

Switching It Up: A New Innovative 3-Way GOAB Switching Structure

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Agenda

- Safety near misses & component failures from in-service 3-way switching structures
- Failure Analysis
- Lessons Learned
- Engineering solution 1 and its challenges
- Engineering solution 2 and its benefits + safety measures
- Solution I & II cost/benefit comparisons
- Conclusion – new innovative structure is safe, reliable, flexible, and easy to maintain.

Fallen Object Safety Near Misses



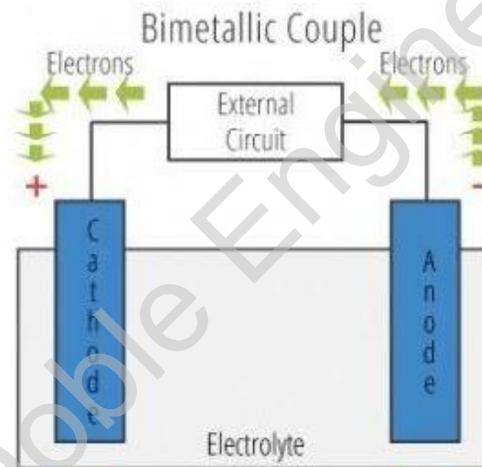
- LCRA experienced two (2) fallen objects from previous GOAB switch design in 2020.
- Assets were 5 years old at the time of failure.
- Switches had been exercised annually (recommended by manufacturer).
- Both switches and interrupters were manufactured from same company.

What is Galvanic Corrosion?

Galvanic corrosion (so called bi-metallic corrosion) occurs when two dissimilar metals are in contact in the presence of an electrolyte.

<Galvanic Series Chart>

CORRODED END (Anodic or less noble)	
	Magnesium
→	Zinc
	Aluminum
	Steel
	Lead
	Tin
	Nickel
	Brass
	Bronzes
	Copper
	Stainless Steel (passive)
	Silver
	Gold
→	Platinum
(Cathodic or more noble)	
PROTECTED END	



Four required elements :

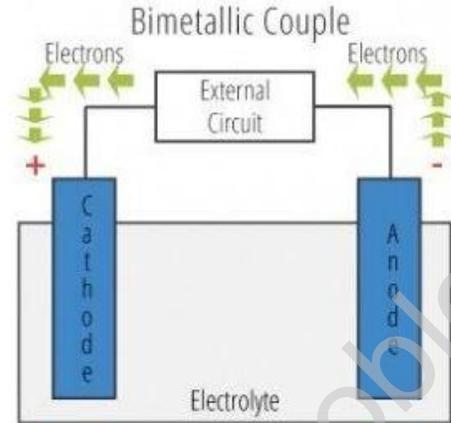
- Anode
- Cathode
- Current path(physical contact)
- Electrolyte

Root Cause Analysis

LCRA investigation team concluded the interrupter operating arm failure was caused by the design allowing galvanic corrosion to take place at the operating arm pivot joint.

Root Cause : Design - absence of separator between bronze and aluminum material at the pivot assembly.

Contributing Cause : Design - the pivot joint assembly is exposed to rainwater.



Four required elements :

- Anode
- Cathode
- Current path(physical contact)
- Electrolyte

Galvanic Corrosion Prevention can be achieved with a design improvement.

- Selecting metals with similar potentials
- Eliminate physical contacts between two dissimilar metals.
- Prevent exposure to electrolyte/rainwater.

“Not Out of the Woods Yet”



- LCRA and the switch manufacturer did not agree on the cause of the aluminum corrosion. No product design change has been made.
- LCRA replaced the top interrupter assembly with new. However, LCRA became concerned with long-term equipment reliability and employee safety as the fallen object problem could continue.
- LCRA halted on all routine switching activities associated with nine(9) 3WAY GOAB transmission switching structures due to safety concerns.
- LCRA decided to re-design the traditional 3-WAY GOAB Transmission Switches as the original design did not meet LCRA’s requirements.

Importance of Annual Switching Routine

All nine(9) switch phases became inoperable

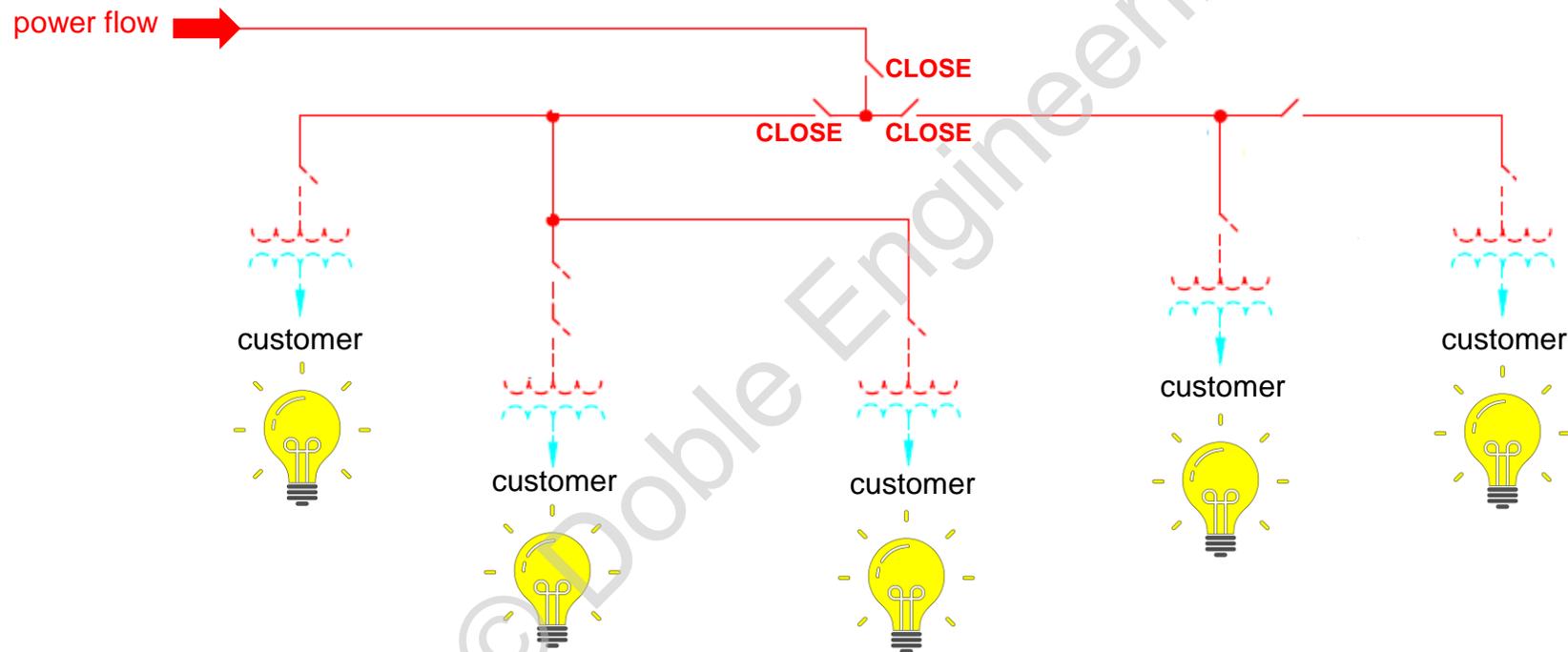
Broken U-Joint

- HV switch manufacturers recommend owners to operate switches annually.
- Annual switching exercise is a good practice; prevents seize/binds ensuring the switch availability.
- Become inoperable when switches are not exercised for 4 to 6 years.
- Leads to component failures and can raise safety concerns.

