SWITCHING IT UP: A NEW INNOVATIVE 3-WAY GOAB SWITCHING STRUCTURE

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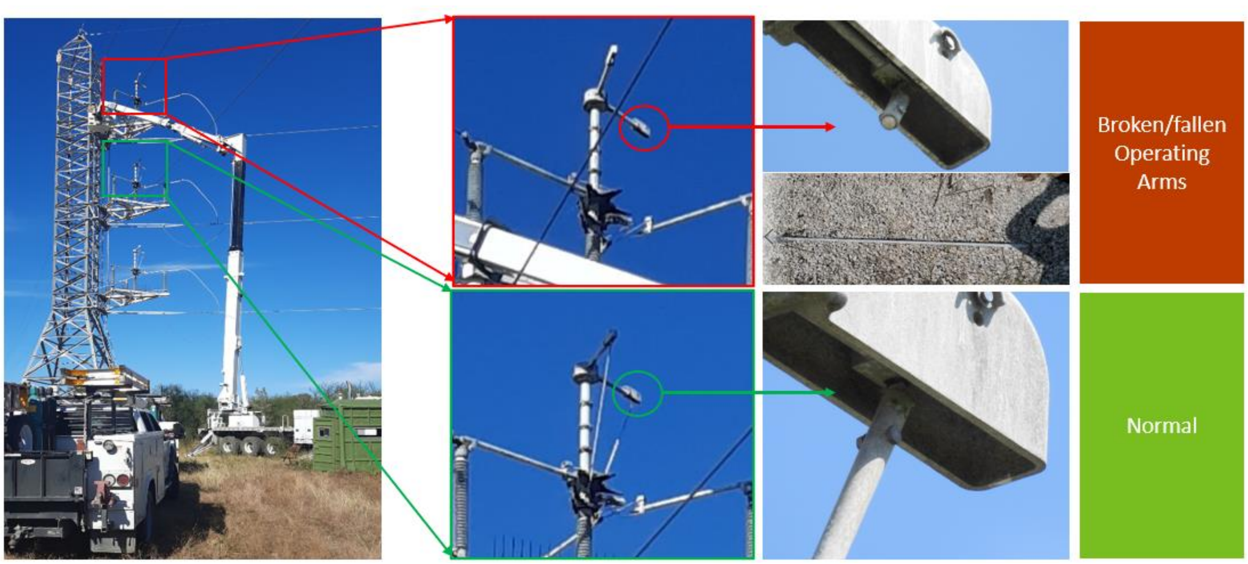
ABSTRACT

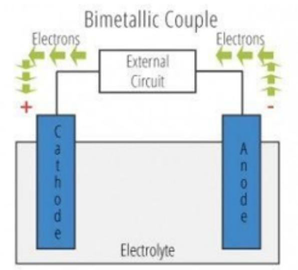
The Lower Colorado River Authority (LCRA) faced significant challenges with the traditional 3-way GOAB (gang operated air-break) transmission line switches, which led to operational and safety issues due to their tendency to bind, seize, and break. In response to these challenges, LCRA has pioneered a new innovative 3-way GOAB alternative design that addresses these issues by enhancing flexibility in operation, safety by design, and overall reliability. Launched in 2024, the first installation of this innovative two-monopole switching structure design not only meets all operational and maintenance requirements but also comes at a significantly lower cost, footprint, and shorter construction timeline compared with another 3-way box structure alternative. This advancement represents a significant step forward in LCRA's commitment to improving infrastructure and service reliability through design solutions.

INTRODUCTION

In May and November 2020, LCRA experienced two safety near miss incidents with objects falling 90 feet from the ground while an LCRA crew was performing a switching operation underneath (Figure 1). The switch structure was only five years old and LCRA had been performing an annual switching exercise as recommended by the manufacturer. An 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. Galvanic corrosion prevention (Figure 2) can be achieved through selecting metals with similar potentials, avoiding physical contacts between dissimilar metals, or eliminating the assembly exposure to electrolyte (e.g. rainwater).



