AUTODESK UNIVERSITY 2013

# Design Efficiency with Multi Planar Pulling Tension Engineering at Southern California Edison

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**UT2345**

In this class, you learn how Southern California Edison (SCE) uses industry standards and the Multi Planar Pulling Tension (MPPT) utility to optimize workflows and the use of materials. We describe how SCE has encapsulated their engineering standards into the design tool to ensure consistency and constructability of designs and to improve knowledge transfer and adoption of standards by new and existing design staff. We then demonstrate how the engineering analysis in Autodesk® AutoCAD® Utility Design 2014 software can be configured to accommodate SCE's specific requirements. You will understand how to configure AutoCAD Utility Design with your own engineering analysis standards that have been used for decades. You will also learn to adjust and optimize your workflows and tools based on the lessons learned at SCE.

## Learning Objectives

At the end of this class, you will be able to:

- Explain how SCE uses industry standards and the Multi Planar Pulling Tension utility to optimize workflows and materials.
- Describe how SCE has encapsulated their engineering standards into the design tool to ensure consistency and constructability.
- Configure AutoCAD Utility Design to your own engineering algorithms and standards.
- Adjust and optimize your workflows and tools based on the lessons learned at SCE.

## About the Speaker

John Deatherage has been with Southern California Edison (SCE) for the past 11 years working in the SCE planning department as a planner designing the SCE Distribution Network for 7 years, and recently 4 years in the Business Process Technology and Integration department (BPT&I) working with Autodesk Utility Design (AUD). Prior to John coming to SCE he spent the past 25 years as an Electrical Contractor in both Residential and Commercial spaces, and is still a Small Business Owner performing electrical jobs.

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## Explain how SCE uses industry standards and the Multi Planar Pulling Tension utility to optimize workflows and materials

Prior to using Autodesk Utility Design (AUD) for design and engineering integration, Southern California Edison (SCE) was using an excel spreadsheet to run Equivalent Pulling Length (EPL) for all underground designs. This was based on SCE's table driven charts. Assumptions were made based on an overall EPL with a certain amount of bends and sweeps associated with the length. Additionally, this did not allow for any changes of elevation using the excel spreadsheet. The EPL program was one of many stand-alone solutions, which after management review, was being looked at for a single integrated solution inside of Autodesk Utility Design.

At the end of 2009, SCE and Autodesk Consulting engaged in the delivery of an AUD solution called Graphical Design Tool (GDT) with a full Multi-planar Pulling Tension (MPPT) solution. This allowed for SCE to a use formula based calculation to determine the actual drafted lengths. This included arc lengths for bends and sweeps and additional cable for makeup inside of underground structures and riser poles. This integration included the ability to draft the design in 2D model space while allowing MPPT to be launched and render the 3D graphical design. Additionally, MPPT adheres to SCE standards which are always applied based on the users 2D drafted model. MPPT allows for a full 360 degree analysis based on any drafted angle, but specific to SCE engineering, approval is required if it deviates from the SCE standard approved angles in conjunction with duct sizes and factory bends and sweeps. This is extremely important when certain circumstances do now allow for structures to be moved.

MPPT also allows for the resizing of duct and applying of SCE bends and sweeps and their respective material types on the fly. The analysis can be re-ran (while still in the MPPT tool) to provide a possible passing solution in a result that had just failed. MPPT also allows for the users to add transition points when an elevation change is necessary; for example, when having to take duct and cable underneath existing facilities, such as a sewer line or running analysis on a downhill slope. MPPT runs calculations in both directions on the initial analysis. In all cases, SCE formulas are being applied when any analysis is being run and returned for review. MPPT is also configured to provide the user with a detailed analysis report that can be printed or saved to an external file (HTML or XML) that can then be used by other applications or forwarded to engineers that do not have the tool for their review.

### Real World MPPT Scenarios Using GDT

The following sections show the usage of the GDT MPPT solution in some real world scenarios.

#### *Changing Elevation to Clear an Object*

This scenario runs MPPT on a Vault to Vault pull of 1000' of 3-1000 Primary Jacketed cable that changes elevations of 50' down to clear an object.

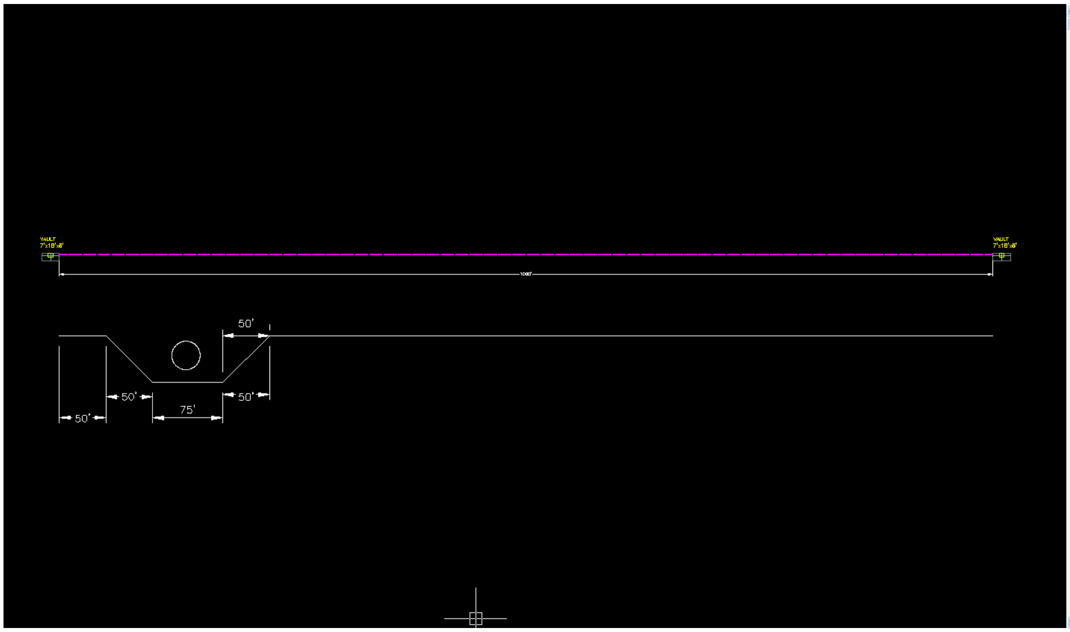



Figure 1 - Initial Vault to Vault Design in Model Space

The user executes MPPT on the primary cable and adds 4 new transition points in the MPPT user interface.

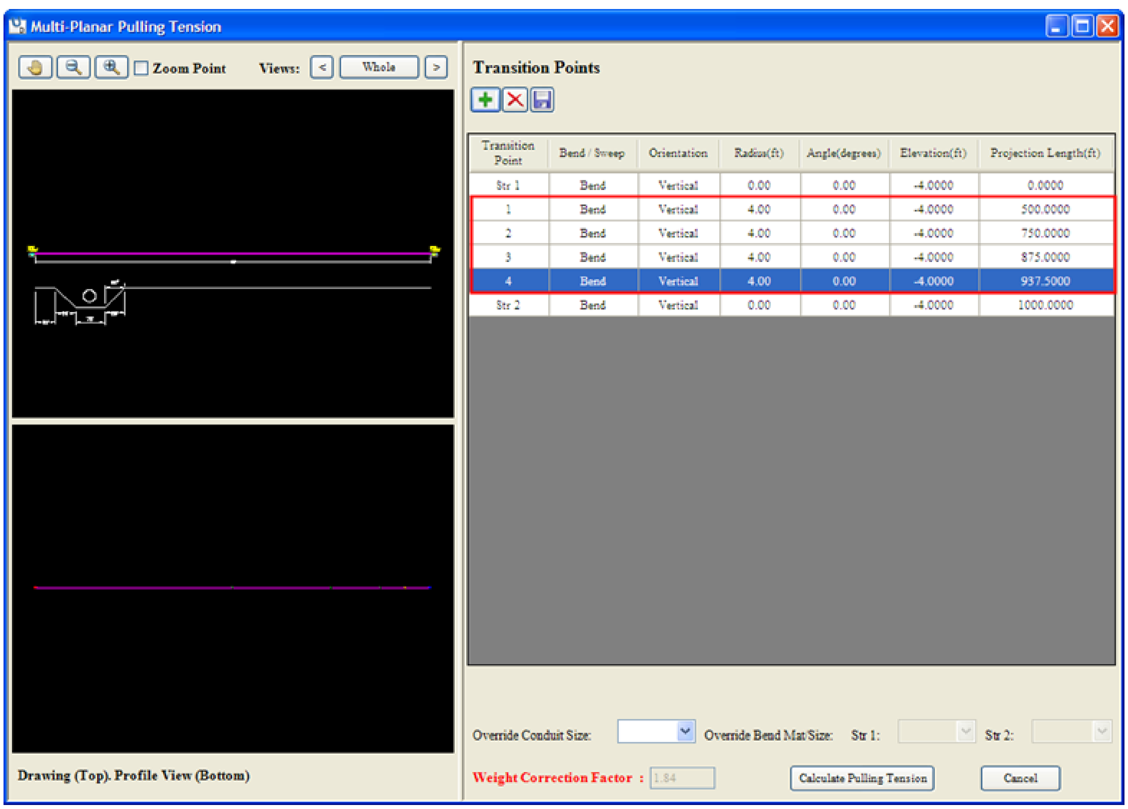



Figure 2 - Insertion of Transition Points

The user then modifies the transition point's project lengths, adjusting them to the actual field conditions. Further, they modify the transitions to be 12.5' radius sweeps from the default 4' radius bends.

