A MATLAB BASED ANALYSIS TOOL FOR CLEARANCE AND THERMAL VIOLATIONS IN TRANSMISSION POWER LINES

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DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science in Engineering at the University of Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at any other University.

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(Signature of Candidate)

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ABSTRACT

Clearances are an important aspect of High Voltage (HV) transmission line design, construction and maintenance. A software tool that combines clearance violation analysis and optimum loading operating conditions for power lines could save power utilities the capital cost of refurbishing transmission power lines that marginally exceed maximum power line clearance distances. This can be achieved by operating the power lines at an optimum amperage level for any given set of weather conditions.

This research project proposes a low cost MATLAB® based software tool that detects clearance violations and determines operational limits on transmission power lines using prevalent weather conditions as well as the power line amperage. Various power lines around the states of Missouri and Illinois in the United States of America are analysed to test the viability and functionality of the software. In order to validate the accuracy of the program, the results obtained were compared to results from PLS-CADD®.

Key Words: conductor, clearance, sag, software, temperature

This work is dedicated to my mother, sister, friend and mentor

Siphiwe Mary Mabuza

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Magnetic heating	P_m
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Corona heating	P_I
Solar heating	P_S
Convective cooling	P_c
Radiative cooling	P_r
Evaporative cooling	P_W
AC resistance of the conductor at 20 ^{0}C (Ω/km)	R_{ac}
Conductor current (A rms)	I_{ac}
Average temperature of the power line conductor (^{0}C)	T_{ave}
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Absorptivity of the surface of the conductor	α
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Span length (ft)	l
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Diameter of the cable (m)	D
Specific density of air $(\frac{kg}{m^3})$	γ
Dynamic viscosity of air $(\frac{Ns}{m^2})$	η
Thermal conductivity of air $(\frac{W}{m^0C})$	λ
Conductor length at any temperature T (^{0}C)	L_T

Conductor length at any temperature T_0 (^{0}C)	L_{T_0}
Coefficient of thermal expansion ($\frac{ft}{ft}\frac{10^{-6}}{^0C}$)	$\propto_T$
Conductor length when subjected to a stress σ (ft)	L_σ
Stress-free value of conductor length (ft)	L
Conductor Elastic Strain ($\frac{ft}{ft}$)	ϵ_o
Conductor Stress ($\frac{lbs}{in^2}$)	σ
Conductor modulus of elasticity ($\frac{lbs}{in^2}$)	E
Conductor cross-sectional area (in^2)	A
Conductor tension (*lbs*)	H
Plastic deformation of the conductor due to high tension and creep (*lbs*)	ϵ_C

1. INTRODUCTION

The increasing need for power coupled with the high cost and diminishing availability of land for power line servitudes brings about the need to share servitudes for multiple lines at different voltages (both transmission and distribution) and use available servitudes efficiently. Maintaining safe clearance distances to adjacent structures, humans, animals and other power lines has also become increasingly important for electricity utilities as regulatory bodies begin to force adherence to safety standards.

The North American Electric Reliability Corporation (NERC) has recently embarked on a program that will force all utilities in North America to comply with the minimum clearance distances set out in NERC's recommendations to industry, issued on October 7, 2010. This task necessitates the modelling and analysis of all alternating current (AC) transmission power lines with the output being the identification of remediation and refurbishment projects where clearance violations exist.

Software packages such as TLCAD and PLS-CADD are used to physically model both the transmission and distribution power lines. These packages are also used to generate reports that show clearance distances between the main line and the obstacles such as ground, under-build conductors, and vegetation as well as natural and man-made structures. Unfortunately PLS-CADD, which is widely used in the electrical engineering design field, is an extremely expensive tool. Furthermore, only a small portion of its functionality is used for clearance violation assignments.

LiDAR data for transmission lines belonging to the AMEREN utility in the United States of America (USA) were used on this project due to the unavailability of similar accurate data on transmission lines from utilities in South Africa such as ESKOM and City Power. The data used on the project includes the time as well as the prevailing weather conditions at the time when the lines were flown. As a consequence, all the data for the analysed lines is presented in imperial units as is the norm in the USA. Conversion of this data would have been a cumbersome exercise and is not essential to the demonstration of the functionality of the developed software tool. The software can be calibrated accordingly for use with metric (SI) units.

1.1 Research Summary

This research report is divided into six chapters, the contents of which are as follows:

Chapter 1 provides an introduction to the research study. In this chapter, the research objectives are given as well as the available programming options to implement the intended power line analysis software tool. The merits of each of these options are also discussed. Lastly, the significance of the research project in the electrical engineering field is given.

Chapter 2 covers the literature study and theoretical analysis of the factors that contribute to conductor sag and temperature in high voltage transmission power lines. The applicable formulas that are used to model static and dynamic conductor temperature as well as conductor sag are given in this chapter.

Chapter 3 lays out the methodology used to formulate the applicable algorithms in MATLAB and also explains the background of the data entered into the program in order to obtain the required results.

Chapter 4 covers the test procedure used for checking the functionality of the developed software tool and also discusses the results obtained from the tests.

In Chapter 5, the results of the research project are discussed in detail and the major differences between the PLS-CADD and PLC-VAST software packages are also discussed. The shortcomings of the developed software are also highlighted in this chapter.

Chapter 6 covers the conclusions and recommendations for future work.

The appendix is made of the corresponding PLS-CADD results for the tested lines, clearance criteria for the various reports, the MATLAB source code for the PLC-VAST program and PLC-VAST screenshots for the various lines that were tested. The user manual for the PLC-VAST program and the project proposal is also included in Appendix D of this report.

1.2 Problem Statement

Overhead power transmission and distribution lines are often designed with clearance violations to humans, animals, vegetation as well as natural and man-made structures such as buildings, railway lines and other crossing conductors. Clearance distances to these impediments are a major design factor and constraint to the power transfer capability of the transmission line.

The environmental, construction and maintenance issues that guide the design process with regards to sag and tension of conductors are discussed in [2]. Due to historical conventional design methods such as the deterministic approach, operational power lines that were constructed decades ago are often under-utilized and using modern design methods can improve the power transfer capability whilst conforming to the clearance regulations.

Utilities around the world are finding it increasingly difficult to construct new lines or even upgrade existing lines in order to meet rising energy demand due to various reasons from high capital costs to acquisition of servitudes. Public opposition to construction of new lines is also a significant concern. By operating existing transmission lines closer to their thermal limits, the construction of new lines can be delayed or abandoned altogether. This can help to reduce the capital cost altogether.

There is a maximum amount of power that can be transmitted by every power line circuit of a transmission and distribution network before violating the regulatory security and safety measures that are enforced by regulatory bodies and power utilities themselves. This maximum transferable power is limited not only by the conductor material but also by the weather conditions which in turn influence the thermal limit of the conductor and its sag. Due to high capital costs of erecting new transmission and distribution networks, growing economies and rising demand for electricity, power utilities are under pressure to efficiently utilize the available network grid components to transfer the maximum possible power without compromising the safety and security of the network, living beings and structures alike.

Since transmission power lines are traditionally designed to transfer a certain amount of maximum power at a specific conductor temperature which corresponds to ‘worst case’ weather conditions, it is therefore possible to transfer additional power under less severe weather conditions without exceeding the regulated minimum clearance distances. If the weather conditions such as ambient air temperature, global solar radiation, wind speed and wind direction are known for sections of a power line circuit, the maximum power transfer capability of the transmission line and the conductor sag can be calculated. Several methods to improve power transfer efficiency have been proposed in the past using various methods such as real time monitoring using global positioning systems (GPS) [6], replacement traditional power conductors (ACSR) by the High-Temperature Low Sag (HTLS) conductor [9] and the power line carrier (PLC) sag technique [7].

Using MATLAB, a cheap solution can be designed to measure conductor sag as a function of weather conditions and amperage loading. Furthermore, if an external method of measuring the weather parameters and amperage loading is available, the sag and thermal limits can be calculated in real-time with a slight time lag.

1.3 Research Objectives

The main objective of this research project is to develop an alternative computer software tool that can analyse clearance violations on overhead transmission and distribution power lines. The use of the MATLAB® development platform is the preferred over other environments for several reasons ranging from capital costs to flexibility and ease of use. It also offers educational institutions the chance to transfer knowledge on transmission line design to scholars without having to purchase expensive industry-accepted software tools.

The researcher has developed the software tool in MATLAB and performed thermal analysis of the transmission lines in the developed PLC-VAST software tool as well as in PLS-CADD for comparison purposes.

The collection of LiDAR data was performed by others and does not form part of the scope of this project.

1.4 Research Questions

The leading research questions that were addressed in this project are the following;

- Can a Light Detection and Ranging (LIDAR) plotting tool be implemented on the MATLAB graphic user interface (GUI) platform using an existing data set for use on transmission lines?
- Can the developed software tool be used to detect clearance violations in overhead transmission lines once the data has been plotted?
- Can the software tool be used to predict the behaviour of the line when subjected to different external weather and environmental conditions as well as different amperage loading conditions?

1.5 Significance of The Research

The research output from this project will enable engineering firms to forgo the purchase of expensive software packages, or at least purchase fewer licenses in order to achieve the same work output. This is due to the fact that the proposed MATLAB based PLC-VAST software tool has some of the functional capacity that PLS-CADD possesses. The PLS-CADD software can then be used to re-design the overhead power lines that are found to violate the NERC code.

Possible avenues for application of the software could be in determining the effect of re-stringing a circuit using a different conductor on the sag given a set of weather conditions, conductor properties and initial tension values. This would give an initial estimate of how the conductor would behave if re-strung with low sag conductors such as Aluminum Conductor Composite Reinforced (ACCR) and Aluminium Conductor Composite Core (ACCC).

In conjunction with long term master planning that forecasts the load growth on the power line over a period of time (typically 20-30 years), refurbishment plans could also be delayed for a few years whilst the line is operated under optimum conditions if funding is not available to immediately implement remediation projects.

If the software tool is developed further and commercialized, it could break down the barriers to market entry for smaller firms that do not have the financial muscle to purchase several licenses of the PLS-CADD software.

The software tool presented in this project could also be used by educational institutions which already possess MATLAB licences as part of their inventory for use with other engineering disciplines and departments such as computer science and mathematics. In the electrical engineering department in particular, the tool could be used to demonstrate the fundamentals of overhead power line conductor selection and operation based on environmental factors and loading, whilst giving real life examples of the clearance violation constraint that has to be considered during the design phase.

2. RESEARCH BACKGROUND

2.1 Literature Review

Several papers and studies have been published on the topics of transmission power line sag studies, conductor rating calculations and processing of LIDAR data using MATLAB. A summary of selected references on overhead line dynamic ratings, conductor sag and LIDAR data processing are shown in Table 2-1 below.

Table 2-1: Selected Literature Study References

Ref. No.	Author	Title of Article	Topic of Research
[1]	Pillay T. Bisnath S.	The Planning, Design and Construction of Overhead Power Lines	General Power Line Design, Clearance violations, conductor temperature calculation using Cigre method
[5]	Krontiris T. Wasserrab A. Balzer G.	Weather-based Loading of Overhead Lines – Consideration of Conductor's Heat Capacity	Conductor temperature calculation based on weather conditions
[9]	Berjozkina S. Sauhats A. Bargels V. Vanzovichs E.	Detecting the Capacity Reserve in an Overhead Line	Conductor temperature calculation based on conductor material properties.
[11]	Slegers J.	Transmission Line Loading - Sag Calculations and High-Temperature Conductor Technologies	Transmission Line Loading: Theory of transmission line sag calculations based on weather conditions, ampacity ratings and conductor material properties.
[15]	IEEE Power Engineering Society	IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors	Conductor sag calculations based on weather conditions, conductor properties and amperage loading using IEEE738:2006 method

Several attempts have previously been made to tackle related problems in the power line design industry [6, 7, 9]. However, recent attempts have used relatively expensive and maintenance intensive methods. The problem with these methods is that they are inaccurate in that they use an average temperature to rate the entire line and do not consider the prevalent conditions on each span or section. These methods may result in a very inaccurate design especially for designs on long distance transmission power lines that may span areas with a broad range of weather conditions.

In addition to commercially available existing software such as PLS-CADD which can be used to detect clearance violations, two known research initiatives have previously been undertaken by the South African power utility, ESKOM. ESKOM has produced the Reticulation Sag and Tension (RSAT) software [4] for MV distribution lines and Real-Time Monitoring System (RETMOS) [1] for a specific HV 400kV line between Tutuka and Kriel power stations.

2.2 Overhead Power Line Sag Theory

The aerial position of overhead power line conductors in space, or their sag, is always changing due to factors such as the ambient temperature, solar radiation, wind speed and wind direction in the vicinity of the affected span. This has an effect on the vertical safety clearance of the conductors and consequently the thermal rating of the whole power line [1]. Other extreme weather phenomena such as galloping and ice loading may also affect the instantaneous position of the power line conductor in space. The sag phenomenon in relation to the ambient and conductor temperatures is illustrated in Figure 2-1 below.

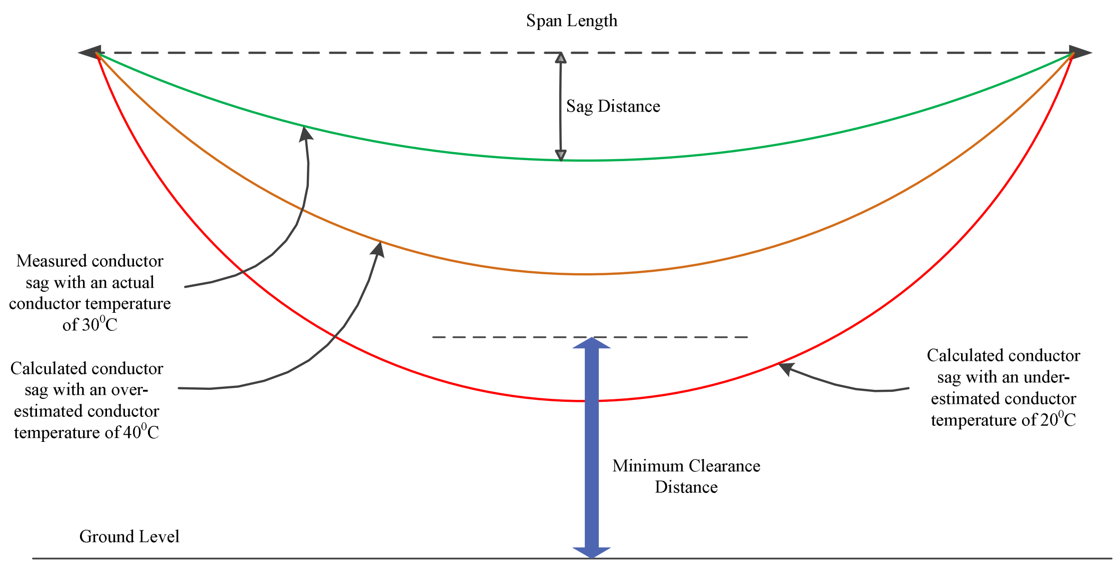

Figure 2-1: Vertical clearance of conductors above ground.

2.3 Clearance and Line Geometry

Various clearance requirements are put in place by power utilities to ensure operational safety and also to protect living beings from being electrocuted. Phase clearances, tower clearances, and live lines working clearances are just some of the clearances to be considered when designing a power line. This study focuses on the horizontal and vertical clearance requirements from the conductors to ground, man-made structures and vegetation points.

To comply with statutory NERC requirements, the conductors must be supported and sagged so that at an ambient temperature of 50 °C (122 °F) and in still air, the minimum clearance above ground or to a structure is in accordance with the clearance criteria set out in Annexure A as used in the design of overhead transmission power lines.

2.4 Environmental Conditions

Various weather conditions also affect the sag of an overhead power line in addition to the current flowing through the conductor. The important weather parameters to take into account with regards to the sag of an overhead power line are the ambient temperature, thermal radiation, wind speed and wind direction. If all these parameters remain constant at any point in time, the conductor temperature which is the average of the temperatures of the conductor core and the conductor surface eventually stabilizes to a uniform steady state value.

Convective cooling is a very important factor in the determination of the thermal rating of overhead transmission or distribution power line conductors. As a result, the thermal rating of power lines is normally cooler at night when the wind is low than during the day. During convective cooling, air around the warmer outer surface of the power line conductor heats up. The density of this heated air then decreases, which in turn causes the heated air to rise or be carried away, depending on the nature of convection (natural or forced) [1]. Wind speed, wind direction, ambient temperature as well as conductor material and type of construction all play a role in the level of cooling that occurs.

