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Modifying Lines Without Changing Existing Wire Lengths

This Technical Note discusses common situations that require going beyond ruling span (RS) sag-tension to a more sophisticated approach based on the length of wire in each span.

Most sag-tension programs assume that the horizontal tension is the same in all spans within a tension section. While a line may be strung with equal horizontal tension in adjacent spans, there are situations where changes made after construction invalidate this assumption. The following examples of several such post-construction situations will be examined below:

- Moving structures
- Raising structures
- Inserting structures
- Wire transfer between spans

Each of these situations results in a horizontal tension imbalance which invalidates the ruling span assumption. These situations must be analyzed using an approach that is based on the length of wire in each span. Users with both PLS-CADD and SAPS can switch from the ruling span approach to a wire length-based approach by going to ***Sections/Modify*** and checking the box for "*Clip Insulators (lock unstressed length, force finite element sag-tension)*" as shown in Figure 1. Once insulators are clipped, you are free to use the normal calculation and editing commands, and PLS-CADD will transparently invoke SAPS as needed for wire length-based **finite element** (FE) sag-tension calculations. Be aware that any changes or modifications to clipped wires will be lost if the wires are unclipped. Once wires have been clipped, they should remain clipped in most scenarios.

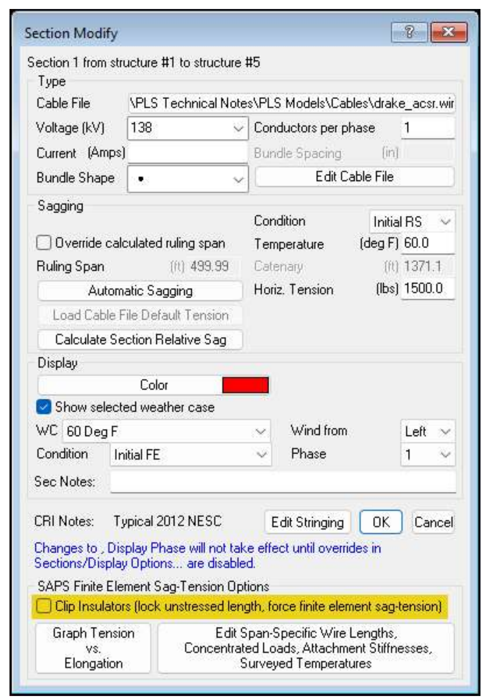
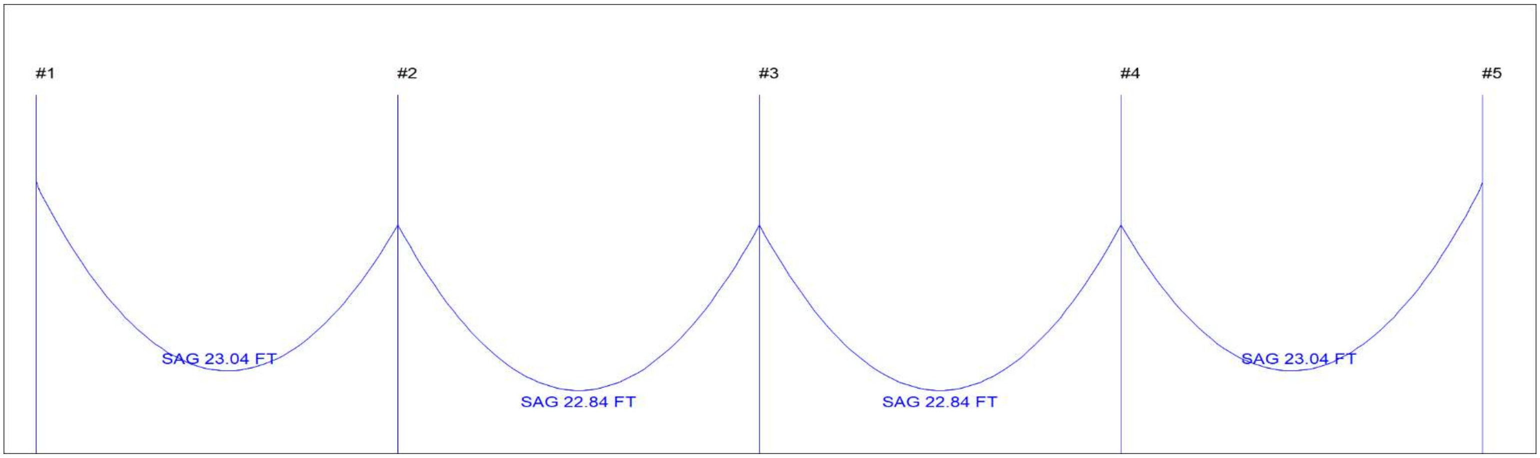