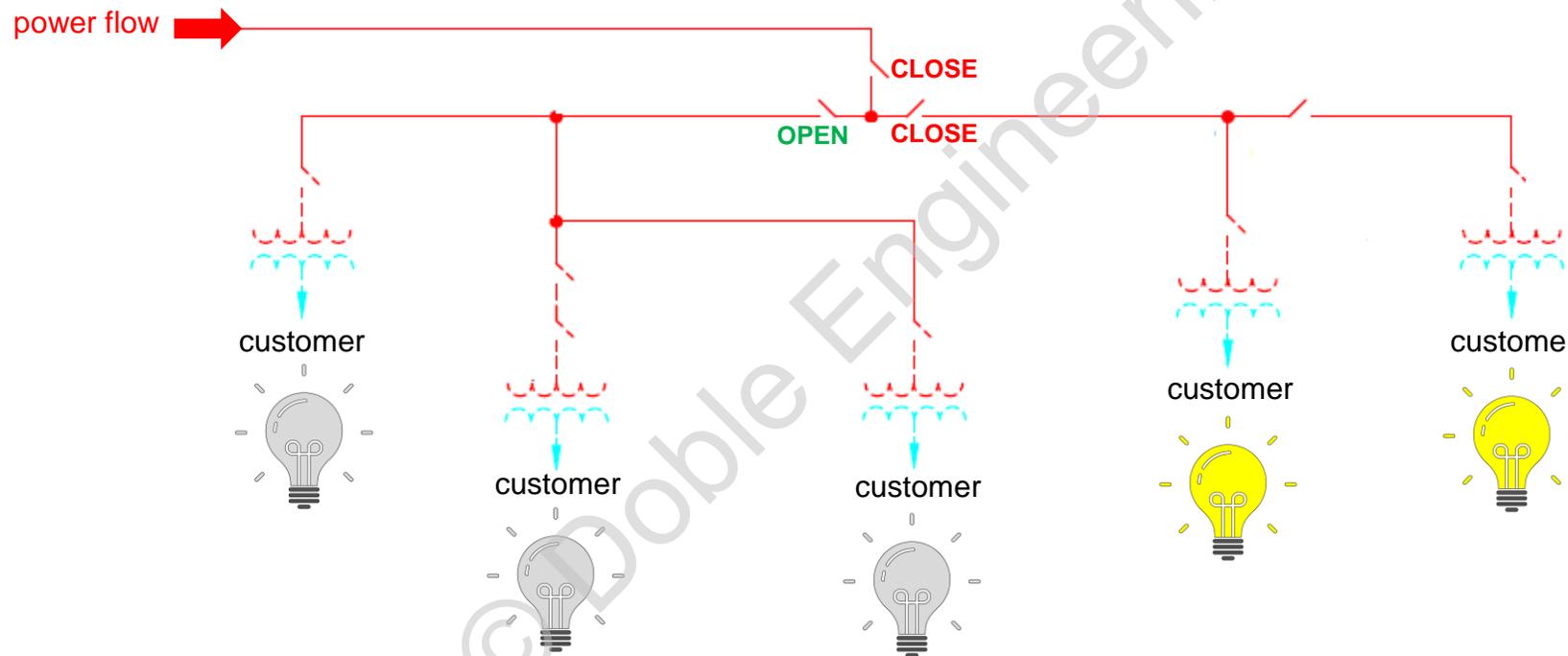
Key points

- All nine(9) switch phases became inoperable after 6 years.
- Manufacturer recommended replacing all three(3) switch assemblies.
- Traditional 3WAY configuration did not permit LCRA to perform the important annual switching routines.

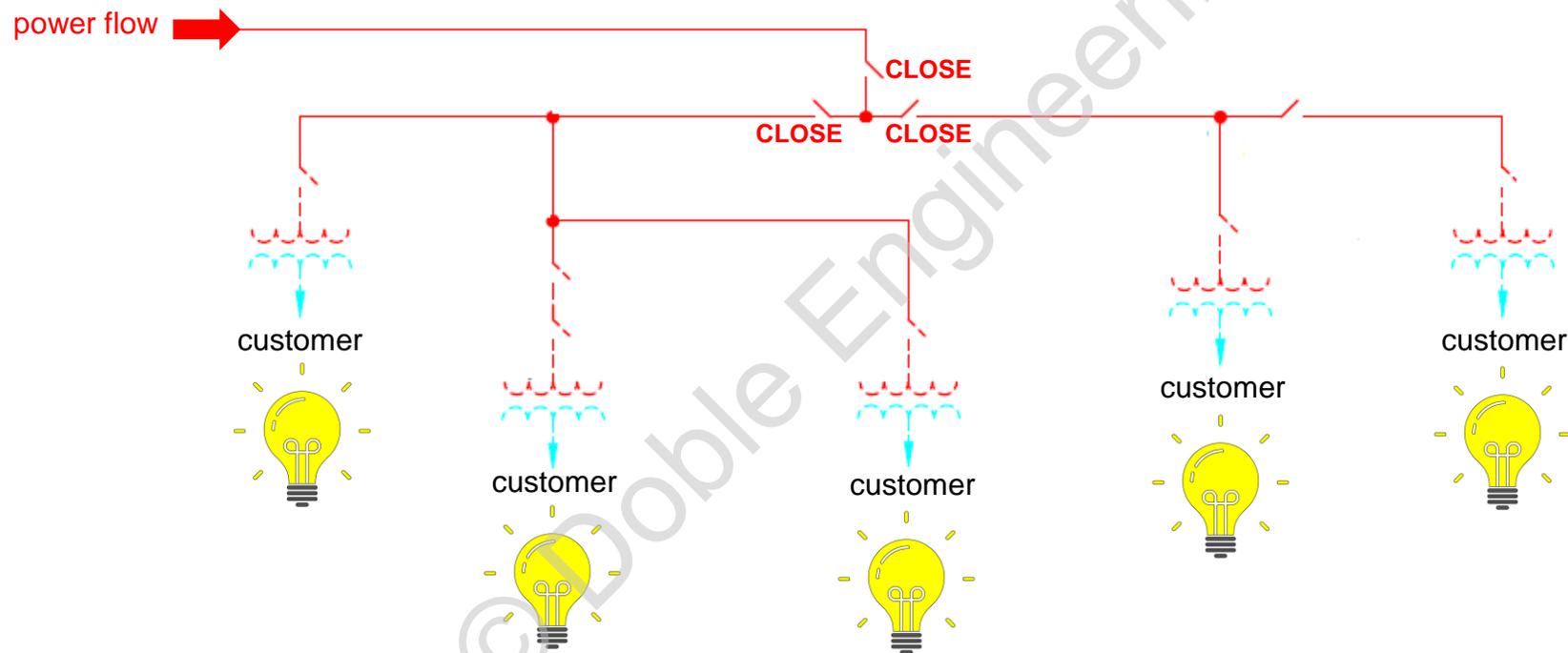
Can You Operate that Switch Without Outages?