Interrupter Operating Arm Failure
Figure 1



Four required elements :

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

Galvanic Corrosion Prevention can be achieved with a design improvement.

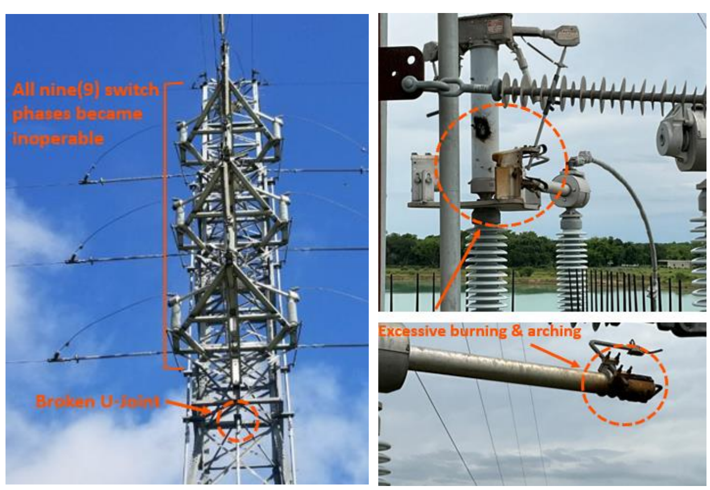
- Selecting metals with similar potentials
- Eliminate physical contacts between two dissimilar metals.
- Prevent exposure to electrolyte/rainwater.

Galvanic Corrosion
Figure 2

The 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. Unfortunately, LCRA and the switch manufacturer could not agree on the cause of the aluminum corrosion. No product design changes have been made. LCRA replaced the top interrupter assembly. However, LCRA became concerned with long-term equipment reliability and employee safety as the fallen object problem would likely continue. The LCRA team learned there might be inherent design flaws with the popular 3-way GOAB transmission switches offered in the industry.

IMPORTANCE OF ANNUAL SWITCHING EXERCISE

High voltage switch manufacturers recommend owners operate switches annually or once every two years. Annual switching exercise is a good practice and recommended for the industry as it prevents seize/bind issues, ensuring the switch will be available to use for use during the next operation. When the switch exercise routine goes overlooked for four to six years, then there is a high probability that the switch may not be able to function properly. A switching operator may get lucky when applying excessive force to free up the bind from the ground. However, it could lead to unfortunate events such as component failures and fallen objects, which raise safety concerns. It is important to perform annual switching exercises for long-term equipment reliability and availability.

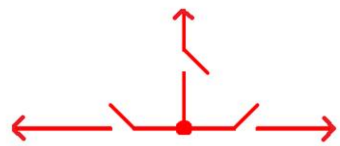


Field and Operational Issues When Annual Switching Exercise is Overlooked
Figure 3

DEFICIENCIES ON TRADITIONAL 3-WAY GOAB TRANSMISSION SWITCHES

LCRA identified the following deficiencies on the traditional 3-way GOAB switching structures:

- 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 seize switches can result in component failures and fallen object events.
- Unfavorable for operations – a switching activity result in a power flow interruption. This is not ideal for operations.
- Chronic wildlife contacts issues - 69kV 3-WAY GOAB transmission switches experience the highest wildlife contact issues in LCRA.

