Transmission Line Clearance Enhancement Using the AMPJACK® Lift System

Company Overview

Ampjack Industries Ltd.

Manitoba, Canada

Ampjack America Ltd.

Las Vegas, Nevada

- Highly experienced utility and industry staff
- Unique understanding of utility challenges
- Strategic partnerships
- Sophisticated engineering support
- International Experience – Canada / USA / UK / EU / Central America

What is the AMPJACK® Lift System

The **AMPJACK® Lift System** is a hydraulically driven, self-contained “crane in a Box” that can be transported and installed easily with minimal environmental impact.

Implemented to increase the height of existing transmission lines without the need of an **Outage.**

AMPJACK® Construction Method

(No Cranes and Minimal Footprint)

- Positive Control = Live Line & Live Load Capabilities
- Eliminates Suspended Loads
- Handles Overturning Loads Tension/Compression/Shear

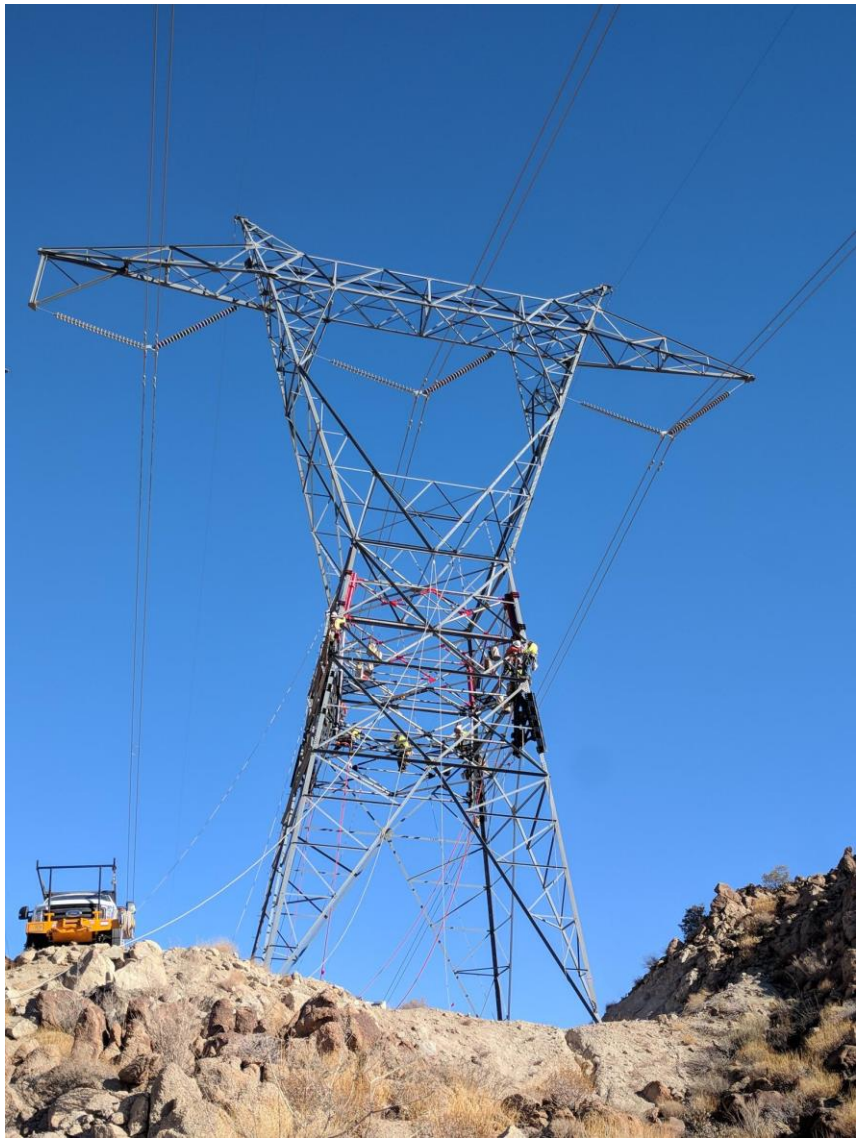
AMPJACK® Operational Benefits

- Utilize Existing Structures & Residual Capacity
- Top-Down Engineering
  - Each lift plan evaluates the wire system, structure & foundation
- Increased SAFETY!
  - Tower does not hang from a crane, so there are NO SUSPENDED LOADS!
  - AMPJACK® always maintains positive control of the tower.
- Facilities remain in service, allowing flexibility in scheduling transmission line work.
- Increased productivity—work can be executed at multiple locations in parallel.
- Versatility for efficient integration at tower locations.



AMPJACK® Operational Benefits

- Detailed engineered lift plan and work methods
  - Step-by step rigging plans, work methods, tower retrofit and upgrades
- Integrated Analysis Approach
  - Method 4 PLS-CADD/Tower Integration
  - “In-situ” Design Criteria Development
- Outputs Drive Design of the AMPJACK® System Design Process



AMPJACK® Operational Benefits

- Effective in Areas with Limited Access Roads
- All Equipment can be Brought in by Truck/ Trailer or Air Lifted.
- Ideal in Space-Restricted Locations:
  - Towers with Less than 20Ft. of Clearance around the Tower Base
  - Remote Areas Where Both Crew and Equipment Must be Flown In/Out

OSHA®
Occupational Safety and Health Administration

AMPJACK®

Congested Corridors

Access into Constrained Utility Corridors:

- Working adjacent to Rail ROW
- Underground and surface pipelines
- Underbuilt crossings
- Interstate and Freeway crossings

AMPJACK® Construction Method causes very little ground disturbance.

Remote Access Capabilities

Helicopter Access into Remote Areas:

All work at this site included:

- Custom scaffolding platform installed for crew & equipment access
- Insulator change-outs
- Conductor re-tensioning
- 15Ft. AMPJACK® tower raise completed by helicopter access only

This work caused very little ground disturbance.

Remote Access Capabilities

AMPJACK® and the *Environment*

- Minimal environmental impact
- No cranes or large aerial equipment needed
- Minimal matting or new access road work required
- Can be installed with a small crew of 10-14
- Install requires only lightweight equipment

Lift Feasibility

Suitable transmission lines for clearance enhancement using the AMPJACK® Lift System:

Primarily Steel Lattice Transmission Lines

- **Line Vintages 1920's to 2000's**
- **Self-Supported and Guyed Towers**

Varying Circuit Configuration

- **Single Circuit / Double Circuit / Triple Circuit**
- **Horizontal / Vertical / Delta / Special Loading Conditions**

Tubular Steel Poles & H-Frames In-Development (Patent Pending)

Lift Feasibility

Suitable transmission lines for clearance enhancement using the AMPJACK® Lift System:

Voltages lifted to date:

- **110kV / 115kV / 138kV / 220kV[230kV] / 345kV / 500kV / 735kV**
- **95% raises completed energized**