2.5 Probabilistic vs. Deterministic Methods

The most prevalent methods used for the thermal rating of overhead power lines in modern electrical engineering are the probabilistic method as well as the deterministic method. The probabilistic method uses actual maximum allowable and probabilistic ambient temperatures. It has the following advantages over the deterministic method;

a) The capital cost of constructing the power line can be greatly reduced as a result of optimal design.

b) Dormant sections of the transmission network with spare capacity can be used when needed during certain times of the day or during critical periods of the year.
c) The allowable emergency period for overloading of the line can be extended, which in turn improves system reliability and security.
d) Individual problematic line spans where line loading results in clearance violations can be fixed by means of re-stringing or reconstructing the span at a higher clearance as opposed to rebuilding the whole power line. This method of remediation has a huge implication on the cost savings.

There are several variations of the probabilistic line thermal rating method. In addition to the probabilistic and deterministic methods is the ‘real-time’ method of conductor ampacity calculation. Real-time monitoring refers to instantaneous calculation of the position of the conductor in space. The position of the conductor is determined using optical cameras or real time measurement of the conductor temperature. The maximum current that can be transmitted before a violation occurs is then calculated using the prevalent weather conditions at the time of the calculation. Examples of real-time monitoring calculators are given in [6, 7, 8].

2.6 Sag Calculation Using Ruling Span Method

The sag of a transmission power line conductor is influenced by various factors such as conductor material, ampacity loading, creep and weather conditions. The sag distance of a conductor is dependent on the conductor initial tension, conductor weight, conductor length and the material properties of the conductor. The conductor has a core cross-sectional area and diameter, unit weight and stress-strain curves for both the core and the conductor. In addition to these properties, each conductor will have a coefficient of thermal elongation. All these properties can be found on the product data sheets from conductor manufacturers such as Southwire [16] as well as CBI African Cables and Aberdare in the context of the South African market.

The distance between the overhead transmission line conductor structural supports (steel lattice towers, concrete towers or wooden poles) is called a span. The catenary curve formed by the conductor between any two structural supports can be described by a hyperbolic function of the following form;

$$s = \frac{H}{w} \times \left[\cosh\left(\frac{w \times l}{2H}\right) - 1\right] \quad (1)$$

Where the symbols denote the following parameters;

s = maximum sag distance (ft)

H = horizontal tension at each support end (lbs)

w = weight per unit length (lbs/ft)

l = span length (ft)

Cosh = non-linear hyperbolic cosine function

Due to the complex nature of the non-linear hyperbolic cosine function when applied to a transmission line with multiple spans, this function is normally simplified as described in [11] by linearization around $l = 0$ to yield the simplified formula;

$$s = \frac{w \times l^2}{8H} \quad (2)$$

The entire length of the transmission line conductor can be described by the following function;

$$L = \frac{2H}{w} \sinh\left(\frac{w \times l}{2H}\right) \quad (3)$$

Similarly, this function can be simplified by linearization around $l = 0$ to yield the simplified formula;

$$L \cong l + \frac{w^2 \times l^3}{24H^2} \cong l + \frac{8s^2}{3l} \quad (4)$$

$$\Delta L = L - l \cong \frac{w^2 \times l^3}{24H^2} \quad (5)$$

Where ΔL represents the slack in the conductor. The slack is defined as the difference between the span length, l and conductor length, L. As seen from the above equations, sag and tension parameters are dependent on the slack.

A transmission line made up of multiple spans can be approximated using the principle of the ruling span [11]. In this approximation, a single representative span is used to define the entire transmission power line. This representative ruling span with the calculated dimensions will have a similar sag value to that which would be seen if the transmission power line had equal spans, and the conductor insulator supports were all of the suspension type and were free to move in any direction. If the insulator supports are allowed to move freely, the horizontal tension from the conductor at any point of the insulator attachment must be equal from both sides of the insulator in the horizontal direction. On the ruling span, the tension at both imaginary attachment points would be equal to the tension that would be prevailing at the end of each of the equal spans. The ruling span method can be used to compare the behaviour of different conductor sizes made up of different materials, along the entire length of a transmission power line. The 'ruling span' S_R is the span length of this conductor. For a transmission line with n spans, the representative equation for the calculation of the ruling span is as follows;

$$S_R = \sqrt{\frac{\Sigma s_i^3}{\Sigma s_i}} \quad \text{ft} \tag{6}$$

This assessment however cannot be entirely accurate since the conductors are normally held in place by insulators in a real transmission power line. The insulator attachments may be fixed (e.g. dead-end insulator) or free to move (e.g. suspension insulator). In either case, the horizontal movement of the conductors will be limited. Transmission lines also have varying elevation distances which alter the distribution of weight of the conductors and consequently affect the tension applied at the insulators supports.

2.7 Conductor Temperature Calculation

The calculation of steady state conductor temperature is derived from the heat equation which summates the relationship between the prevailing environmental conditions, the ampacity loading of the line and the electrical characteristics of the conductor material. A differential equation can be derived to represent the heat transfer process for conductors under dynamic conditions. The derivation of this equation is explained in [2] and is not part of the scope of this research project. Weather based loading of transmission lines under dynamic conditions is also discussed extensively in [5] using a case study to illustrate the calculations.

The heat balance equation for power line conductors is explained in detail in [1] and can be summarized as follows;

Heat Gain = Heat Loss

$P_m + P_J + P_I + P_S = P_c + P_r + P_W$ (units are W/m)

Where;

P_m = magnetic heating

P_J = Joule heating

P_I = Corona heating

P_S = Solar heating

P_c = Convective cooling

P_r = Radiative cooling

P_W = Evaporative cooling

Corona heating, P_I can be assumed to be negligible and is only considered during excessively wet conditions when the evaporative cooling factor is high.

The individual equations for the components of the heat balance equation are shown below;

$$P_j = I_{ac}^2 \times \frac{R_{ac}}{1000}[1 + 0.00403(T_{ave} - 20)] \qquad \text{W/m} \qquad (7)$$

Where;

R_{ac} = AC resistance of the conductor at 20 ^{0}C (Ω/km)

I_{ac} = conductor current (A rms)

T_{ave} = average temperature of the power line conductor (^{0}C)

$$P_s = \alpha_s \times Dia[I_D \times (\sin\eta + \frac{\pi}{2} \times F \times \sin H_s) + B] \qquad W/m \qquad (8)$$

The following equations can be used to derive the components of the solar heating equation above;

$$I_D = 1280 \times \sin\frac{H_s}{(\sin H_s + \pi)} \qquad W/m^2 \qquad (9)$$

Where H_s is the solar altitude

$$B = I_d \times (\frac{\pi}{2})(1 + F) \qquad (10)$$

$$\eta = \cos^{-1}[\cos H_s \times \cos(\Upsilon_s - \Upsilon_c)] \qquad (11)$$

$$H_s = \sin^{-1}[(\sin\Phi \times \sin\delta_s) + (\cos\Phi \times \cos\delta_s \times \cos Z)] \qquad (12)$$

$$\Upsilon_s = \sin^{-1}[\cos\delta_s \times \frac{\sin Z}{\cos H_s}] \qquad (13)$$

$$\delta_s = 23.4 \times \sin[(360 \times (284 + N))/365] \qquad (14)$$

Where N represents the day of the year (e.g. January the 5th would be represented as N=5)

The radiation energy of the sun can be measured using a solar sensor such that the representative equation for the solar heat can be simplified to;

$$P_s = \alpha \times solar\frac{Dia}{1000} \qquad W/m \qquad (15)$$

Where

α = absorptivity of the surface of the conductor
Dia = outside diameter of the conductor (m)
Solar = radiation level of the sun in W/m^2

The magnetic heating, P_m can be calculated from Morgan's empirical equation as;

$$P_m = 4.9 \times 10^6 \times \frac{A_s}{10^6} \times B_m^{1.82} \times e^{(-2.5 \times T_c \times 10^{-3})} * \sqrt{\frac{d_s}{1000}} \qquad W/m \qquad (16)$$

Where

A_s = cross sectional area of the steel core (mm^2)
T_c = the conductor core temperature (^0C)
B_m = the peak value of the magnetic induction in steel core (Tesla)

The core temperature, T_c, can be calculated from the following equation;

$$T_c = T_s + \frac{P_{gain}}{4\pi}\left[0.5 - \frac{d_s^2}{\left(\frac{Dia^2}{1000}\right) - d_s^2}\left(\ln\left(\frac{\frac{Dia}{1000}}{d_s}\right)\right)\right] \qquad °C \qquad (17)$$

Where

T_s = surface temperature of ACSR conductor (°C)
P_{gain} = total of Joule heating (P_j) and solar heating (P_s)
Dia = outside diameter of the conductor (m)
d_s = diameter of the steel wire in the core of the ACSR conductor (mm)

The equations for the cooling factors can be calculated as follows;

$$P_{rad} = \pi \times \frac{Dia}{1000} \times \varepsilon \times \sigma_B \times [(T_s)^4 - (T_a)^4] \qquad W/m \qquad (18)$$

Where;

ε = emissivity of the conducting material

σ_B = 5.6697 x 10^{-8} (W/m^2.^{0}K)

The radiative and evaporative cooling components are normally far smaller in comparison to the value of the convective cooling and are sometimes considered negligible in the heat balance equation.

Under dynamic conditions, the average temperature of the power line conductor, T_{ave}, is taken to be the average of the conductor core and surface temperatures.

Several methods are commonly used in industry for the calculation of the conductor temperature. Some of the more common ones are the Cigré method which is detailed in [1] and the IEEE 738:2006 method [15]. A recent revision of the IEEE 738:2006 method is available and was published in 2012. A 2013 draft is also available even though it hasn't been officially published. However, for the purposes of this research project, the IEEE 738:2006 standard has been used to calculate the conductor temperature for all spans and sections.

In the IEEE 738:2006 standard, the convective heat loss per unit length, P_c, is formulated by first calculating the Nusselt number Nu as follows;

$$Nu_{lo} = 0.32 + (043 \times Re^{0.52}) \text{ for low wind speeds} \qquad (19)$$

$$Nu_{hi} = 0.24 \times Re^{0.6} \text{ for high wind speeds} \qquad (20)$$

Where

$$Re = \frac{v \times D \times \gamma}{\eta} \tag{21}$$

Then $P_c = \pi \times \lambda \times Nu\ [(T_s - T_a)]$ (22)

The symbols *v, D, γ, η* and *λ* in equations (21) and (23) represent the following parameters;

v = Wind speed around the main power line conductor ($\frac{m}{s}$)

D = Diameter of the cable (m)

γ = specific mass of air ($\frac{kg}{m^3}$)

η = Dynamic viscosity of air ($\frac{Ns}{m^2}$)

λ = Thermal conductivity of air ($\frac{W}{m^0C}$)

2.8 Creep and Permanent Elongation

Most of the overhead transmission lines that were analysed as part of the NERC clearance violation project have been in operation for more than a decade and in some cases they are approaching the end of their recommended operational lifecycle (approximately 40 years). It would therefore be expected that the conductors would have undergone permanent thermal elongation due to continued exposure to heat. During thermal elongation, the length of the transmission line conductor, *L*, will increase while the span length, *l*, remains the same since the position of the support structures does not change. The tension in the span will decrease as a result of this thermal elongation. The thermal expansion and strain under tension must therefore be considered when calculating the sag distance of a current-carrying conductor. To find the sag distance of a hot conductor, one must consider both the thermal expansion and the strain under tension. The sag can be calculated by using the following equations:

Starting with an initial temperature T_0, which is close to a temperature *T*, the length of a conductor at the temperature *T* can then be calculated as follows;

$$L_T = [1 + \propto_T \times (T - T_0) \times L_{T_0}] \tag{24}$$

Where the symbols stand for the following parameters;

L_T = Conductor length at any temperature T (^{0}C)

L_{T_0} = Conductor length at any temperature T_0 (^{0}C)

$\propto_T$ = coefficient of thermal expansion ($\frac{ft}{ft}\frac{10^{-6}}{^0C}$)

The continuous stress-strain behaviour of the conductor over time due to high tension forces causes permanent elongation. The behaviour of the conductor within the elastic elongation range can be represented by the following equation;

$$L_\sigma = L \times (1 + \epsilon_o + \epsilon_C) \quad (25)$$

$$\epsilon_o = \frac{\sigma}{E} = \frac{H}{E \times A} \quad (26)$$

Where the symbols in the equation stand for the following parameters;

L_σ = Conductor length when subjected to a stress σ (ft)

L = Stress-free value of conductor length (ft)

ϵ_o = Conductor Elastic Strain ($\frac{ft}{ft}$)

σ = Conductor Stress ($\frac{lbs}{in^2}$)

E = Conductor modulus of elasticity ($\frac{lbs}{in^2}$)

A = Conductor cross-sectional area (in^2)

H = Conductor tension (lbs)

ϵ_C= Plastic deformation of the conductor due to high tension and creep (lbs)

Simplifying the equations yields the following expression which can be used to compute the sag:

$$l + \frac{w^2 \times l^3}{24 \times H^2} = \left(l + \frac{w^2 \times l^3}{24 \times H_0^2}\right) + = \left[1 + \propto_T \times (T - T_0) \times L_{T_0}\right] \times (1 + \frac{H - H_0}{EA} + \epsilon_C) \quad (27)$$

The maximum expected sag can therefore be calculated given the worst case weather conditions and amperage loading in any particular area. The maximum current that can be transported along the conductor whilst conforming to the clearance criteria from applicable standards such as SANS 10280-1:2008 can then be determined using the known weather parameters such as wind speed, wind direction, solar radiation and maximum sag.

The collected LiDAR for each transmission line can therefore be used to calibrate equation 27 and predict its behaviour under different load and weather parameters.

The tension has however not been measured for the individual lines and typical values have been used based on the ultimate tensile strength of the conductor. For example, ESKOM recommends a maximum conductor tension of 40% of the Ultimate Tensile Strength (UTS) at a temperature of –5 °C and a 700Pa wind pressure. The everyday tension (EDT) is recommended to be 20% of the UTS of the conductor.

2.9 MATLAB® and other Development Environments

MATLAB® is a computing language and interactive environment for programming, numerical calculation and visualization. This programming environment has built-in tools and functions that allow the user to employ a variety of methods to solve problems, unlike other software languages such as Visual Basic, Java and C/C++. Today MATLAB® is used in a wide range of industries for different applications ranging from computational finance, image and video processing, control systems, computational biology, signal processing and communications.

The Graphical User Interface Developmental Environment (GUIDE) toolbox within MATLAB® allows the user to build a graphical user interface interactively using its in-built buttons, menus, sliders and or programmatically through compiling source code that ensures more control over design and development.

C++ would have been the best choice to implement the PLC-VAST software tool, given its broad library of in-built suites for building GUI applications. However, limited knowledge of the programming language by the researcher precluded the viability of this option. The wide usage of MATLAB in the engineering academic field also informed the decision to opt for this language.

3. METHODOLOGY

The following section describes the principle of operation of the PLC-VAST software package from the receipt of Light Detection and Ranging (LIDAR) data from a third party surveyor to the production of clearance and thermal violation reports on the software tool. A functional flow diagram of the procedure is illustrated in Figure 3-1 below.