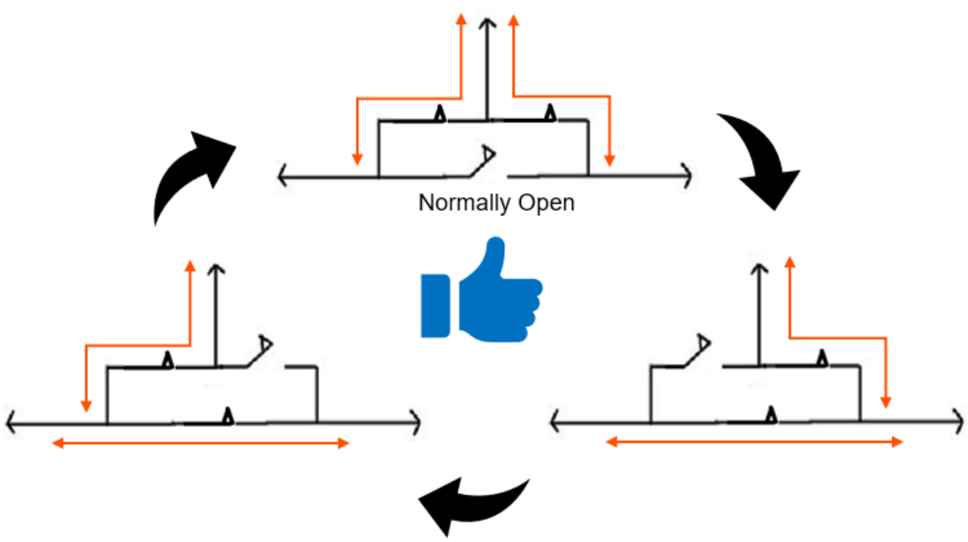


One Line for 3-WAY GOAB Transmission Line Switches

3-Way GOAB Transmission Switches and their Deficiencies
Figure 4

NEW INNOVATIVE 3-WAY ONE-LINE

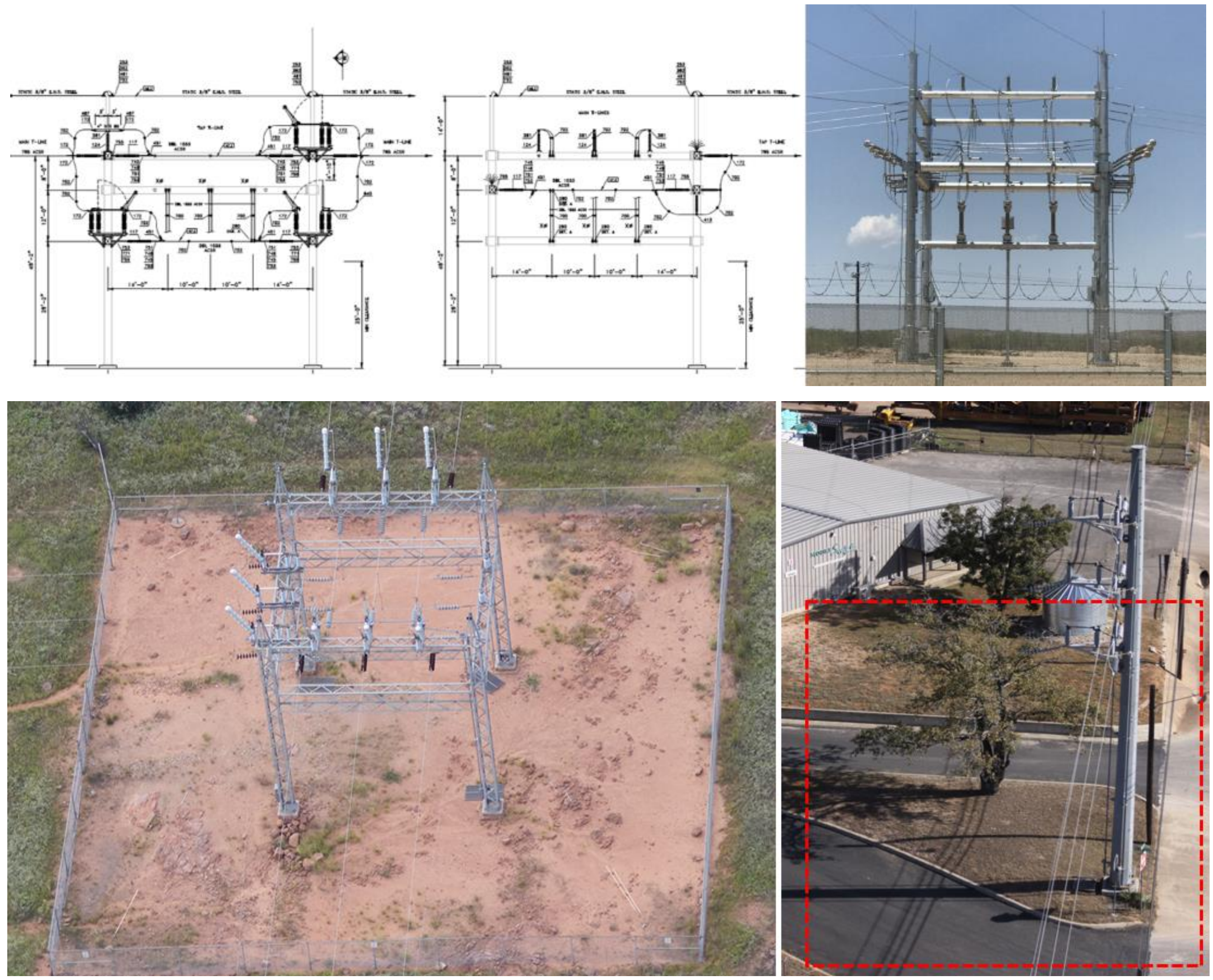
The LCRA investigation team (engineering, maintenance and operations) developed a new one-line design that provides greater flexibility to meet operations and maintenance needs. The new 3-way design (Figure 5) allows switches to be exercised at any time without load outages.