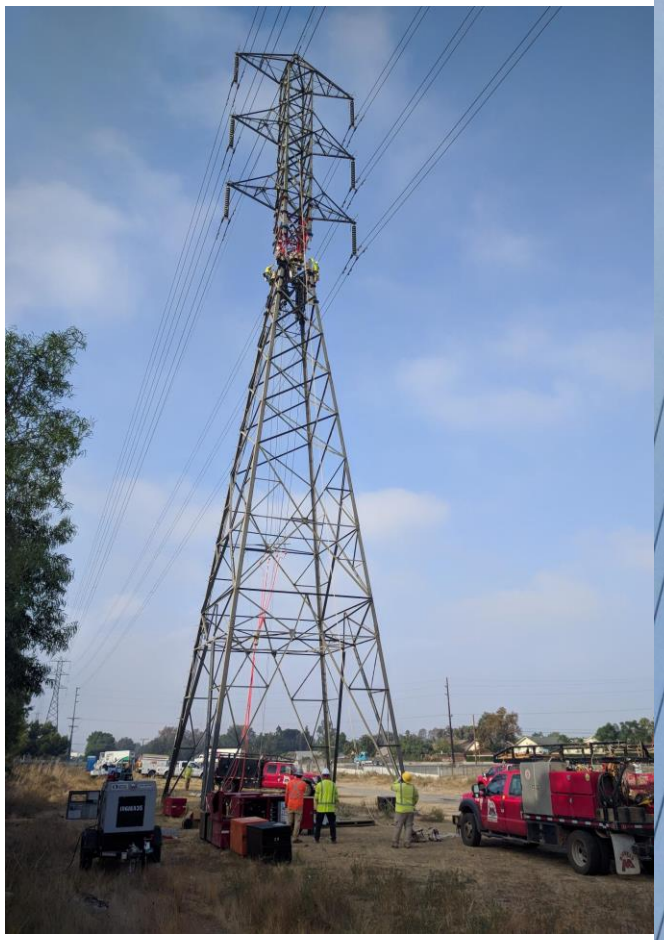
- **Towers raised > 1,000**
- **Line Angles > 22° energized**
- **Line Angles > 61° de-energized**

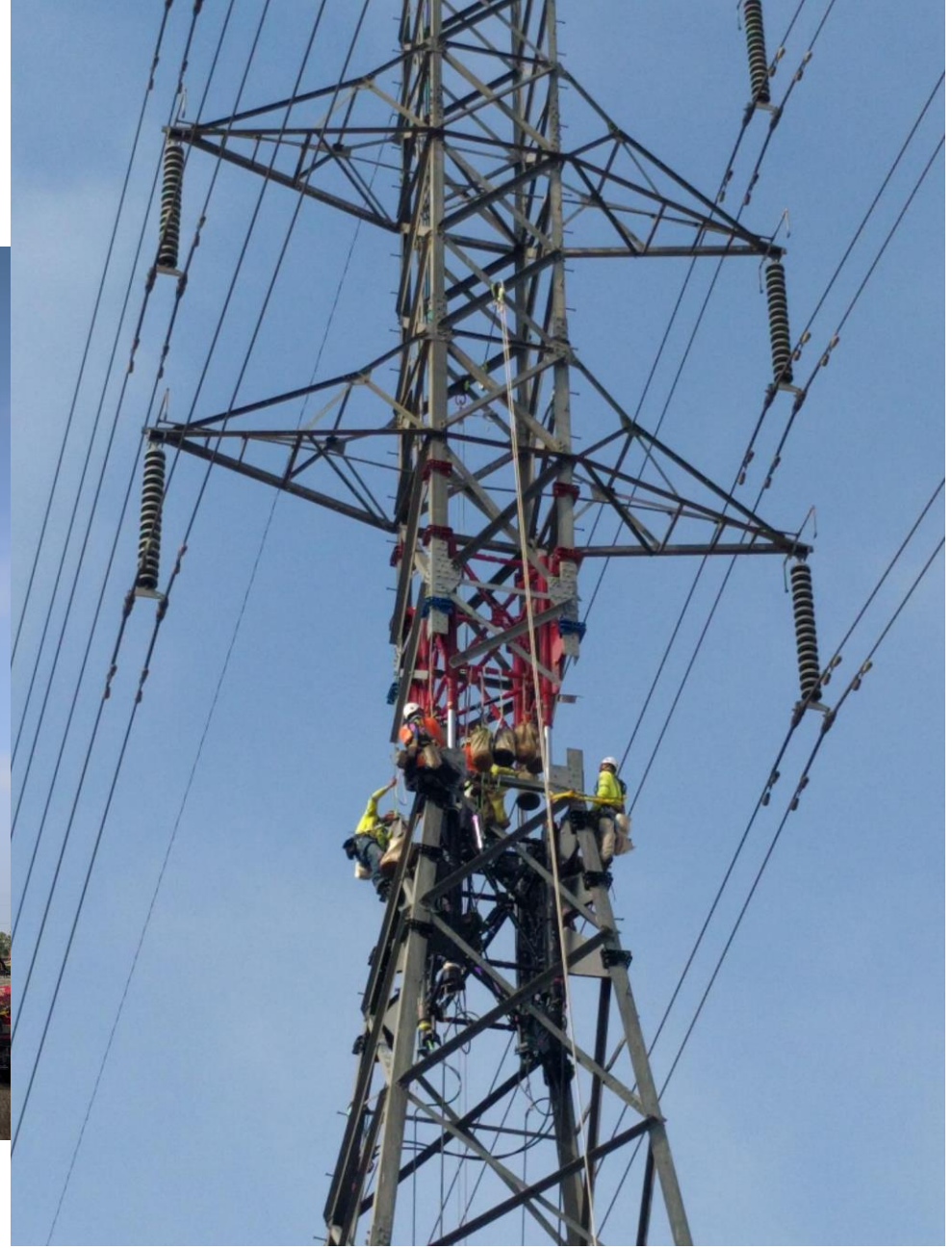
Lift Feasibility - 115kV Double Circuit

- Urban Right-of Way
- Light Weight Equipment for Access
- Compact System
- Efficient Tower and Foundation Upgrades – Combined with HTLS

Lift Feasibility - 220kV Double Circuit

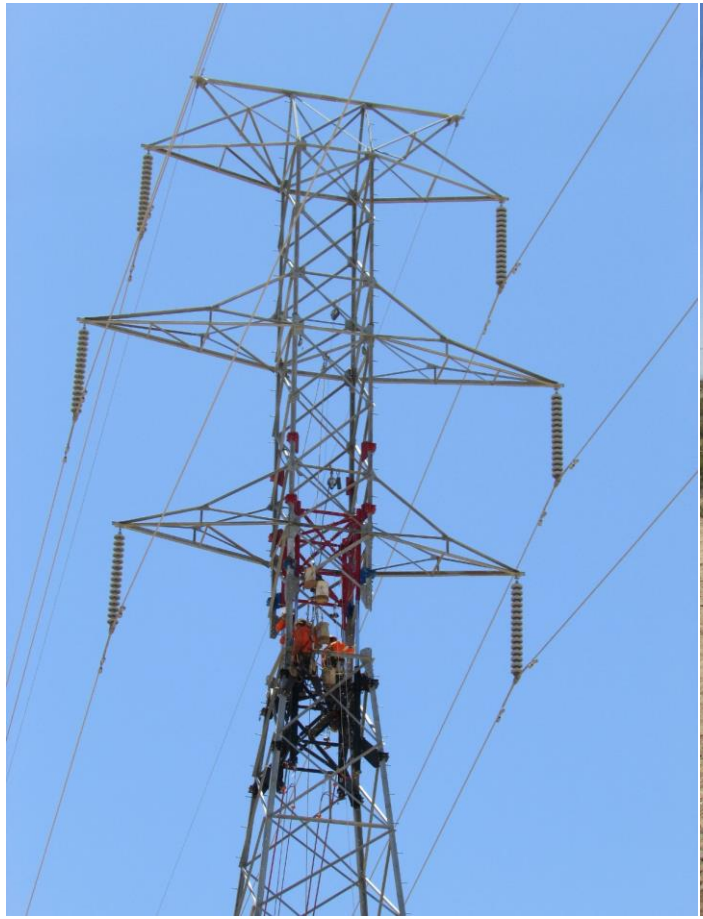
- Urban Right-of Way
- Light Weight Equipment for Access
- Compact System
- Precision Controlled Lift Sequencing





