Collocation Considerations & Best Practices for Financial Services Organizations

A structural engineering perspective

AMERICAN TOWER®

Outline

- Structural Impact of Dishes
- Serviceability – Twist and Sway
- Radio Frequency Interference
- Best Towers for Installation
- Worst Towers for Installation
- Best Practices for Dish Mounting
- Summary

Structural Impact of Dishes

Impact of dish size

- A 10 ft HP dish has over six times the area of a 4 ft HP dish

HP Dish Diameter (ft)	Wind Area (ft^2)	Ratio of Diameter vs. 4 ft HP Dish	Ratio of Wind Area vs. 4 ft HP Dish
4	15.86	1.0	1.00
6	35.68	1.5	2.25
8	63.44	2.0	4.00
10	99.12	2.5	6.25

- (12) 72 in X 12 in panels on (3) sector frame mounts have a wind area equivalent to approximately 90 ft^2 after applying orientation and Ka factors

Structural Impact of Dishes

Impact of installation elevation

- A dish installed at 200 ft can have approximately 1.5 times the load as one installed at 50 ft

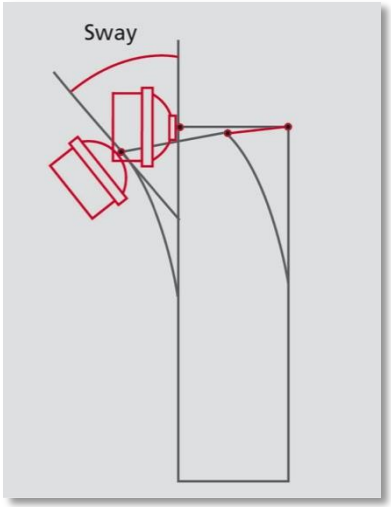
HP Dish Elevation (ft)	25	50	100	150	200	250	300
Load Factor (Exposure B)	0.82	1.00	1.22	1.37	1.49	1.58	1.67
Load Factor (Exposure C)	0.86	1.00	1.16	1.26	1.34	1.40	1.46

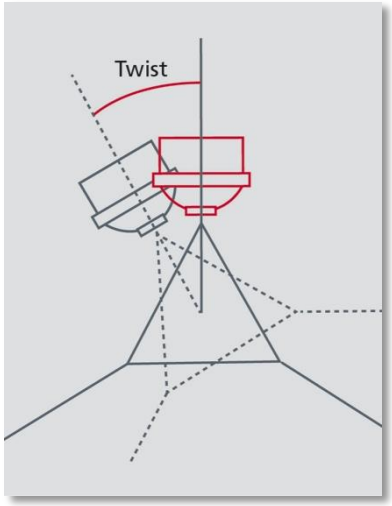
Proximity to guy wires

- Close proximity offers best structural and service results
- Center span installation offers worse structural and service results
- Physical installation can be hindered by guy wires and torque arms

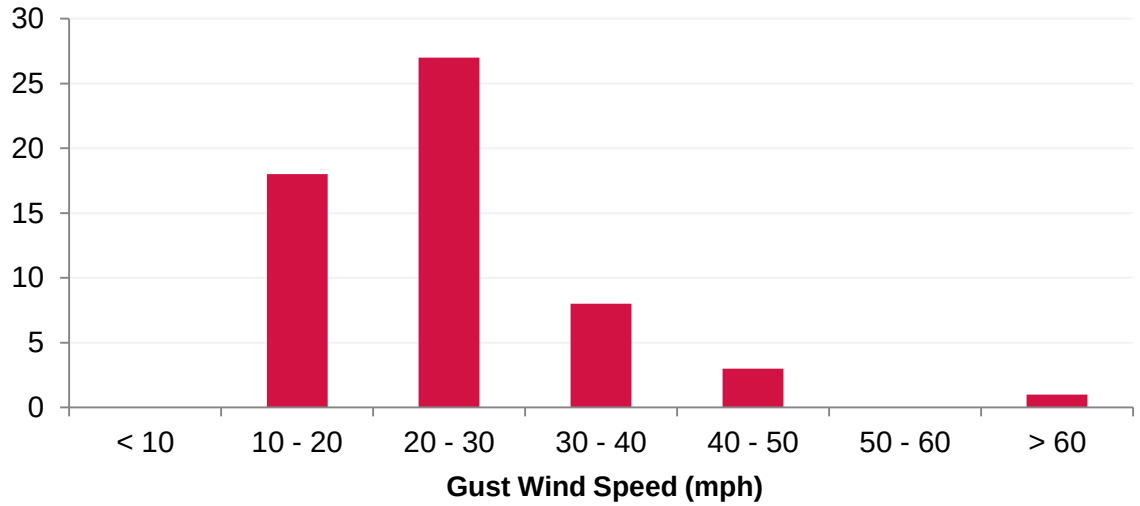
Serviceability – Twist and Sway

- 10 dB degradation in signal is typical limit
- Calculated using 60-mph wind speed (TIA-222-G)
- Exceeding twist and sway limits
  - Does not imply structural failure
  - Calculated for 60-mph wind gusts
    - Will still work during most day-to-day conditions