New LCRA 3-Way One-Line Design
Figure 5

ENGINEERING SOLUTION I: BOX GOAB SWITCHING STRUCTURE

LCRA standard Engineering Solution I was a box switching structure, which is a proven solution for the industry. However, the LCRA project team faced several challenges when it came to the project implementation for replacing the existing in-service traditional single monopole 3-way switching structures. These challenges included limited real estate/land, large scale ground grid, and substation parameter fence requirements (Figure 6). The box structure did not offer a practical solution when it came to replacing the existing line switching structures.



Box Structure Real Estate Challenges
Figure 6

ENGINEERING SOLUTION II: TWO-MONOPOLE GOAB SWITCHING STRUCTURE

To reduce the footprint requirements needed for the GOAB structure, a two-monopole design was proposed. This proposed design was new to LCRA, which required visuals to explain the fit up and operation. To help present this solution to stakeholders, programs like AutoCAD and PLS-CADD were utilized. AutoCAD was most useful for providing visuals of how, where, and in what orientation the switches were mounted to the structure. Also, AutoCAD drawings were useful for explaining how jumpers were to be connected from the conductor compression dead-ends to the switches. PLS-CADD was most useful for showing the application of the structure in a real-world setting. PLS-CADD has the capability to export concepts into Google Earth. This functionality provided a virtual representation of what the final build would look like in the field within a program like Google Earth, to which more users had access.

SAFETY BY DESIGN

The most important focus of the design for the 3-way GOAB switching structure was safety. One way to achieve this goal was to place the field operator away from underneath the switches. This was so that in the unexpected event that any material from the switches were to fall below, the operator would not be in the material's direct path. The location of the operator was offset90° clockwise from the side of the monopole where the switches were mounted (Figure 7).