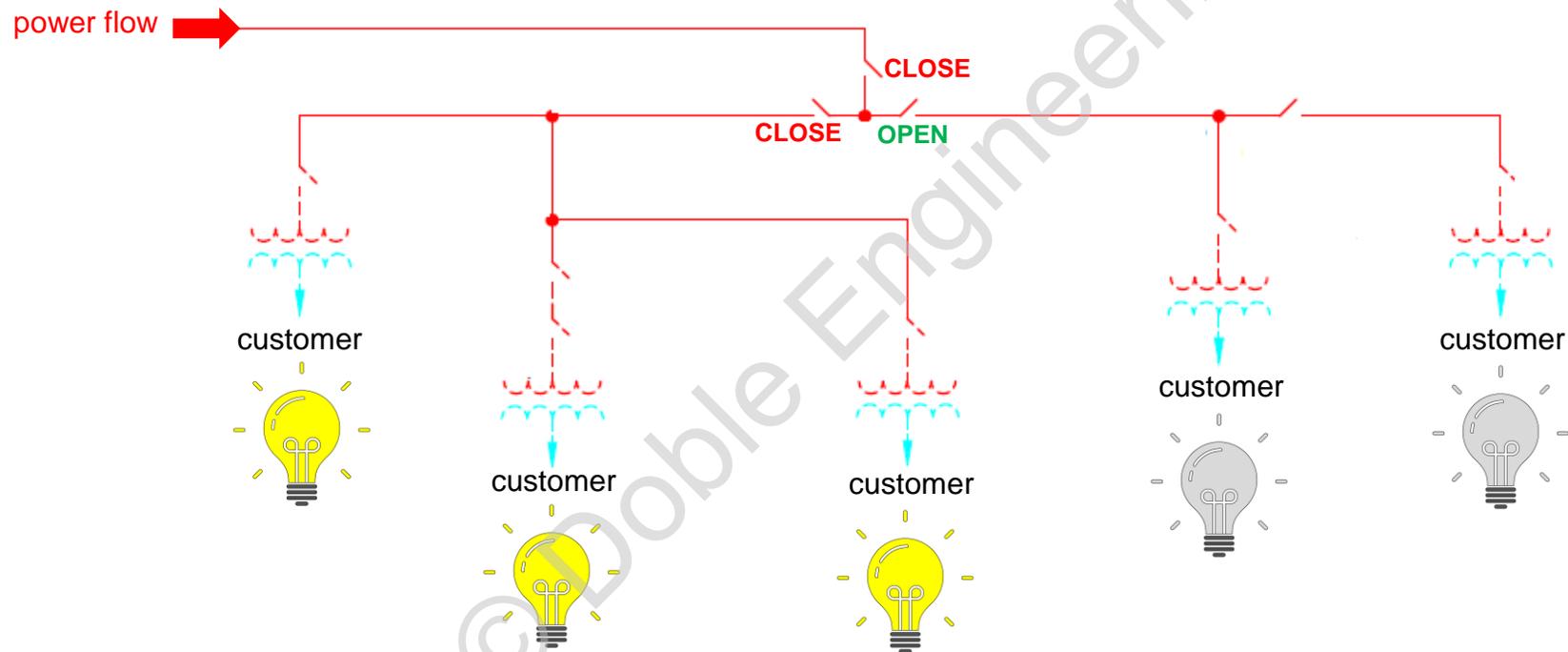
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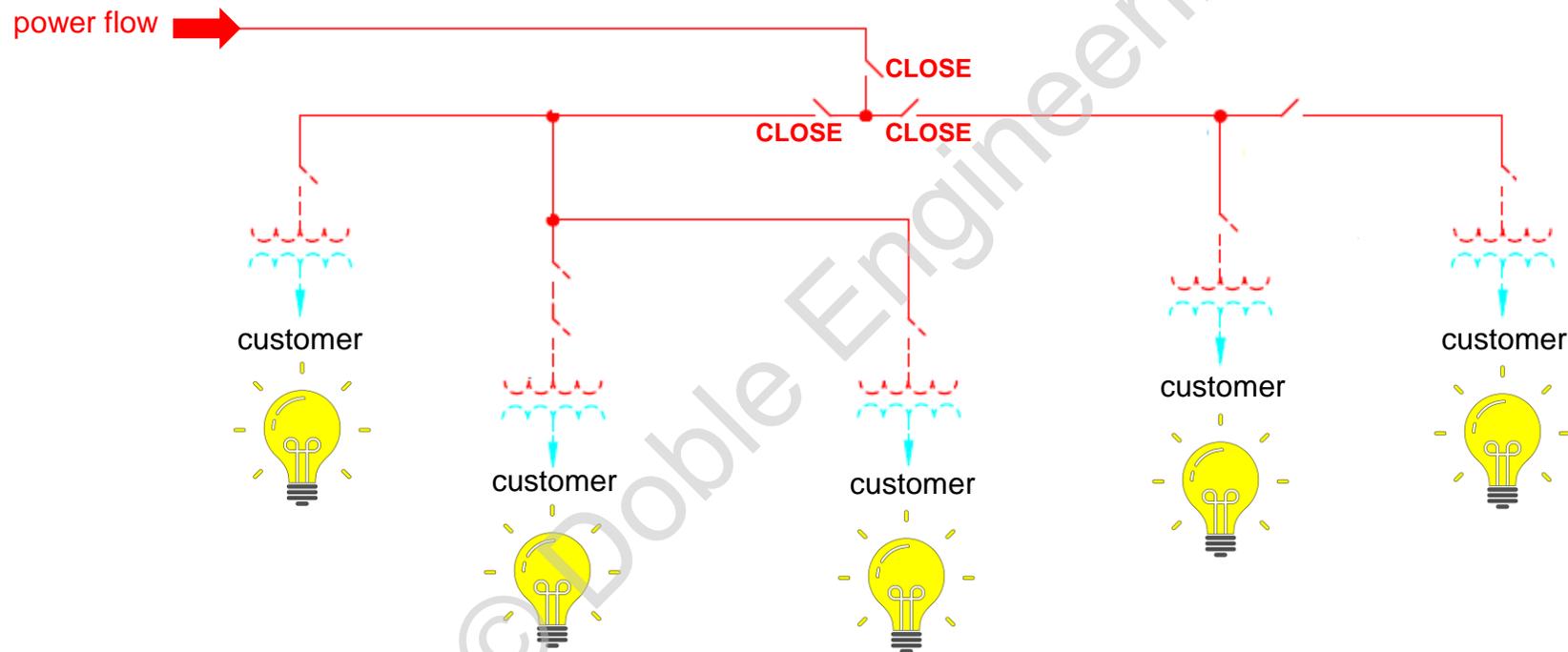
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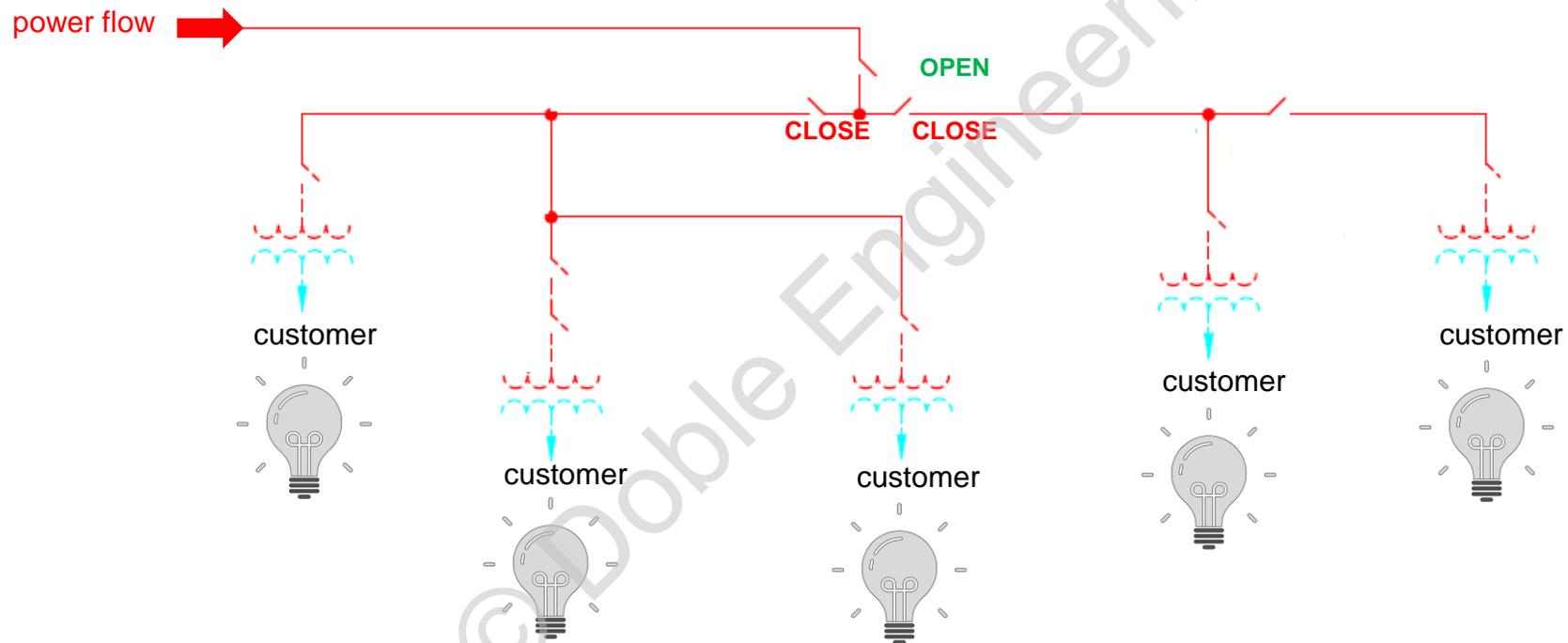
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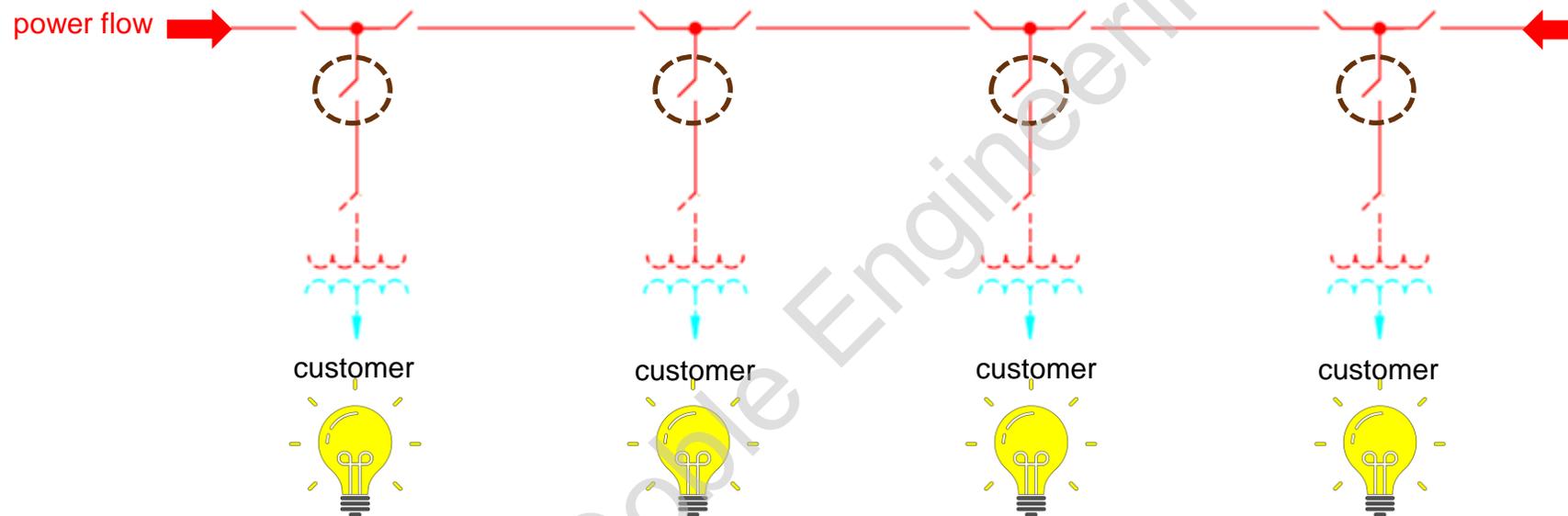
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Can You Operate that Switch Without Outages?



Can You Operate that Switch Without Outages?

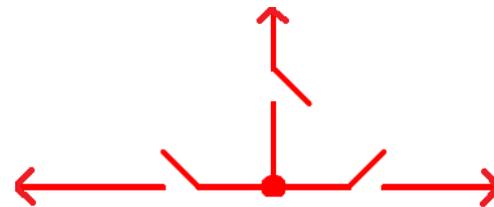


Traditional 3-WAY Transmission Switching Structure includes **one** or **more** switches that cannot support annual switching routines.