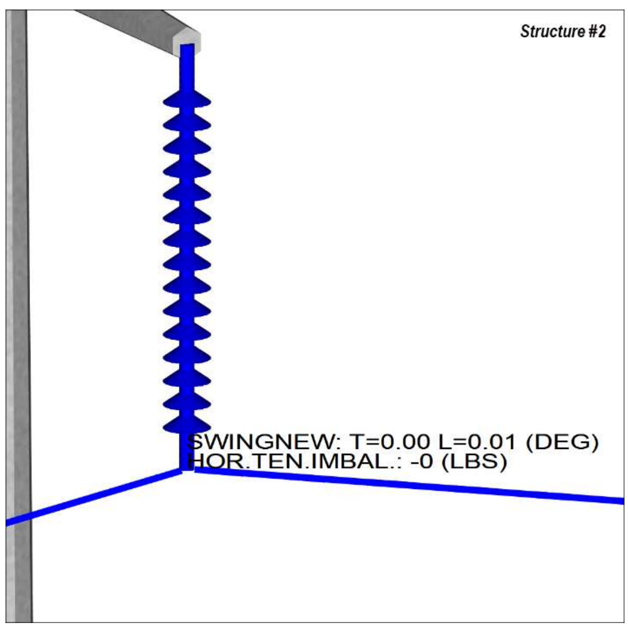
Figure 1: "Clip Insulators" check box

The examples below all begin with four (4) 500 ft spans for the tension section and Drake ACSR conductor strung to 1500 lbs at the 60°F Initial condition. On the following pages, the initial line configuration is shown in blue, the altered configuration is shown in red, and the vertical scale is exaggerated by a factor of 10. Although PLS-CADD is able to account for structure flexibility (see related PLS Technical Note *Why Structure Flexibility Matters*), we have elected to ignore structure deflections here in the interest of simplicity. Meaning the calculations are done in SAPS Level 2 (L2) where there is no interaction between wires and the structures are infinitely stiff.

The figure below shows the initial conditions of the line. Note the nearly identical sags across all spans, and absence of any horizontal tension imbalance at all structures aside from the deadend structures. The lack of horizontal tension imbalance allows the suspension insulators to hang plumb. In this scenario, the ruling span method could be employed with sufficiently accurate results.

*For quick reference, the horizontal tension imbalance at structures and insulator swing angles have been displayed using **Sections/SAPS Label Options**. Wire sag values have also been displayed using **Drafting/Structure and Section Labeling/Profile View**.*