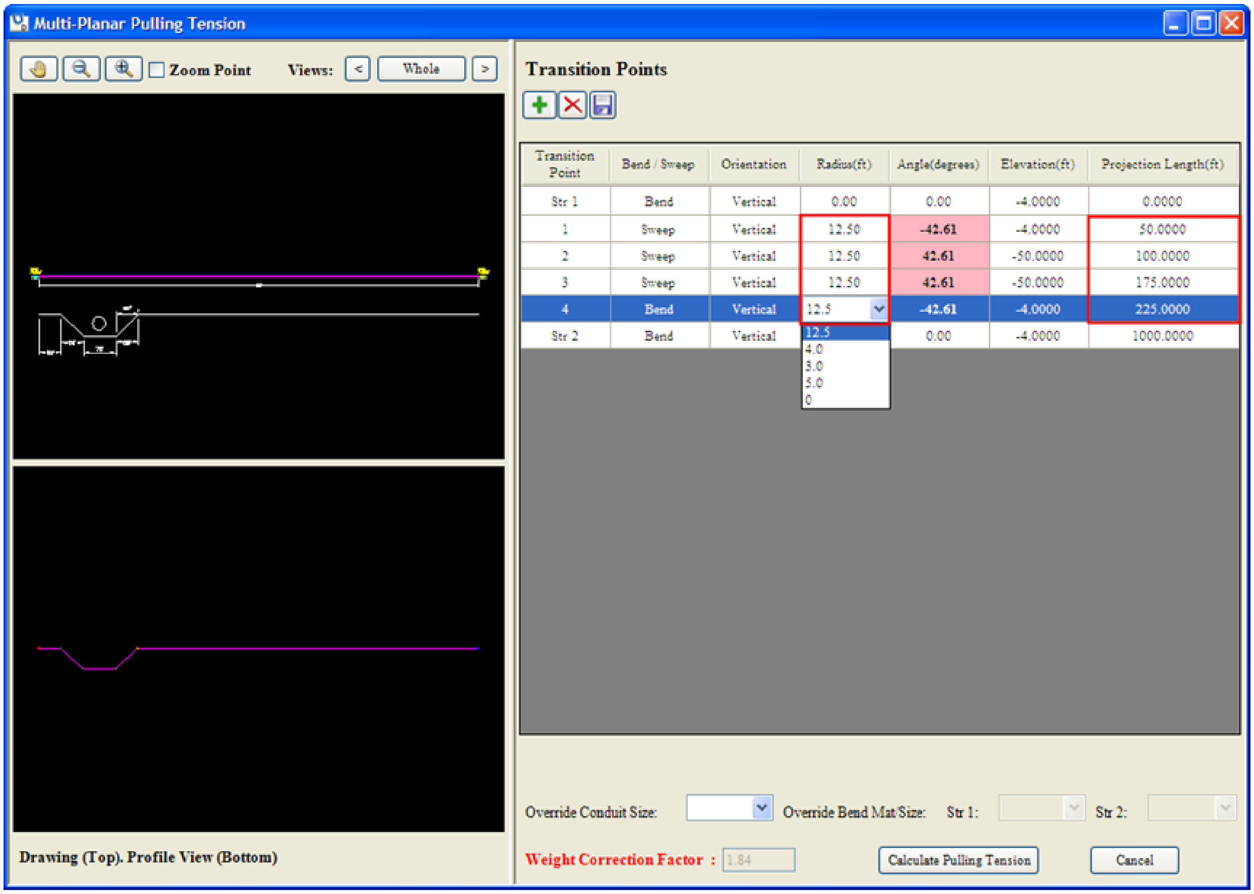
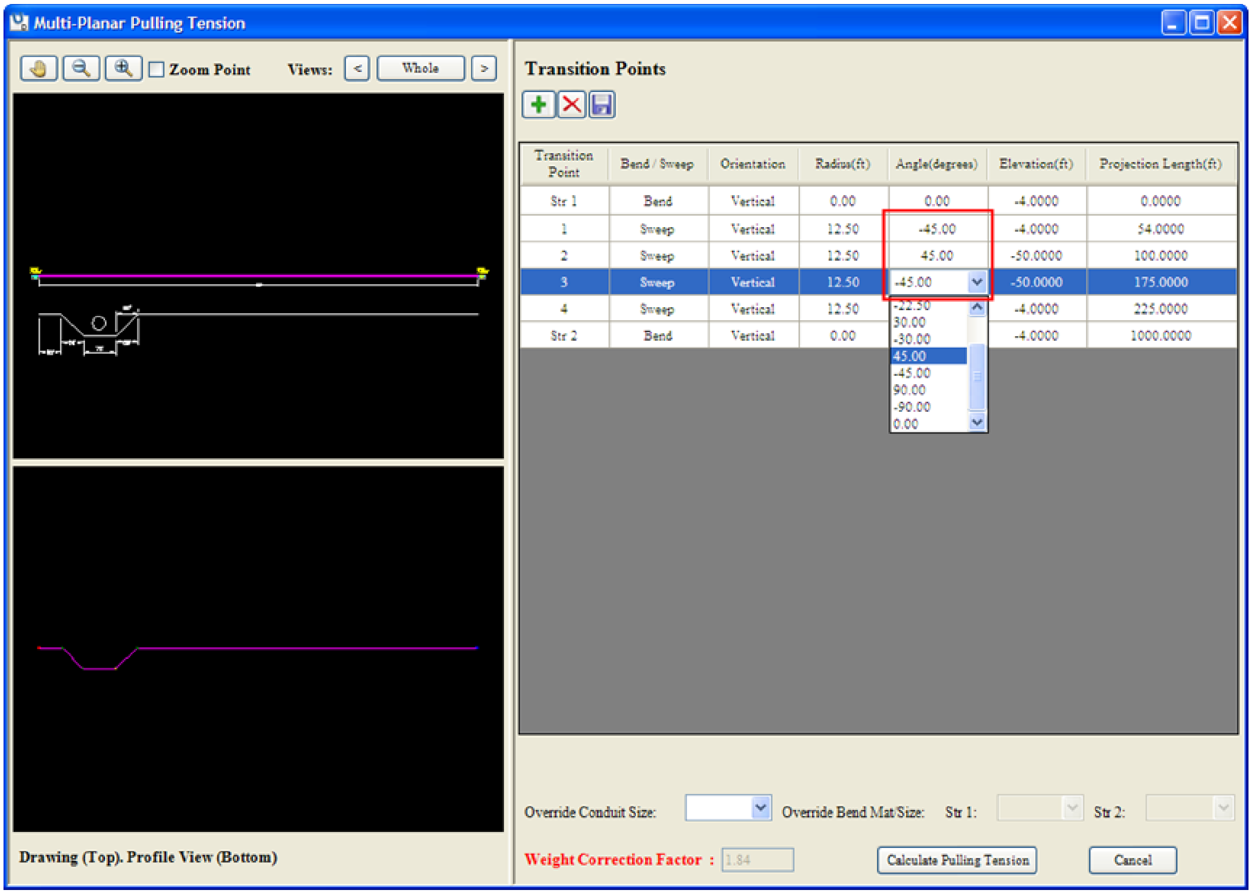



**Figure 3 - Modification of Projection Lengths and Sweep Radius**

MPPT calculates the projection length by the elevation change applied and thus produces the angle, which happens to be an invalid SCE angle. MPPT is configured with all SCE approved angles, and can be forced to an allowable angle which now re-works the projection and elevation to produce the correct projection length for analysis and material ordering.