Deficiencies on Traditional 3-WAY GOAB Transmission Switches

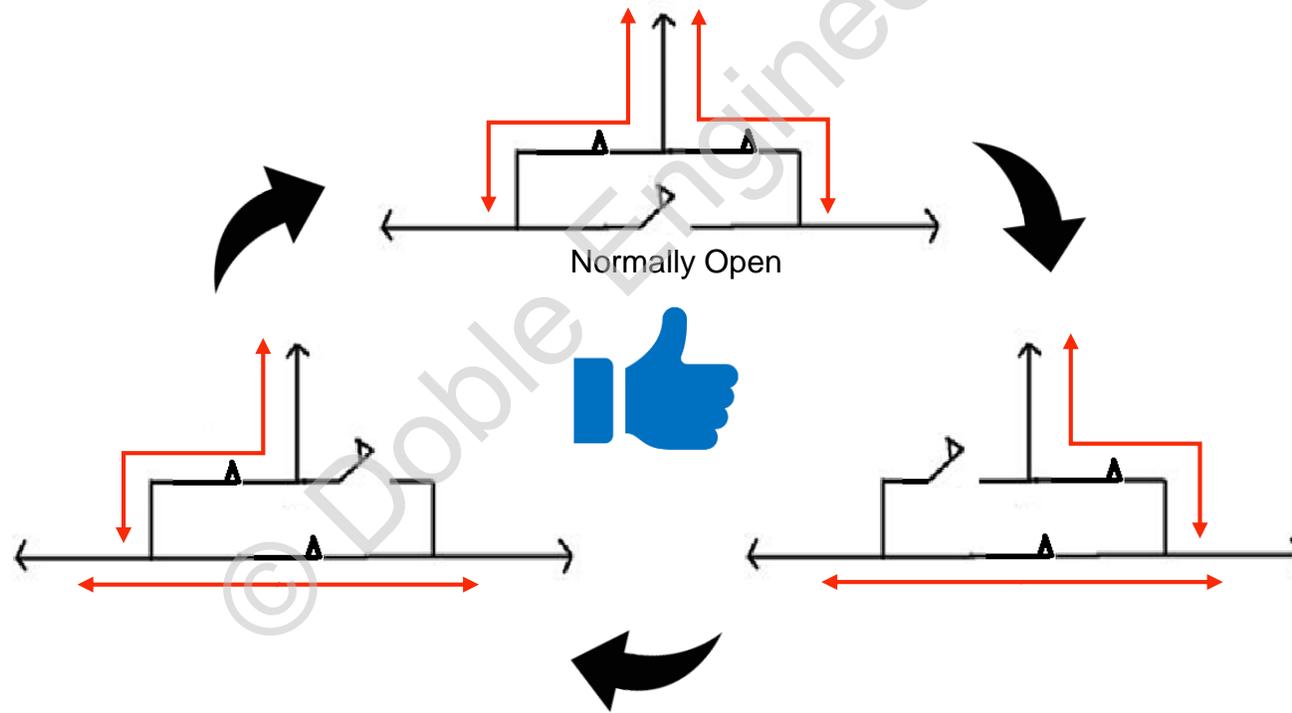
- **Unavailable Switches** - Unable to support annual routine switch exercise due to radial load drop/customer outage. Switches come to bind/seize and become unavailable to function as switches.
- **Safety concerns** - operating seized switches can result in component failures and fallen object events.
- **Unfavorable for operations** - a switching activity results in a power flow interruption. This is not ideal for operations.



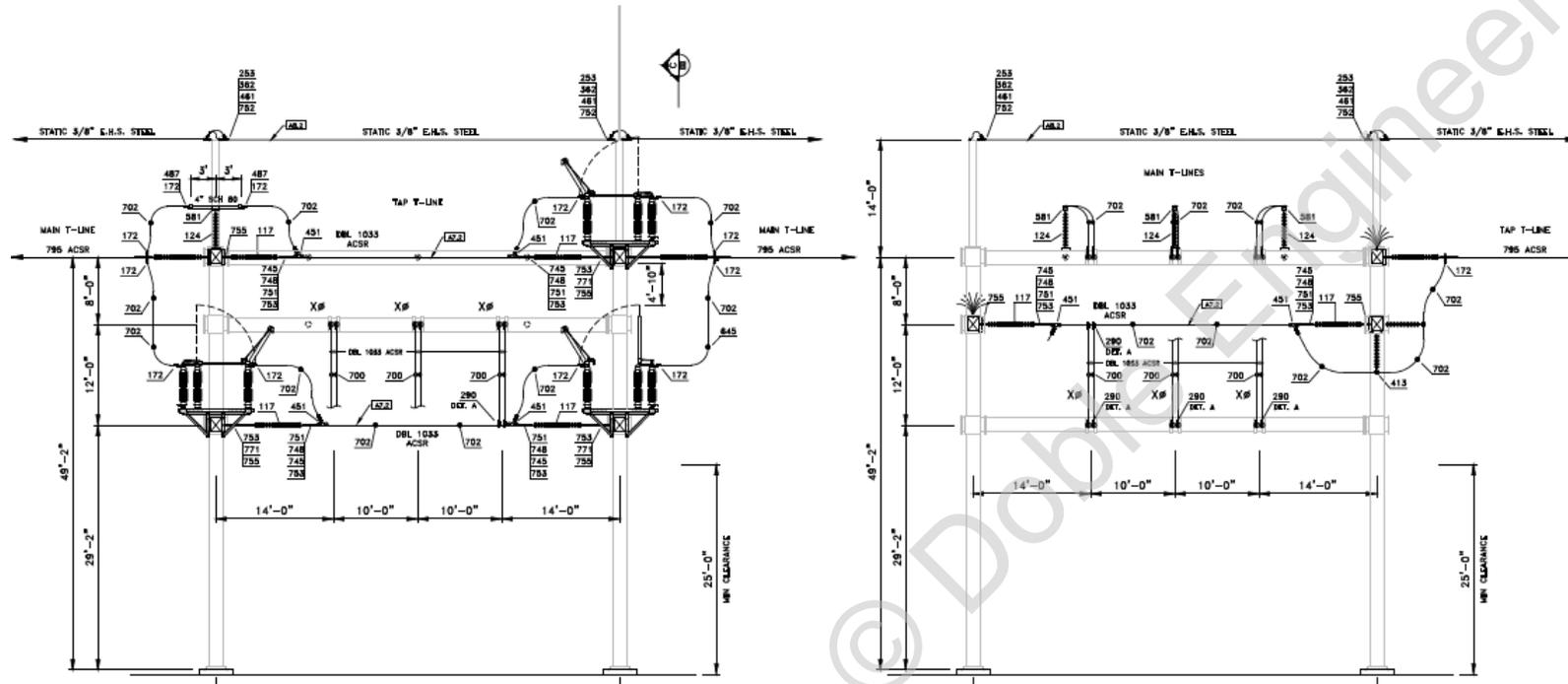
One Line for 3-WAY GOAB Transmission Line Switches

New Innovative 3-WAY One-Line

LCRA investigation team (engineering, maintenance, and operations) together developed a new one-line design that provides great flexibility that meets operations and maintenance needs.



Engineering Solution I: Box GOAB Switching Structure



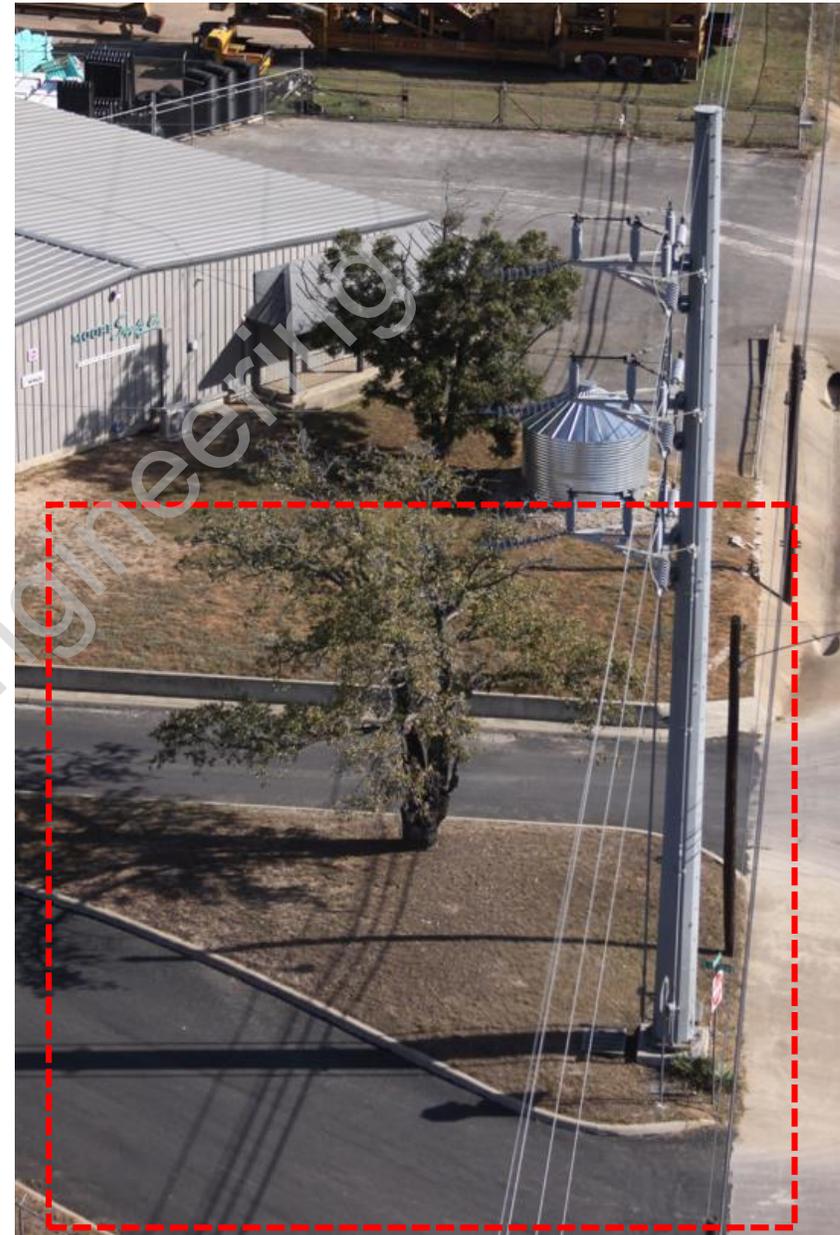
< 3-WAY Box Structure example. Not a LCRA substation >