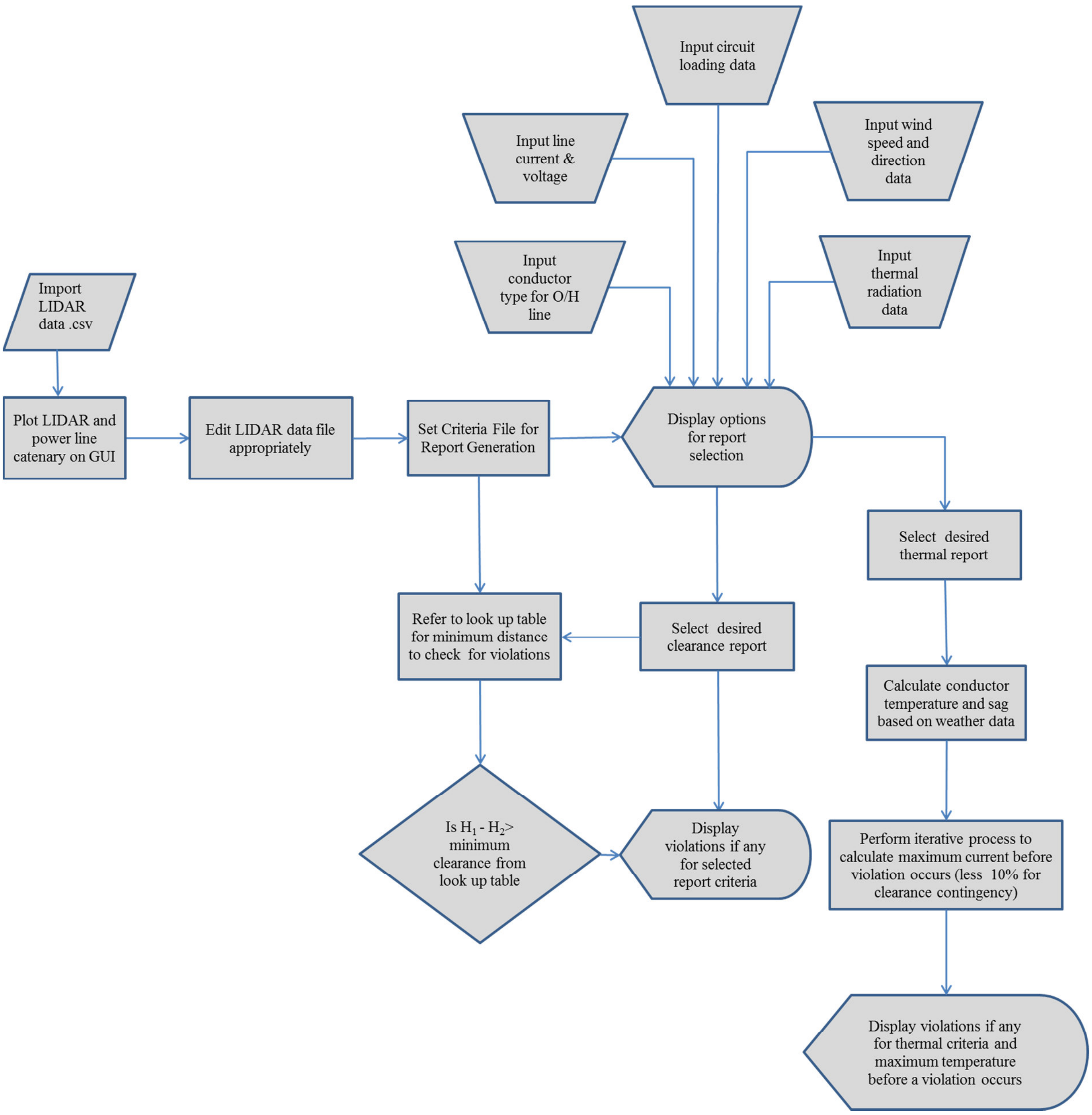

Figure 3-1: System Flow Diagram

The prevalent weather conditions and loading data are inserted manually by the end user on the GUI. Once the LIDAR has been plotted on the GUI, the end user then selects the type of conductor in order for the program to accurately compute the sag of the conductor using the characteristics of the conductor material.

The user can then select the desired report from a drop down menu on the GUI and the clearance violations, if any, will be displayed in a separate window. The user can also alter the LIDAR data by deleting and hiding points for example.

3.1 LIDAR Data Processing

The process of evaluating transmission power lines for clearance violations requires a LIDAR survey to identify all of the owning electricity utility's structure locations and conductor spans within specified corridors. The LIDAR survey and subsequent data analysis detects structure types, pole heights, conductor/shield wire attachment points and conductor/shield wire sag conditions as they exist in the field. In addition to this, the LIDAR survey captures topographical data located near or within the right of way (RoW) or line servitude including: ground elevations, vegetation, man-made structures, line crossings, etc.

The collected data is then analysed so that clearance impediments to ground, vegetation, other conductors, other utilities and encroachments can be identified. The existing clearances are examined and compared to the standards set forth by the owning electricity utility and any other regulatory bodies. In this case Ameren is the electricity utility and the National Electric Safety Code (NERC) is the set of minimum clearance conditions from the regulating authority.

The implementation of graphical user interfaces (GUIs) within MATLAB for processing of LIDAR data is discussed in [17] and forms the basis of some of the functionality on the PLC-VAST software.

The following feature codes shown in Table 3-1 to Table 3-3 are used for the purposes of this study, as a means of identifying each unique overhead and ground feature. Table 3-1 lists all the points which are located at ground level while Table 3-2 and Table 3-3 show the aerial and obstacle feature codes, respectively.

Table 3-1: Ground Feature Codes

Ground Points			
Item	**Feature Code**	**Description**	**Aerial or Ground Obstacle**
1	11	Set Control Point / Instrument Point	Ground
2	13	PI (point of intersection)	Ground
3	14	New TIN PI (defined by engineer)	Ground
4	100	Ground	Ground
5	104	Water	Ground
6	110	Road	Ground
7	116	Railroad	Ground
8	126	Swimming Pool	Ground
9	200	UNKNOWN FEATURE CODE	Ground
10	220	Guy wire anchor	Ground
11	500	Interpolated Points	Ground
12	1008	Temporary Objects	Ground

Table 3-2: Aerial Feature Codes

Wire Points			
Item	**Feature Code**	**Description**	**Aerial or Ground Obstacle**
1	230	Conductor/shield wire attachment point	Aerial
2	232	Insulator attachment point at structure	Aerial
3	236	Shield Wire	Aerial
4	237	Guy Wire	Aerial
5	240	Crossing conductor unknown voltage	Aerial
6	241	Crossing shield wire	Aerial
7	242	Crossing conductor 345kV	Aerial
8	243	Crossing conductor 230kV	Aerial
9	244	Crossing conductor 161kV	Aerial
10	245	Crossing conductor 138kV	Aerial
11	246	Crossing conductor 69kV	Aerial
12	247	Crossing conductor 34kV	Aerial
13	248	Crossing conductor 12kV / 4Kv	Aerial
14	275	Conductor splices	Aerial
15	276	Shield wire splices	Aerial
16	277	Aerial marker ball	Aerial
17	268	Comm. conductors, cables and messengers	Aerial
18	1001	Conductor Left/Bottom	Aerial
19	1002	Conductor Center/Middle	Aerial
20	1003	Conductor Right/Top	Aerial

Table 3-3: Obstacle Feature Codes

Obstructions			
Item	**Feature Code**	**Description**	**Aerial or Ground Obstacle**
1	131	Vegetation/ Tree / Brush	N/A
2	253	Transmission Structure Steel	N/A
3	254	Transmission Structure Wood	N/A
4	255	Other supporting structures	N/A
5	256	Center of Structure	N/A
6	301	Building	N/A
7	306	Silo / grain bin	N/A
8	321	Fence	N/A
9	335	Bridge	N/A
10	400	Street Light	N/A
11	405	Antenna, radio / TV	N/A
12	410	Sign	N/A
13	425	Pipeline	N/A
14	1007	Substation	N/A

3.2 Weather Data and Clearance Reports

The following procedure has been followed in predicting the conductor sag for arbitrary entered weather and loading data.

- Calculate the average values of ambient temperature, solar radiation, wind speed and wind direction.
- Using the IEEE738:2006 method, calculate the average conductor temperature for the entire line.
- Calculate the sag of the conductor based on formulae given in Chapter 2.

Weather data collected from line surveyors is received with information on the time at which the data was recorded as well as temperature, wind speed, wind direction and solar radiation. Table 3-4 on the next page shows the parameters required for the thermal calculation as well as the units and sources of this information. The form in which the weather data is presented is shown in chapter 4 for each of the tested transmission lines. Table 3-5 below shows the ampacity loading data from the Ameren Operations Department for the day on which the loading data was recorded.

The conductor properties such as cross sectional area, core diameter and rated strength are obtained from the Southwire product catalog [16].

Table 3-4: Parameters Required For Thermal Calculation

Parameter	**Unit**	**Source**
Wind Speed	feet per second (FPS)	Network Mapping Ground Station
Ambient Temperature	Degrees Farenheit	Network Mapping Ground Station
Wind Direction	Degrees	Network Mapping Ground Station
Solar Radiation	$Watt/ft^2$	Network Mapping Ground Station
Line Direction	Degrees	Network Mapping Ground Station
Elevation	Feet (From MSL)	Ameren Standard
Conductor	N/A	Ameren 0.5 Standard
Coeffecient of Absorption	N/A	Ameren 0.5 Standard
Ampacity Load	N/A	Ameren Operations Department

Table 3-5: Ampacity Loading Data From Ameren Operations Department

Date	Time	Hour Ending	DST	DUPOFERY LINE DPFE_SEL_1 MW	Ampacity	Voltage	138
11/20/2012	0:00	1	s	51.68	216		
11/20/2012	1:00	2	s	50.78	212		
11/20/2012	2:00	3	s	52.54	220		
11/20/2012	3:00	4	s	47.2	197		
11/20/2012	4:00	5	s	29.43	123		
11/20/2012	5:00	6	s	23.07	97		
11/20/2012	6:00	7	s	29.85	125		
11/20/2012	7:00	8	s	21.31	89		
11/20/2012	8:00	9	s	20.22	85		
11/20/2012	9:00	10	s	15.96	67		
11/20/2012	10:00	11	s	15.76	66		
11/20/2012	11:00	12	s	16.49	69		
11/20/2012	12:00	13	s	10.83	45		
11/20/2012	13:00	14	s	11.16	47		
11/20/2012	14:00	15	s	9.29	39		
11/20/2012	15:00	16	s	5.2	22		
11/20/2012	16:00	17	s	-30.78	129		
11/20/2012	17:00	18	s	-27.88	117		
11/20/2012	18:00	19	s	-10.68	45		
11/20/2012	19:00	20	s	4.5	19		
11/20/2012	20:00	21	s	2.73	11		
11/20/2012	21:00	22	s	0.18	1		
11/20/2012	22:00	23	s	5.35	22		
11/20/2012	23:00	24	s	28.02	117		

Since the tested lines are relatively short, the weather data is averaged to obtain a single value for each of the parameters required for the thermal calculation. The single values are then used on the ruling span to obtain the initial sag values. The worst case weather conditions are then used to calculate the maximum current that can be transmitted by each transmission line before a violation occurs. The user has to verify the load on the transmission line at the time of survey since the time noted in Table 3-5 is at Greenwich Meridian Time (GMT). The corresponding time for reading the value in Table 3-4 can be obtained from the time conversion sets shown in Table 3-6 below depending on whether the data was taken during US Central Standard Time (CST) or US Central Daylight Time (CDT). The periods for which the CST times are applicable are as shown below for the years 2011, 2012 and 2013 when the bulk of the transmission lines were surveyed. Users should be careful to note these times when reading the GMT times from Table 3-6.

- 2011 (3/13/2011 @ 2:00 AM – 11/06/11 @ 2:00 AM)
- 2012 (3/11/2012 @ 2:00 AM – 11/04/12 @ 2:00 AM)
- 2013 (3/10/2013 @ 2:00 AM – 11/03/13 @ 2:00 AM)

Table 3-6: Time Conversion Table

CST		CDT		GMT	
1:00	1:00:00 AM	2:00	2:00:00 AM	7:00	7:00:00 AM
2:00	2:00:00 AM	3:00	3:00:00 AM	8:00	8:00:00 AM
3:00	3:00:00 AM	4:00	4:00:00 AM	9:00	9:00:00 AM
4:00	4:00:00 AM	5:00	5:00:00 AM	10:00	10:00:00 AM
5:00	5:00:00 AM	6:00	6:00:00 AM	11:00	11:00:00 AM
6:00	6:00:00 AM	7:00	7:00:00 AM	12:00	12:00:00 PM
7:00	7:00:00 AM	8:00	8:00:00 AM	13:00	1:00:00 PM
8:00	8:00:00 AM	9:00	9:00:00 AM	14:00	2:00:00 PM
9:00	9:00:00 AM	10:00	10:00:00 AM	15:00	3:00:00 PM
10:00	10:00:00 AM	11:00	11:00:00 AM	16:00	4:00:00 PM
11:00	11:00:00 AM	12:00	12:00:00 PM	17:00	5:00:00 PM
12:00	12:00:00 PM	13:00	1:00:00 PM	18:00	6:00:00 PM
13:00	1:00:00 PM	14:00	2:00:00 PM	19:00	7:00:00 PM
14:00	2:00:00 PM	15:00	3:00:00 PM	20:00	8:00:00 PM
15:00	3:00:00 PM	16:00	4:00:00 PM	21:00	9:00:00 PM
16:00	4:00:00 PM	17:00	5:00:00 PM	22:00	10:00:00 PM
17:00	5:00:00 PM	18:00	6:00:00 PM	23:00	11:00:00 PM
18:00	6:00:00 PM	19:00	7:00:00 PM	0:00	Midnight
19:00	7:00:00 PM	20:00	8:00:00 PM	1:00	1:00:00 AM
20:00	8:00:00 PM	21:00	9:00:00 PM	2:00	2:00:00 AM
21:00	9:00:00 PM	22:00	10:00:00 PM	3:00	3:00:00 AM
22:00	10:00:00 PM	23:00	11:00:00 PM	4:00	4:00:00 AM
23:00	11:00:00 PM	0:00	Midnight	5:00	5:00:00 AM
0:00	Midnight	1:00	1:00:00 AM	6:00	6:00:00 AM

In addition to the provided information, the user has to verify if the phase conductor is a single wire or a bundled conductor. For circuits with bundled conductors assume half the ampacity listed in Table 3-5. For example if the ampacity loading table shows a load of 400A for a particular span, therefore a bundled conductor would have a loading of 200A.

The formulas given in Chapter 2 for the conductor temperature and sag calculations are then used to determine the clearance distances. The ruling span method is used for the purposes of this study for reasons already discussed.

The procedure for sag determination using PLS-CADD is given in [12, 13]. Specific techniques for resolving specific issues are given in [13, 14]. Such issues range from unstable insulators due to uneven tensioning during stringing and LIDAR data which returned inaccurate information regarding the height of crops due to the time of year when the data was taken.

3.3 Thermal Calculations

The thermal calculations are meant to determine the maximum current or power that can be transmitted through the conductor before a clearance violation occurs under the worst case weather conditions. The procedure followed in the computation of this current is derived from [15] as follows;

a) The height of conductor attachment points on the span is measured.
b) The voltage-dependent minimum clearance distance is subtracted from the measured height. The applicable clearance distances are given in Appendix A for each voltage level. The result of this calculation is the maximum allowable sag for the conductor.
c) The design value for the conductor maximum operating temperature (MOT) is taken from the utility operational diagrams.
d) The worst-case weather conditions for a specific area are then used to calculate the heat gain and losses corresponding to the MOT are calculated.
e) The corresponding conductor current that results from the input values is then calculated and taken to be the maximum temperature that be transmitted by the conductor.

The input values required for this calculation are mainly the voltage of the circuit, the height of the span, the weather conditions, conductor type, conductor maximum MOT and the initial horizontal tension of the conductor.

3.4 Report Generation

The generation of clearance and thermal reports on the MATLAB GUI is based on the clearance criteria shown in Appendix A. Each impediment class has two sets of reports, namely the normal clearance report and the critical clearance report.

The normal report only includes survey points with a horizontal distance to impediment of less than 30 ft. The critical report on the other hand includes survey points with a horizontal distance to impediment of less than 5 ft. This distance is measured from each conductor point to each impediment point within a 30 ft or 5 ft radius (depending on the type of report) of each conductor LIDAR point. The 30 ft is meant to cater for displacement of the conductor that may have happened due to wind.

Only the points on the main transmission line which do not meet the minimum requirements of the clearance violation criteria are included in the report. This is a contrast to the method which PLS-CADD uses to report violations whereby the impediments are included in the report as opposed to the main transmission line points which could not meet the minimum requirements.

This criterion for the reporting of the clearance violations should not be confused with the criteria for the checking of the violations listed in Appendix A. A summary of the checking procedure is shown in Figure 3-2 on the next page to illustrate the difference in each of the aforementioned distances and the different criteria.