Note:

- Angle plus Elevation equals Projection
- Projection plus Elevation equals Angle




| Transition Point | Bend / Sweep | Orientation | Radius(ft) | Angle(degrees) | Elevation(ft) | Projection Length(ft) |
|---|---|---|---|---|---|---|
| Str 1 | Bend | Vertical | 0.00 | 0.00 | -4.0000 | 0.0000 |
| 1 | Sweep | Vertical | 12.50 | -45.00 | -4.0000 | 54.0000 |
| 2 | Sweep | Vertical | 12.50 | 45.00 | -50.0000 | 100.0000 |
| 3 | Sweep | Vertical | 12.50 | -45.00 | -50.0000 | 175.0000 |
| 4 | Sweep | Vertical | 12.50 | | -4.0000 | 225.0000 |
| Str 2 | Bend | Vertical | 0.00 | | -4.0000 | 1000.0000 |

Figure 4 - Modify Sweep Angles to SCE Approved Angles

MPPT shows the rendering of the elevation change in the Profile View along with the results, which in this case only is acceptable in one direction.

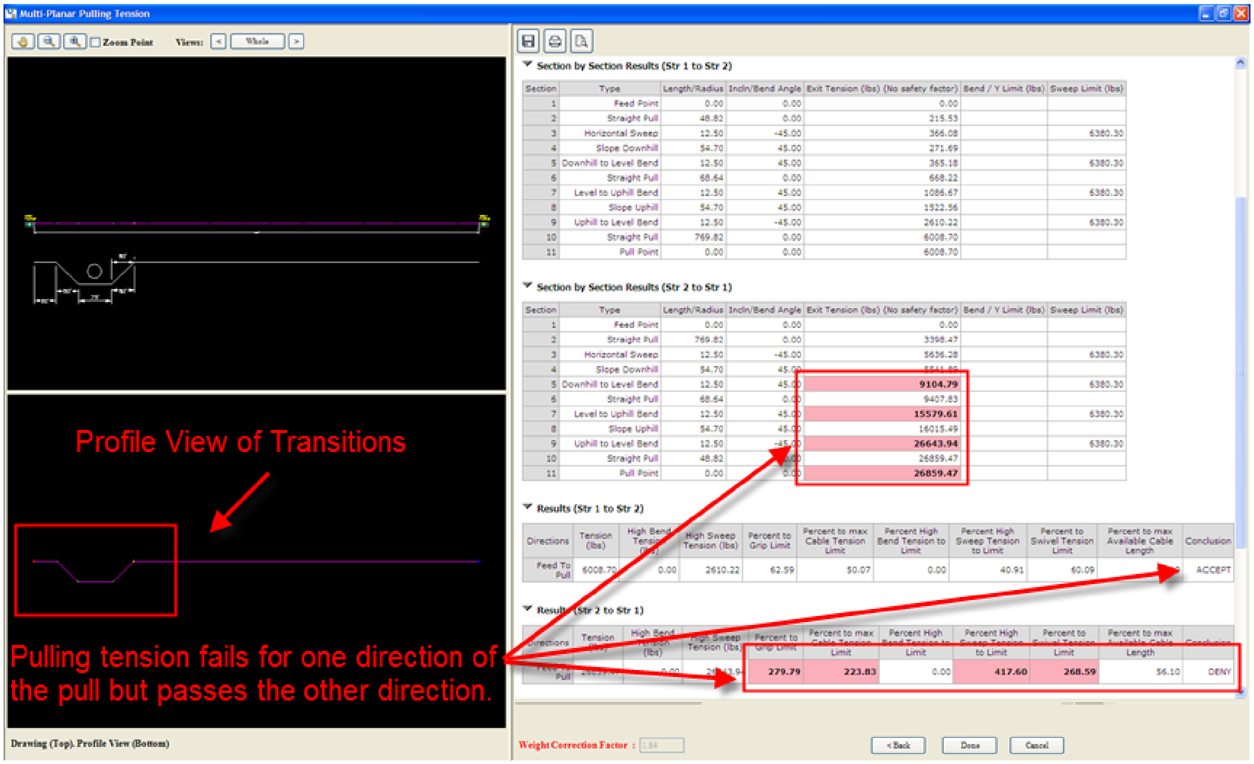



Figure 5 - MPPT Results

When saved, MPPT updates model space automatically with cable pulling results and places an arrow(s) indicating the passing pull direction(s).

Note: If the MPPT solution passed for both directions, two arrows would be placed, allowing the crews to choose which direction they want to pull from.

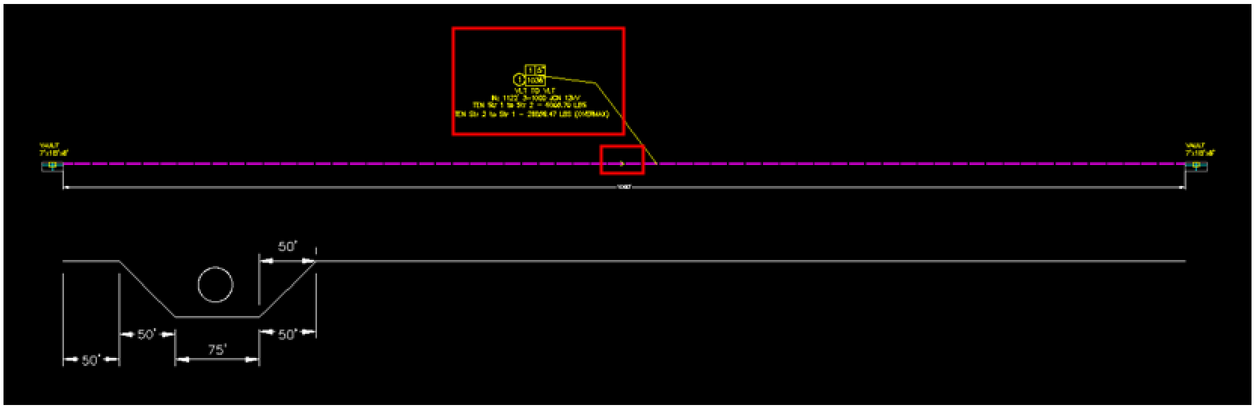



Figure 6 - Model Space View of Results Callout and Pull Direction Arrow

### *Riser Pole to a Padmount Tranformer with Elevation Change*

This scenario shows how MPPT will be used to calculate pulling tension for a primary cable from a Riser Pole to a Vault with a slope downhill. A riser height of 40' has been determined at the pole and entered into model space using the GDT Riser Height feature.