Engineering Solution I: Box GOAB Switching Structure

3-WAY Box Structure was unfeasible to replace the existing 3-WAY Switching Structure due to its size and real estate concerns.



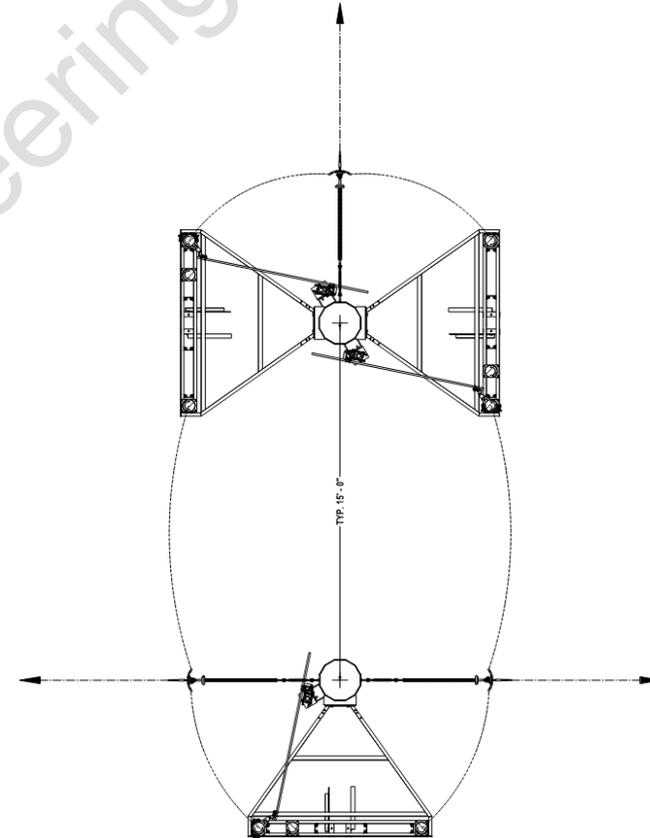
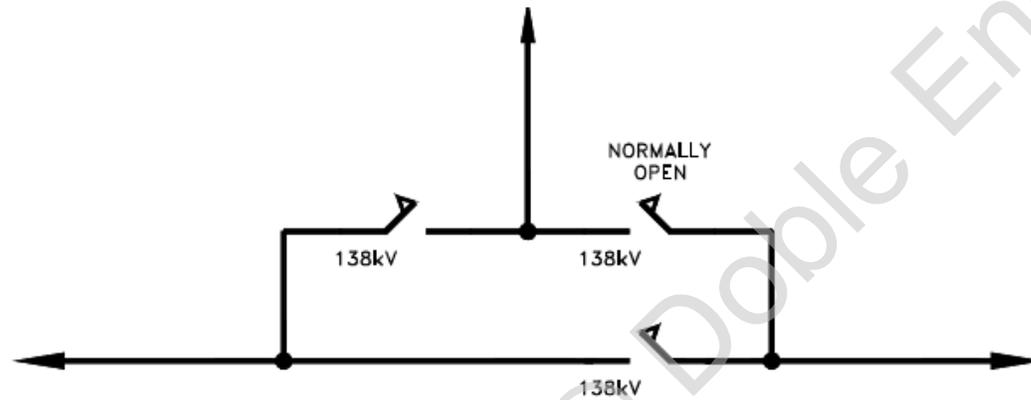
< 3-WAY Box Structure Example >



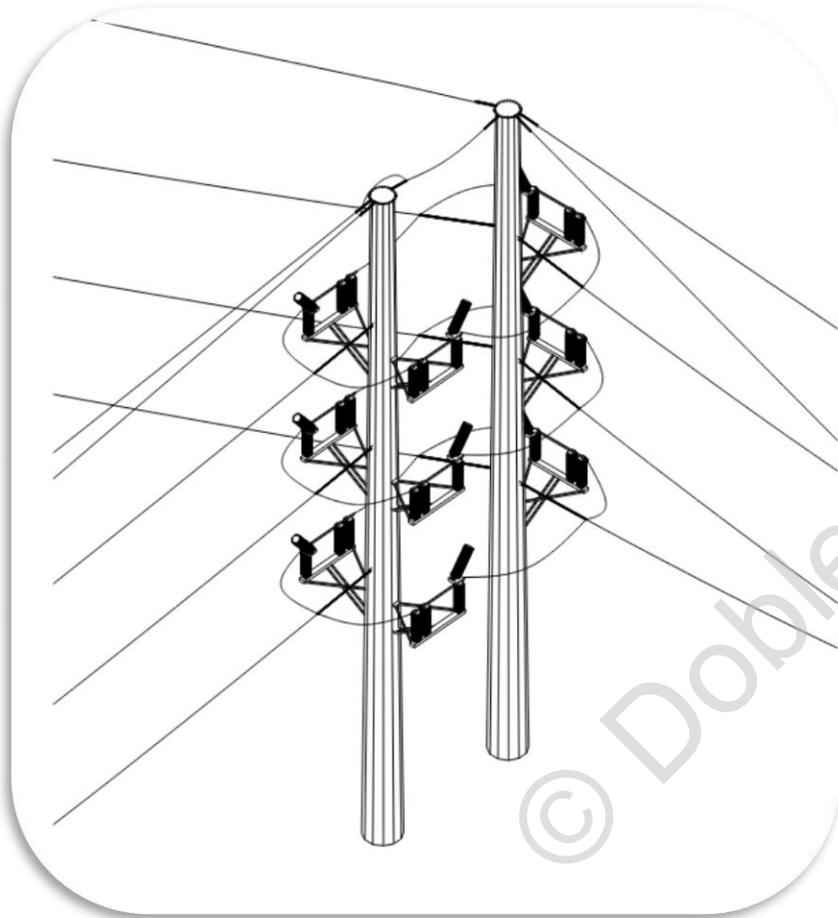
< Existing LCRA owned 3-WAY Switching Structure >



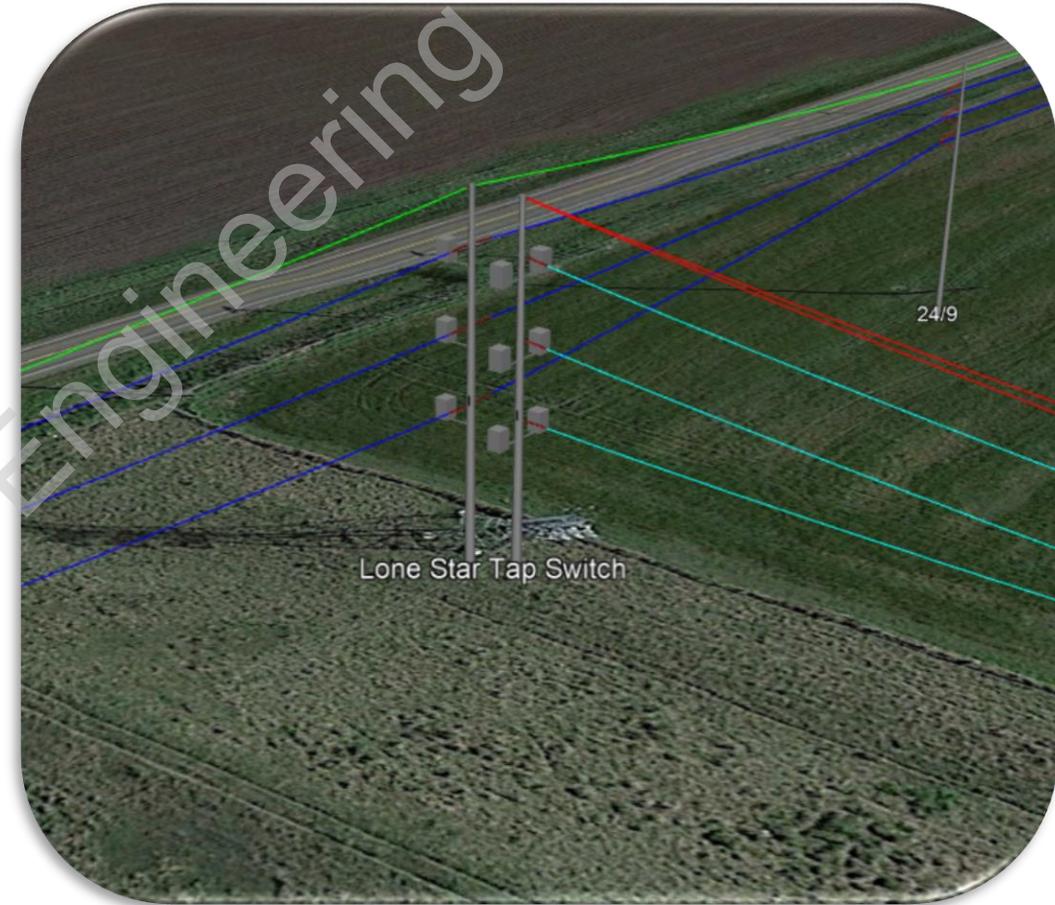
Engineering Solution II: Two Monopole GOAB Switching Structure