Daily Max Wind Gust Occurrences for North Side Chicago (06/01/12 – 07/28/12)



Serviceability – Twist and Sway

$$\theta = C_{10}/D\alpha$$

θ = Twist or sway deformation limit, degrees

C = Constant based upon dB degradation in signal level

- C_{10} = 53.1 10 dB degradation limit is default limit
- C_3 = 31.0 3 dB degradation limit shown for comparison purposes

D = Dish diameter, ft

α = Dish frequency, GHz

Dish Diameter (ft)	Dish Frequency (GHz)	Degradation Limit (dB)	Twist/Sway Deformation Limit (θ)	Ratio of θ vs. 8 ft, 11GHz, C_{10}
8	11	10	0.60	1.00
8	7	10	0.95	1.57
6	11	10	0.80	1.33
8	11	3	0.35	0.58

Serviceability – Twist and Sway

Best results are obtained from the following:

- Use of smaller diameter dishes
- Use of lower frequency dishes
- Installation near guy points

When exceeding twist and sway limits:

- Site-specific data can be used by a radio frequency engineer to broaden twist and sway limits
  - Node distance
  - Reliability
- Determine if relocation is an option
  - Reduce installation elevation
  - Move closer to a guy point
- Strengthen (or replace) tower

Radio Frequency Interference

The FCC regulates frequency coordination for channel assignment

- Proximity to other equipment can still cause radio frequency interference at the tower level
- Knowing proximity and radio frequency isolation is advantageous to the carrier

Radio frequency interference typically occurs due to power level and obstructions

- Not typically caused by actual frequency
- Millimeter wave technology must have special consideration for all three factors
  - Power level
  - Obstructions
  - Frequency

Best Towers for Installation

Self-support towers with large face widths

- Face width greater than or equal to the dish diameter
- Stiffer toward the base of tower
- Difficult to correct for twist and sway

Guyed towers with large face widths

- Face width greater than or equal to half the dish diameter
- Guy points straighten tower periodically
- Most able to fix when twist and sway is out of tolerance
  - Add torque arms
  - Add or swap guy wires

Specialty towers built for microwave installs

- AT&T tag towers
- H-frame towers

Worst Towers for Installation

Monopoles

- Often yield large twist and sway values
- Expensive to stiffen
- Often too far out of tolerance to convert for twist and sway to be feasible to fix

Guyed towers with small face widths

- Often not built for large dishes
- May result in large structural failures
- May result in large twist and sway values

Self-support towers with small face widths

- Top of structures yield high twist and sway values
- Often not built for large dishes

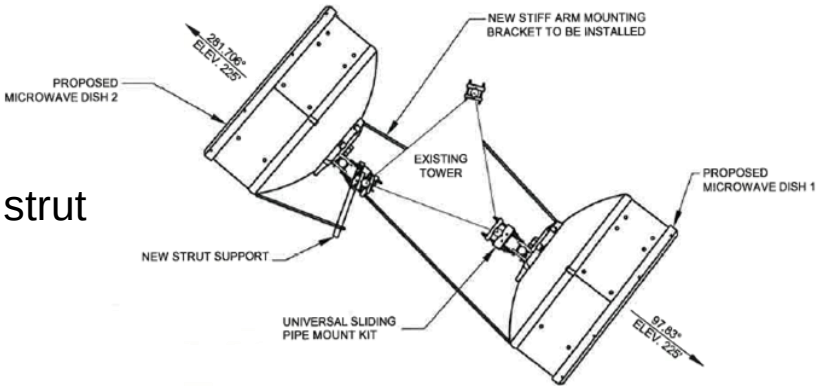
Best Practices for Dish Mounting

Inboard strut

- Should be placed on opposite side of mounting pipe
- Should not be more than 25º out of plane (or follow manufacturer recommendation)

Outboard strut

- Should be placed on opposite side of inboard strut
- Should not be more than 25º out of plane (or follow manufacturer recommendation)
- An onboard strut is not always required
- Adding extra struts does not improve reliability



Struts should be attached properly to rigid members

- Strut supports should be used if rigid member connections can't be made

Key takeaways

- Proper mount installation is not occurring per field observations
- Improper mounting can hinder service