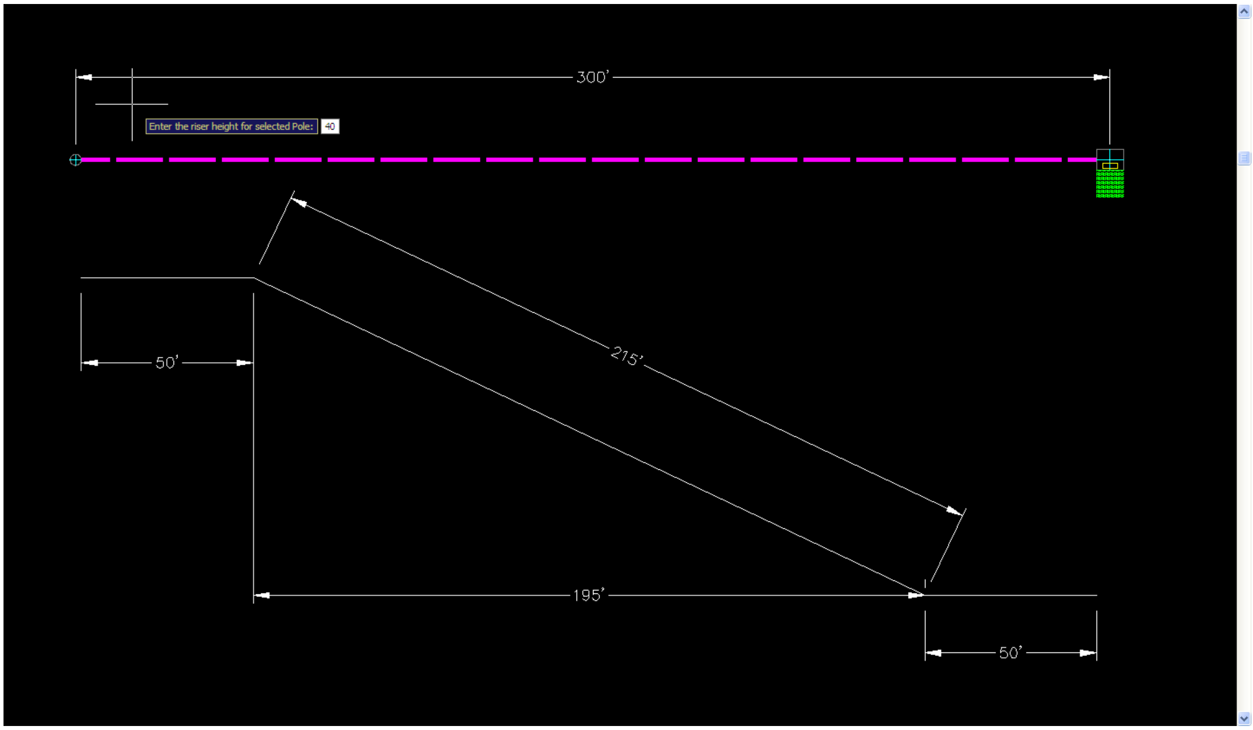
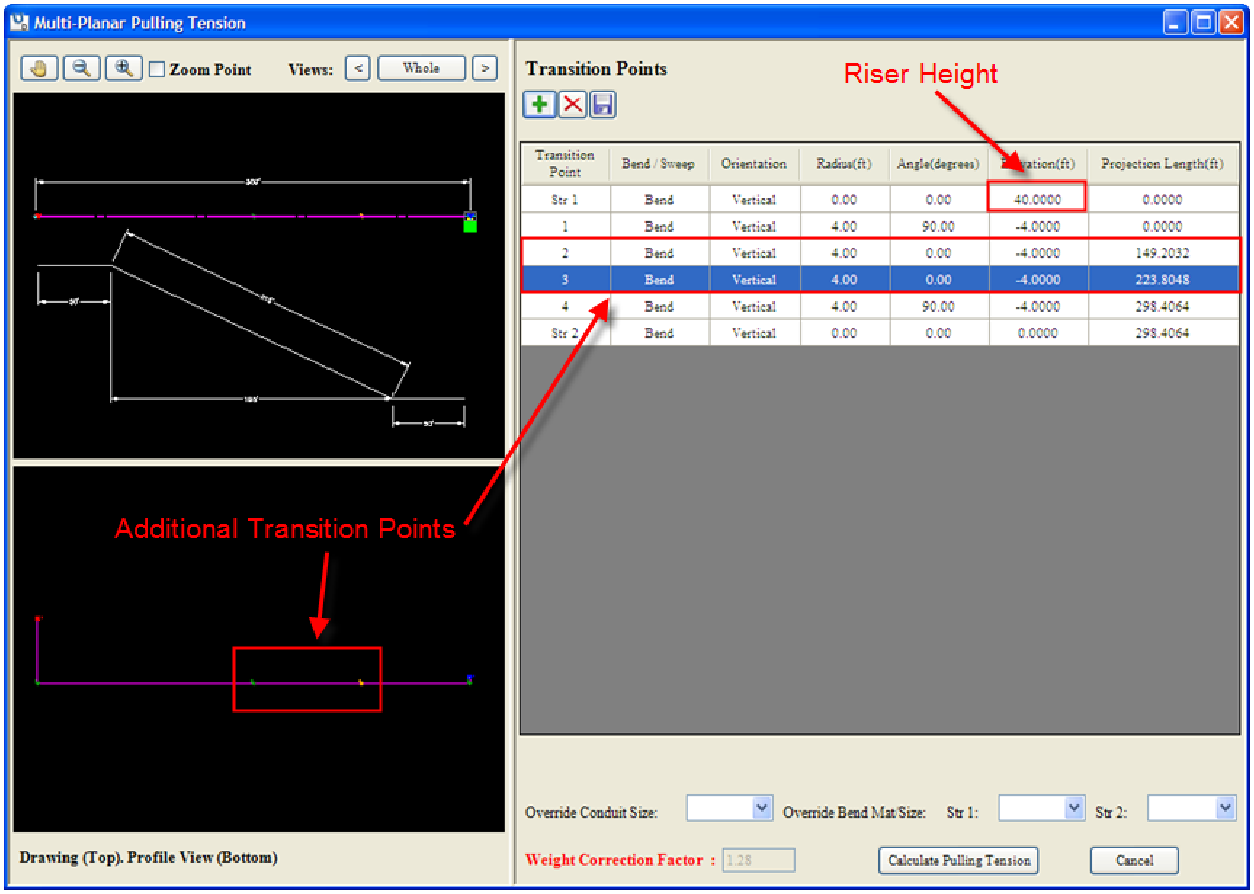



**Figure 7 - Model Space View Pole to Padmount Transformer**

MPPT is run on the primary cable. The user adds two transition points after the bend at the pole to account for the downhill elevation. MPPT automatically picks up the the Primary Riser Height of 40' that was added in model space.




| Transition Point | Bend / Sweep | Orientation | Radius(ft) | Angle(degrees) | Elevation(ft) | Projection Length(ft) |
|---|---|---|---|---|---|---|
| Str 1 | Bend | Vertical | 0.00 | 0.00 | 40.0000 | 0.0000 |
| 1 | Bend | Vertical | 4.00 | 90.00 | -4.0000 | 0.0000 |
| 2 | Bend | Vertical | 4.00 | 0.00 | -4.0000 | 149.2032 |
| 3 | Bend | Vertical | 4.00 | 0.00 | -4.0000 | 223.8048 |
| 4 | Bend | Vertical | 4.00 | 90.00 | -4.0000 | 298.4064 |
| Str 2 | Bend | Vertical | 0.00 | 0.00 | 0.0000 | 298.4064 |

Figure 8 - Riser Height and Additional Transition Points

The user then enters projection lengths and adjusts the elevations to match the field conditions of the slope downhill.

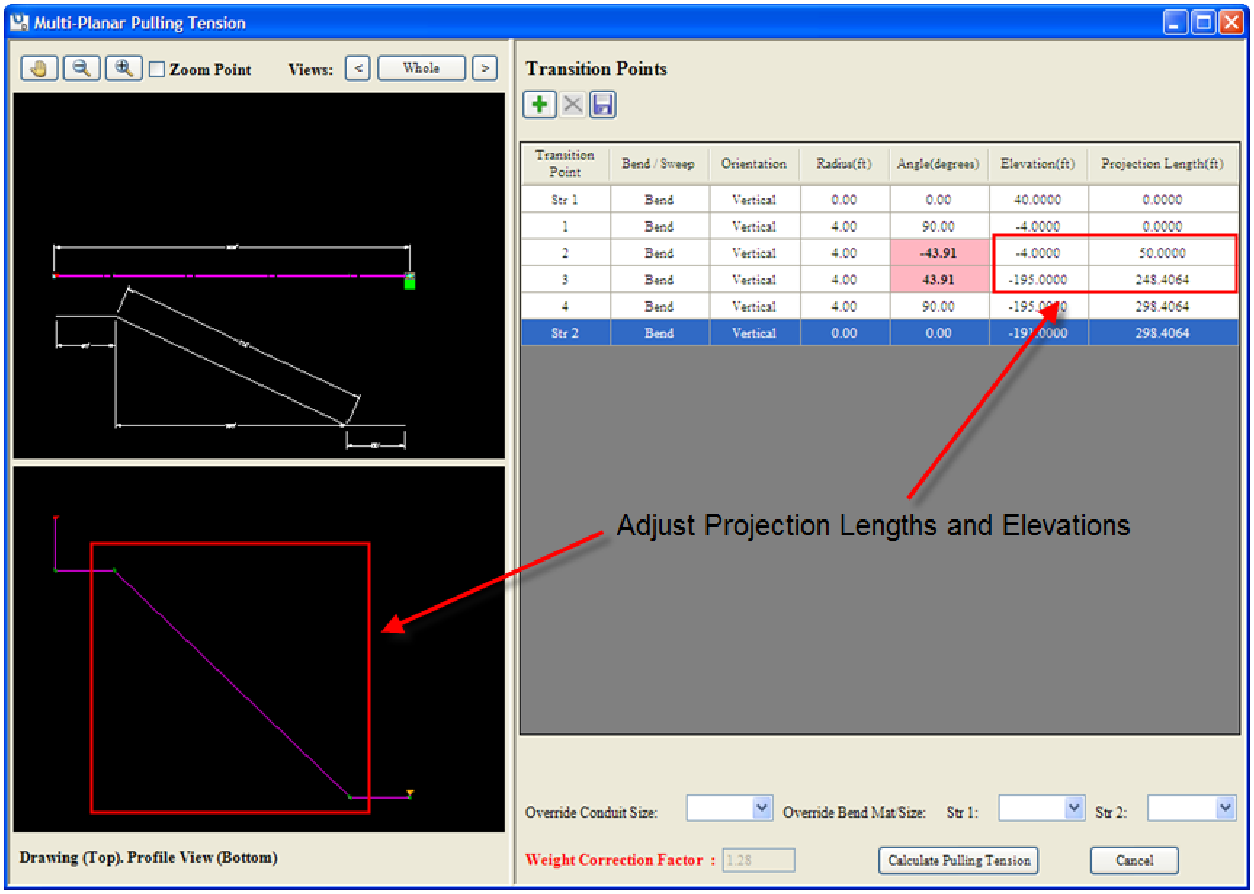



Figure 9 - Adjust Projection Lengths and Elevation

The user then modifies the angles and sweep/bend radius of the transition points to match SCE standards prior to running analysis.

