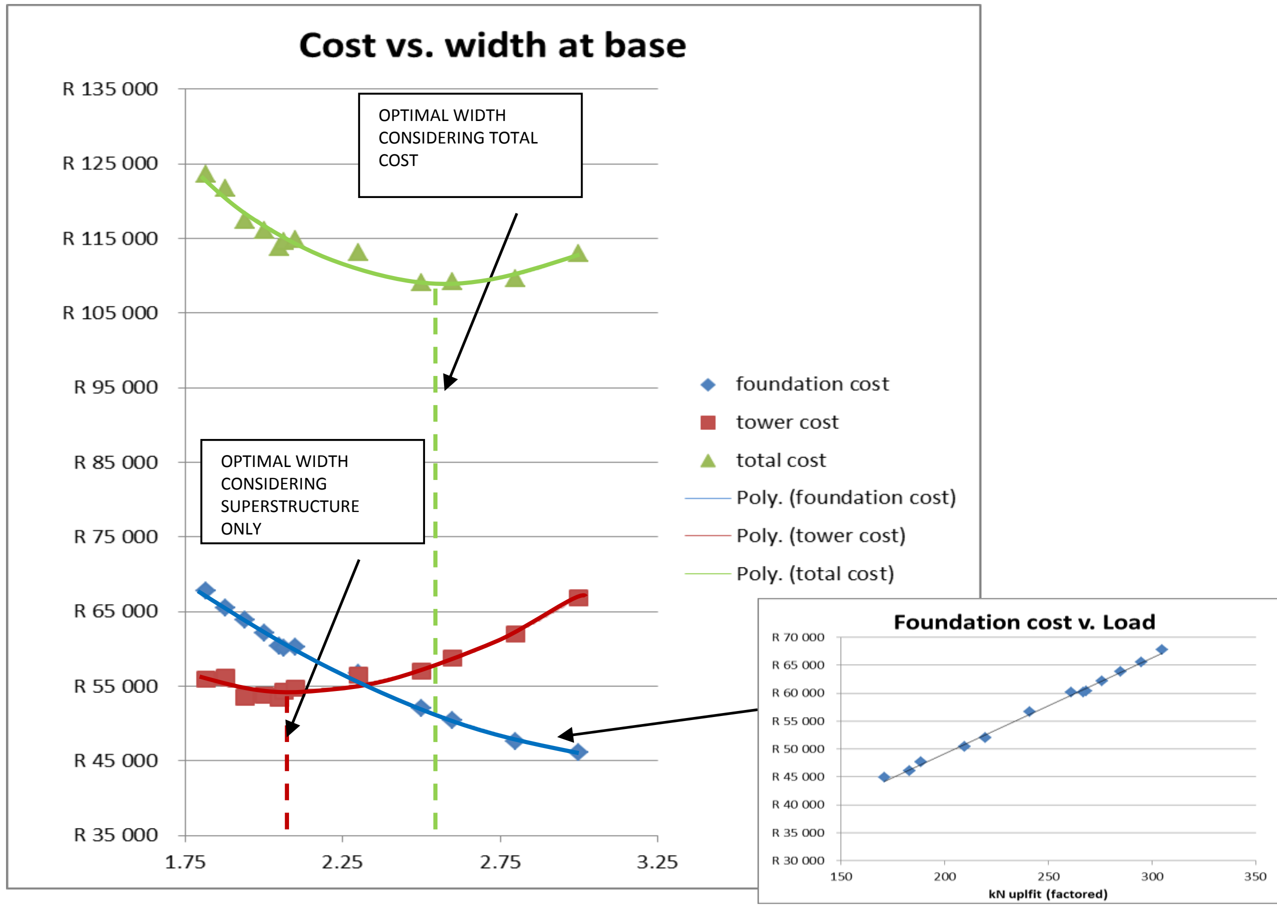
Conventional

Integrated

Optimising Inter-related Components

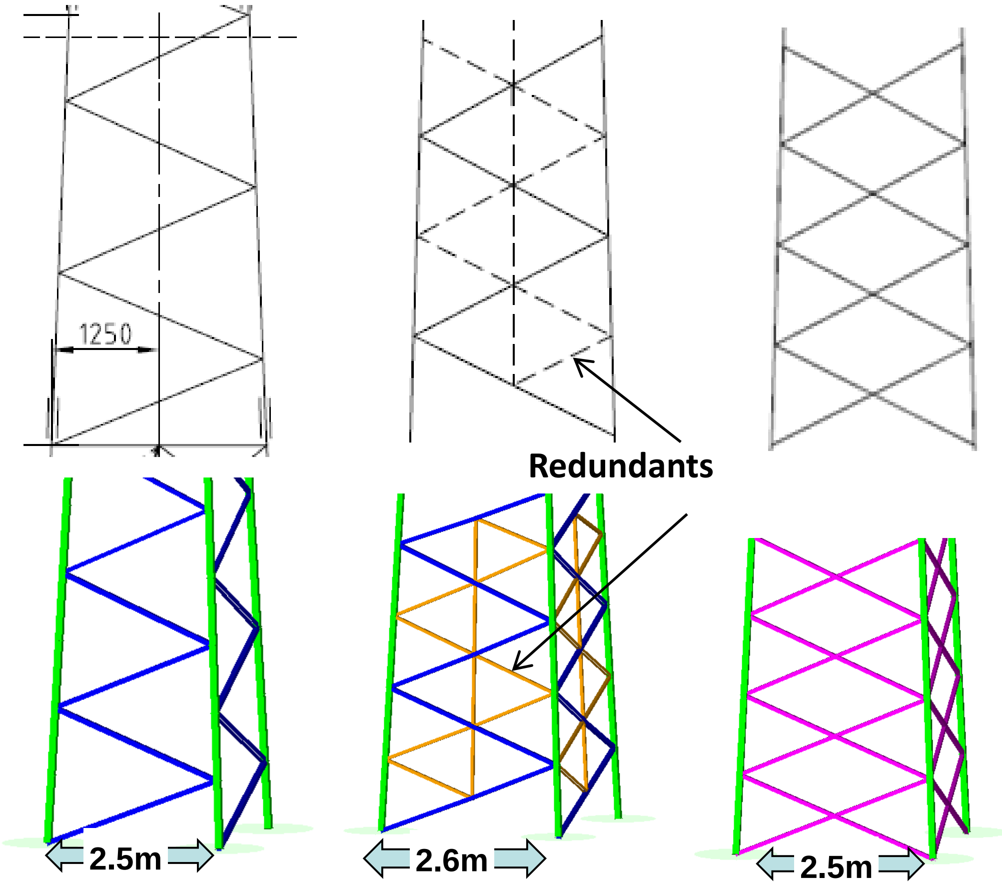


Base width



Base width

Impact of Bracing Patterns



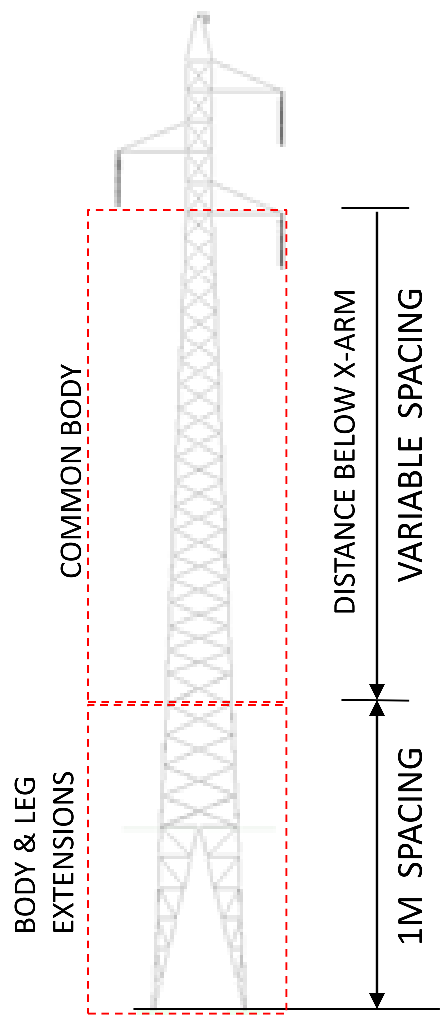
Staggered Bracing

Staggered Bracing with redundants

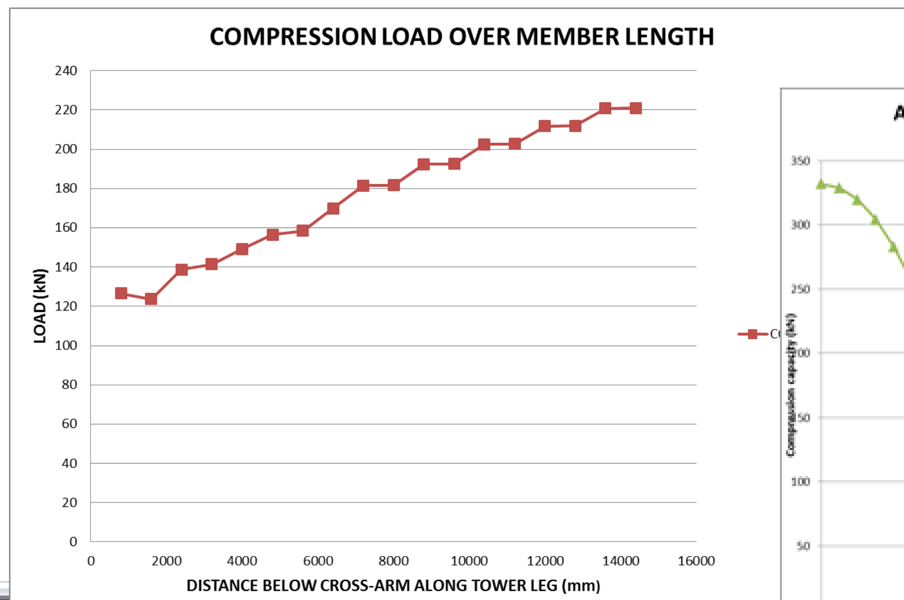
X - Bracing