Lift Feasibility - 220kV Double Circuit (BLM Lands)

- AMPJACK® trolleyed to tower base
- No equipment was driven across sensitive BLM areas
- BLM access permit time reduced to 14 days



Lift Feasibility - 220kV Single Circuit

- Transmission line upgraded exclusively using the AMPJACK® Lift System
- 28% of Spans (61 Towers Lifted)
- Reduced Permitting Time

Lift Feasibility - 500kV Single Circuit (USA)

- Remote Access Area
- Sensitive Environment
- Reduced permits because of the small AMPJACK® footprint

Lift Feasibility - 500kV Single Circuit (USA)

- Remote Access Area
- 90,000 lbs Net Lift Load
- 5Ft to 20Ft Extension Height
- Reduced permits because of the small AMPJACK® footprint

Lift Feasibility - 500kV Double Circuit (USA)

- Urban Area
- 500kV Double Circuit Energized Lift (2x Bundled)
- 235Ft Structure Height / 15Ft Lift Height
- 120,000 lbs Net Lift Weight
- No special permits required because of the small AMPJACK® footprint

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- Urban Area
- 500kV Double Circuit Energized Lift (2x Bundled)
- 235Ft Structure Height / 15Ft Lift Height
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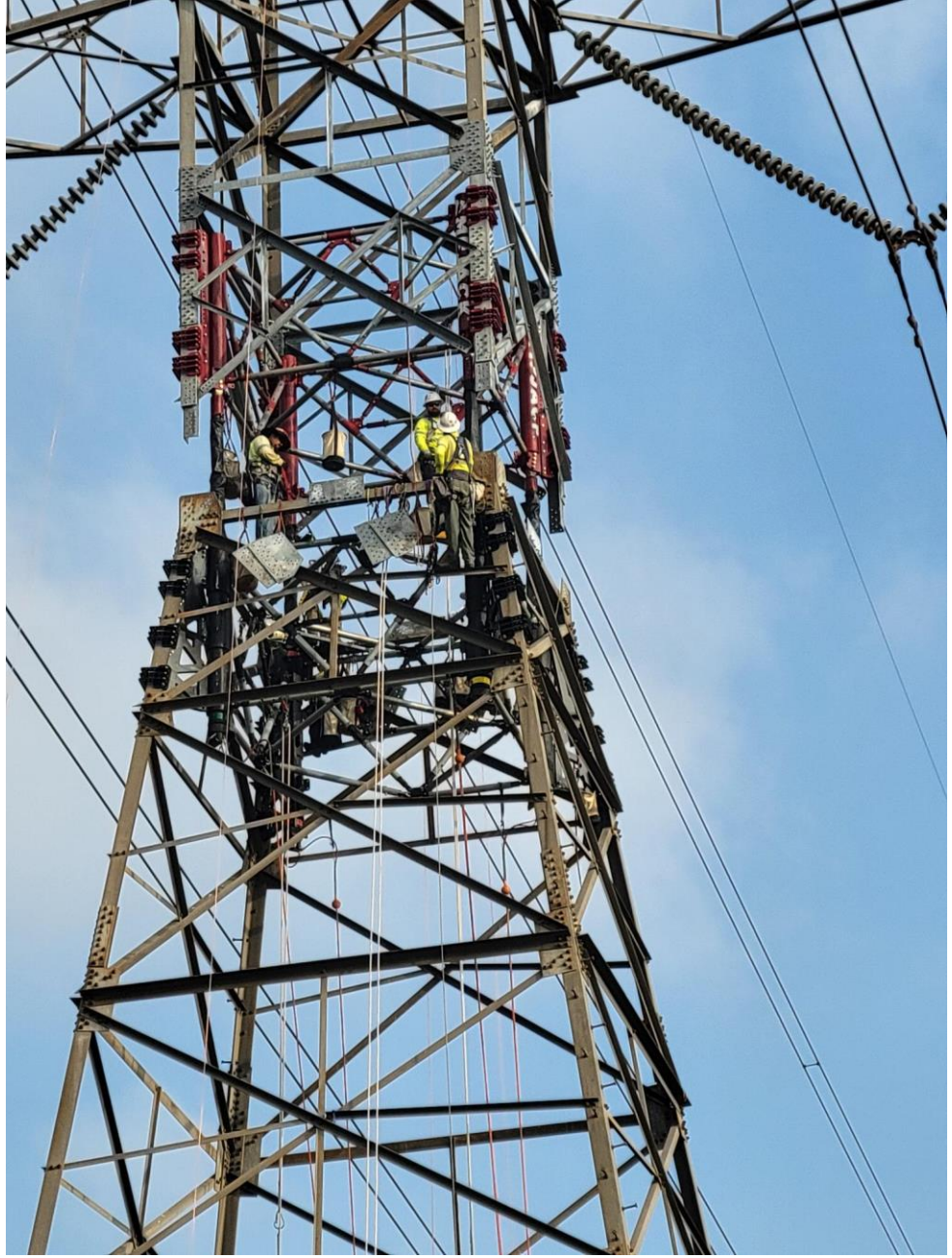


Lift Feasibility - 500kV Single Circuit DE (USA)

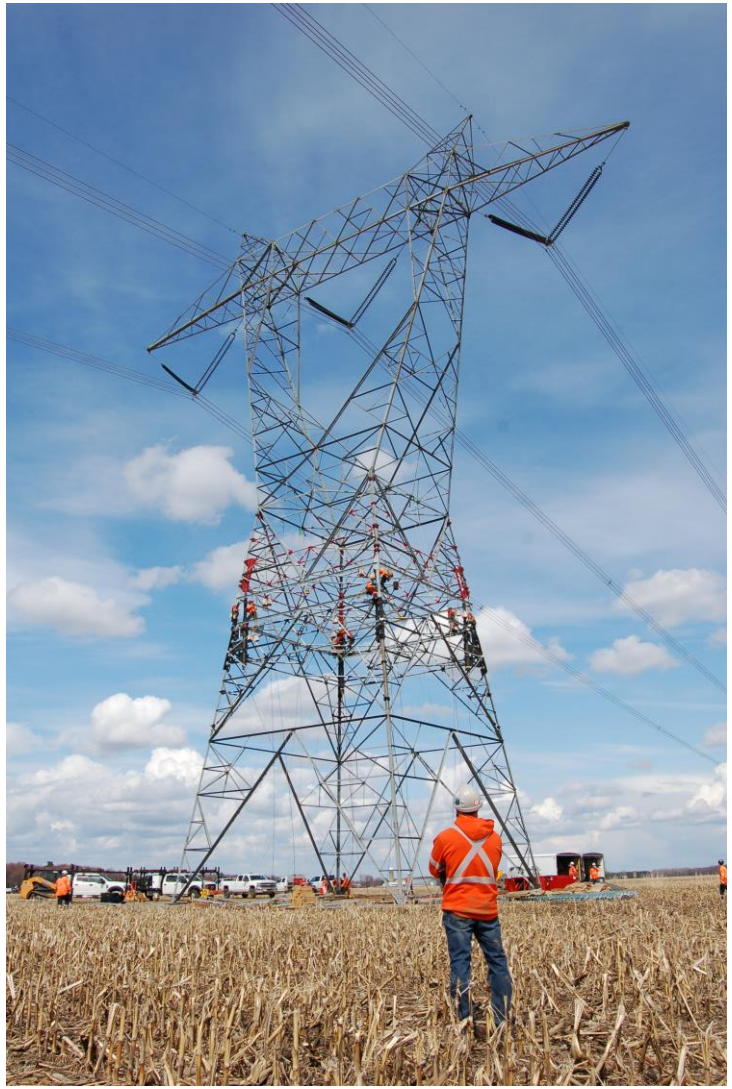
- Mountainous Area – Remote Access
- 500kV Single Circuit Dead-End Energized Lift (2x Bundled)
- No special permits required because of the small AMPJACK® footprint
- 14,000lbs Everyday Tension per Sub-Conductor