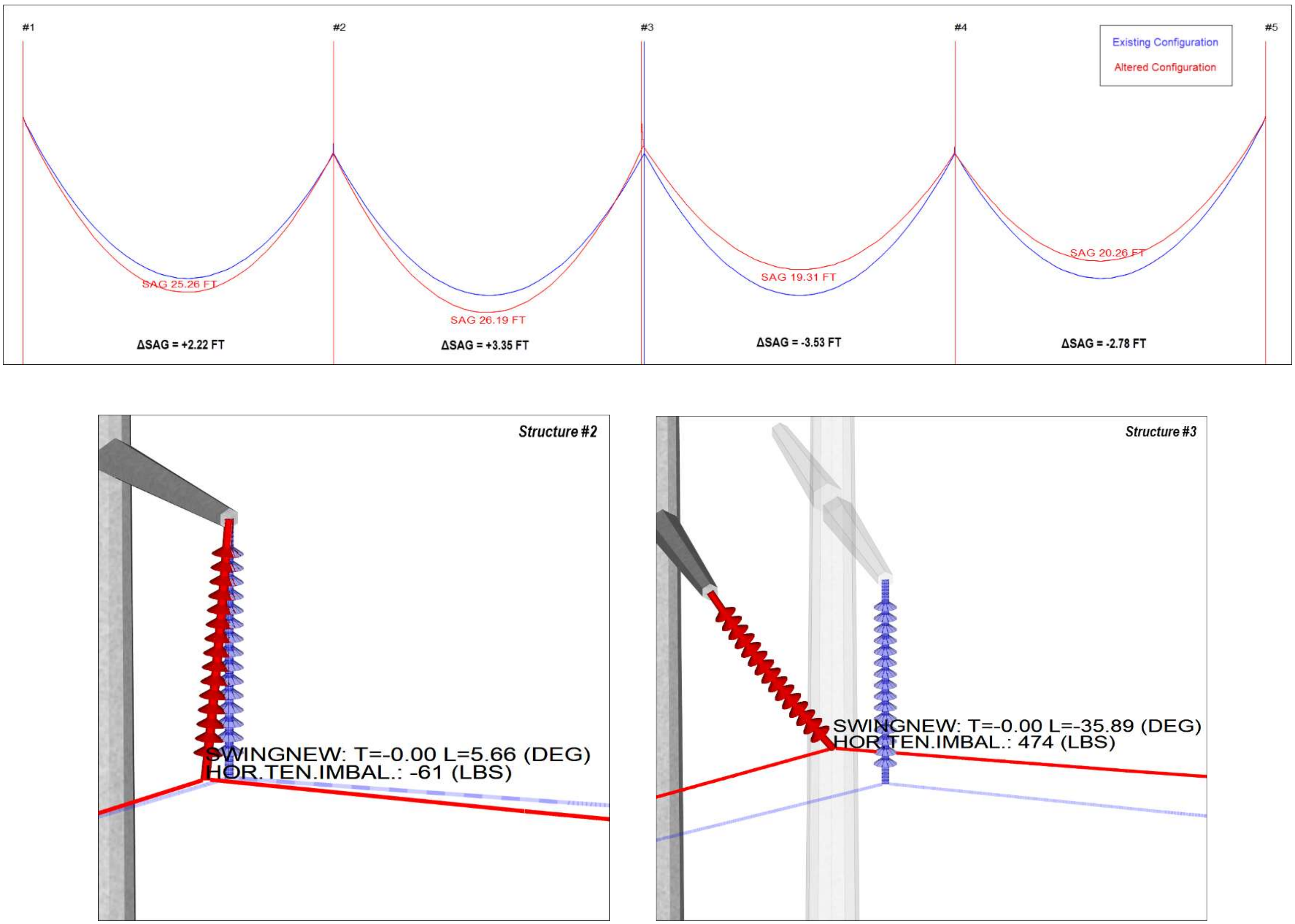




Figures 2a and 2b: Initial conditions of the line. Equilibrium in horizontal tension allows suspension insulators to hang plumb