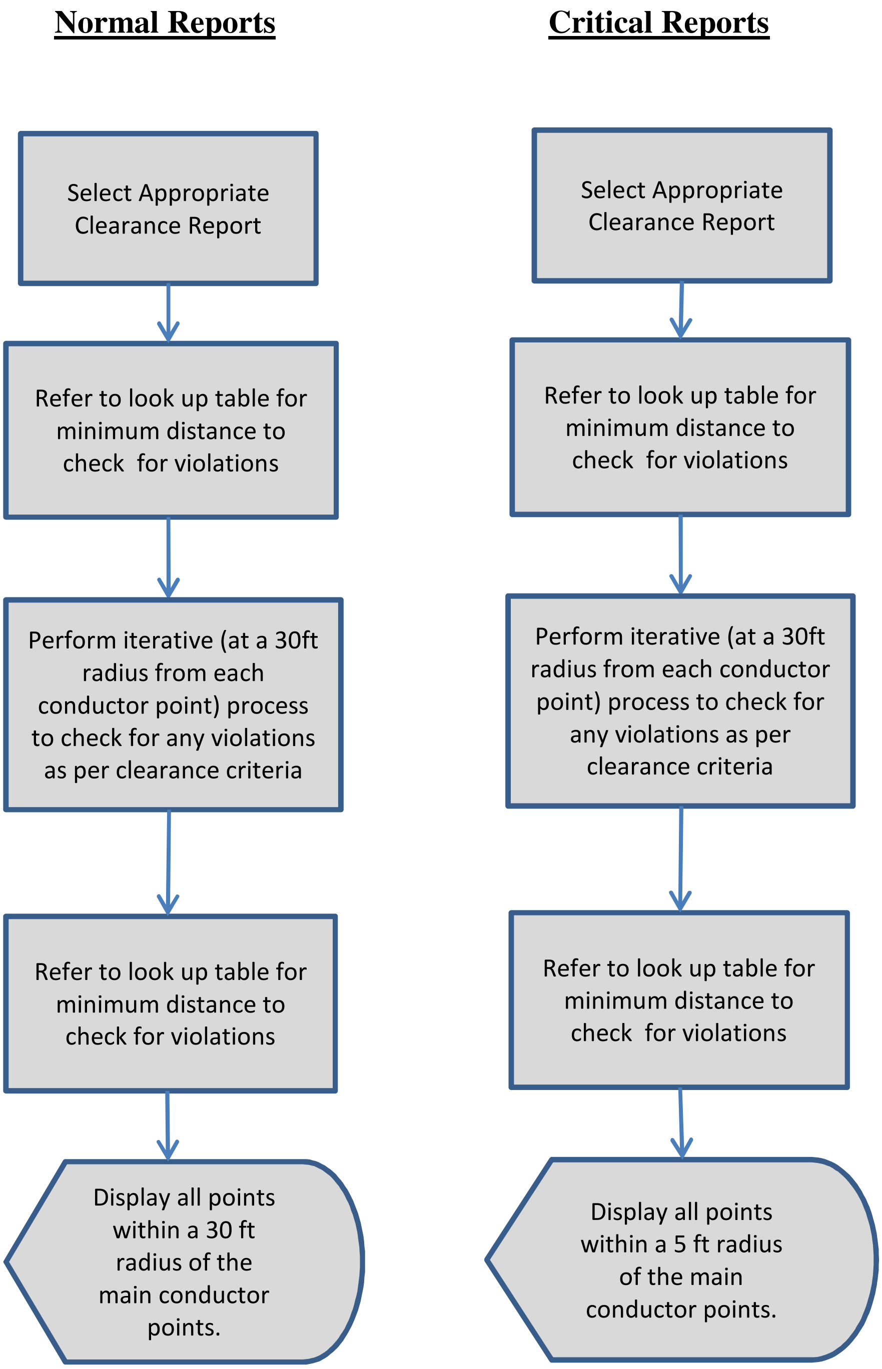

Figure 3-2: System Flow Diagrams for Report Generation

4. RESULTS

4.1 Test Procedure

The test procedure used for verifying the functionality of the developed PLC-VAST tool is as follows;

Stage 1 – Model the power line in PLS-CADD software using LIDAR data from surveyors.

Stage 2 – Run clearance and thermal violation reports in PLS-CADD.

Stage 3 – Model power line in PLC-VAST software using LIDAR data from surveyors.

Stage 4 - Run clearance and thermal violation reports in PLC-VAST.

Stage 5 – Compare results from PLC-VAST to PLS-CADD results to identify any similarities.

4.2 Software Functionality

The functionality of the PLC-VAST software is discussed extensively in the user manual which is included in Appendix D of this report. Screenshots from the program showing LIDAR data for various transmission lines displayed in the GUI window are also included in Appendix G. These can be compared to the screenshots from PLS-CADD for the same transmission lines. The PLS-CADD screenshots are shown in Appendix F.

Sample reports from PLC-VAST are also included in Appendix B of this report. These reports can also be compared to the corresponding PLS-CADD reports in Appendix C for the criteria given in Table A-1 - Table A-4 of Appendix A.

The complete MATLAB source code for the PLC-VAST program is included in Appendix E of this document. The source code encompasses the enabling call-back functions for the options on the GUI and the mathematical formulae involved in the calculation of conductor temperature and sag as presented in Chapter 2 of this report.

4.3 Test Results

The following overhead transmission power lines were analysed and tested on both the PLS-CADD and PLC-VAST software packages to determine the accuracy and capability of the developed PLC-VAST software.

- C-TKHL-1492-877: Cahokia Substation–Turkey Hill Substation
- BARN-CALF-1-36: Apache Flats Tap-off – California Substation
- HUST-BELU-3-354: Belleau Substation - Ft. Zumwalt Tap-Off
- DPFE-SEL-1-1485: Buck Knob Switching Station - Selma Substation
- DPFE-SEL-1-1558: River Cement Substation – Selma Substation
- SEL-RIV-2-779: St. Francois Substation Tap-off – Selma Substation/Rivermines Substation Tap-off
- PANN-R51D-1462-381: Decatur Rt 51 - Mt Zion Ppg Tap-off
- NDEC-EMST-1522-587: 27th Street tap-off - Decatur E. Main Substation

The results from each software package were then compared.

In the interest of time and due to the fact the reports take up a long time on PLC-VAST, the violations are only checked along the spans where violations were found on PLS-CADD to verify if PLC-VAST can detect the same violations as opposed to checking the entire length of the transmission line. In addition to this, only the reports which generated violations in PLS-CADD are produced in PLC-VAST in order to obtain a direct comparison. Other reports are generated merely for the purpose of showing the functionality of the program. The PLC-VAST reports in Appendix B do not include all the violating points due to space limitations. Only a few coordinates are shown for the purposes of demonstrating functionality. The report lists the total number of violating points nonetheless.

4.3.1 C-TKHL-1492-877: Cahokia Substation–Turkey Hill Substation

This overhead transmission line connecting Cahokia and Turkey Hill substations is situated in the state of Illinois, USA and belongs to the Ameren IP power utility. It is a 0.16 mile line operated at 138kV using 2156ACSR 84/19 Bluebird conductor. The design value for the maximum operating temperature (MOT) is 120°C. The line is supported by steel lattice towers and has a total of three spans. The meteorological line survey data for this circuit was completed on the 20th of October 2012, yielding the following weather results shown in

Table 4-1 below for the individual line spans. The ampacity loading at the time of the line survey was recorded as 54A.

The LIDAR data for the line displayed in the PLS-CADD and PLC-VAST environments is shown in Annexures respectively. The clearance and thermal violation reports can be found in Annexures B of this document.

Table 4-1: Meteorology Data for the C-TKHL-1492-877 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	10/20/2012	14:23:03	570182.6	50.7	232	6.05	4.16
2	10/20/2012	14:23:01	570181.0	50.7	232	6.05	4.16
3	10/20/2012	14:22:59	570179.2	50.7	232	6.05	4.16
4	10/20/2012	14:22:57	570177.1	50.7	232	6.05	4.16

4.3.2 BARN-CALF1-36: Apache Flats Tap-off – California Substation

This overhead transmission line runs from California substation to the Apache Flats tap-off. It is situated in the state of Illinois, USA and belongs to the Ameren UE power utility. It is a one mile long line operated at 161kV using 556ACSR 26/7 Dove conductor. The design value for the maximum operating temperature (MOT) is 110°C. The line is supported wood H-frame and has a total of nine spans. The line survey for this circuit was completed on the 12th of December 2012, yielding the following weather results shown in Table 4-2 for the individual line spans. The ampacity loading at the time of the line survey was recorded as 174A.

Table 4-2: Meteorology Data for the BARN-CALF1-36 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	11/12/2012	20:21:51	246110.8	41.6	222.00	10.9	32.4
2	11/12/2012	20:21:46	246105.7	41.6	222.00	10.9	32.4
3	11/12/2012	20:21:37	246097.0	41.6	222.00	10.9	32.4
4	11/12/2012	20:21:30	246090.4	41.6	229.00	11.1	32.6
5	11/12/2012	20:21:24	246083.8	41.6	229.00	11.1	32.6
6	11/12/2012	20:21:17	246077.3	41.6	229.00	11.1	32.6
7	11/12/2012	20:21:10	246069.8	41.6	229.00	11.1	32.6
8	11/12/2012	20:21:01	246061.2	41.6	229.00	11.1	32.6
9	11/12/2012	20:20:53	246052.6	41.6	229.00	11.1	32.6
10	11/12/2012	20:20:44	246044.1	41.6	229.00	11.1	32.6

4.3.3 HUST-BELU-3-354: Belleau Substation - Ft. Zumwalt Tap-Off

This overhead transmission line runs from Belleau substation to the Ft. Zumwalt tap-off. It is situated in the state of Missouri, USA and belongs to the Ameren UE power utility. It is also a one mile long circuit operated at 138kV using 795 ACSR 26/7 Drake conductor. The design value for the maximum operating temperature (MOT) is 110°C. The line is supported by steel lattice towers and has a total of seven spans.

The line survey for this circuit was completed on the 22nd of October 2012, yielding the following weather results shown in Table 4-3 below for the individual line spans. The ampacity loading at the time of the line survey was recorded as 12A.

Table 4-3: Meteorology Data for the HUST-BELU-3-354 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	October 22nd, 2012	16:58:29	147509.1	73.3	179	1.5	9.3
2	October 22nd, 2012	16:58:41	147520.7	73.3	179	1.5	9.3
3	October 22nd, 2012	16:58:52	147532.4	73.3	179	1.5	9.3
4	October 22nd, 2012	16:59:04	147544.0	73.3	179	1.5	9.3
5	October 22nd, 2012	16:59:18	147558.2	73.3	179	1.5	9.3
6	October 22nd, 2012	16:59:31	147571.4	73.4	181	1.6	9.4
7	October 22nd, 2012	16:59:46	147585.7	73.4	181	1.6	9.4
8	October 22nd, 2012	17:01:47	147707.2	73.4	162	1.6	9.9

4.3.4 DPFE-SEL- 4-1 -1485: Buck Knob Switching Station - Selma Substation

This O/H transmission line connects the Buck Knob switching substation to Selma substation. It is situated in the state of Missouri, USA and belongs to the Ameren UE power utility. It is a 2.33 mile line operated at 138kV using 336ACSR 26/7 Linnet conductor. The design value for the maximum operating temperature (MOT) is 100°C. The line is supported by a steel lattice towers and has a total of nineteen spans.

The line survey for this circuit was completed on the 20th of November 2012, yielding the following weather results shown in

Table 4-4 for the individual line spans. The ampacity loading at the time of the line survey was recorded as 66A.

Table 4-4: Meteorological Data for the DPFE-SEL-1-1485 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	11/20/2012	16:24:32	231871.9	53.1	58	7.3	23.9
2	11/20/2012	16:24:33	231872.5	53.1	58	7.3	23.9
3	11/20/2012	16:24:49	231889.3	53.1	58	7.3	23.9
4	11/20/2012	16:24:54	231894.5	53.1	58	7.3	23.9
5	11/20/2012	16:25:07	231906.8	53.0	69	7.2	23.6
6	11/20/2012	16:25:23	231922.8	53.0	69	7.2	23.6
7	11/20/2012	16:25:28	231927.9	53.0	69	7.2	23.6
8	11/20/2012	16:25:44	231943.7	53.0	69	7.2	23.6
9	11/20/2012	16:25:60	231959.7	53.0	61	6.9	23.1
10	11/20/2012	16:26:08	231968.5	53.0	61	6.9	23.1
11	11/20/2012	16:50:31	233431.3	53.3	98	5.5	29.0
12	11/20/2012	16:50:37	233436.6	53.3	98	5.5	29.0
13	11/20/2012	16:50:42	233442.0	53.3	98	5.5	29.0
14	11/20/2012	16:51:02	233462.0	53.4	94	5.0	28.0
15	11/20/2012	16:51:04	233464.3	53.4	94	5.0	28.0
16	11/20/2012	16:51:07	233466.6	53.4	94	5.0	28.0
17	11/20/2012	16:51:12	233471.8	53.4	94	5.0	28.0
18	11/20/2012	16:51:17	233477.1	53.4	94	5.0	28.0
19	11/20/2012	16:51:32	233491.9	53.4	94	5.0	28.0
20	11/20/2012	16:51:39	233499.3	53.4	94	5.0	28.0
21	11/20/2012	16:51:48	233508.2	53.4	94	5.0	28.0
22	11/20/2012	16:51:60	233519.9	53.4	69	4.7	27.6
23	11/20/2012	16:52:09	233529.2	53.4	69	4.7	27.6
24	11/20/2012	16:52:22	233542.0	53.4	69	4.7	27.6
25	11/20/2012	16:52:23	233542.6	53.4	69	4.7	27.6

4.3.5 DPFE-SEL-1-1558 – River Cement Substation – Selma Substation

This transmission power line connects the River Cement switching substation to Selma substation. It is situated in the state of Illinois, USA and belongs to the Ameren UE power utility. The length of the line is unknown and it is operated at 138kV using 336ACSR 26/7 Linnet conductor. The design value for the maximum operating temperature (MOT) is 120°C. The line is supported by wooden monopole structures and has a total of forty two spans.

The line survey for this circuit was completed on the 20th of November 2012, yielding the following weather results shown in Table 4-5 for the individual line spans. The ampacity loading at the time of the line survey was recorded as 66A.

Table 4-5: Meteorological Data for the DPFE-SEL-1-1558 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	11/20/2012	16:29:58	232198.3	53.0	52	6.8	23.7
2	11/20/2012	16:30:01	232201.3	53.0	52	6.8	23.7
3	11/20/2012	16:30:04	232204.3	53.0	52	6.8	23.7
4	11/20/2012	16:30:08	232207.6	53.0	52	6.8	23.7
5	11/20/2012	16:30:13	232212.7	53.0	52	6.8	23.7
6	11/20/2012	16:30:16	232216.1	53.0	52	6.8	23.7
7	11/20/2012	16:30:19	232218.9	53.0	52	6.8	23.7
8	11/20/2012	16:30:23	232222.8	53.0	52	6.8	23.7
9	11/20/2012	16:30:27	232226.7	53.0	52	6.8	23.7
10	11/20/2012	16:30:29	232229.3	53.0	52	6.8	23.7
11	11/20/2012	16:36:25	232584.9	53.0	93	6.9	26.3
12	11/20/2012	16:36:28	232587.8	53.0	93	6.9	26.3
13	11/20/2012	16:36:31	232590.7	53.0	93	6.9	26.3
14	11/20/2012	16:36:34	232593.9	53.0	93	6.9	26.3
15	11/20/2012	16:36:38	232597.8	53.0	93	6.9	26.3
16	11/20/2012	16:36:42	232601.7	53.0	93	6.9	26.3
17	11/20/2012	16:36:45	232604.7	53.0	93	6.9	26.3
18	11/20/2012	16:39:28	232767.8	53.0	70	6.9	26.3
19	11/20/2012	16:39:30	232770.2	53.0	70	6.9	26.3
20	11/20/2012	16:39:33	232773.4	53.0	70	6.9	26.3
21	11/20/2012	16:41:10	232869.8	53.0	58	7.2	25.1
22	11/20/2012	16:41:14	232873.5	53.0	58	7.2	25.1
23	11/20/2012	16:41:17	232876.6	53.0	58	7.2	25.1
24	11/20/2012	16:41:20	232879.7	53.0	58	7.2	25.1
25	11/20/2012	16:43:33	233012.6	53.0	42	6.7	24.2
26	11/20/2012	16:43:37	233017.0	53.0	42	6.7	24.2
27	11/20/2012	16:43:41	233021.2	53.0	42	6.7	24.2
28	11/20/2012	16:43:45	233025.4	53.0	42	6.7	24.2
29	11/20/2012	16:43:49	233029.0	53.0	42	6.7	24.2
30	11/20/2012	16:43:53	233032.5	53.0	42	6.7	24.2
31	11/20/2012	16:43:56	233035.5	53.0	42	6.7	24.2
32	11/20/2012	16:47:19	233238.6	53.1	59	6.4	27.0
33	11/20/2012	16:47:16	233236.1	53.1	59	6.4	27.0
34	11/20/2012	16:47:14	233233.7	53.1	59	6.4	27.0
35	11/20/2012	16:47:11	233230.8	53.1	59	6.4	27.0
36	11/20/2012	16:47:08	233228.0	53.1	59	6.4	27.0
37	11/20/2012	16:47:05	233225.0	53.1	59	6.4	27.0
38	11/20/2012	16:47:02	233221.7	53.1	59	6.4	27.0
39	11/20/2012	16:46:57	233217.1	53.1	64	6.7	25.3
40	11/20/2012	16:46:55	233214.8	53.1	64	6.7	25.3
41	11/20/2012	16:46:52	233212.5	53.1	64	6.7	25.3
42	11/20/2012	16:46:50	233210.3	53.1	64	6.7	25.3
43	11/20/2012	16:46:49	233209.1	53.1	64	6.7	25.3

4.3.6 SEL-RIV-2-779: St. Francois Substation Tap-off – Selma Substation/Rivermines Substation Tap-off

This overhead transmission line connecting the Selma substation – Rivermines substation circuit to the St. Francois substation tap-off is situated in the state of Missouri, USA and belongs to the Ameren UE power utility. It is a 1.11 mile line operated at 138kV using 1590 ACSR 45/7 Lapwing conductor. The design value for the maximum operating temperature (MOT) is 110°C. The line is supported by a combination of steel lattice towers and wood H-frame structures with a total of eleven spans.