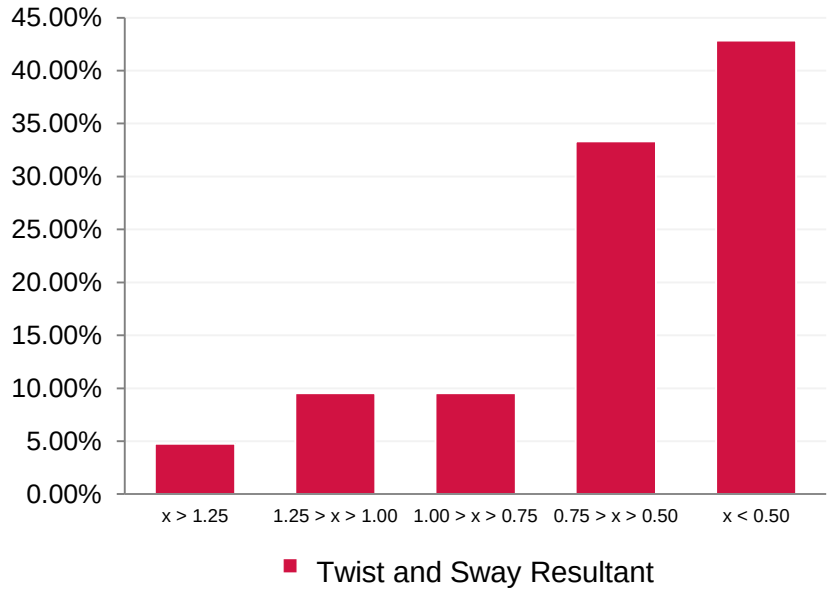
Summary

Factors Effecting Stress & Service

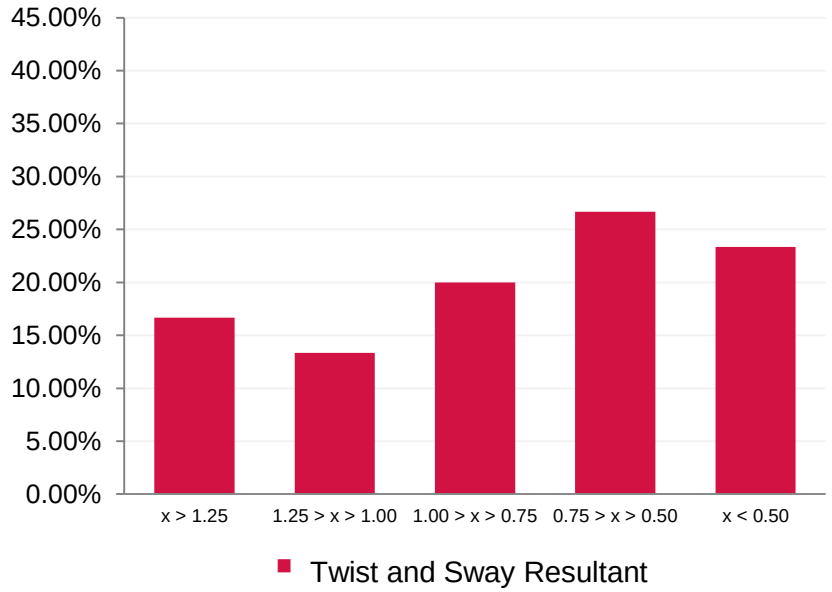
Multiple factors affect tower stresses and service quality

- Dish size
- Installation location
- Tower type
- Mounting configuration

Twist and Sway Resultant: Guyed Tower



Twist and Sway Resultant: Self-Support Tower



Based on random sampling of towers with multiple large dish loadings added

Summary
Best-Case Options

Dishes
- Smaller dishes have higher twist and sway allowances given the same dB degradation
- Low-frequency dishes have higher twist and sway allowances given the same dB degradation

Installation location
- Directly above guy points
- Locations with large face widths
  - Typically lower on self-support towers
- Locations with isolation from nearby equipment

Tower types
- Self-support towers with large face widths
- Specialty towers designed for microwave installs
- Guyed towers

Mounting
- Use proper number of struts
- Install struts within proper alignment (<25º)
- Install struts to properly stiff members or to strut supports

Summary
Worst-Case Options

Dishes
- Larger dishes have smaller twist and sway allowances given the same dB degradation
- High-frequency dishes have smaller twist and sway allowances given the same dB degradation

Installation location
- Center of guy spans
- Locations with small face widths
  - Typically higher on self-support towers or on long extensions
- Locations in close proximity to nearby equipment

Tower types
- Self-support and guyed towers with small face widths
- Monopoles

Mounting
- Install struts on wrong sides of dishes
- Install struts outside of proper alignment (>25º)
- Install struts to coax guides or small bracing members