Case 1: Structure Location Change

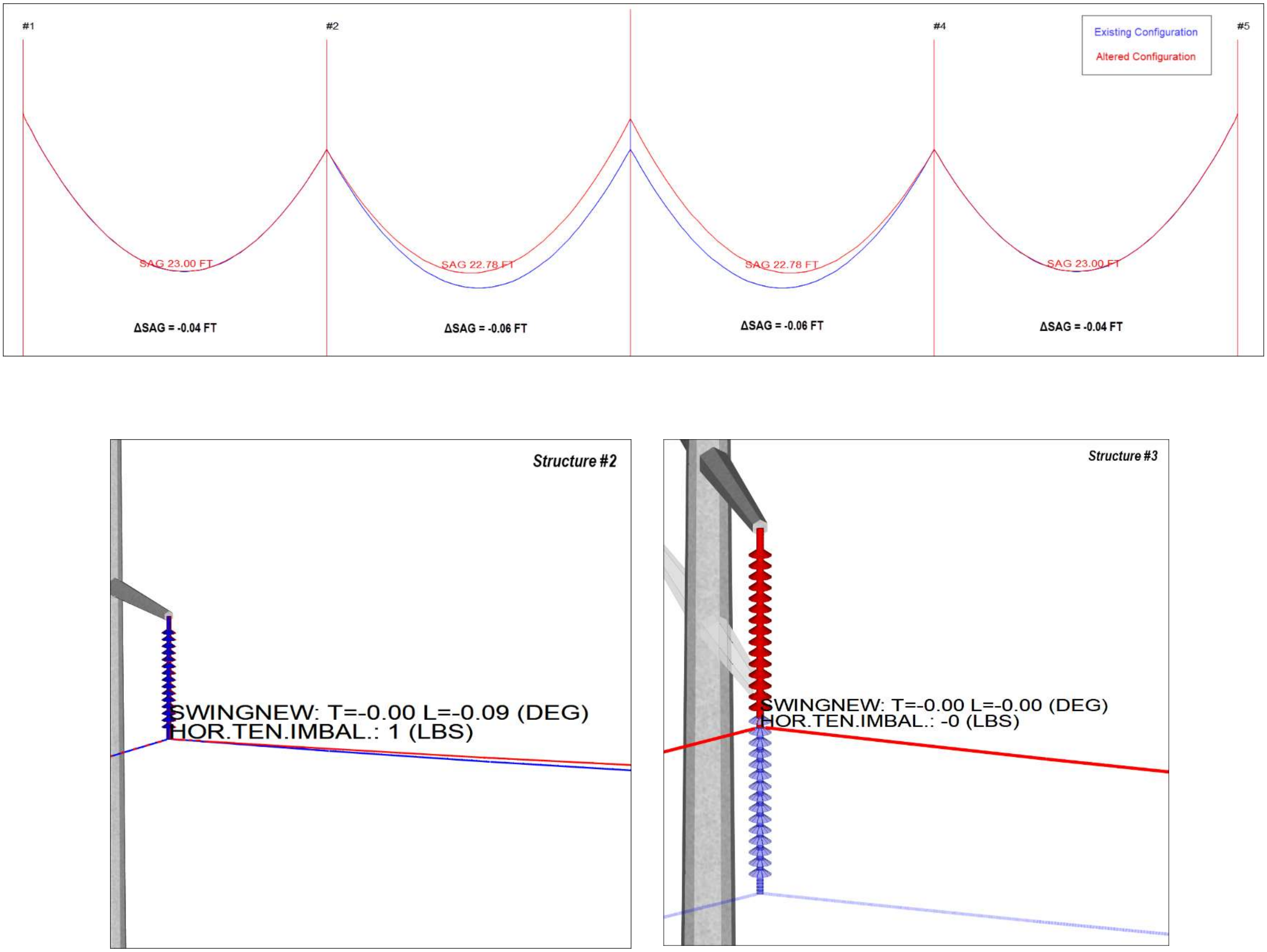
Occasionally, existing structures may need to be moved due to new construction such as modifications to roads or sidewalks, access to underground utilities, or the installation of other new infrastructure. In this example, Structure #3 has been moved 5 ft to the left by using either one of the options under ***Structures/Move*** or by manually changing the structure's station using ***Structures/Modify***. Note how moving Structure #3 significantly impacts the sags and insulator swings in every span. As shown by the red insulators in Figure 2, there is now a tension imbalance which invalidates the use of a ruling span analysis. Although this case is meant to demonstrate the tension imbalance created when moving a structure supporting clipped wires, this is not realistic to typical construction operations. Wire tensions would likely be allowed to equalize during the relocation of the existing structure. See the "Equalizing Tensions" section at the end of this Technical Note for more information.