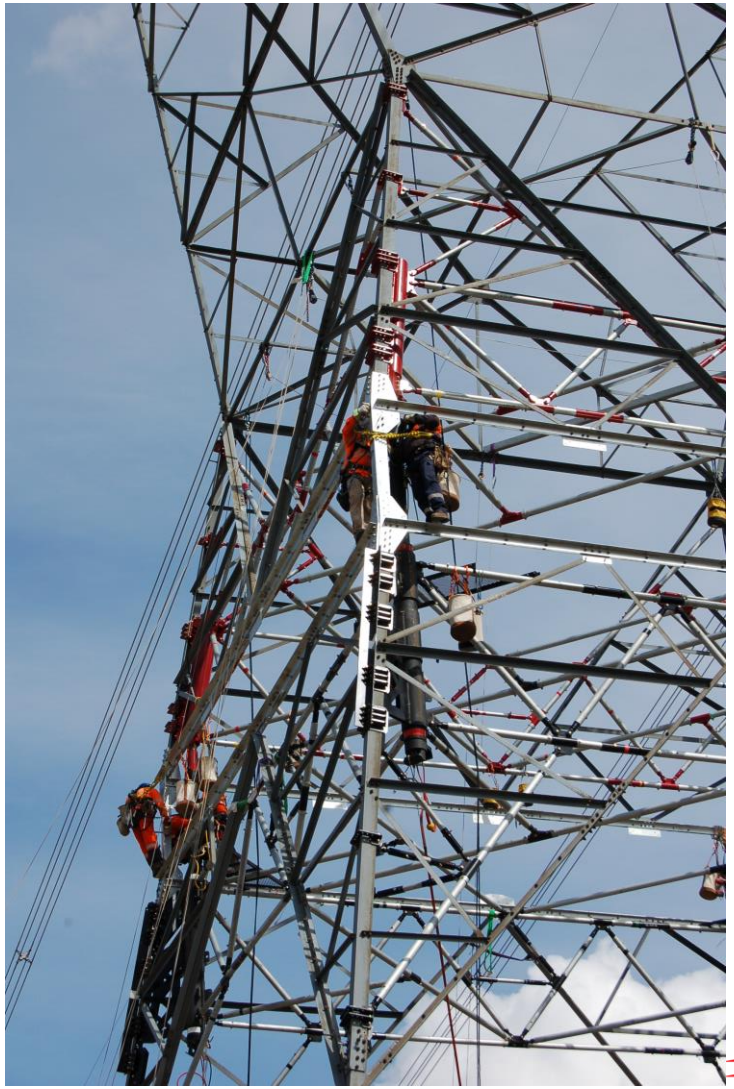
Lift Feasibility - 500kV Single Circuit DE (USA)

- Mountainous Area – Remote Access
- 500kV Single Circuit DE Energized Lift (2x Bundled)
- No special permits required because of the small AMPJACK® footprint
- 14,000lbs Everyday Tension per Sub-Conductor

Lift Feasibility - 735kV Single Circuit Quad Bundle (Canada)

- Agricultural Area
- 735kV Single Circuit Energized Lift – Quad Bundle
- 130,000 lbs Net Lift Load
- 5Ft and 10Ft Extensions
- Project Consisted of 50+ Tower Lifts on Two Parallel Transmission Lines
- 4 Unique Tower Types





Special Loading Conditions:

Single Circuit Vertical Configuration

- Unbalance & Eccentric Loading Profiles
- Tension & Compression Reaction Couple
- Control Overturning Moment at Split Locations

Special Loading Conditions:

Line Angles

- 145Ft structure height / 10Ft lift height
- 220kV Vertical Double Circuit @7.2deg Line Angle (2x Bundled with 9,000lbs line tension per conductor @ everyday conditions) Energized Lift / Without Tension Mitigation
- 52,000lbs lift weight / 15,000lbs shear due to line angle
- Greater than 50% Uplift Load Ratio
  - 2 Cylinders Pushing @ 56,000lbs each
    2 Cylinders Pulling @ 30,000lbs