GOAB Two-Monopole Structure with Operator Offset
Figure 7

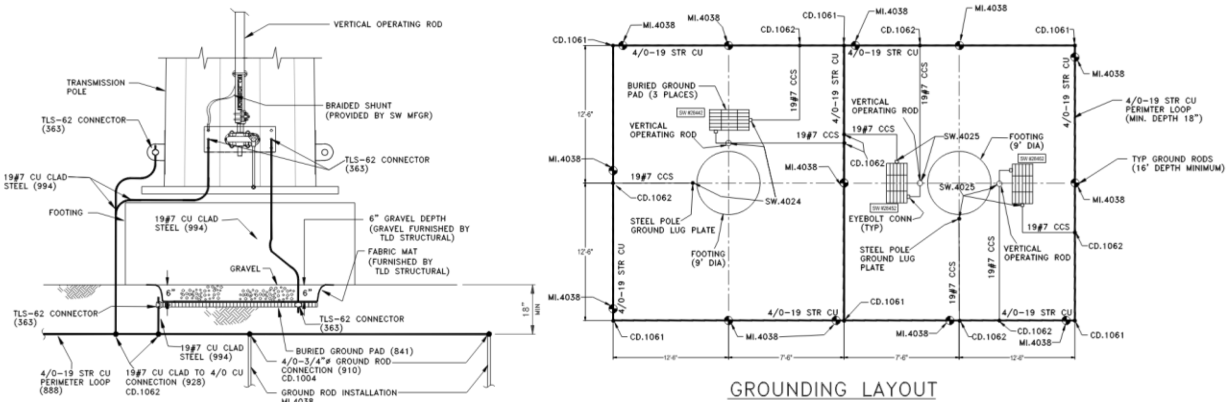
To move the operator from underneath the switches, pipe knuckles were added within the vertical operator pipe. Pipe knuckles allow for the switch operator pipe to move from one face to another of the 12 sided poles. The two-monopole switch structure was designed for flange connections instead of slip-joint connections between pole sections. The structure design from the pole manufacturer required three pole sections. The decision to utilize flange splices was made to minimize the potential of splicing sections coming into contact with brackets. The location of the flanges connecting the middle and bottom sections of the pole was between pipe knuckles, (Figure 8) transitioning the vertical operator pipe further away from the switches. The flange connection extends outward from the face of the monopole, which reduced the gap between the operator pipe and the pole face. A check during design was made to ensure the operator pipe would not rest against or come into contact with the flange plates.

Operator Pipe Knuckles
Figure 8

An additional measure to protect the operator was taken by designing a cover 10 feet directly above operator platform (Figure 9). If an object from above were to unexpectedly fall in the path of the operator, then the operator would be protected by the steel cover above. Also, another measure of safety as well as ergonomics was taken to install a worm gear for rotating the operator pipe. The rotation of the operator pipe is the mechanism used to open or close the three separate phase switches in unison. By utilizing a worm gear, the operator can remain in place, underneath the cover, while operating the opening or closing of switches. The worm gear also requires lower exertion of force from the operator due to the gear ratios from the handle to the operator pipe. Lastly, additional holes were designed on the worm gear mounting bracket for the purpose of installing the worm gear at the desired elevation, which places the worm gear at chest height of the operator.

Operator Overhead Protection
Figure 9

Proper grounding of the two-monopole switching structure was critical for safety. In the event of a system fault, a voltage rise can be introduced to the structures. To quickly extinguish the induced voltage, grounding wire is bonded to the structure to carry the current into the soil. To ensure proper grounding, a below grade ground grid was installed around the two-pole GOAB structure, similar to substation grounding. The ground grid consisted of installing copper clad steel, above grade, and copper, below grade, with a perimeter outside of the operator platforms. The below grade perimeter also included ground rods to further improve the function of the grounding system (Figure 10).



Grounding Layout
Figure 10

FIELD IMPLEMENATION

The two-pole GOAB structure was first installed on LCRA Altair – Garwood 69 kV line. The rebuild of the existing line required the circuit to remain energized throughout the duration of construction. The new GOAB structure was installed offset from behind the existing circuit and beside the existing GOAB (Figure 11). Shortly after setting the two-monopole structure, the switch mounting frames and switches were then installed onto the monopoles. The first monopole consisted of one set of three individual switches. The first monopole was designed to terminate the main circuit continuing past the tap location. The second monopole consisted of two sets of switches totaling to six individual switches. The sets of switches on the second structure were mounted on opposite sides of each other. The second monopole was designed to terminate the tap circuit with jumpers connecting the circuit to the sets of switches on both sides of the structure. Next the operator pipe connections to the switches were adjusted so that all switches within a set open or close in unison. The switch manufacturer sent their own professionals to assist the field and ensure the adjustments were performed properly. Circuit conductor and shield wire was then terminated into both monopoles followed by the installation of jumpers. The energized line was flipped over from the existing transmission line over to the new transmission line. After the new transmission was energized, the existing line was removed followed by the existing GOAB structure.