Two-Pole GOAB Concept Model

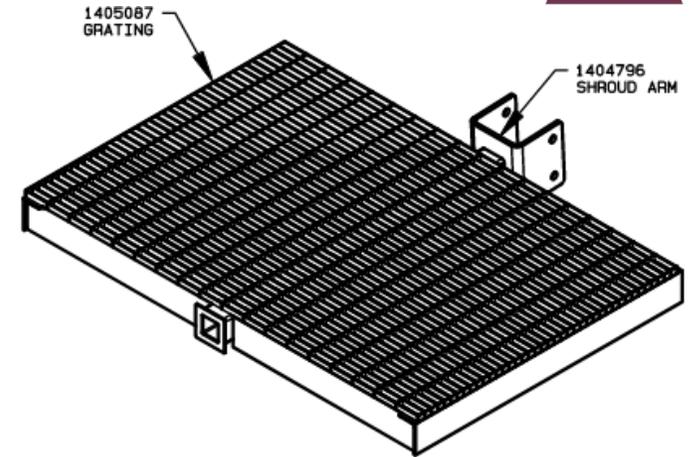
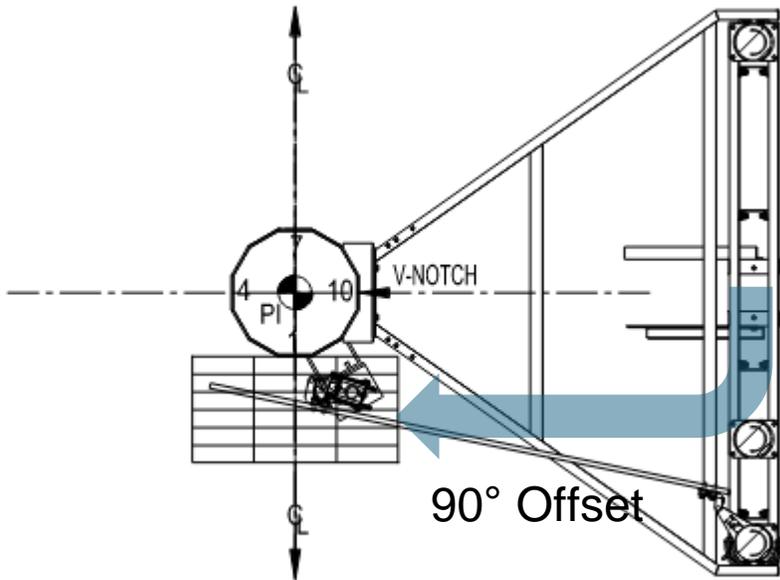


AutoCAD



PLS-CADD

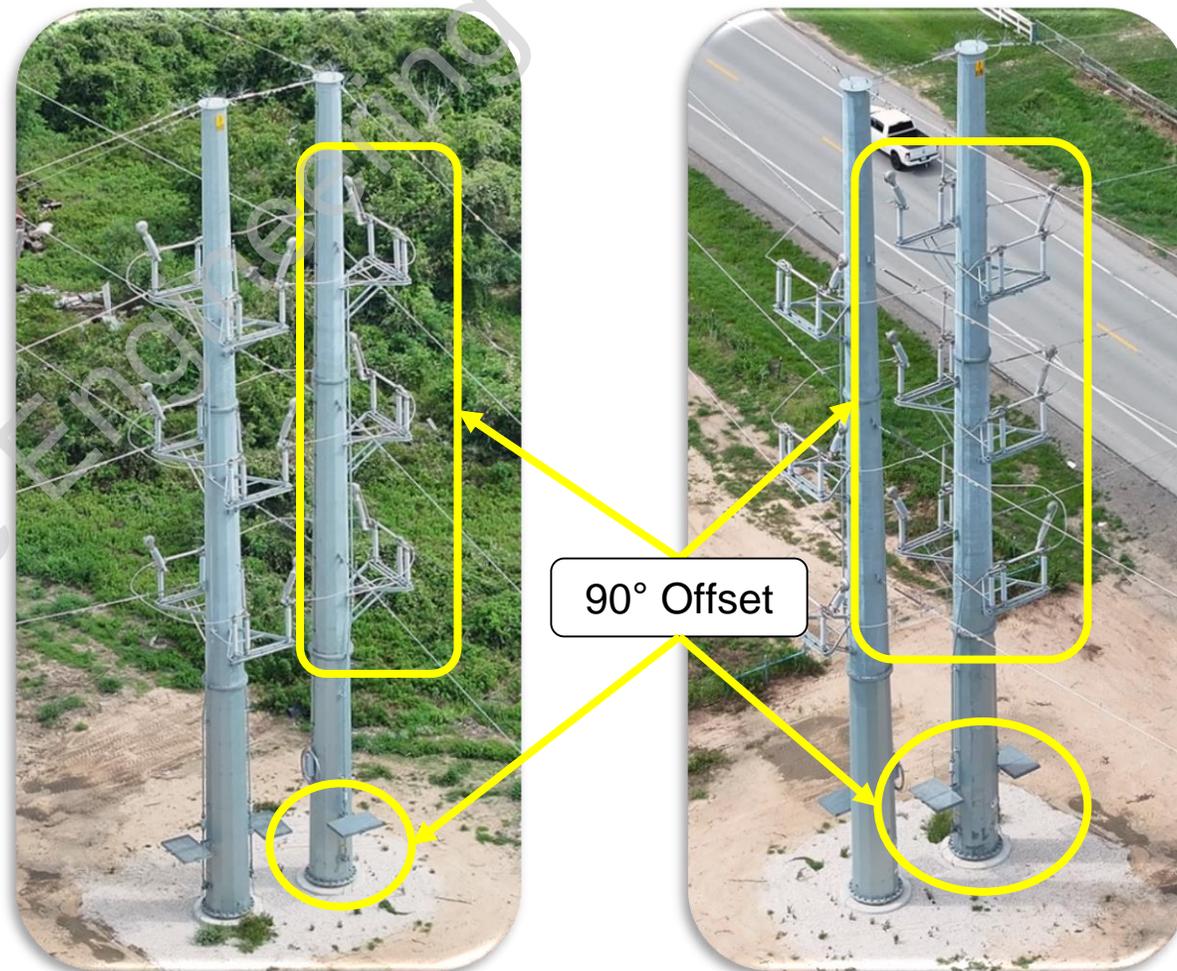
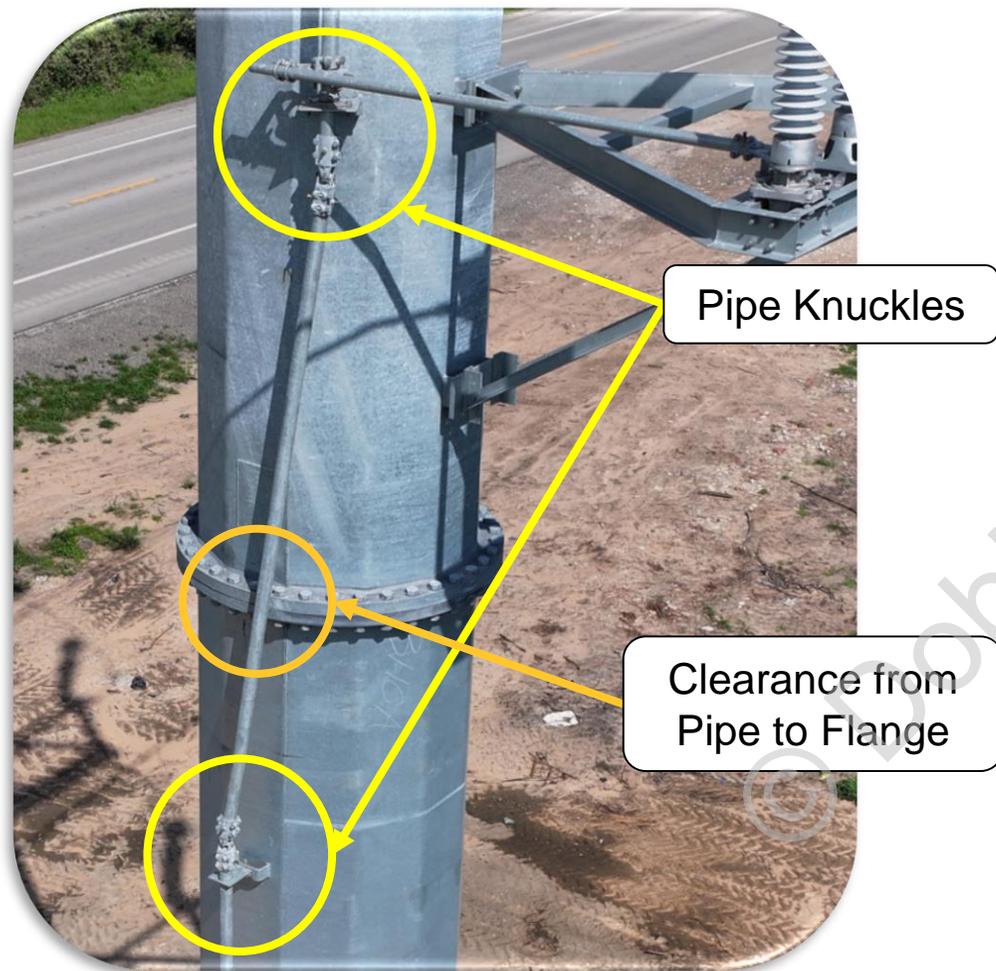
Safety by Design – Operator Safety