Figures 3a, 3b and 3c: Effects of a structure move on existing line tensions, sags and insulator swings

Case 2: Structure Height Change

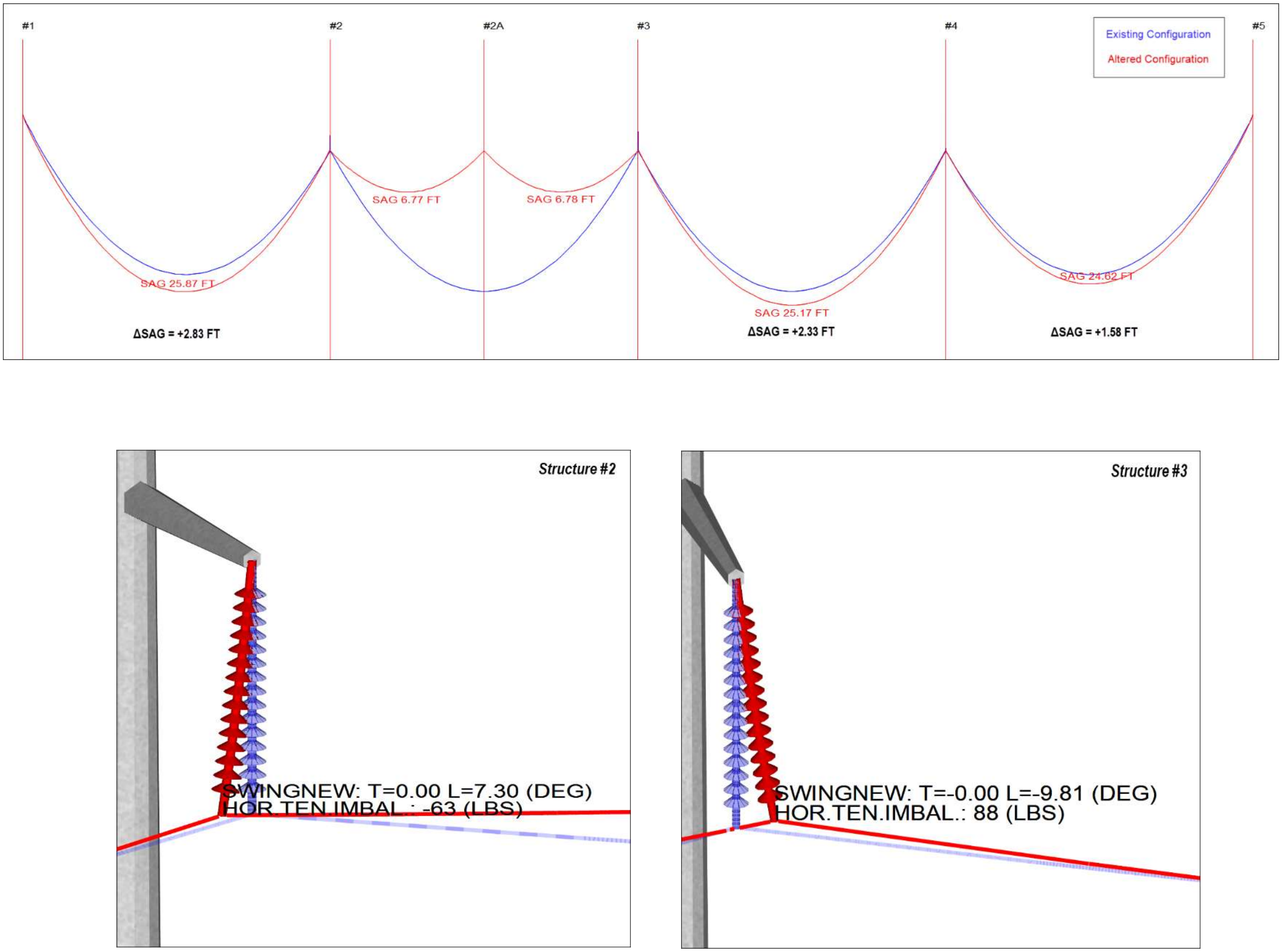
Now, Structure #3 has been raised 5 ft by using ***Structures/Modify***. This could be done when additional clearance is needed in a span. Perhaps a utility wants to operate one of their transmission lines at a higher temperature to transmit more power. However, clearance to ground is no longer maintained in one span when the conductor is at this elevated temperature. The utility may decide to raise one of the structures at this span in order to gain some additional ground clearance— provided the raised structure can support the increased vertical loading. Note how raising Structure #3 has minimal impacts on the first and last spans.