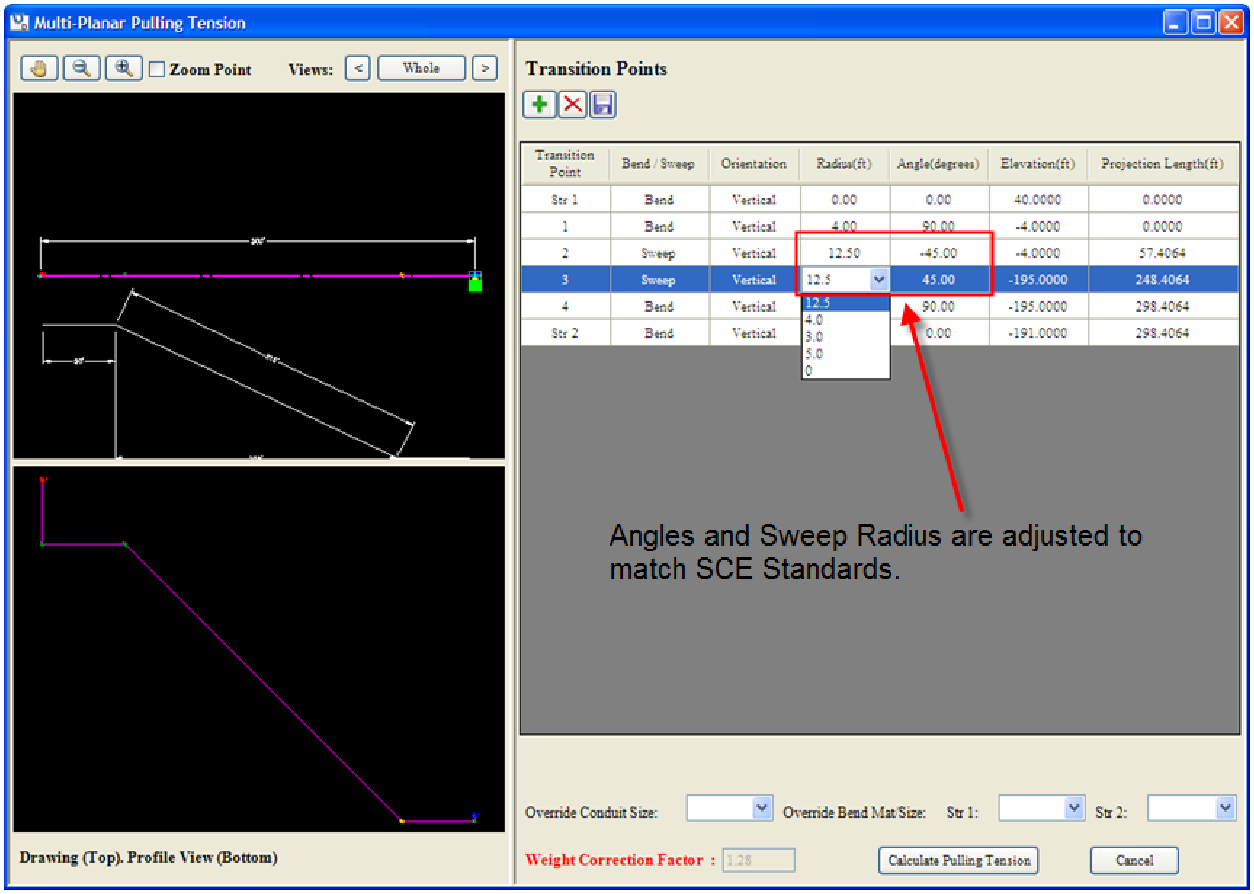



**Figure 10 - Modify Radius Sweep and Angles**

MPPT is run calculating the pull uphill and downhill and it is failing in both directions.

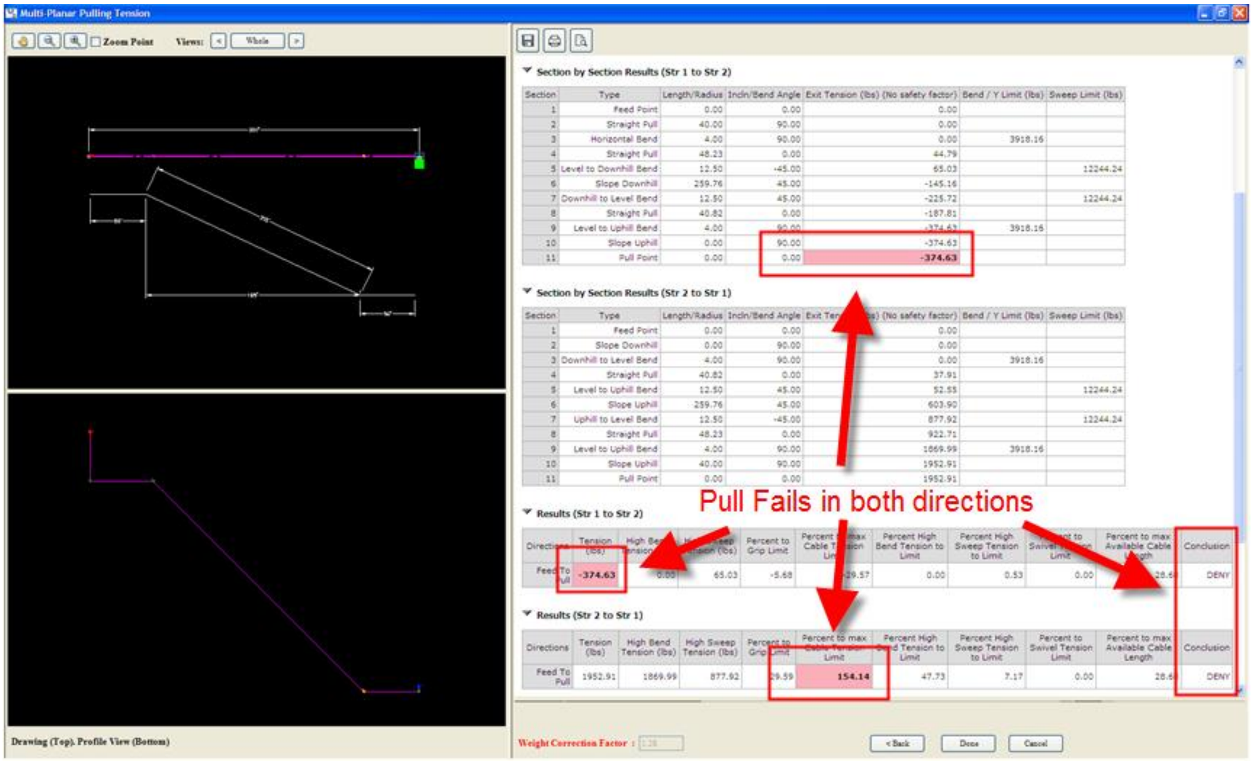



Figure 11 - Failed Pull Results

MPPT allows for the manual override of the default PVC 90 bends and sweeps to HDG or Fiberglass, and additionally the user can increase the duct size while in MPPT for modeling and engineering acceptance. Here Fiberglass sweeps are being selected overriding the PVC 90, and new angles of 22.5 degrees are selected. This produces a pass in both directions.