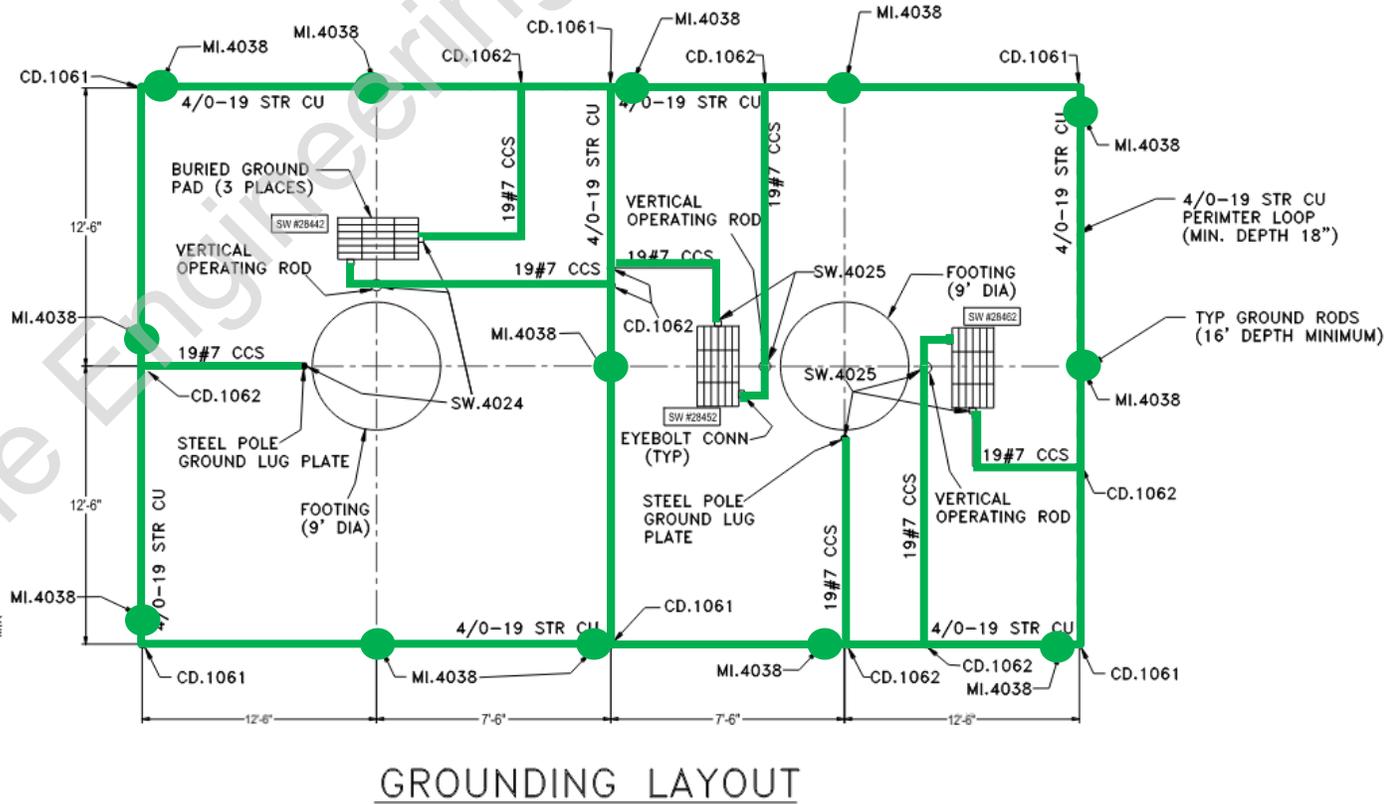
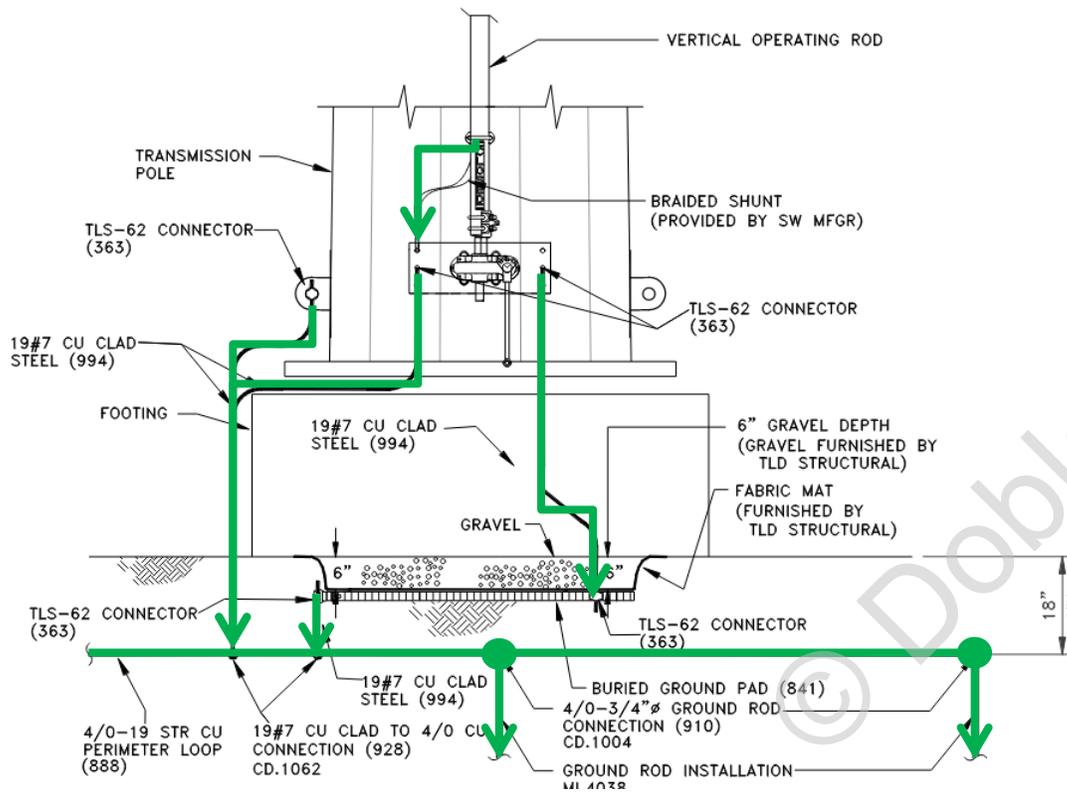
ISOMETRIC VIEW