Figures 4a, 4b and 4c: Effects of a structure height change on existing line tensions, sags and insulator swings

Case 3: New Structure Insertion

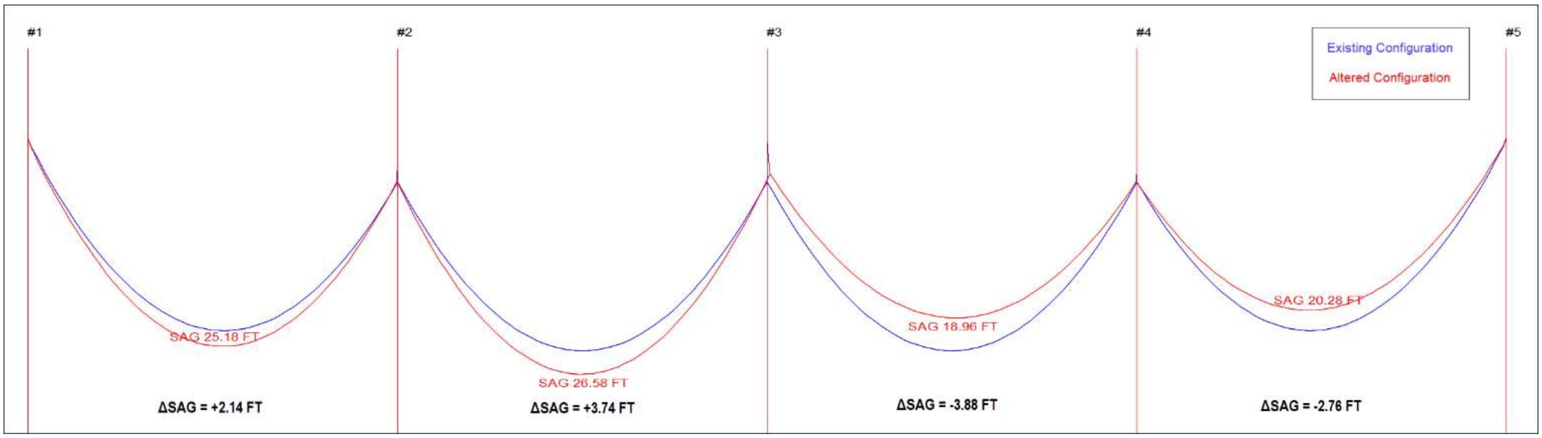
In this scenario, a new structure has been added between existing Structures #2 and #3 by using one of the options under ***Structures/Add***. Note how the insertion of Structure #2A significantly increases the sag in the first span and the last two spans.