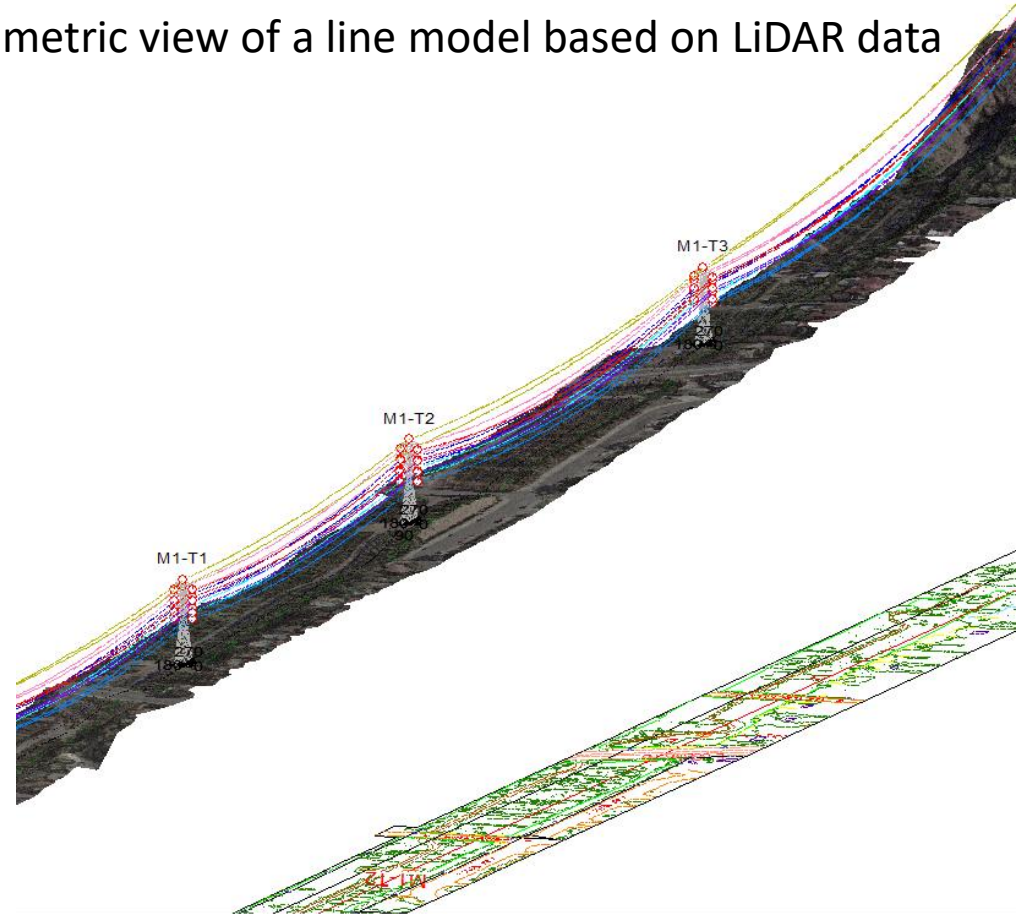
Line Re-Rating with AMPJACK®

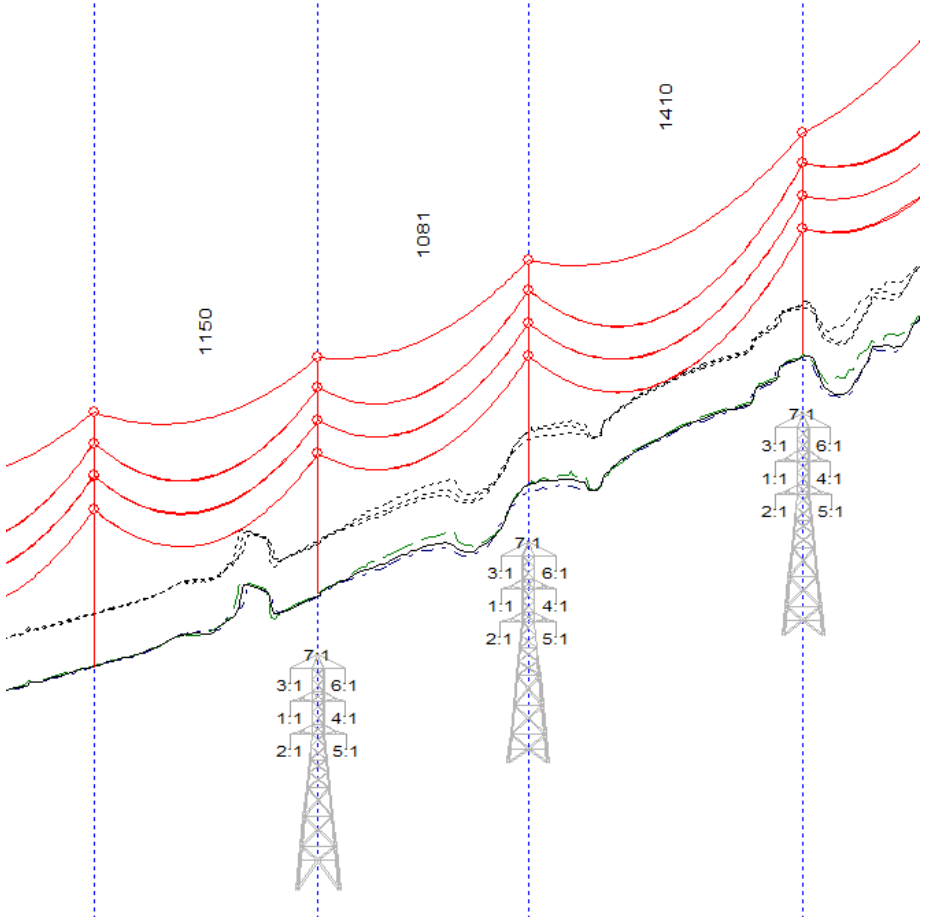
Utilities typically are driving the upgrade requirements, however this is changing with interconnection initiatives (“Gen-tie” developer driven projects)

- Historical design of ACSR conductors is 60°C to 90°C
- Line ratings is often dictated by Emergency Operation 135°C [275°F]

Line Re-Rating with AMPJACK®

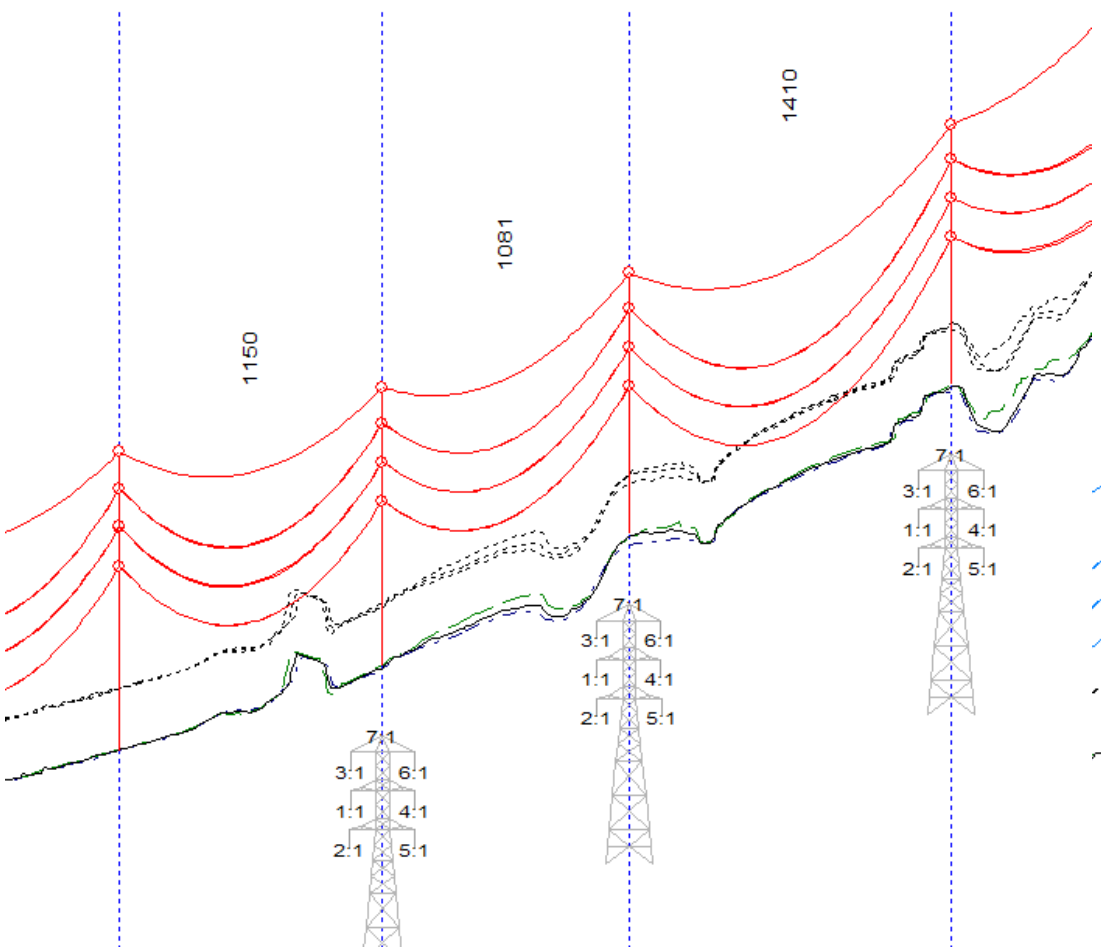
Isometric view of a line model based on LiDAR data