The line survey for this circuit was completed on the 28th of November 2012, yielding the following weather results shown in Table 4-6 for the individual line spans. The ampacity loading at the time of the line survey was recorded as 146A.

Table 4-6: Meteorological Data for the SEL-RIV-2-779 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	11/28/2012	20:27:24	332843.7	51.4	236	3.34	29.80
2	11/28/2012	20:27:24	332843.7	51.4	236	3.34	29.80
3	11/28/2012	20:27:24	332843.7	51.4	236	3.34	29.80
4	11/28/2012	20:38:48	333528.0	51.6	239	2.95	27.54
5	11/28/2012	20:38:48	333528.0	51.6	239	2.95	27.54
6	11/28/2012	20:39:03	333542.9	51.6	222	2.77	27.33
7	11/28/2012	20:39:03	333542.9	51.6	222	2.77	27.33
8	11/28/2012	20:39:11	333550.6	51.6	222	2.77	27.33
9	11/28/2012	20:39:19	333559.3	51.6	222	2.77	27.33
10	11/28/2012	20:39:28	333568.0	51.6	222	2.77	27.33
11	11/28/2012	20:41:28	333688.0	51.6	214	3.01	26.92
12	11/28/2012	20:41:27	333687.5	51.6	214	3.01	26.92

4.3.7 PANN-R51D-1462-381: Decatur Rt 51 - Mt Zion Ppg Tap-off

This overhead transmission line circuit connecting the Decatur Rt 51 tap-off to the Mt. Zion Ppg Tap-off is situated in the state of Illinois, USA and belongs to the Ameren IP power utility. It is a 1.43 mile long line and is operated at 138kV using 1272 ACSR 45/7 Bittern conductor. The design value for the maximum operating temperature

(MOT) is 120°C. The line conductor is supported by wood H-frame structures with a total of thirty six spans.

The line survey for this circuit was completed on the 28th of October 2012, yielding the following weather results shown in Table 4-7 for the individual line spans. The ampacity loading at the time of the line survey was recorded as 225A.

Table 4-7: Meteorological Data for the PANN-R51D-1462-381 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	10/28/2012	16:13:47	58427.4	45.8	223	12.4	52.6
2	10/28/2012	16:13:44	58424.2	45.8	223	12.4	52.6
3	10/28/2012	16:13:42	58421.5	45.8	223	12.4	52.6
4	10/28/2012	16:13:39	58418.7	45.8	223	12.4	52.6
5	10/28/2012	16:13:36	58415.9	45.8	223	12.4	52.6
6	10/28/2012	16:13:33	58412.9	45.8	223	12.4	52.6
7	10/28/2012	16:13:30	58410.0	45.8	223	12.4	52.6
8	10/28/2012	16:13:27	58407.1	45.8	223	12.4	52.6
9	10/28/2012	16:13:24	58404.2	45.8	223	12.4	52.6
10	10/28/2012	16:13:21	58401.2	45.8	223	12.4	52.6
11	10/28/2012	16:13:18	58398.1	45.8	223	12.4	52.6
12	10/28/2012	16:13:15	58395.0	45.8	223	12.4	52.6
13	10/28/2012	16:13:12	58392.0	45.8	223	12.4	52.6
14	10/28/2012	16:13:09	58388.6	45.8	223	12.4	52.6
15	10/28/2012	16:13:06	58385.9	45.8	223	12.4	52.6
16	10/28/2012	16:13:03	58383.0	45.8	223	12.4	52.6
17	10/28/2012	16:13:00	58380.2	45.8	223	12.4	52.6
18	10/28/2012	16:12:57	58377.5	45.8	220	12.1	52.7
19	10/28/2012	16:12:55	58374.7	45.8	220	12.1	52.7
20	10/28/2012	16:12:52	58372.0	45.8	220	12.1	52.7
21	10/28/2012	16:12:49	58369.3	45.8	220	12.1	52.7
22	10/28/2012	16:12:46	58366.4	45.8	220	12.1	52.7
23	10/28/2012	16:12:43	58363.0	45.8	220	12.1	52.7
24	10/28/2012	16:12:40	58360.3	45.8	220	12.1	52.7
25	10/28/2012	16:12:38	58357.5	45.8	220	12.1	52.7
26	10/28/2012	16:12:35	58354.7	45.8	220	12.1	52.7
27	10/28/2012	16:12:31	58351.0	45.8	220	12.1	52.7
28	10/28/2012	16:12:28	58347.9	45.8	220	12.1	52.7
29	10/28/2012	16:12:25	58344.9	45.8	220	12.1	52.7
30	10/28/2012	16:12:22	58342.0	45.8	220	12.1	52.7
31	10/28/2012	16:12:19	58339.1	45.8	220	12.1	52.7
32	10/28/2012	16:12:16	58336.2	45.8	220	12.1	52.7
33	10/28/2012	16:12:13	58333.3	45.8	220	12.1	52.7
34	10/28/2012	16:12:10	58330.4	45.8	220	12.1	52.7
35	10/28/2012	16:12:08	58327.6	45.8	220	12.1	52.7
36	10/28/2012	16:06:21	57980.8	45.3	205	10.9	47.0
37	10/28/2012	16:06:20	57980.3	45.3	205	10.9	47.0

4.3.8 NDEC-EMST-1522-587: 27th Street tap-off - Decatur E. Main Substation

This overhead transmission line circuit connecting the 27th Street tap-off to the Decatur E. Main Substation is situated in the state of Illinois, USA and belongs to the Ameren IP power utility. It is a 0.79 mile long line and is operated at 138kV using 1272SAC 61Str conductor. The design value for the maximum operating temperature (MOT) is 93°C. The line conductor is supported by wood single pole structures with a total of fifteen spans.

The line survey for this circuit was completed on the 28th of October 2012, yielding the following weather results shown in Table 4-8 for the individual line spans. The ampacity loading at the time of the line survey was recorded as 160A between 15h00 and 16h00 and 149A between 16h00 and 17h00.

Table 4-8: Meteorological Data for the NDEC-EMST-1522-587 Line

STRUCTURE	DATE	TIME (GMT)	GPS TIMESTAMP	TEMPERATURE (deg F)	WIND DIRECTION	WIND SPEED (ft/s)	SOLAR RADIATION (w/ft^2)
1	10/28/2012	15:59:04	57543.7	44.8	223	11.1	33.6
2	10/28/2012	15:59:00	57539.7	44.8	223	11.1	33.6
3	10/28/2012	15:58:57	57537.0	44.7	209	11.3	31.2
4	10/28/2012	15:58:54	57534.2	44.7	209	11.3	31.2
5	10/28/2012	16:03:17	57797.4	45.1	211	10.4	41.7
6	10/28/2012	16:03:21	57801.0	45.1	211	10.4	41.7
7	10/28/2012	16:03:26	57805.9	45.1	211	10.4	41.7
8	10/28/2012	16:03:29	57808.7	45.1	211	10.4	41.7
9	10/28/2012	16:03:33	57813.2	45.1	211	10.4	41.7
10	10/28/2012	16:03:37	57817.4	45.1	211	10.4	41.7
11	10/28/2012	16:03:42	57821.6	45.1	211	10.4	41.7
12	10/28/2012	16:03:44	57824.2	45.1	211	10.4	41.7
13	10/28/2012	16:03:47	57826.7	45.1	211	10.4	41.7
14	10/28/2012	16:03:49	57829.2	45.1	211	10.4	41.7
15	10/28/2012	16:01:13	57673.1	44.9	213	11.1	37.4
16	10/28/2012	16:01:14	57674.4	44.9	213	11.1	37.4

5. DISCUSSION AND SOFTWARE COMPARISON

Comparing the graphical results from Appendix F and Appendix G shows that the PLC-VAST software is capable of displaying the LIDAR data as well as PLS-CADD. The graphic images for the lines SEL-RIV-2-779, PANN-R51D-1462-381 and NDEC-EMST-1522-587 are shown in the figure pairs F-5 and G-1, G2 and F4 as well as F-3 and G-3 respectively. It can be seen from these images that the graphics quality is very close for the two programs.

The test results are reproduced here for illustration purposes.

5.1 Graphics

Figure 5-1 and Figure 5-2 illustrate the developed software's graphic capability. The software is able to reproduce the LiDAR data as with the exact precision and accuracy of the PLS_CADD software. The program therefore fulfils the first research question.

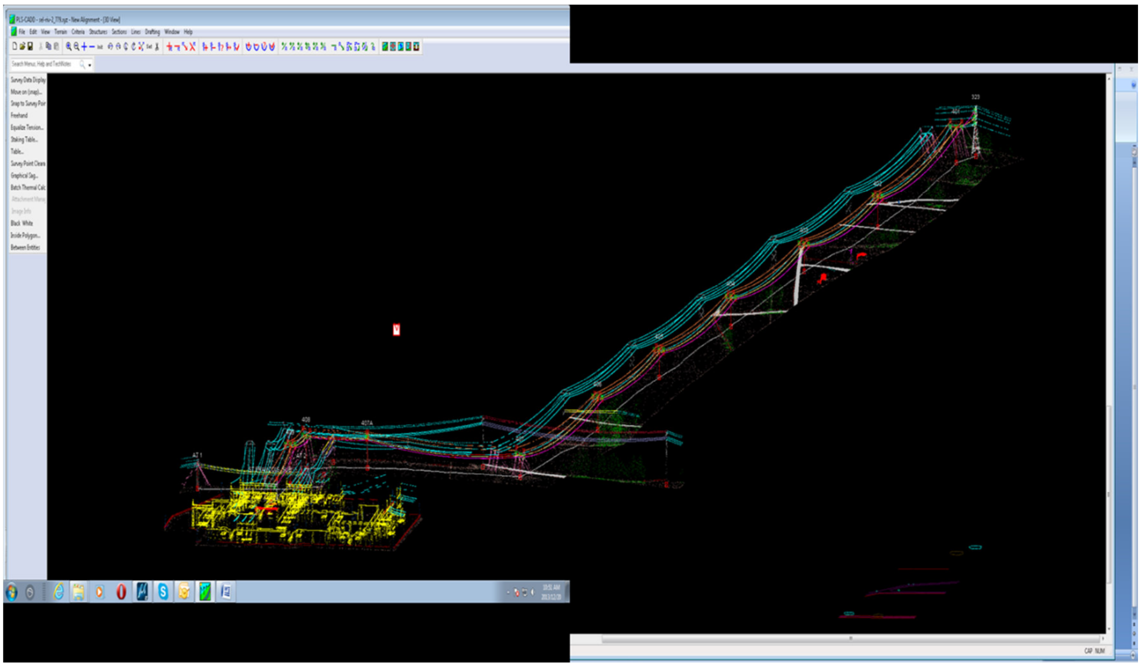

Figure 5-1: PLS-CADD Screenshot for SEL-RIV-2-779 Transmission Line

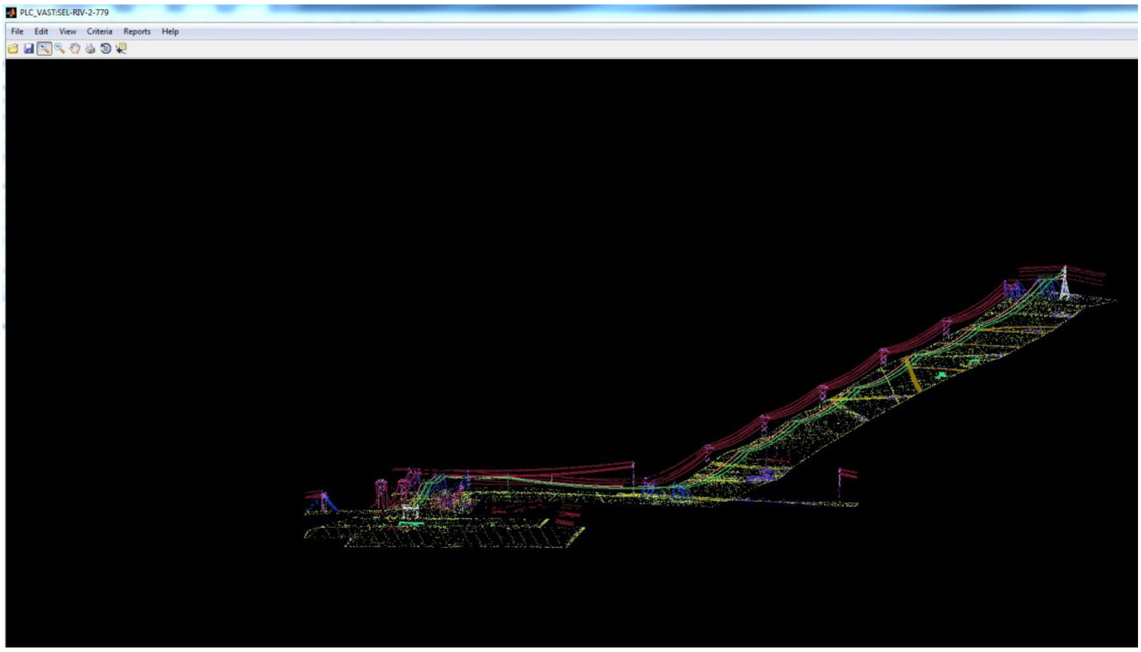

Figure 5-2: PLC_VAST Screenshot for SEL-RIV-2-779 Transmission Line

5.2 Clearance Violations

The results from the DPFE-SEL-1-1558: River Cement Substation – Selma Substation transmission line are discussed to illustrate the functionality of the PLC_VAST software. An excerpt of the results from each software package is reproduced in Table 5-1 and Table 5-2 on the next page for illustration purposes. The ground report checks for clearance violations between each of the phase conductors and ground points (feature code – 100) as well as interpolated points (feature code 500). The distance criteria for the reports was set at a horizontal distance of 22ft and vertical distance of 23ft. This results in an effective distance of 31.828ft using the Pythagoras theorem. The vertical distance criteria for the PLS-CADD reports was set at a vertical distance of 30ft only.

The total number of violations for the PLC_VAST software were found to be 936 and 873 for the ground points and interpolated points respectively. This is in contrast to the 11 clearance violations produced by the PLS-CADD for the same report even though the latter software has much more stringent criteria. Only a summarized version of the PLC_VAST ground clearance report is presented in Table 5-1 for brevity purposes.

All the results presented in Table 5-1 and Table 5-2 are show that the violations are all the coordinates points which have an effective less than 31.828ft and 30ft from the conductor points for PLC_VAST and PLS-CADD respectively. Close analysis of the results shows that the violations occur around the same area beneath the line. This can be seen from the coordinates of the violating points on both report summaries.

Table 5-1: PLC_VAST Ground Clearance Report Summary for the DPFE-SEL-1-1558 Line

Phase 1 Conductor and Ground Points					
Conductor Point Coordinates			**Distances (ft.)**		**Effective Distance (ft.)**
X	Y	Z	Vertical	Horizontal	
865743.970	854688.970	572.03	19.26	17.07	25.735
865745.220	854689.100	571.97	19.20	17.67	26.093
865745.710	854688.940	572.03	19.26	17.74	26.185
865746.890	854689.200	571.93	19.16	18.52	26.648
Phase 1 Conductor and Interpolated Points					
Conductor Point Coordinates			**Distances (ft.)**		**Effective Distance (ft.)**
X	Y	Z	Vertical	Horizontal	
865743.970	854688.970	572.03	20.23	16.77	26.277
865745.220	854689.100	571.97	20.17	17.88	26.954
865745.710	854688.940	572.03	20.23	18.20	27.212
865746.890	854689.200	571.93	20.13	19.35	27.922

Table 5-2: PLC-CADD Ground Clearance Report Summary for the DPFE-SEL-1-1558 Line

Phase Conductors to Ground Points and Interpolated Points					
Conductor Point Coordinates			**Clearance Margin (ft.)**		**Effective Distance (ft.)**
X	Y	Z	Vertical	Horizontal	
859014.91	854880.54	543.57	-0.34	0.00	27.66
860838.00	853231.91	578.93	-2.10	0.00	27.90
861668.14	852927.38	655.96	-0.39	0.00	29.61
861843.19	853013.40	668.66	-2.44	0.00	27.56
862076.82	853238.73	675.36	-1.46	0.00	28.54
862274.10	853458.59	674.21	-0.58	0.00	29.42
863167.58	854353.16	639.07	-1.61	0.00	28.39
863314.58	854404.57	634.98	-3.31	0.00	26.69
864600.12	854343.15	608.33	-1.58	0.00	28.42
864945.83	854513.86	578.12	-2.48	0.00	27.52
865715.90	854684.17	553.35	-4.25	0.00	25.75

Although the method in which the violation checks were carried is slightly different, the results from the software packages are comparable and show that the PLC_VAST is capable of computing clearance distances, thereby meeting the requirements of the second research question.