Safety by Design – Operator Safety

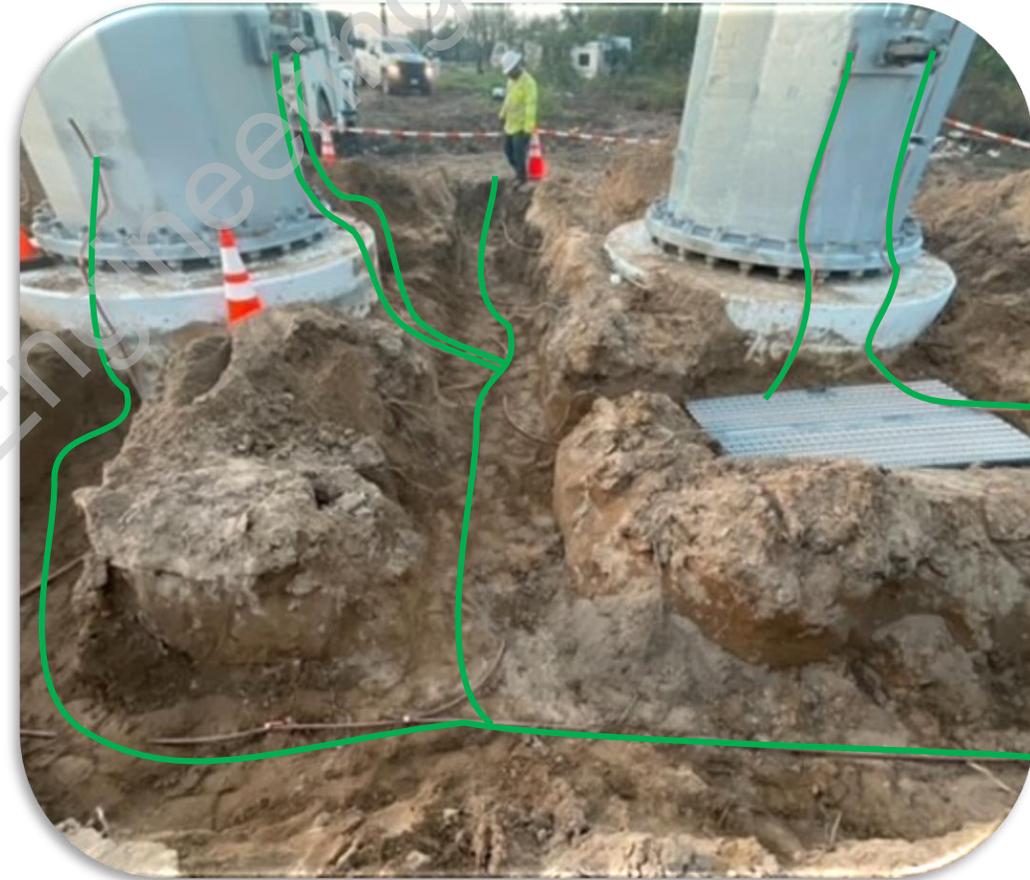


Safety by Design – Robust Ground Grid System



GROUNDING LAYOUT

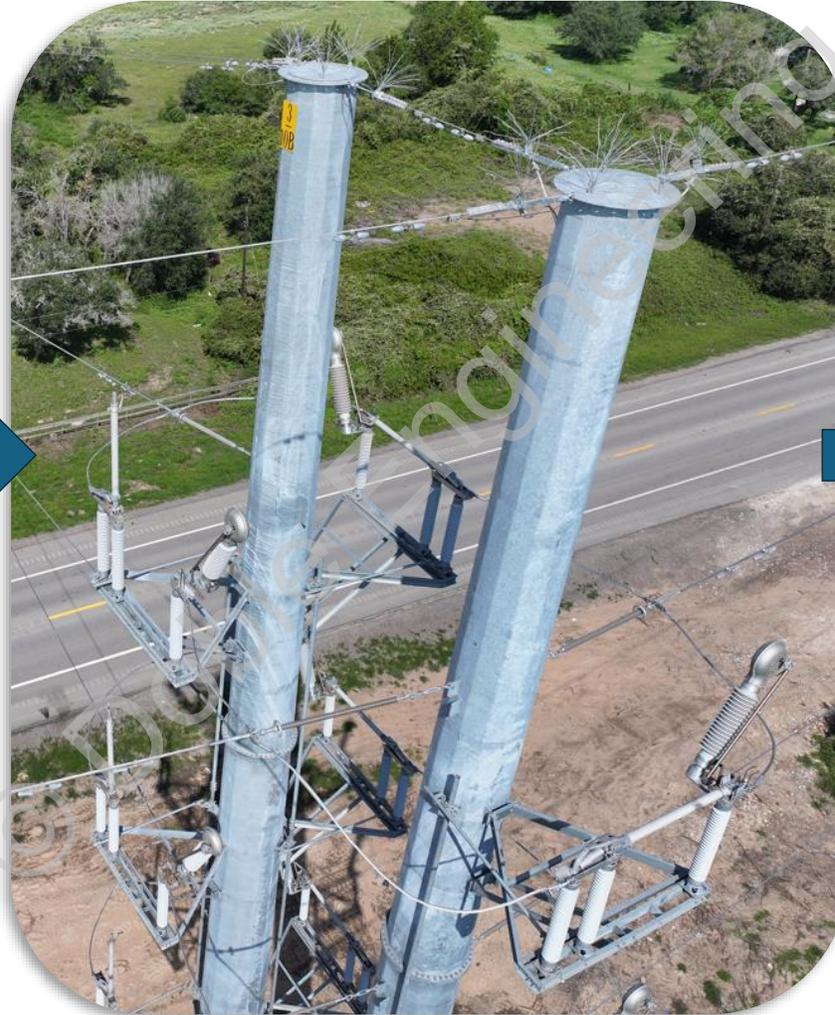
Safety by Design – Robust Ground Grid System



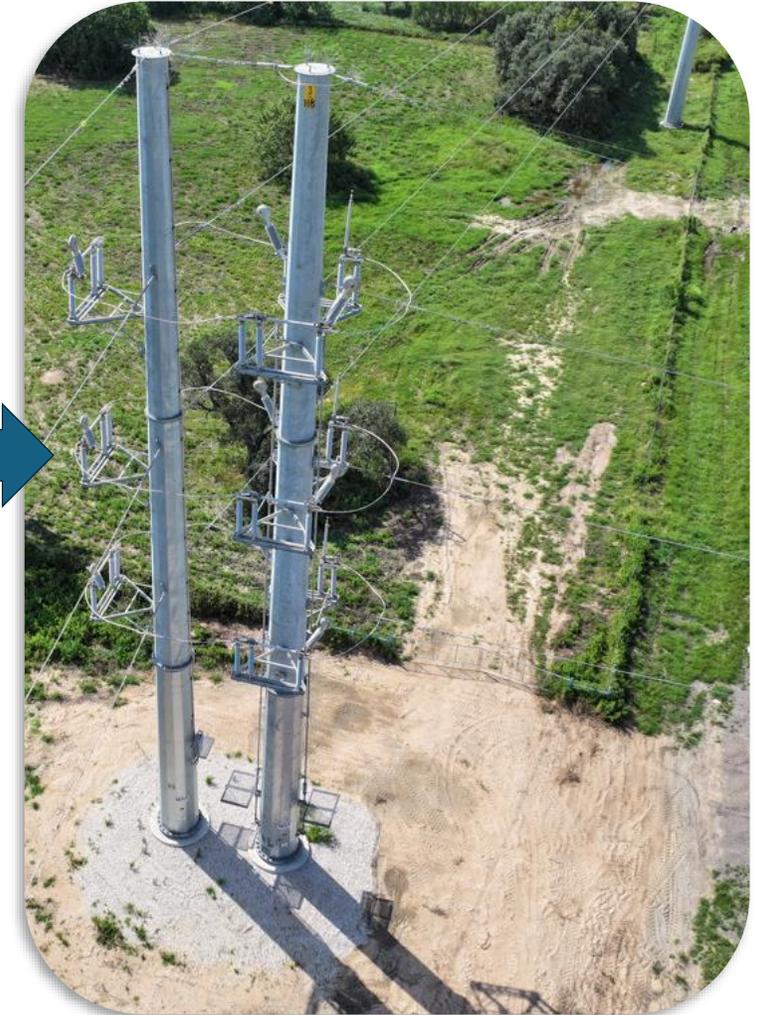
Field Installation



Structure and Switch Install



Remove Old and Install New Wire



Remove Old Switch Structure

Cost/Benefit Analysis



Solution I : 3-WAY Box GOAB

VS.

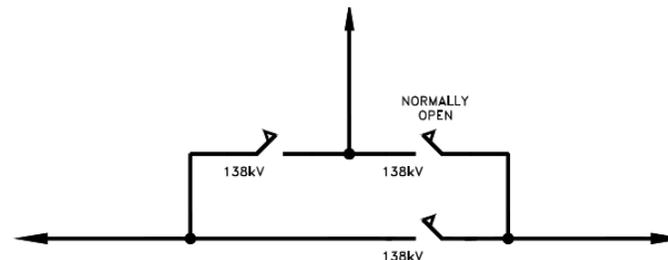


Solution II : 3-WAY Two Pole GOAB

Engineering Solution I vs. II Comparison		
Subgrade Footprint Reduction	-0.6 acres	-96%
Above Ground Footprint Reduction	-0.61 acres	-99%
Construction Schedule Reduction	-10 Weeks	-83%
Total Cost Savings	-\$1.7M per site	-55%

Benefits of Engineering Solution II

- **Switching device availability and reliability** - ability to perform MFG recommended annual routine switch exercise.
- **Improves employee safety** - prevents switch component binds/seizes, failures, and falling object events. 90-degree operator off set & canopy structure provide great improvements.
- **Favorable for operations** - a switching activity does NOT result in a power flow interruption. This is ideal for operations.
- **Significant Engineering Economics** - \$1.7 million USD and 0.61-acre savings per structure. LCRA plans to replace eight(8) existing 3-WAY switching structures by 2027.



Engineering Solution II Team Members



Substation Engineering

- Drew Skinner
- Bil Kahane
- Carlos Frias
- Gerald Garcia
- Cory Coker

Line Engineering

- Hunter Boggs
- Alex Bonnette

Reliability Engineering

- Nick Choi

Thank you.

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