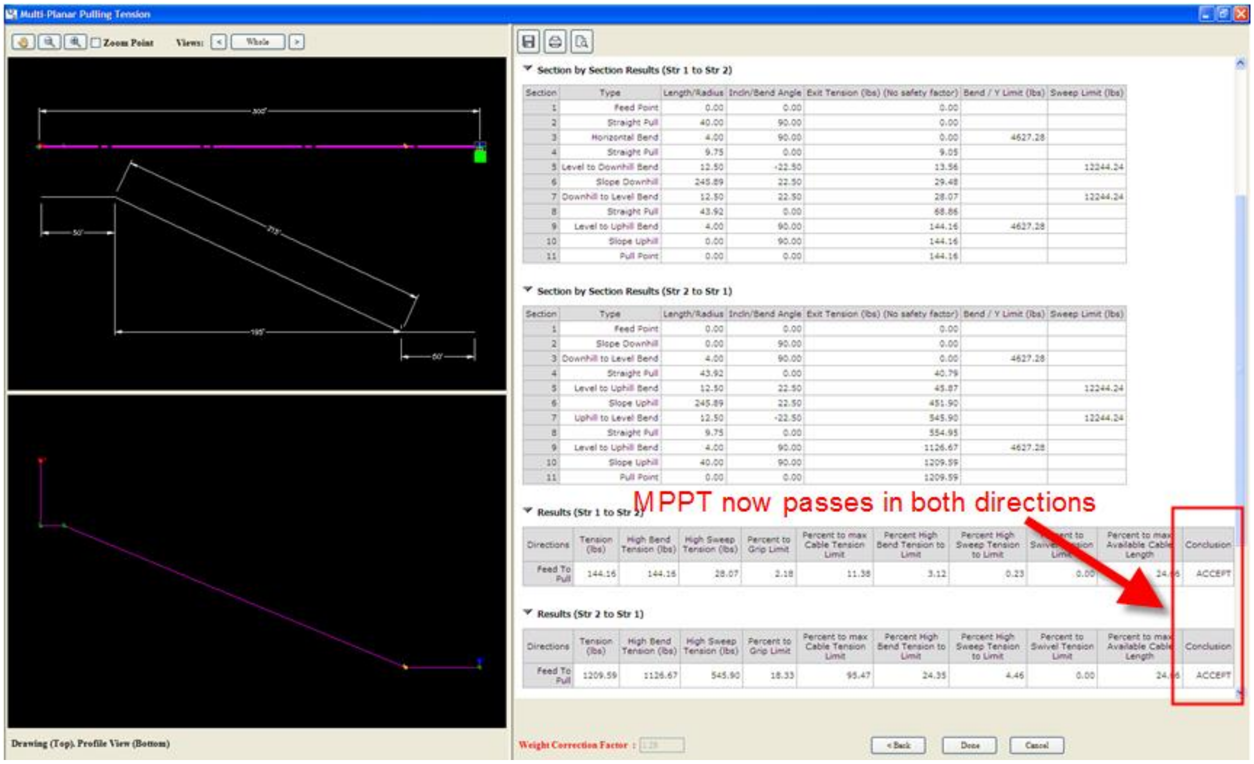
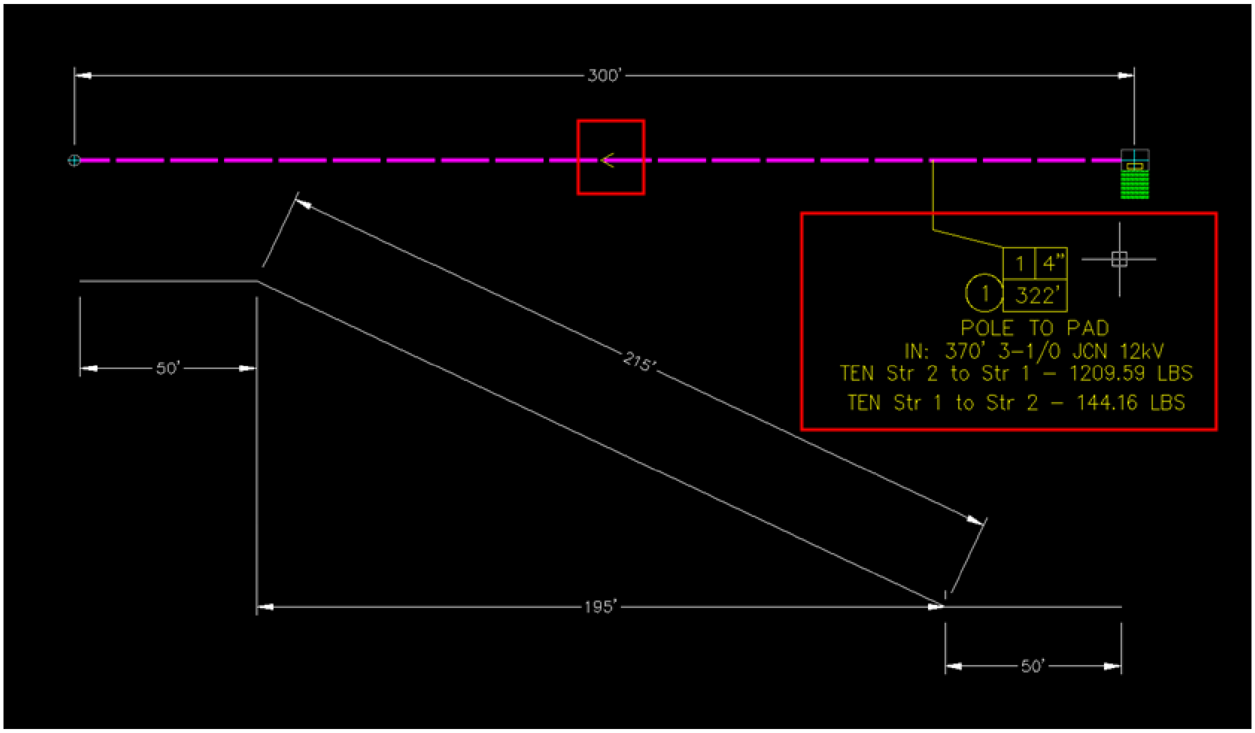



**Figure 12 - Pull Results Now Pass**

After saving, Model Space is updated with the results automatically and an arrow is placed showing the preferred pull direction per SCE standards.

Note: although the results showed a pull in either direction SCE standards are always to pull up through the riser; however, a deviation from the standards can be requested allowing cable to be pulled at the base of the pole and the riser to be built by hand.




## Describe how SCE has encapsulated their engineering standards into the design tool to ensure consistency and constructability

SCE's mandate was to have a single integrated Graphical Design Tool solution. This included looking into all of SCE's standalone engineering, material ordering and pricing solutions. With the support of SCE Subject Matter Experts and Autodesk Consulting, AUD 2009 was configured and customized to adhere to all SCE standards and became the single integrated solution. The Graphical Design Tool was rolled out in 2009 and included not only MPPT, but solutions for Voltage Drop and Flicker, Pole Modeling which included pole loading analysis and 3D rendering, Automated Material Ordering, and many other SCE specific add-on solutions to adhere to the single integrated mandate.

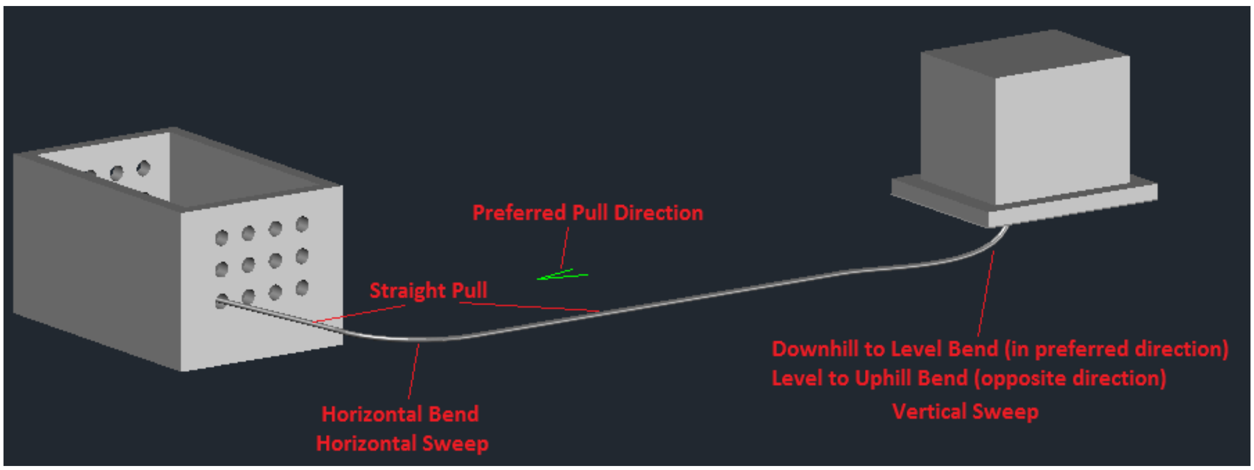
The above solution comes with a configuration that must adhere to the SCE standards to ensure that the users design models are consistent with SCE drafting standards, all the while running engineering to provide an analysis of the 2D model which adheres to SCE's constructability in the field. Autodesk Consulting configured AUD solely based on SCE engineering requirements and SCE's design support drafting standards. These two are the main drivers to ensure consistency and constructability of engineering analysis and the final design.