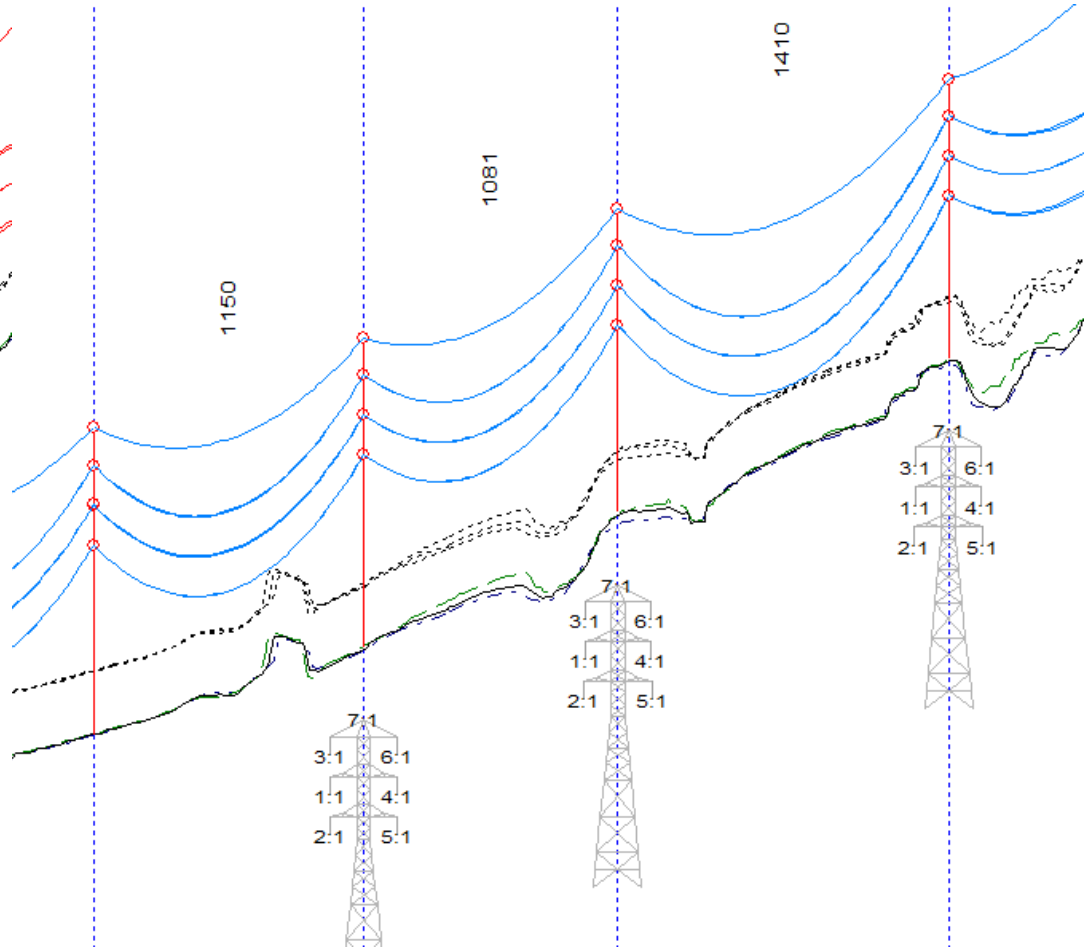


Existing max operating temperature: 69 °C [157°F]

Line Re-Rating with AMPJACK®



Sag at 135°C [275°F] (required emergency operating temperature).



Upgraded with AMPJACK® Extensions @ 3 Tower Locations

Line Re-Rating with AMPJACK®

					Mesa - Walnut	
M0-T5	4435.7	1149.9	0.1	O	+7.5/+7.5/+7.5/+7.5	-
M1-T1	5585.5	1080.5	0.1	O	+0/+0/+0/+0	10
M1-T2	6666.0	1409.6	0.0	O	-7.5/-7.5/-7.5/-7.5	15
M1-T3	8075.6	1890.6	0.0	O	-7.5/-7.5/-7.5/-7.5	5
M1-T4	9966.2	1383.4	0.0	O	+0/+0/+0/+0	-

Conductor Properties

Description: 1033.5 kcmil 54/7
Strands CURLEW ACSR

Analysis Results Existing

Conductor temperature 69 °C [157°F]
Current: 905 (Amps)

Analysis Results Upgrade

Conductor temperature 90°C [194°F]
Everyday Maximum Operational Temperature
Current: 1208 (Amps)

Ampacity Improvement

Current Increase: 303 (Amps)
Percent Increase: 33.5%

Design Consideration

Structural validation of superstructure (have any applications involved strengthening of the superstructure outside (below) the inserted portion?

- Validation of Structure, Foundation and Wire System
- Determination of requirement for Increased Height
- Calculation of increased Design Loads
  - Design codes
    - International – IEC / Euro Codes
    - State/Provincial Jurisdiction
    - Design Guides – ASCE 74 & Others