No further clearance violations were found on this line. Both software packages did not detect any violations, which shows consistency of the PLC_VAST software.

5.3 Thermal Behaviour Prediction

The third research question pertains to the extrapolation of data to predict the behaviour of transmission line when subjected to different external weather and environmental conditions as well as different amperage loading conditions.

Thermal calculations could not be tested on the PLC-VAST platform and later be compared to the results from PLS-CADD for the given LIDAR data due to the lack of initial tensioning values for the existing transmission lines. However, the thermal calculation capability has been tested by implementing the examples shown in [11].

Thermal violation tests were however carried out for the PLS-CADD software and are presented in Appendix C of this report.

5.4 Software Comparison

From the results it can be seen that the PLC-VAST software is capable of detecting clearance violations to a fairly acceptable level when compared to the PLS-CADD software which is considered to be the industry benchmark. However, the computation time on PLC-VAST is extremely long compared to PLS-CADD and might render the program commercially impractical. For example, the 41MB file for the DPFE-SEL-1-1485 line took approximately twenty minutes to open on the PLC-VAST program whereas it only took less than two minutes to open on the same computer. The PLC-VAST program was also unable to run reports for this line due to the extensive computation load. The PLC-VAST program is therefore only suited to analysing short lines or individual spans.

Worth noting is the fact that PLS-CADD detects the points on impediments such as structures, crossing conductors, vegetation etc. whereas PLC-VAST has been designed to detect the points on the power line conductor which cause a violation to the obstruction points. This technique results in a shorter computation time and can be considered to be a better method since we are interested to see which sections on the power line cause a violation as opposed to the obstruction points. This enables the utility or engineer to correct the problem by redesigning the line and not the impediment point.

The difference in this method of checking for violations means the PLS-CADD results cannot be compared to the PLC-VAST on a coordinate for coordinate basis as earlier anticipated. A percentage error cannot be calculated as was proposed in the research proposal. However, the area of concern can still be compared on both software tools. For example, if a power line point is in violation on the PLC-VAST program, the area beneath that power line coordinate can be analysed to ascertain if this is the same area which was detected on PLS-CADD. This can be done by checking if the (x, y) coordinates of the violating point on PLC-VAST fall within the range of the (x, y) coordinates of the violating points on the PLS-CADD program.

Also worth noting is the fact that the deterministic method has been employed to determine the average temperature of the conductor by using the IEEE738:2006 method. A deterministic approach is fairly accurate when employed on short lines since there is only a slight variation in the weather conditions between spans and sections along a short line. The calculated average temperature is therefore very close to the calculated average temperature on the PLS-CADD program. A different method based on the probabilistic method would have to be developed in order to analyse long lines which fall in areas with very different weather conditions. The deterministic approach is sufficient for this study since only short lines were analysed.

The IEEE738:2006 based thermal calculator on PLS-CADD uses section temperature averages between dead-end insulators. A process to determine the start and termination of power line sections on the PLC-VAST platform would be cumbersome and would add unnecessary computational time. The batch thermal calculator in this case averages the conductor temperature along the whole section of the line.

The results from the PLC-VAST program may also be inaccurate due to the time of survey of the transmission lines. Some of the transmission lines were surveyed during the winter months and therefore the LIDAR coordinates represent a very conservative scenario since the conductor would sag significantly under hotter weather conditions. The ampacity loading on the lines at the time of survey could have also been low in comparison to the design value or the prevalent maximum demand on a particular transmission line. This would also result in a very conservative calculation. However, the thermal rating and vegetation reports aim to correct this underestimation that may have occurred. These two reports aim to estimate the sag and subsequent clearance distance under worst case weather conditions and a maximum power transfer scenario. In essence these reports are meant to determine the maximum power that can be transferred during worst case weather conditions before a clearance violation occurs.

Unlike PLS-CADD, PLC-VAST does not have the capability to calculate the tension at the conductor support ends within a span. This is due to the fact that the conductor is strung in PLS-CADD whilst PLC-VAST only uses the LIDAR points as a means for estimation of the clearance distances. PLS-CADD is therefore able to accurately estimate the initial tension values that were applied when the power lines was originally constructed. Stringing the conductor and calculating the tension is therefore considered to be beyond the scope of this research project as it requires additional computation, resulting in slower execution of the calculations.

While PLS-CADD is able to handle large amounts of data and process reports in a relatively short space of time, it is often necessary to reduce the density of the LIDAR data in the PLC-VAST program. This then shortens the processing time in the case of longer transmission lines with large data sets since there is less data to check. The trade-off in employing this technique is that the reports may not be as accurate as those from PLS-CADD.

As already discussed, the ruling span method is applied in this study to determine the sag and tension on the lines as compared to the finite element (FE) analysis which is preferred in the PLS- CADD software, although PLS-CADD also offers the user the ruling span method as an alternative calculation method. The ruling span method is considered adequate in this case because the transmission lines under consideration are fairly short and are located on a flat terrain. This would not be the case if the lines were located in mountainous terrain where the variation in span lengths is normally quite considerable. In such cases, a detailed force balance analysis would have to be performed at the insulator supports using finite element methods.

6. CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

6.1 Conclusion

This research study has proven the functionality and viability of a cheap alternative to the commercial PLS-CADD software in analysing clearance violations on high voltage transmission power lines. PLS-CADD is globally accepted as the leading software tool for the design of power lines by utilities, consultants and academics alike. However, it is an extremely expensive tool and is often one of the barriers to market entry for engineering start-ups and small and medium enterprises (SMEs). This can be alleviated with the development and availability in the market of free software packages such as PLC-VAST which can perform power line clearance analysis just as well.

The study has also illustrated the fact that the PLC-VAST package can operate as a stand-alone program, with the only external requirement being a MATLAB R2012a compiler which is available at no cost from the Mathworks website (www.mathworks.com). This level of autonomy had not been anticipated at the conceptualization stage of the program.

The results from the PLC_VAST tool compare well with those from PLS-CADD and show that the PLC-VAST software is capable of clearance violation analysis of short transmission power lines. PLS-CADD has however proven to be a superior product and generally showed better graphics, faster computation time as well as expanded functionality and a variety of ways to solve problems and compile reports.

The thermal violations in particular have proven to be a challenge to assess because the sag dependency of a transmission line span is dependent on the terrain of the area in which the span is situated. This makes it difficult to formulate a dynamic mathematical model to represent the catenary curve of a line span under different weather conditions such as wind, ice loading as well as galloping.

The MATLAB environment has also proven to be inferior when it comes to data processing of large data sets that exceed 50MB and this renders the PLC-VAST tool incapable of analysing transmission lines longer than 3 miles since the LIDAR data for such files is typically larger than 50MB. The student version of MATLAB has added limitations and will be unable to handle the requirements of the PLC-VAST tool, contrary to what had been earlier anticipated.

A useful avenue for the developed tool could be in the assessment of single critical spans which have critical violation issues such as a river crossing, railway crossing or even a wire crossing. The use of the tool in this manner could be similar to the RETMOS tool currently being used by ESKOM for real-time monitoring of the Kriel-Tutuka 400 kV line crossing over the Camden-Zeus 400 kV line [1]. Proper calibration of the tool and modelling of the behaviour of the catenary curve of the conductor under different weather and line loading conditions would alleviate the need for certain equipment such as the corona rings.

6.2 Recommendations For Future Work

The PLC-VAST software tool can be used to analyse transmission power lines in other utilities such as ESKOM (South Africa), ZESCO (Zambia), SEC (Swaziland), NAMPOWER (Namibia). The only feature that would have to be changed is the clearance violations criteria since different power utilities use custom set of rules. Users should also be cognizant of the system of units used when compiling and entering the clearance violations criteria as the PLC-VAST software is capable of computing using both the imperial and the metric systems of units.

Proposed further work on the tool would be to incorporate the probabilistic method of thermal rating into the PLC-VAST software tool in order to allow users to determine the maximum and optimum line current loading that can be allowed under different weather conditions before the line conductor sag starts violating clearance regulations. The program in its current form uses the deterministic method due to its limitations in functionality.

Mathematical models can also derived for the dynamic behaviour of the transmission line under different weather conditions in order to analyse the performance of the line under extreme weather conditions whilst taking the clearance violations into consideration. Real-time measurement devices could be integrated into the program in order to continually sense the weather parameters and load current through power line communication (PLC) or other means.

Seeing that MATLAB has proven to be an unsuitable environment for processing large amounts of data sets, the option of developing a similar tool using Visual Basic, Java and C++ should be explored. MATLAB is an interpreted language and therefore executes slower than compiled languages such as C and C++. In particular, Visual Basic should be explored since it is compatible with MATLAB and a GUI can be developed on the platform to easily interface with MATLAB using the dynamic data exchange (DDE). However, it should also be noted that some of the higher level math functions in MATLAB such as power spectral density (PSD), fast Fourier transform (FFT) and curve fitting are not available in Visual Basic, hence the need to interface with MALTLAB in order to reap the benefits of both software packages' functionalities.

7. REFERENCES

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8. APPENDIX

A. APPENDIX A: Clearance Criteria

Table A-1: Ground Clearance Report Criteria

Ground Clearance Criteria		Required Clearances (feet)							
Feature Codes	Description	138kV		161kV		230kV		345kV	
		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
100	Ground	22.00	0.00	23.00	0.00	24.00	0.00	26.00	0.00
500	Interpolated Points	22.00	0.00	23.00	0.00	24.00	0.00	26.00	0.00

Table A-2: Vegetation and Critical Vegetation Clearance Report Criteria

Vegetation Clearance Criteria		Required Clearances (feet)							
Feature Codes	Description	138kV		161kV		230kV		345kV	
		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
131	Vegetation/ Tree / Brush	15.00	20.00	15.00	20.00	15.00	30.00	15.00	30.00

APPENDIX A

Table A-3: Wire and Critical Wire Clearance Report Criteria

Wire Clearance Criteria		Required Clearances (feet)							
Feature Codes	Description	138kV		161kV		230kV		345kV	
		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
240	Crossing conductor unknown voltage	8.00	14.00	9.00	14.00	12.00	17.00	16.00	22.00
241	Crossing shield wire	6.00	11.00	6.00	11.00	8.00	13.00	10.00	15.00
242	Crossing conductor 345kV	12.00	18.00	13.00	18.00	14.00	20.00	16.00	22.00
243	Crossing conductor 230kV	10.00	15.00	10.00	16.00	12.00	17.00	14.00	20.00
244	Crossing conductor 161kV	8.00	14.00	9.00	14.00	10.00	16.00	13.00	18.00
245	Crossing conductor 138kV	8.00	14.00	8.00	14.00	10.00	15.00	12.00	18.00
246	Crossing conductor 69kV	6.00	12.00	7.00	13.00	8.00	14.00	11.00	16.00
247	Crossing conductor 34kV	6.00	11.00	6.00	12.00	8.00	13.00	10.00	16.00
248	Crossing conductor 12kV/4kV	6.00	11.00	6.00	11.00	8.00	13.00	10.00	15.00
545	Underbuild conductor 138kV - Ameren Owned	8.00	7.00	8.00	7.00	10.00	8.00	12.00	10.00
546	Underbuild conductor 69kV - Ameren Owned	6.00	7.00	7.00	7.00	8.00	8.00	10.00	10.00
547	Underbuild conductor 34kV - Ameren Owned	5.00	7.00	6.00	7.00	7.00	8.00	10.00	10.00
548	Underbuild conductor 12kV/4kV - Ameren Owned	5.00	7.00	5.00	7.00	7.00	8.00	9.00	10.00
549	Underbuild conductor 138kV - Non-Ameren Owned	9.00	7.00	10.00	7.00	11.00	8.00	13.00	10.00
550	Underbuild conductor 69kV - Non-Ameren Owned	8.00	7.00	8.00	7.00	10.00	8.00	12.00	10.00
551	Underbuild conductor 34kV - Non-Ameren Owned	7.00	7.00	7.00	7.00	9.00	8.00	11.00	10.00
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	6.00	7.00	7.00	7.00	8.00	8.00	11.00	10.00
1009	Parallel Line	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1241	Crossing shield wire/By Engineer	6.00	11.00	6.00	11.00	8.00	13.00	10.00	15.00
1242	Crossing conductor 345kV/By Engineer	12.00	18.00	13.00	18.00	14.00	20.00	16.00	22.00
1243	Crossing conductor 230kV/By Engineer	10.00	15.00	10.00	16.00	12.00	17.00	14.00	20.00
1244	Crossing conductor 161kV/By Engineer	8.00	14.00	9.00	14.00	10.00	16.00	13.00	18.00
1245	Crossing conductor 138kV/By Engineer	8.00	14.00	8.00	14.00	10.00	15.00	12.00	18.00
1246	Crossing conductor 69kV/By Engineer	6.00	12.00	7.00	13.00	8.00	14.00	11.00	16.00
1247	Crossing conductor 34kV/By Engineer	6.00	11.00	6.00	12.00	8.00	13.00	10.00	16.00
1248	Crossing conductor 12kV/4kV/By Engineer	6.00	11.00	6.00	11.00	8.00	13.00	10.00	15.00
1545	Underbuild conductor 138kV - Ameren Owned/By Engineer	8.00	7.00	8.00	7.00	10.00	8.00	12.00	10.00
1546	Underbuild conductor 69kV - Ameren Owned/By Engineer	6.00	7.00	7.00	7.00	8.00	8.00	10.00	10.00
1547	Underbuild conductor 34kV - Ameren Owned/By Engineer	5.00	7.00	6.00	7.00	7.00	8.00	10.00	10.00
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By Engineer	5.00	7.00	5.00	7.00	7.00	8.00	9.00	10.00
1549	Underbuild conductor 138kV - Non-Ameren Owned/By Engineer	9.00	7.00	10.00	7.00	11.00	8.00	13.00	10.00
1550	Underbuild conductor 69kV - Non-Ameren Owned/By Engineer	8.00	7.00	8.00	7.00	10.00	8.00	12.00	10.00
1551	Underbuild conductor 34kV - Non-Ameren Owned/By Engineer	7.00	7.00	7.00	7.00	9.00	8.00	11.00	10.00
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By Engineer	6.00	7.00	7.00	7.00	8.00	8.00	11.00	10.00

APPENDIX A

Table A-4: Structure and Critical Structure Clearance Report Criteria

Structure Clearance Criteria		Required Clearances (feet)							
Feature Codes	Description	138kV		161kV		230kV		345kV	
		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
104	Water	21.00	0.00	21.00	0.00	23.00	0.00	25.00	0.00
110	Road	30.00	0.00	23.00	0.00	24.00	0.00	26.00	0.00
116	Railroad	22.00	17.00	31.00	18.00	32.00	19.00	34.00	21.00
126	Swimming Pool	29.00	31.00	29.00	31.00	31.00	33.00	33.00	35.00
255	Other Suppoting Structures	8.00	10.00	9.00	11.00	10.00	12.00	12.00	14.00
301	Building	17.00	13.00	18.00	14.00	19.00	15.00	21.00	17.00
306	Silo/ Grain Bin	22.00	24.00	22.00	24.00	24.00	26.00	26.00	28.00
321	Fence	12.00	13.00	12.00	14.00	14.00	15.00	16.00	17.00
335	Bridge	16.00	13.00	17.00	13.00	18.00	15.00	20.00	17.00
400	Street Light	12.00	13.00	12.00	14.00	14.00	15.00	16.00	17.00
405	Antenna, Radio/TV	12.00	13.00	12.00	14.00	14.00	15.00	16.00	17.00
410	Sign	12.00	13.00	12.00	14.00	14.00	15.00	16.00	17.00
425	Pipeline	22.00	0.00	23.00	0.00	24.00	0.00	26.00	0.00
1007	Substation	8.00	14.00	9.00	14.00	12.00	17.00	16.00	22.00
1008	Temporary Objects	12.00	13.00	12.00	14.00	14.00	15.00	16.00	17.00

B. APPENDIX B: PLC-VAST REPORTS

Ground Clearance

Input file: F:\Academic\Wits Msc\Year 2\ELEN 7000 - Thesis Dissertation\Project\Rev.2\Program\DPFE-SEL-1-1558\DPFE-SEL-1-1558.mat
Clearance file:Ground Clearance Criteria.xlsx