## Configure AutoCAD Utility Design 2014 to your own engineering algorithms and standards

The latest version of AutoCAD Utility Design 2014 provides built-in configuration and tools to run pulling tension analysis out of the box. It is configured to follow the National Rural Electric

Cooperative Association (NRECA) standards for cable pulling (either electrical cable or communication cable) through conduit. Standardized calculations are performed to determine tension as well as sidewall bearing pressure (SWBP) that will result when pulling the cable through bends and sweeps.

Currently, AUD 2014 supports pulling tension analysis for 2D sweeps and straight pulls as well as vertical bends located at the end of a conduit where it attaches to an underground structure. Autodesk is continuing to roll out new capabilities and functionality for Pulling Tension and other AUD features based on customer engagements and feedback.




When tension analysis is executed, the pull is evaluated in both directions. The system will indicate the best direction for pulling by inserting an arrow block into the design. Further, validation errors are displayed along with possible resolutions if tension or SWBP falls outside of the specified limits.

**Pulling Tension Configuration**

In AUD 2014, pulling tension configuration is defined in two areas:

1. Option Set Variables
2. Rules

The Option Set Variables provide a list of key variables that can be set by the user when performing pulling tension calculations. They are found in the Dashboard->Analysis tab under the Pulling Tension->Variables section:

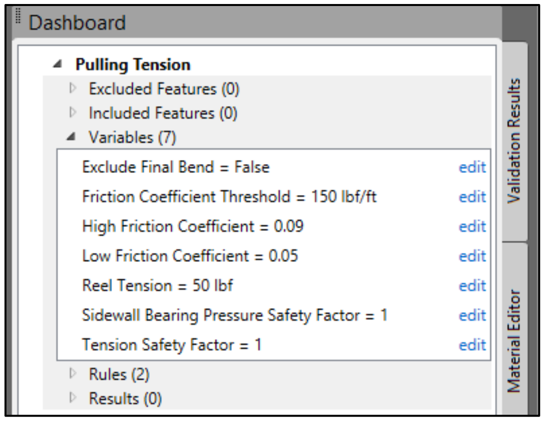



Figure 13 - Pulling Tension Variables

Each variable is described below:

| Variable Name | Description |
|---|---|
| Exclude Final Bend | If set to true, pulling tension will not take the last bend into account. |
| Friction Coefficient Threshold | Used with Sidewall Bearing Pressure to determine the friction coefficient value. |
| High Friction Coefficient | Candidate of friction coefficient. Used when the SWBP is lower than the Fiction Coefficient Threshold. |
| Low Friction Coefficient | Candidate of friction coefficient. Used when the SWBP is Higher than the Fiction Coefficient Threshold. |
| Reel Tension | The initial value of entrance tension. |
| Sidewall Bearing Pressure Safety Factor | The safety factor for Sidewall Bearing Pressure validation. |
| Tension Safety Factor | The safety factor for Pulling Tension validation. |

The pulling tension rules can be found in the Rules Configuration Panel (available from the Configuration Ribbon->Manage Rules) under the Analysis->Pulling Tension section:

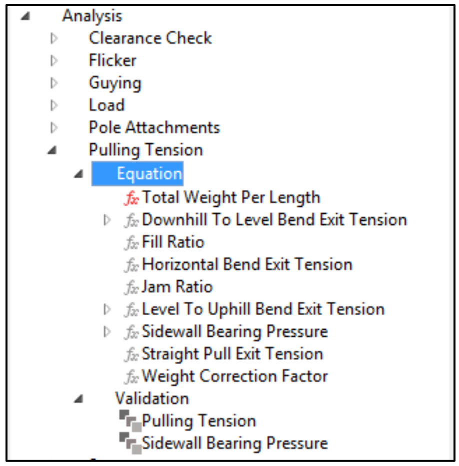



**Figure 14 – Pulling Tension Rules Configuration**

These are then divided into two types, Equation Rules and Validation Rules:

- Equation rules define all the equations used for calculation. These conform to the NRECA equations for each type of calculation and can be changed to your own standards equation if it differs.
- Validation rules check the calculation result and reports messages to the user.

### *Modify a Pulling Tension Equation to Meet Your Standards*

If an existing pulling tension equation does not meet your organization's standards, it can be easily changed using the Rule Configuration panel. For example, the NRECA formula for calculating Weight Correct Factor (F) is:

**Single Cable**

$$F = 1$$

**Two or Three Cables**

$$F = 1 + \frac{4}{3}\left(\frac{1}{J-1}\right)^2$$

**Four Cables**

$$F = 1.4$$

Where

$F$ = Weight Correction Factor
$J$ = Jam Ratio

This formula is configured in the Rule Configuration panel as follows:

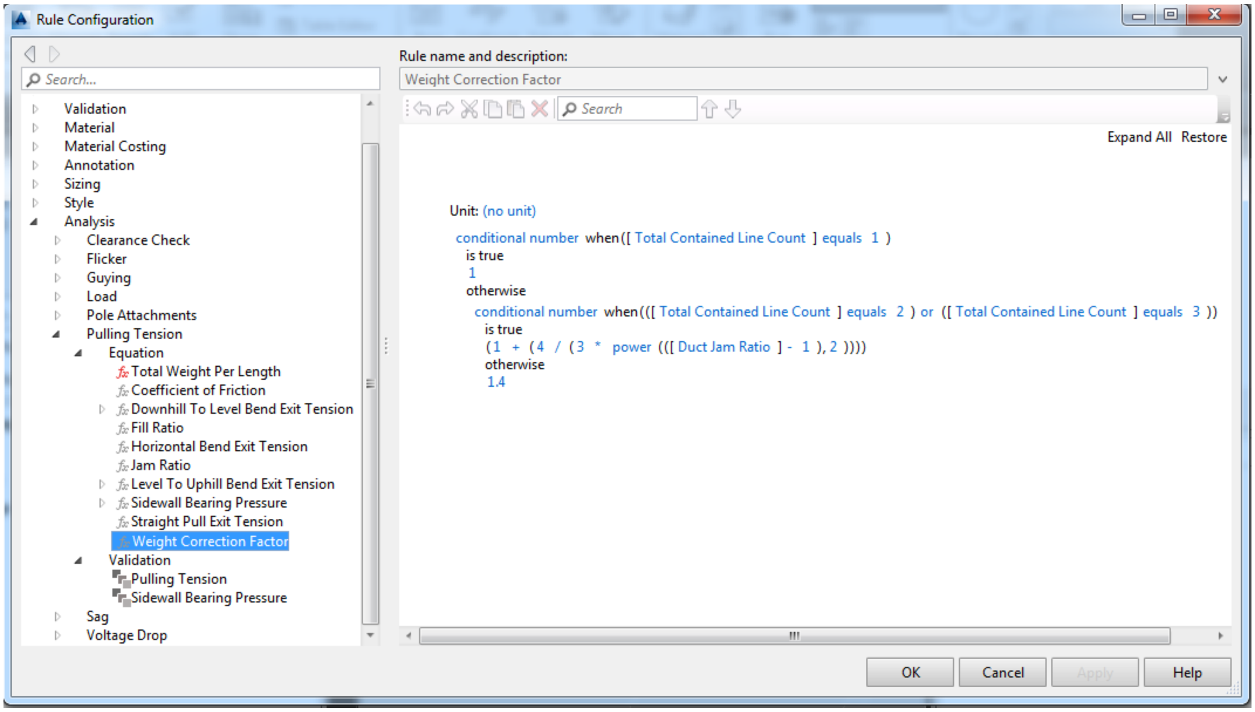



**Figure 15 - Weight Correction Factor Equation Rule**

If your organization's formula differed by using F=1.5 when the cable count is 4, you can simply redefine the rule:

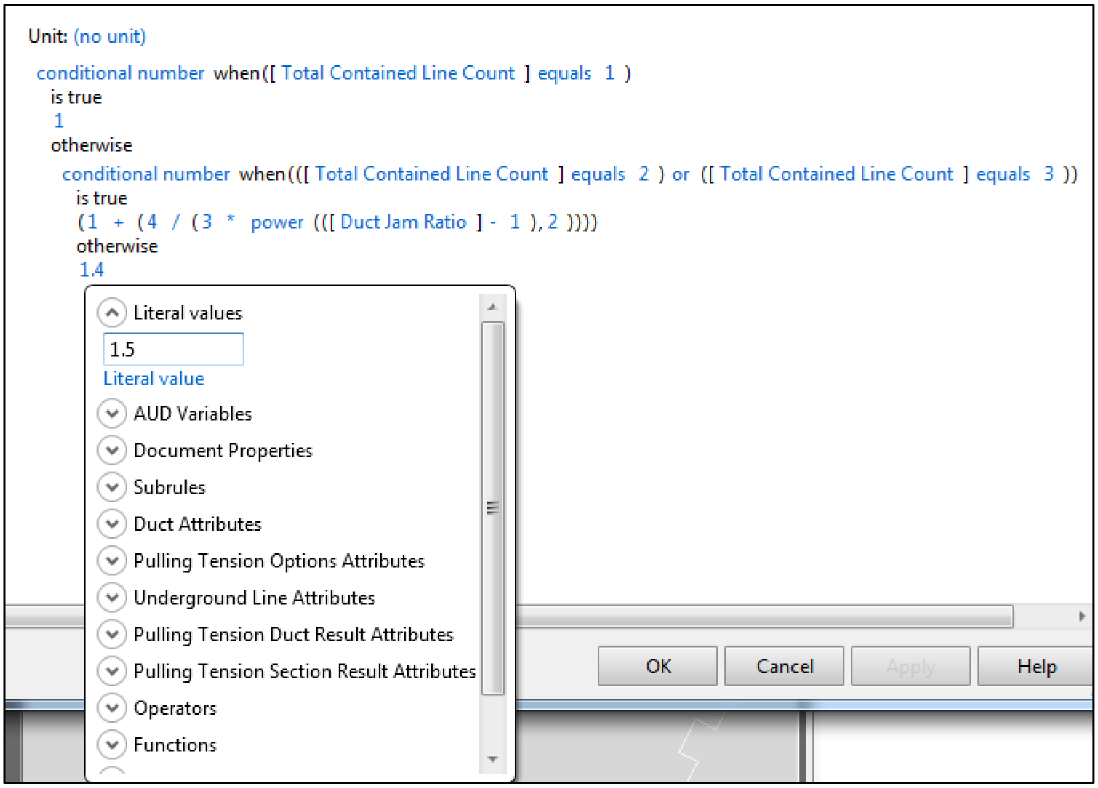



Figure 16 - Weight Correction Factor Equation Modification

### *Modifying a Pulling Tension Validation Rule*

Similarly, validation rules can also be customized. For example, the validation rule for pulling tension throws an alert to the user if pulling tension exceeds the maximum eye and grip pulling tensions for the cable:

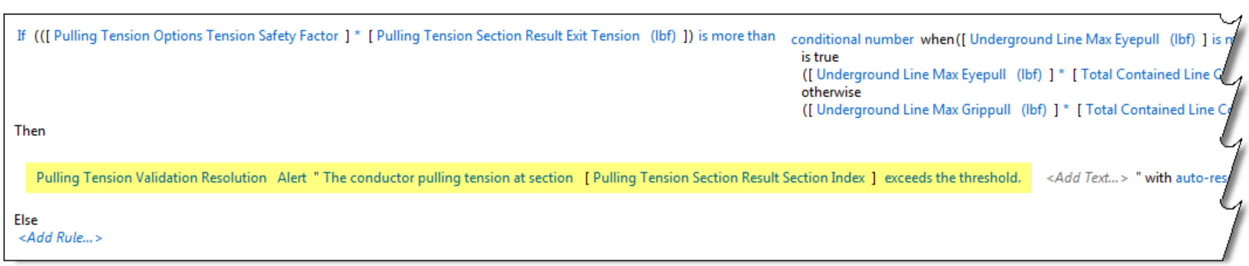



Figure 17 - Alert for Pulling Tension

In this situation, your organization would like to also recommend the user to try adjusting to a larger conduit size. This message can be easily added to the validation rule by adding an additional literal text value to the alert:

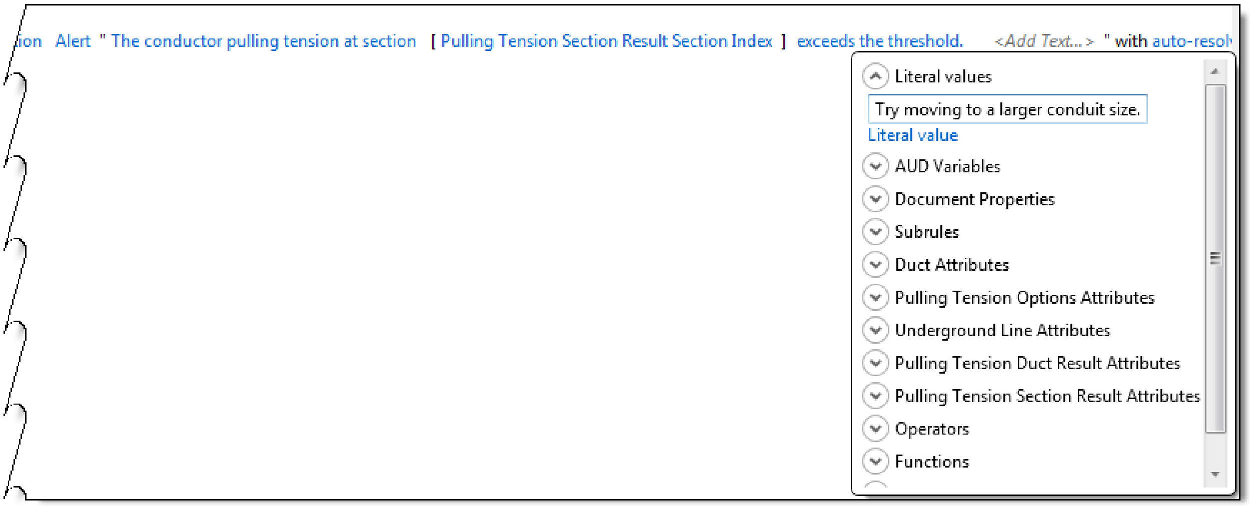



**Figure 18 - Modify the Alert Text**

Now when pulling tension exceeds the allowed value, the user will get the updated custom alert:

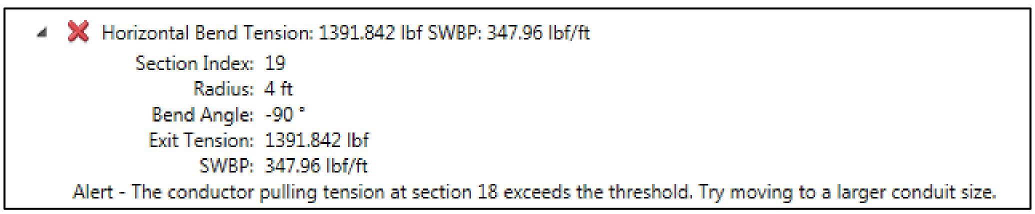



**Figure 19 - Updated Alert**

## Adjust and optimize your workflows and tools based on the lessons learned at SCE

Prior to AUD, SCE planners and designers used to hand draw maps and provide it to the crews for installation of the Transmission and Distribution networks. In the late 90's SCE started to integrate into an automated drafted design called the Planner Office Project (POP). This allowed for the basic designs to be created in a non-scaled environment which had the ability to upload material to SCE's pricing engine.

In an effort to improve SCE's drafting standards in the early 2000's, SCE's planning department moved to a Microsoft Visio based design until late 2009 when the Graphical Design Tool was launched into the Transmission and Distribution user base.

Prior to release, SCE aggressively conducted training on the new Graphical Design Tool, which included an extensive self-learning web based training (WBT) developed by Autodesk Consulting with SCE input to ensure consistency in the drafting standards. This WBT is still leveraged today as we develop new functionality and bring on new designers and planners in GDT as basic AutoCAD skills are a prerequisite prior to using AUD.

SCE staffs and maintains a user support team for AUD questions and user issues. SCE also provides refresher training as new functionality is developed and integrated into the GDT solution.

SCE underwent an extensive review of all its standards manuals (ESR, DDS, UGS, DOH, etc…) to understand the full intent of the standard and to remove any ambiguity prior to implementation into the GDT tool. SCE still mandates and requires SCE engineering and standards approvals for any changes made to the GDT core code or back end engineering configuration.