North America – NESC / CSA / ASCE 10
Utility Standard

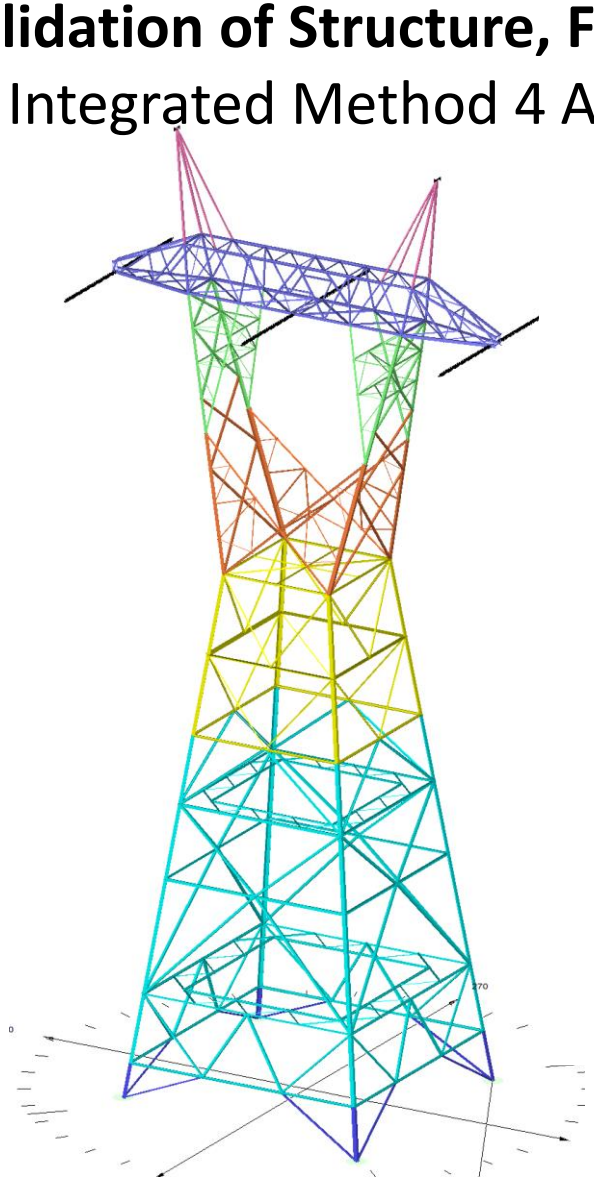
Design Consideration

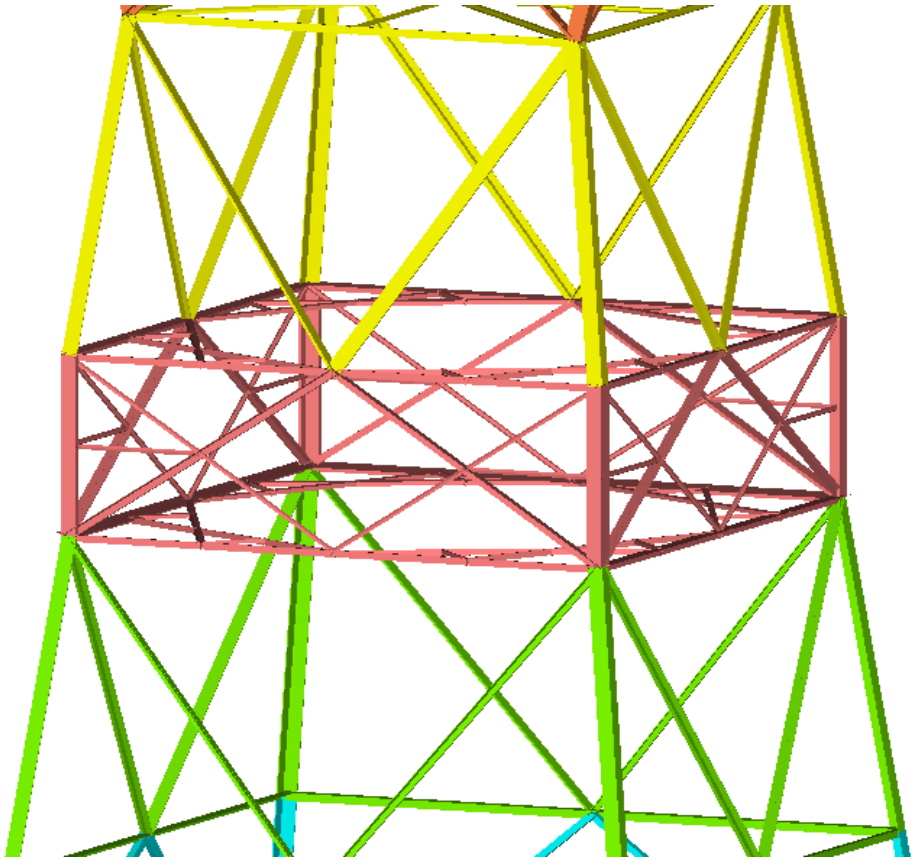
Specialized engineering in analysis of legacy (existing) transmission lines and towers and development of tools, work procedures and methods to upgrade, repair and maintain lattice towers and transmission lines.

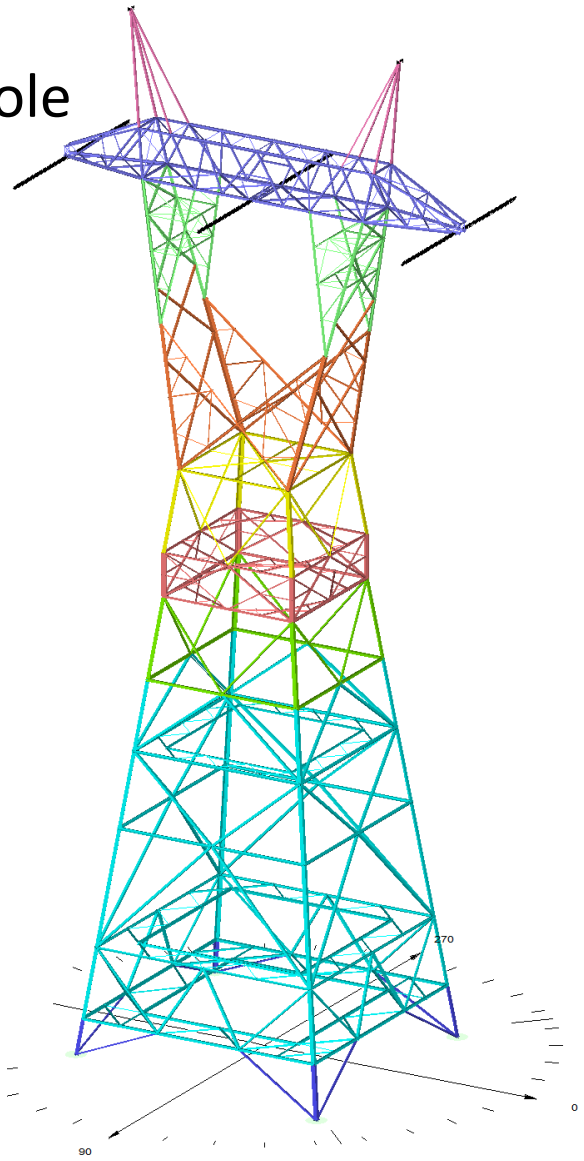
- Validation of Structure, Foundation and Wire System
  - Integrated Method 4 Analysis between PLS-CADD/Tower/Pole
  - Develop Design Criteria based on combination of standards (Collaboration with Utility/Owner)
  - Frame & Stress Analysis Applications / FEA using NASTRAN In-CAD
  - Autodesk Inventor 3D CAD Modelling & Analysis