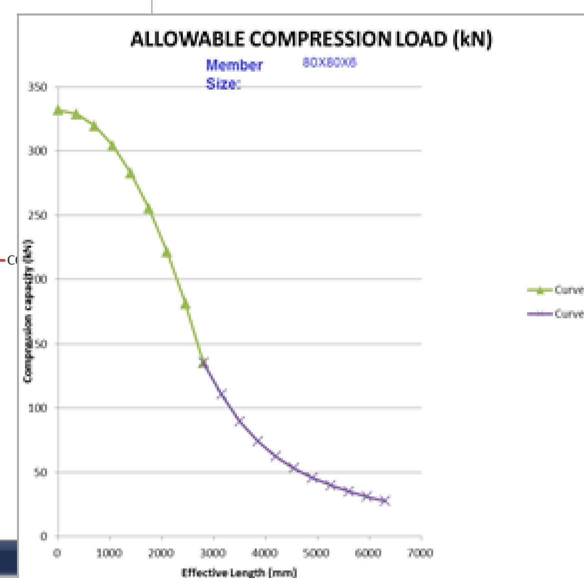
- Different bracing patterns may have slightly different optimal base widths
- Minimal difference in overall cost between options
- For standard width towers more significant differences expected

Determination of optimal bracing interval

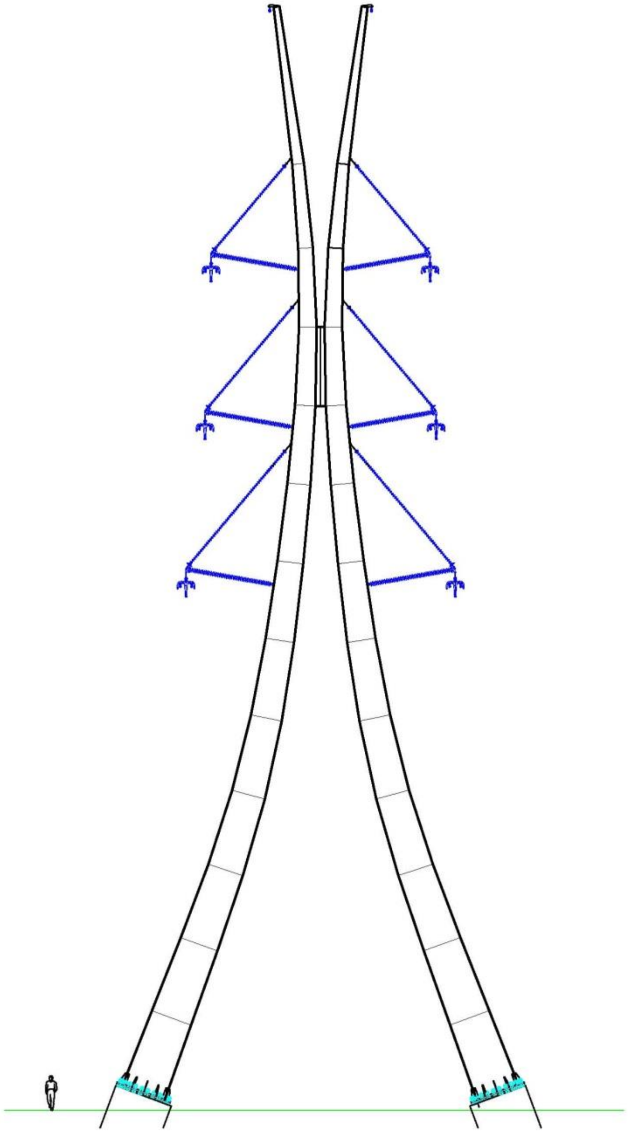


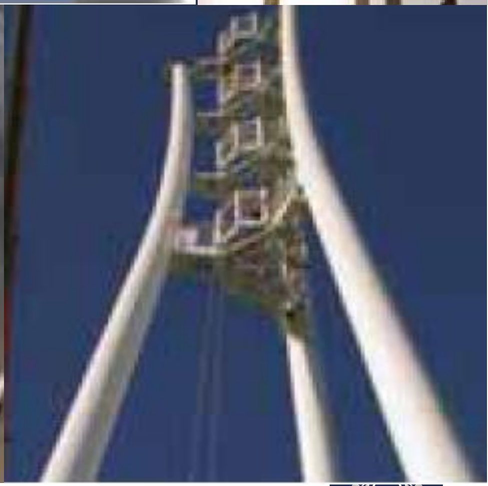
- Variable spacing on common body provides additional efficiency
  1. Determine load vs. position on main leg (max of <u>all</u> load cases)
  2. Determine compression load curve for main leg
  3. Calculate bracing interval incrementally with successive locations down the main leg





"Tusk Tower" 400kV Multi-Circuit Sculpture Tower





Thank You

Questions?

pierrem@taprojects.co.za