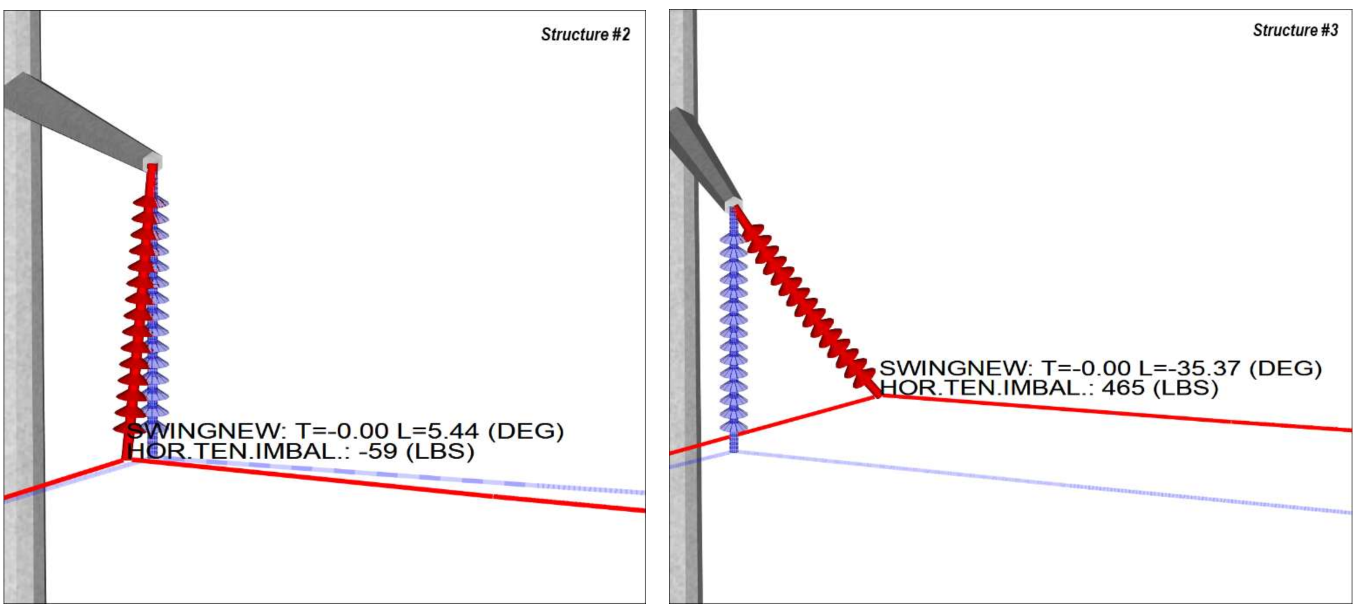


Figures 5a, 5b and 5c: Effects of a structure insertion on existing line tensions, sags and insulator swings

Case 4: Transfer of Wire Between Spans

Returning to the example described in Case 2, assume the utility decides raising a structure is not an option due to other constraints. Instead, the utility may decide to resolve their ground clearance issue by shifting a small amount of wire from a “problem” span into an adjacent span. In this example, 5 ft of wire has been transferred from the right side of Structure #3 to the left side by using ***Sections/Slip and Clip***, or by adjusting the wire length in the spans by pressing the “*Edit Span-Specific Wire Lengths, Concentrated Loads, Attachment Stiffnesses, Surveyed Temperatures”* button in the ***Section/Modify*** dialog. Note the significant sag increases to the left of Structure #3, and sag decreases to the right.