Validation of Structure, Foundation and Wire System

- Integrated Method 4 Analysis between PLS-CADD/Tower/Pole

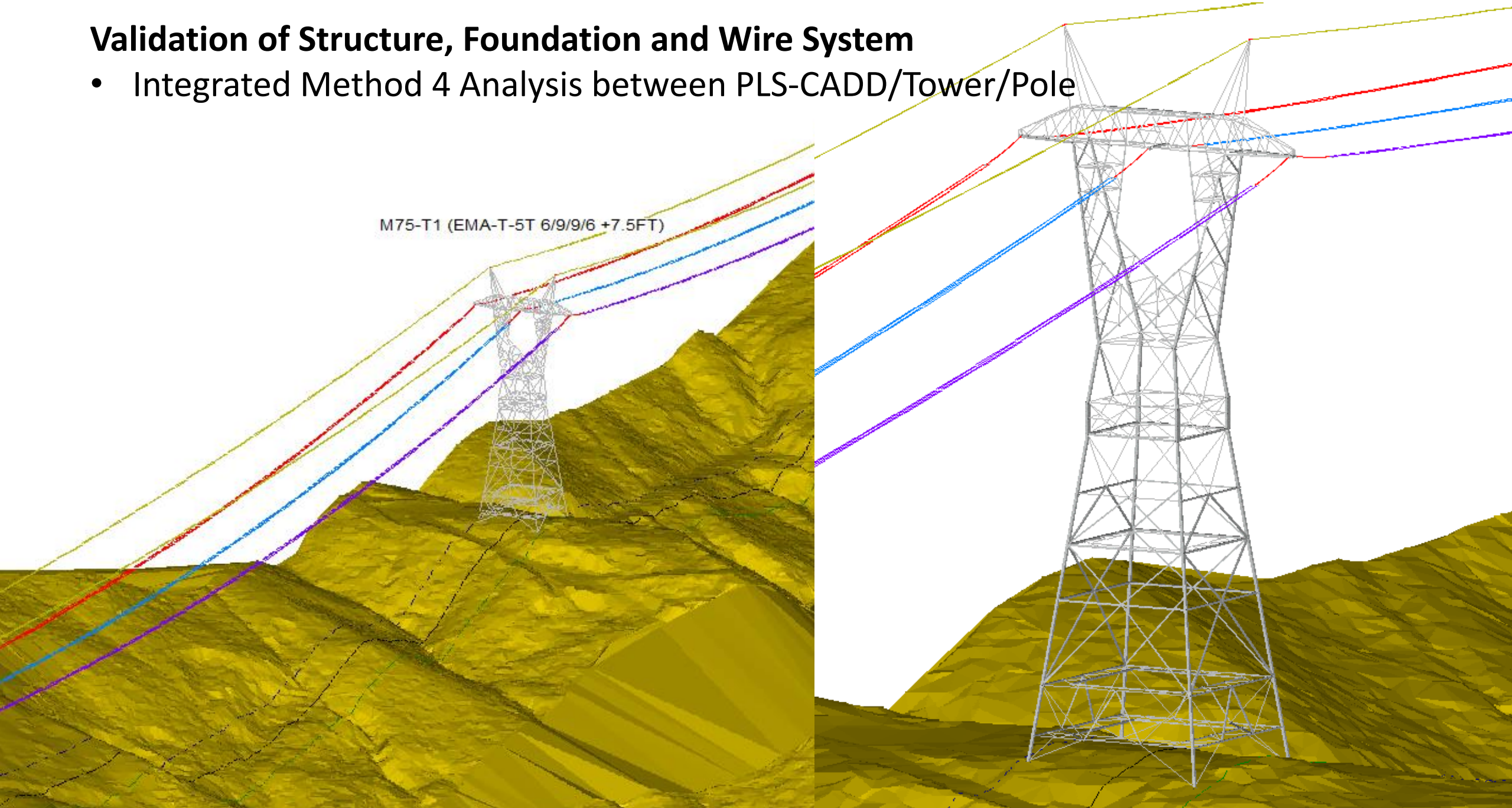






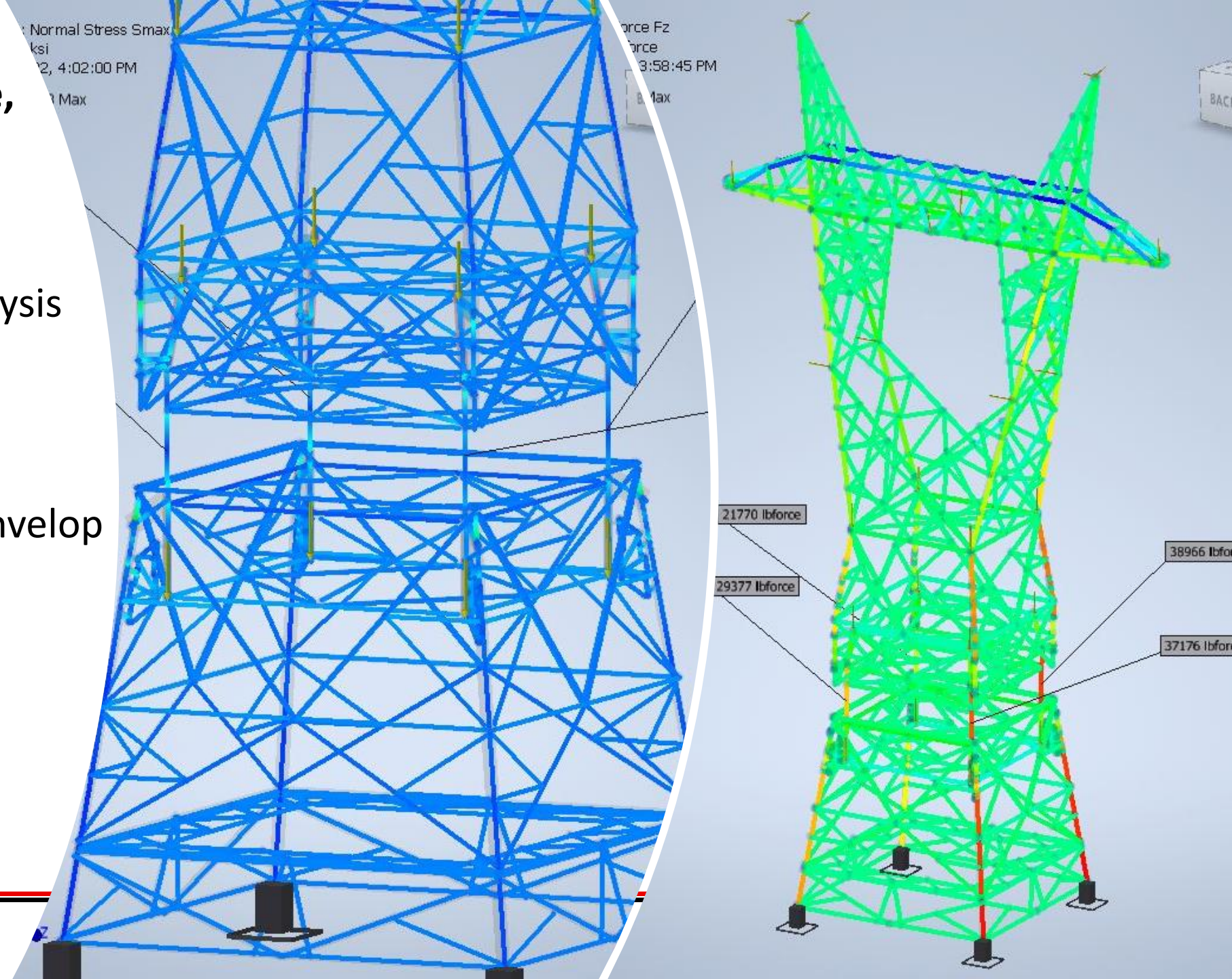
Validation of Structure, Foundation and Wire System

- Integrated Method 4 Analysis between PLS-CADD/Tower/Pole



Validation of Structure, Foundation and Wire System

- AMPJACK® System
- Frame & Stress Analysis
- FEA using NASTRAN
- AMPJACK® System Interaction Analysis
- Cylinder Reaction Envelop Analysis



Safety Consideration

Mechanical Safety Protocols

- AMPJACK® Certified Technician Monitors Installation and All Work Methods
- Ampjack Operational Criteria [40 KPH / 25 MPH Wind Gust]
- Handheld Wind Meter Measuring Instantaneous Gusts During Lift
- System Designed to a Factor of Safety of 4.0
- Hydraulic System limited to 1.25x Allowable Load (Relief Valving)
- Load Handling within Cylinder Only
- Temporary Emergency Splice Kits On-site
- Positive Control eliminate No Suspended Loads
- Tension Mitigation as Required

Safety Consideration

Electrical Safety Protocols

- Working outside of Minimum Approach Distance to Energized Circuits
- Only Qualified and Trained Personnel / High-Vis Flame Resistance Clothing
- Utilize Rated Bonding Chain Across the Split Tower Sections for Electrical Continuity to Ground
- Utility Do-not Reclose / Safety Hold-off Permits in Place

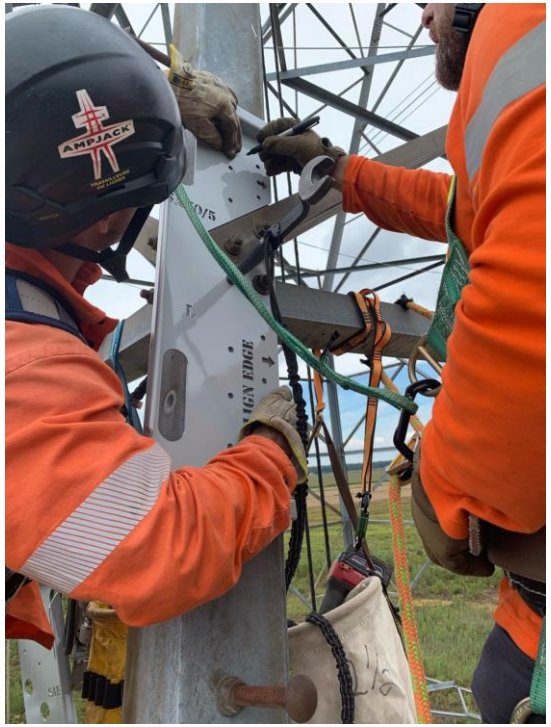
Execution

Fabrication of Extension & Upgrade Sections

- 3D CAD Modelling Environment => Output Digital Files for Fabrication (CNC)
- Tower Templating => Prior to Fabrication
- Complete Trial Assembly of Extension Sections
- Fieldwork Templating

Execution

Tower Templating / Trial Assembly / Fieldwork Templating



Execution

Construction Timelines

- On average, the AMPJACK® system takes...

- ½ day to 1 ½ days to install – depending on complexity
- Approx. 2 to 4 hours per 5-ft. lift increment
- 1 day to remove, clean up and demobilize to next site

Execution

Questions?

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