New GOAB Two-Monopole Structure Install
Figure 11

BENEFITS OF 3-WAY GOAB SWITCHING STRUCTURE ALTERNATIVE II

Significant benefits were realized when comparing the 3-way GOAB switching structure Alternative I (Box GOAB) versus Alternative II (two-monopole GOAB). Utilizing transmission monopoles with mounted switches removed the need to install station grading and security fencing. The overall footprint above and below grade between the alternatives was reduced by 0.6 acres. This is a benefit in reducing or even eliminating the need for additional real estate. The duration of construction was reduced by 10 weeks due to the more simplistic design. Lastly, there is an expected savings of $1.7 million per site for labor and material to install the Two-Monopole GOAB.

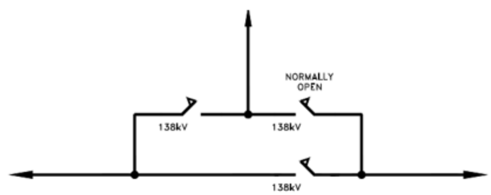
Table 1
Alternative I vs. II Analysis

	Alternative I vs. II Overall Reduction	
Subgrade Footprint	-0.6 acres	-96%
Above Ground Footprint	-0.61 acres	-99%
Construction Timeline Duration	-10 Weeks	-83%
Total Costs	-$1.7M per site	-55%

CONCLUSIONS

By utilizing the 3-way GOAB switching structure two-monopole design, we were able to utilize switches that do not have the same binding concerns as the previous switch design. The new one-line configuration does not result in a power flow interruption. The operator is moved from underneath the switches and has overhead protection. The switches can be opened or closed more smoothly with the worm gear. Reduction of wildlife contact is expected with the change in switch design, spacing and separation.

- Gain on switching device availability and reliability - ability to perform MFG recommended annual routine switch exercise.
- Improves employee safety – prevents switch component binds/seizes, failures, and fallen object events. Canopy provides additional safety margins.
- Favorable for operations – a switching activity does NOT result in a power flow interruption. This is ideal for operations.
- Reduced wildlife contacts issues de-cluttered traditional 69-kV 3-WAY GOAB transmission switches with the new 138-kV 3WAY Alternative.
- Excellent Engineering Economics – $1.7 million USD and 0.6-acre savings.



3-Way GOAB Switching Structure Two-Monopole Design and its Benefits
Figure 12

BIOGRAPHY

Nick Choi has been employed at the Lower Colorado River Authority since 2015. He is a substation maintenance engineer and a licensed Professional Engineer in the state of Texas. He earned a B.S. in Mechanical Engineering from the University of Illinois at Urbana-Champaign. He served as chair and vice chair on Doble Client Committees. He serves in various industry organizations and actively participates in IEEE, NATF, TSDOS and Doble conferences.

Alex Bonnette was previously a transmission line engineering supervisor for the Lower Colorado River Authority (LCRA). Alex has 10 and a half years of experience working for electric utility TSP's. His job focus at LCRA was transmission line engineering. He has designed or overseen design for brownfield and greenfield projects across various regions of Texas. Project types include rebuild, new build, switch structures, interconnections, storm restoration, storm hardening and TxDOT relocation to name a few. While at LCRA, Alex was a subject matter expert within his department for lightning, grounding, insulation, and optical ground wire. Alex earned his B.S. in Civil Engineering at Louisiana State University. He also has a Professional Engineering license in the state of Texas.