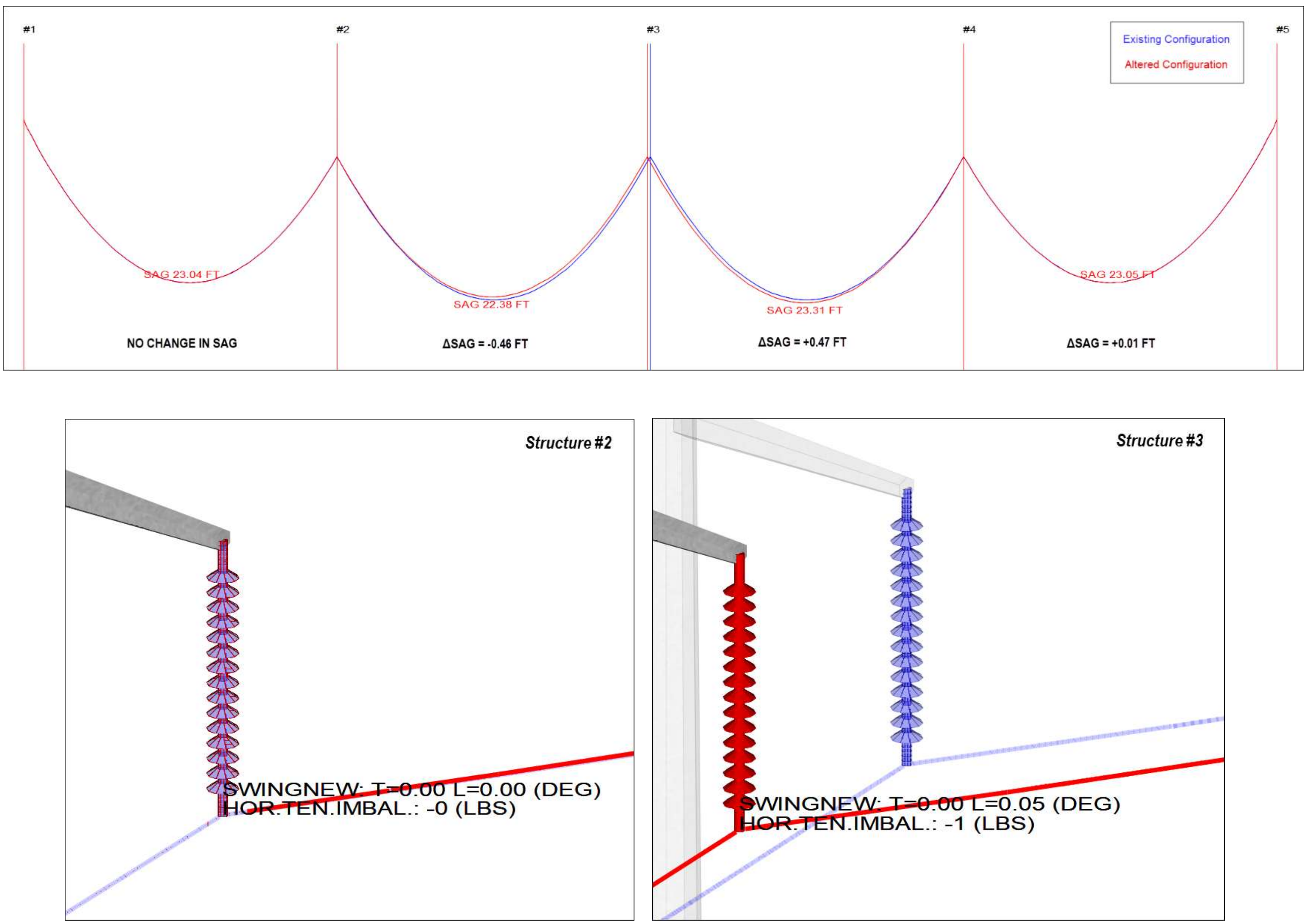


Figures 6a, 6b and 6c: Effects of a wire transfer on existing line tensions, sags and insulator swings

Equalizing Tensions: Accounting for the Use of Stringing Blocks

There is one other consideration to bear in mind when discussing the modification of clipped wires in PLS-CADD. In many of the scenarios examined above, it's possible that the clamps on the insulators will be open or stringing blocks will be used to allow the wire tension to equalize across the updated structure on an existing line. For example, in Case 1, the existing conductor could be placed into stringing blocks (or "sheaves") after Structure 3 is moved or the clamp could be left open to allow the insulator to remain plumb while the horizontal tension on either side equalizes. Unlike a clipped wire, these stringing blocks allow conductor to travel freely between spans in order to equalize the horizontal tension in the spans. This behavior can be modeled in PLS-CADD by either one of two different functions: ***Structures/Equalize Tension*** and ***Sections/Slip and Clip***. ***Equalize Tension*** is a more automated option for accounting for the behavior of stringing blocks, whereas ***Slip and Clip*** allows users to manually move wires between spans in order to equalize tensions. ***Slip and Clip*** actually also contains the ***Equalize Tension*** function, so both tension equalization methods can be utilized from within the ***Slip and Clip*** function. Sections 10.3.6.1 and 10.3.6.2 of the PLS-CADD manual describe these functions in greater detail.

The images below show the results of using the ***Equalize Tension*** function after moving Structure 3 as described in Case 1.



Figures 7a, 7b and 7c: Effects of the "Equalize Tension" function after moving a structure