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 100
Target Feature name: Ground
Horizontal Clearance Dist: 22
Vertical Clearance Dist: 23

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-100

Total number of violations found: 936

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
865743.970	854688.970	572.03	19.26	17.07
865745.220	854689.100	571.97	19.20	17.67
865745.710	854688.940	572.03	19.26	17.74
865746.890	854689.200	571.93	19.16	18.52

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 500
Target Feature name: Interpolated Points
Horizontal Clearance Dist: 22
Vertical Clearance Dist: 23

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-500

Total number of violations found: 873

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
865743.970	854688.970	572.03	20.23	16.77
865745.220	854689.100	571.97	20.17	17.88
865745.710	854688.940	572.03	20.23	18.20

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 100
Target Feature name: Ground
Horizontal Clearance Dist: 22
Vertical Clearance Dist: 23

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-100

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1002

Voltage: 161kV
Target Feature code: 500
Target Feature name: Interpolated Points
Horizontal Clearance Dist: 22
Vertical Clearance Dist: 23

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-500

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 100
Target Feature name: Ground
Horizontal Clearance Dist: 22
Vertical Clearance Dist: 23

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-100

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 500
Target Feature name: Interpolated Points
Horizontal Clearance Dist: 22
Vertical Clearance Dist: 23

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-500

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Vegetation Management Clearance

Input file: F:\Academic\Wits Msc\Year 2\ELEN 7000 - Thesis Dissertation\Project\Rev.2\Program\SEL-RIV-2-779\SEL-RIV-2-779.mat
Clearance file:Vegetation Clearance Criteria.xlsx

Conductor Feature code: 1001
Voltage: 230kV
Target Feature code: 131
Target Feature name: Vegetation
Horizontal Clearance Dist: 30
Vertical Clearance Dist: 15

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-131

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1002
Voltage: 230kV
Target Feature code: 131
Target Feature name: Vegetation
Horizontal Clearance Dist: 30
Vertical Clearance Dist: 15

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-131

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 230kV
Target Feature code: 131
Target Feature name: Vegetation
Horizontal Clearance Dist: 30
Vertical Clearance Dist: 15

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-131

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Wire Clearance

Input file: F:\Academic\Wits Msc\Year 2\ELEN 7000 - Thesis Dissertation\Project\Rev.2\Program\NDEC-EMST-1522-587.mat
Clearance file:Wire Clearance Criteria.xlsx

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 241
Target Feature name: Crossing shield wire
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 9

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-241

Total number of violations found: 24

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
811390.930	1156871.900	725.16	6.53	9.38
811391.390	1156873.340	725.03	6.40	10.09
811391.980	1156874.260	724.90	6.27	10.92
811392.640	1156875.180	724.86	6.23	11.85
811392.800	1156876.100	724.70	6.07	12.36
811393.160	1156876.920	724.70	6.07	13.05
811393.260	1156875.970	724.90	6.27	12.73
811393.850	1156877.870	724.60	6.07	13.30
811389.520	1156869.440	725.16	6.53	8.03
811382.300	1156855.690	724.08	6.33	13.82
811382.990	1156856.940	724.21	5.58	13.98
811383.740	1156858.550	724.27	5.64	12.48
811384.240	1156859.560	724.31	5.68	11.59
811384.830	1156860.480	724.44	5.81	10.86

811385.420	1156861.300	724.57	5.94	10.28
811385.650	1156862.150	724.57	5.94	9.59
811386.240	1156863.170	724.60	5.97	8.97
811386.990	1156864.710	724.70	6.07	8.16
811387.880	1156865.860	724.90	6.27	8.01
811387.980	1156867.080	724.83	6.20	7.40
811388.440	1156866.940	725.16	6.53	7.87
811388.470	1156867.900	724.96	6.33	7.47
811388.930	1156867.760	725.03	6.40	7.95
811388.930	1156868.780	725.03	6.40	7.61

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 246
Target Feature name: Crossing conductor 69kV
Horizontal Clearance Dist: 11
Vertical Clearance Dist: 6

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-246

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 547
Target Feature name: Underbuild conductor 34kV - Ameren Owned

Horizontal Clearance Dist: 18
Vertical Clearance Dist: 13

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-547

Total number of violations found: 2064

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
812568.580	1160085.740	721.68	11.09	8.12
812568.650	1160085.050	721.48	10.89	8.17
812568.650	1160086.660	721.81	11.22	7.97
812568.910	1160086.160	721.68	11.09	7.74
812569.080	1160085.640	721.54	10.95	7.64
812569.140	1160084.950	721.41	10.82	7.72
812569.140	1160086.560	721.64	11.05	7.49
812568.580	1160083.770	721.45	10.86	8.61
812568.620	1160082.850	721.02	10.43	8.94
812568.720	1160080.190	720.63	10.04	10.33
812568.810	1160078.450	720.43	9.84	11.47
812568.880	1160072.060	719.77	9.18	16.69
812568.910	1160074.910	720.07	9.48	14.21
812568.950	1160070.580	719.64	9.05	17.99
812568.950	1160081.240	720.72	10.13	9.50
812568.980	1160071.170	719.67	9.08	17.44

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 1009
Target Feature name: Parallel Lines
Horizontal Clearance Dist: 16

Vertical Clearance Dist: 10

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-1009

Total number of violations found: 55

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
812568.580	1160085.740	721.68	-30.01	15.59
812568.650	1160085.050	721.48	-30.21	15.75
812568.650	1160086.660	721.81	-29.88	15.27
812568.910	1160086.160	721.68	-30.01	15.15
812569.080	1160085.640	721.54	-30.15	15.15
812569.140	1160084.950	721.41	-30.28	15.32
812569.140	1160086.560	721.64	-30.05	14.82
812568.580	1160083.770	721.45	-30.18	14.19
812568.620	1160082.850	721.02	-30.61	14.60
812568.720	1160080.190	720.63	-30.97	15.70

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 1241
Target Feature name: Crossing shield wire/By Engineer
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 9

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-1241

Total number of violations found: 25

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
811390.930	1156871.900	725.16	6.24	7.86
811391.390	1156873.340	725.03	6.11	8.45
811391.980	1156874.260	724.90	5.98	9.22
811392.640	1156875.180	724.86	5.94	10.13
811392.800	1156876.100	724.70	5.78	10.61
811393.160	1156876.920	724.70	5.78	11.28
811393.260	1156875.970	724.90	5.98	10.98
811393.850	1156877.870	724.60	5.68	12.34
811394.700	1156879.310	724.50	5.58	13.81
811389.520	1156869.440	725.16	6.24	6.89

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 1246
Target Feature name: Crossing conductor 69kV/By Engineer
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 8

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-1246

Total number of violations found: 72

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
811126.890	1156642.500	716.27	7.14	13.34
811126.990	1156643.030	716.20	7.07	13.81
811127.710	1156642.960	716.07	6.94	13.56

811127.810	1156643.450	716.27	7.22	13.02

Conductor Feature code: 1001
Voltage: 161kV
Target Feature code: 1547
Target Feature name: Underbuild conductor 34kV - Ameren Owned/By Engineer
Horizontal Clearance Dist: 13
Vertical Clearance Dist: 7

The following lists the coordinates of point violating for conductor feature code-1001 and target feature code-1547

Total number of violations found: 394

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
812584.200	1159640.860	718.63	6.94	12.90
812584.200	1159642.530	718.54	6.98	12.59
812584.270	1159640.040	718.67	6.98	12.09
812584.430	1159638.630	718.77	6.95	12.68
812584.500	1159634.520	719.03	6.94	12.55
812584.560	1159636.330	718.86	6.91	12.38
812584.660	1159637.440	718.77	6.88	12.50
812584.690	1159639.350	718.67	6.92	12.42
812584.790	1159633.610	718.99	6.83	12.65
812584.820	1159630.030	719.13	6.76	12.07
812584.860	1159628.420	719.29	6.78	12.45
812584.890	1159629.140	719.26	6.82	12.18

Conductor Feature code: 1002

Voltage: 161kV
Target Feature code: 241
Target Feature name: Crossing shield wire
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 9

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-241

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 246
Target Feature name: Crossing conductor 69kV
Horizontal Clearance Dist: 11
Vertical Clearance Dist: 6

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-246

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 547
Target Feature name: Underbuild conductor 34kV - Ameren Owned
Horizontal Clearance Dist: 18
Vertical Clearance Dist: 13

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-547

Total number of violations found: 705

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
812208.380	1158518.680	728.88	12.99	16.27
812525.510	1159167.040	737.53	12.99	17.39
812522.690	1159151.030	739.70	12.69	17.66
812522.750	1159152.140	739.57	12.66	17.86
812523.340	1159153.060	739.30	12.52	17.37
812523.340	1159153.650	739.34	12.56	17.96

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 1009
Target Feature name: Parallel Lines
Horizontal Clearance Dist: 16
Vertical Clearance Dist: 10

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-1009

Total number of violations found: 53

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
812568.950	1160086.130	731.81	-19.88	15.12
812569.080	1160085.610	731.65	-20.04	15.16
812569.140	1160084.920	731.52	-20.17	15.33
812569.140	1160086.560	731.78	-19.91	14.82
812569.440	1160086.070	731.65	-20.04	14.67
812568.980	1160081.210	730.86	-20.77	15.19
812569.010	1160081.830	730.86	-20.77	14.81

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 1241
Target Feature name: Crossing shield wire/By Engineer
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 9

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-1241

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 1246
Target Feature name: Crossing conductor 69kV/By Engineer
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 8

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-1246

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1002
Voltage: 161kV
Target Feature code: 1547
Target Feature name: Underbuild conductor 34kV - Ameren Owned/By Engineer
Horizontal Clearance Dist: 13
Vertical Clearance Dist: 7

The following lists the coordinates of point violating for conductor feature code-1002 and target feature code-1547

Total number of violations found: 0

Conductor Point Coordinates Distances (ft.)

X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 241
Target Feature name: Crossing shield wire
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 9

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-241

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 246
Target Feature name: Crossing conductor 69kV
Horizontal Clearance Dist: 11
Vertical Clearance Dist: 6

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-246

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 547
Target Feature name: Underbuild conductor 34kV - Ameren Owned
Horizontal Clearance Dist: 18
Vertical Clearance Dist: 13

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-547

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 1009
Target Feature name: Parallel Lines
Horizontal Clearance Dist: 16

Vertical Clearance Dist: 10

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-1009

Total number of violations found: 52

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal
812568.980	1160086.100	741.62	-10.07	15.10
812569.080	1160085.570	741.52	-10.17	15.17
812569.140	1160086.520	741.69	-10.00	14.83
812569.180	1160084.880	741.49	-10.20	15.31
812569.470	1160086.030	741.62	-10.07	14.66
812569.600	1160085.470	741.49	-10.20	14.71
812569.670	1160084.820	741.33	-10.36	14.88

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 1241
Target Feature name: Crossing shield wire/By Engineer
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 9

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-1241

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 1246
Target Feature name: Crossing conductor 69kV/By Engineer
Horizontal Clearance Dist: 14
Vertical Clearance Dist: 8

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-1246

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

Conductor Feature code: 1003
Voltage: 161kV
Target Feature code: 1547
Target Feature name: Underbuild conductor 34kV - Ameren Owned/By Engineer
Horizontal Clearance Dist: 13
Vertical Clearance Dist: 7

The following lists the coordinates of point violating for conductor feature code-1003 and target feature code-1547

Total number of violations found: 0

Conductor Point Coordinates			Distances (ft.)	
X	Y	Z	Vertical	Horizontal

--------------No violations found-------------

C. APPENDIX C: PLS CADD REPORTS

PLS-CADD Version 12.50x64 9:42:43 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes:
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN checked at 3.28 (ft) station and offset intervals along wire. Clearances are being checked out to an offset 20.00 (ft) from wire.
Required clearance to TIN is that for feature code 'Interpolated Points' (set in Terrain/Feature Code Data/Feature Code for Ground Clearance and Interpolated TIN Points

NDEC-EMST-1522-587

Ground Clearance Report

10/16/2013

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
53	DECATUR_E.MAIN_SUB.	199.4	-2.05	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	3991.11	-11.44	811012.51	1156614.01	656.36	0.00

1 spans with clearance violations NG

15 spans without clearance violations (spans without violations excluded from report above)

NDEC-EMST-1522-587

Wire Crossing Clearance Report 10/16/2013

PLS-CADD Version 12.50x64 9:45:20 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. 0 kV (ft)	Horiz. 0 kV (ft)	Vert. 138 kV (ft)	Horiz. 138 kV (ft)	Vert. 161 kV (ft)	Horiz. 161 kV (ft)	Vert. 230 kV (ft)	Horiz. 230 kV (ft)	Vert. 345 kV (ft)	Horiz. 345 kV (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000

552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 240 241 242 243 244 245 246 247 248 545 546 547 548 549 550 551 552 1241 1242 1243 1244 1245 1246 1247 1248 1545 1546 1547 1548 1549 1550 1551 1552
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
40	41	199.4	-0.40	-4.77	NG		72	0		Underbuild conductor 34kV - Ameren Owned	449.25	8.12	812582.82	1159638.89	711.28	0.00
		199.4	-0.14	-5.00	NG		90	0		Underbuild conductor 34kV - Ameren Owned/By POWER	457.20	7.85	812583.49	1159630.96	711.49	0.00
42	43	199.4	-0.61	-6.87	NG		20	0		Underbuild conductor 34kV - Ameren Owned	970.00	5.41	812519.01	1159125.27	728.55	0.00
		199.4	-0.53	-6.96	NG		30	0		Underbuild conductor 34kV - Ameren Owned/By POWER	971.34	5.65	812518.56	1159123.98	728.61	0.00
43	44	199.4	-3.46	-2.98	NG		522	0		Underbuild conductor 34kV - Ameren Owned	1081.60	5.98	812469.63	1159027.21	723.49	0.00
		199.4	-3.19	-2.30	NG		1028	0		Underbuild conductor 34kV - Ameren Owned/By POWER	1092.17	6.30	812464.58	1159017.93	722.99	0.00
44	45	199.4	-0.42	-2.42	NG		131	0		Underbuild conductor 34kV - Ameren Owned	1471.28	-2.08	812300.25	1158676.19	712.84	0.00
		199.4	-0.23	-2.32	NG		148	0		Underbuild conductor 34kV - Ameren Owned/By POWER	1470.18	-1.97	812300.65	1158677.21	712.69	0.00
51	52	199.4	-0.14	-0.36	NG		6	0		Crossing shield wire/By POWER	3501.15	6.57	811376.99	1156868.44	718.41	0.00
		199.4	-2.36	-0.30	NG		28	0		Crossing conductor 69kV/By POWER	3604.61	-13.37	811348.96	1156766.86	714.79	0.00

5 spans with clearance violations NG
11 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 9:48:01 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000

1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 240 241 242 243 244 245 246 247 248 545 546 547 548 549 550 551 552 1241 1242 1243 1244 1245 1246 1247 1248 1545 1546 1547 1548 1549 1550 1551 1552
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
40	41	199.4	-0.40	-4.77	NG		72	0		Underbuild conductor 34kV - Ameren Owned	449.25	8.12	812582.82	1159638.89	711.28	0.00
		199.4	-0.14	-5.00	NG		90	0		Underbuild conductor 34kV - Ameren Owned/By POWER	457.20	7.85	812583.49	1159630.96	711.49	0.00
42	43	199.4	-0.61	-6.87	NG		20	0		Underbuild conductor 34kV - Ameren Owned	970.00	5.41	812519.01	1159125.27	728.55	0.00
		199.4	-0.53	-6.96	NG		30	0		Underbuild conductor 34kV - Ameren Owned/By POWER	971.34	5.65	812518.56	1159123.98	728.61	0.00
43	44	199.4	-3.46	-2.98	NG		351	0		Underbuild conductor 34kV - Ameren Owned	1081.60	5.98	812469.63	1159027.21	723.49	0.00
		199.4	-3.19	-2.30	NG		700	0		Underbuild conductor 34kV - Ameren Owned/By POWER	1092.17	6.30	812464.58	1159017.93	722.99	0.00
44	45	199.4	-0.42	-2.42	NG		128	0		Underbuild conductor 34kV - Ameren Owned	1471.28	-2.08	812300.25	1158676.19	712.84	0.00
		199.4	-0.23	-2.32	NG		148	0		Underbuild conductor 34kV - Ameren Owned/By POWER	1470.18	-1.97	812300.65	1158677.21	712.69	0.00
51	52	199.4	-2.17	-7.16	NG		12	0		Crossing conductor 69kV/By POWER	3608.57	-6.42	811340.97	1156766.40	714.62	0.00

5 spans with clearance violations NG
11 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 9:58:14 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 104 110 116 126 255 301 306 321 335 400 405 410 425 1007 1008
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
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Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Controlli Weather Case	-Clearance--- ---Margin---- Vert. (ft)	Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
53	DECATUR_E.MAIN_SUB.	60F 6psf	-3.81	-2.80	NG	Nonprojectable.	43	0		Substation	4001.08	12.98	810998.41	1156636.30	681.36	0.00

1 spans with clearance violations NG
15 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64   10:00:55 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert. (ft)	0 kV Horiz. (ft)	138 kV Vert. (ft)	138 kV Horiz. (ft)	161 kV Vert. (ft)	161 kV Horiz. (ft)	230 kV Vert. (ft)	230 kV Horiz. (ft)	345 kV Vert. (ft)	345 kV Horiz. (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000

Feature code used to determine required clearance to ground 100

Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 104 110 116 126 255 301 306 321 335 400 405 410 425 1007 1008
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	--Clearance--- ---Margin----- Vert. (ft)	Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
53	DECATUR_E.MAIN_SUB.	199.4	-2.06	-13.07	NG		15	0		Substation	3991.17	-10.51	811012.29	1156614.91	670.37	0.00

1 spans with clearance violations NG
15 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 10:03:30 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range
of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but
adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 131
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but
reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).

Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

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Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point: Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)

0 spans with clearance violations OK
16 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 10:04:24 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
12	199.4	0.00256	0	0.0	0.00	0.000	0.00	199	199	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	12	199.4	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 131
This report is checking clearances to wires between structures 39 to DECATUR_E.MAIN_SUB..
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).

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Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point Point ID	Controlling Point Feature Code Description	Controlling Point Station (ft)	Controlling Point Offset (ft)	Controlling Point X (ft)	Controlling Point Y (ft)	Controlling Point Z (ft)	Controlling Point Height (ft)

0 spans with clearance violations OK
16 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 10:05:42 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. ----0 kV----- (ft)	Horiz. ----0 kV----- (ft)	Vert. ---138 kV---- (ft)	Horiz. ---138 kV---- (ft)	Vert. ---161 kV---- (ft)	Horiz. ---161 kV---- (ft)	Vert. ---230 kV---- (ft)	Horiz. ---230 kV---- (ft)	Vert. ---345 kV---- (ft)	Horiz. ---345 kV---- (ft)	Stucture Base/Guy to Spotting Constraint (ft)
11	Set Control Point/Instrument Point	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
13	PI (point of intersection)	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
14	New TIN PI (defined by engineer)	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
200	UNKNOWN FEATURE CODE	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
220	Guy wire anchor	No	Yes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	Conductor/shield wire attachment point	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
232	Insulator attachment point at structure	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
236	Shield Wire	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
237	Guy Wire	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
253	Transmission Structure Steel	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
254	Transmission Structure Wood	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
256	Center of Structure	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
275	Conductor splices	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
276	Shield wire splices	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
277	Aerial marker ball	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
468	Comm conductors, cables and messengers	Yes	No	0.000	0.000	9.000	11.000	9.000	11.000	11.000	13.000	13.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1001	Conductor Left/Bottom	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1002	Conductor Center/Middle	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1003	Conductor Right/Top	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
1009	Parallel Line	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1102	?UNKNOWN FEATURE CODE?	No	Yes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Thermal Rating Report Settings

Structure range: 39 to DECATUR_E.MAIN_SUB. Temperature range: 32 (°F) to 500 (°F)
Cable condition: Max Sag FE
Maximum offset from wires 5.00 (ft)
Special Temperature Values:
32 (deg F) indicates that a violation occurs even at the minimum temperature (will be indicated as NG)
500 (deg F) indicates that there is never a violation even at the maximum temperature

Results based on vertical clearances to survey points that are within a 5.00 (ft) offset from wires.
This report includes only survey points that do not have the following feature codes: 131

Results based on clearance to ground calculated at 3.28 (ft) station intervals along span. If a TIN model is available it is used to calculate the ground level directly below the span and 5.00 (ft) left or right of that point. If the program is unable to determine the ground elevations at these points from the TIN model then it will try to construct a profile below the wire. This profile consists of line segments created by connecting survey points with known ground elevations within a 3.00 (ft) offset of the wire in order of increasing station. Segments with lengths in excess of 30.00 (ft) are not included.

Thermal Rating Summary

Note: Spans sorted in order of temperature causing vertical clearance violations

Back Structure Number	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
53	**DECATUR_E.MAIN_SUB.**	**32**	**3990.97**	**-10.01**	**811012.39**	**1156615.44**	**670.34**	**1.42**	**NG Point Substation , Aborted critical point search since wire can't clear point at 32 (deg F)**
43	44	57	1017.49	5.79	812498.74	1159084.33	725.85	1.11	Point Underbuild conductor 34kV - Ameren Owned
42	43	70	970.00	5.41	812519.01	1159125.27	728.55	-0.64	Point Underbuild conductor 34kV - Ameren Owned
51	52	75	3608.57	-6.42	811340.97	1156766.40	714.62	-4.84	Point Crossing conductor 69kV/By POWER
40	41	175	449.25	8.12	812582.82	1159638.89	711.28	2.16	Point Underbuild conductor 34kV - Ameren Owned
44	45	185	1446.85	-2.15	812311.43	1158697.91	714.08	4.30	Point Underbuild conductor 34kV - Ameren Owned
39	40	224	162.66	-1.11	812577.94	1159925.60	702.65	-4.58	Point Underbuild conductor 34kV - Ameren Owned
50	51	354	3365.56	-2.33	811447.69	1156984.63	710.46	2.08	Point Underbuild conductor 34kV - Ameren Owned
46	47	434	2190.53	7.04	811966.88	1158038.79	708.42	-1.31	Point Underbuild conductor 34kV - Ameren Owned
41	42	500	575.81	-0.76	812588.60	1159513.33	713.98	-3.41	No violations found at max temp. of 500.00
45	46	500	1853.99	-8.05	812131.87	1158332.49	717.07	0.86	No violations found at max temp. of 500.00
47	48	500	2558.30	-5.83	811813.14	1157704.44	700.54	2.77	No violations found at max temp. of 500.00

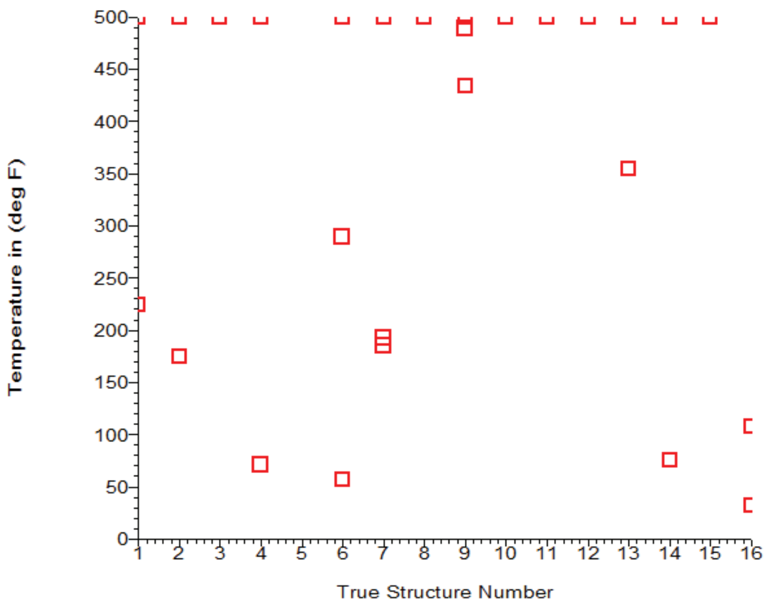
48	49	500	2907.37	-3.09	811655.59	1157392.99	701.50	3.15	No violations found at max temp. of 500.00
49	50	500	3201.59	-5.48	811526.00	1157128.76	709.97	-1.07	No violations found at max temp. of 500.00
52	53	500	3872.12	-8.67	811129.47	1156638.62	708.46	-4.70	No violations found at max temp. of 500.00

NDEC-EMST-1522-587
Obstacle New Rating Report
10/16/2013

Thermal Rating Detail

Note: Temperatures printed are those at which ahead spans get vertical clearance violations

Cable File Name	Back Structure Number	Set No.	Phase No.	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
narcissus_aac.wir	39	3	1	40	224	162.66	-1.11	812577.94	1159925.60	702.65	-4.58	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	39	3	2	40	500	162.66	-1.11	812577.94	1159925.60	702.65	1.31	No violations found at max temp. of 500.00
narcissus_aac.wir	39	3	3	40	500	165.66	-0.69	812577.67	1159922.58	702.61	-3.91	No violations found at max temp. of 500.00
narcissus_aac.wir	40	3	1	41	175	449.25	8.12	812582.82	1159638.89	711.28	2.16	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	40	3	2	41	500	437.18	-2.71	812593.03	1159651.49	710.20	-2.72	No violations found at max temp. of 500.00
narcissus_aac.wir	40	3	3	41	500	427.97	8.11	812581.77	1159660.15	710.04	2.95	No violations found at max temp. of 500.00
narcissus_aac.wir	41	3	1	42	500	575.81	-0.76	812588.60	1159513.33	713.98	-3.41	No violations found at max temp. of 500.00
narcissus_aac.wir	41	3	2	42	500	568.91	0.96	812588.07	1159520.42	714.47	-3.35	No violations found at max temp. of 500.00
narcissus_aac.wir	41	3	3	42	500	568.91	0.96	812588.07	1159520.42	714.47	-3.37	No violations found at max temp. of 500.00
narcissus_aac.wir	42	3	1	43	70	970.00	5.41	812519.01	1159125.27	728.55	-0.64	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	42	3	2	43	500	955.08	0.74	812525.95	1159139.27	726.11	-3.95	No violations found at max temp. of 500.00
narcissus_aac.wir	42	3	3	43	500	883.46	7.27	812530.69	1159211.03	669.85	2.63	No violations found at max temp. of 500.00
narcissus_aac.wir	43	3	1	44	57	1017.49	5.79	812498.74	1159084.33	725.85	1.11	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	43	3	2	44	289	1150.77	6.23	812438.20	1158965.60	723.10	-0.21	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	43	3	3	44	500	1146.86	-1.87	812447.19	1158965.43	722.28	-0.73	No violations found at max temp. of 500.00
narcissus_aac.wir	44	3	1	45	185	1446.85	-2.15	812311.43	1158697.91	714.08	4.30	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	44	3	2	45	192	1467.60	6.87	812293.95	1158683.54	714.74	-1.14	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	44	3	3	45	500	1482.34	-1.91	812295.06	1158666.42	712.38	4.81	No violations found at max temp. of 500.00
narcissus_aac.wir	45	3	1	46	500	1853.99	-8.05	812131.87	1158332.49	717.07	0.86	No violations found at max temp. of 500.00
narcissus_aac.wir	45	3	2	46	500	1848.23	6.95	812121.08	1158344.40	717.92	-1.32	No violations found at max temp. of 500.00
narcissus_aac.wir	45	3	3	46	500	1860.61	-3.75	812125.05	1158328.52	717.36	5.01	No violations found at max temp. of 500.00
narcissus_aac.wir	46	3	1	47	488	2170.15	-7.53	811989.06	1158050.44	707.20	1.35	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	46	3	2	47	434	2190.53	7.04	811966.88	1158038.79	708.42	-1.31	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	46	3	3	47	500	2182.89	-7.96	811983.71	1158038.86	706.74	0.85	No violations found at max temp. of 500.00
narcissus_aac.wir	47	3	1	48	500	2558.30	-5.83	811813.14	1157704.44	700.54	2.77	No violations found at max temp. of 500.00
narcissus_aac.wir	47	3	2	48	500	2505.94	3.29	811828.49	1157755.33	702.97	-5.27	No violations found at max temp. of 500.00
narcissus_aac.wir	47	3	3	48	500	2558.30	-5.83	811813.14	1157704.44	700.54	2.63	No violations found at max temp. of 500.00
narcissus_aac.wir	48	3	1	49	500	2907.37	-3.09	811655.59	1157392.99	701.50	3.15	No violations found at max temp. of 500.00
narcissus_aac.wir	48	3	2	49	500	2896.64	-2.84	811660.09	1157402.74	701.27	-4.93	No violations found at max temp. of 500.00
narcissus_aac.wir	48	3	3	49	500	2907.37	-3.09	811655.59	1157392.99	701.50	3.24	No violations found at max temp. of 500.00
narcissus_aac.wir	49	3	1	50	500	3201.59	-5.48	811526.00	1157128.76	709.97	-1.07	No violations found at max temp. of 500.00
narcissus_aac.wir	49	3	2	50	500	3203.65	3.54	811517.04	1157131.05	710.49	1.72	No violations found at max temp. of 500.00
narcissus_aac.wir	49	3	3	50	500	3179.50	-5.41	811536.04	1157148.44	709.64	-0.54	No violations found at max temp. of 500.00
narcissus_aac.wir	50	3	1	51	354	3365.56	-2.33	811447.69	1156984.63	710.46	2.08	Point Underbuild conductor 34kV - Ameren Owned
narcissus_aac.wir	50	3	2	51	500	3366.54	4.20	811441.45	1156986.79	706.56	-1.64	No violations found at max temp. of 500.00
narcissus_aac.wir	50	3	3	51	500	3381.53	-1.70	811439.72	1156970.78	710.10	3.02	No violations found at max temp. of 500.00
narcissus_aac.wir	51	3	1	52	75	3608.57	-6.42	811340.97	1156766.40	714.62	-4.84	Point Crossing conductor 69kV/By POWER
narcissus_aac.wir	51	3	2	52	500	3611.05	-2.07	811335.97	1156766.11	714.51	-4.40	No violations found at max temp. of 500.00
narcissus_aac.wir	51	3	3	52	500	3608.57	-6.42	811340.97	1156766.40	714.62	-4.52	No violations found at max temp. of 500.00
narcissus_aac.wir	52	3	1	53	500	3872.12	-8.67	811129.47	1156638.62	708.46	-4.70	No violations found at max temp. of 500.00
narcissus_aac.wir	52	3	2	53	500	3848.23	1.11	811150.44	1156653.69	693.04	4.31	No violations found at max temp. of 500.00
narcissus_aac.wir	52	3	3	53	500	3871.46	0.27	811128.03	1156647.47	707.79	-4.92	No violations found at max temp. of 500.00
narcissus_aac.wir	**53**	**3**	**1**	**DECATUR_E.MAIN_SUB.**	**32**	**3990.97**	**-10.01**	**811012.39**	**1156615.44**	**670.34**	**1.42**	**NG Point Substation , Aborted critical point search since wire can't clear point at 32 (deg F)**
narcissus_aac.wir	53	3	2	DECATUR_E.MAIN_SUB.	108	3989.85	-2.41	811012.16	1156623.11	670.57	-1.26	Point Substation
narcissus_aac.wir	**53**	**3**	**3**	**DECATUR_E.MAIN_SUB.**	**32**	**3988.16**	**5.99**	**811012.35**	**1156631.68**	**670.24**	**-4.00**	**NG Point Substation , Aborted critical point search since wire can't clear point at 32 (deg F)**


Temperature in (deg F)
500
450
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
True Structure Number

PLS-CADD Version 12.50x64 10:06:43 AM Wednesday, October 16, 2013
Power Engineers
Project Name: 'p:\power projects\128389 ameren illinois 2013\dd (design & drawing)\pls-cadd\projects\128389\ndec-emst-1522-587\ndec-emst-1522_587.DON'
Line Title: 'Reports'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
				(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Thermal Rating Report Settings

Structure range: 39 to DECATUR_E.MAIN_SUB. Temperature range: 32 (°F) to 500 (°F)
Cable condition: Max Sag FE
Maximum offset from wires 5.00 (ft)
Special Temperature Values:
32 (deg F) indicates that a violation occurs even at the minimum temperature (will be indicated as NG)
500 (deg F) indicates that there is never a violation even at the maximum temperature

Results based on vertical clearances to survey points that are within a 5.00 (ft) offset from wires.
This report includes only survey points that have the following feature codes: 131

Results based on clearance to ground calculated at 3.28 (ft) station intervals along span. If a TIN model is available it is used to calculate the ground level directly below the span and 5.00 (ft) left or right of that point. If the program is unable to determine the ground elevations at these points from the TIN model then it will try to construct a profile below the wire. This profile consists of line segments created by connecting survey points with known ground elevations within a 3.00 (ft) offset of the wire in order of increasing station. Segments with lengths in excess of 30.00 (ft) are not included.

Thermal Rating Summary

Note: Spans sorted in order of temperature causing vertical clearance violations

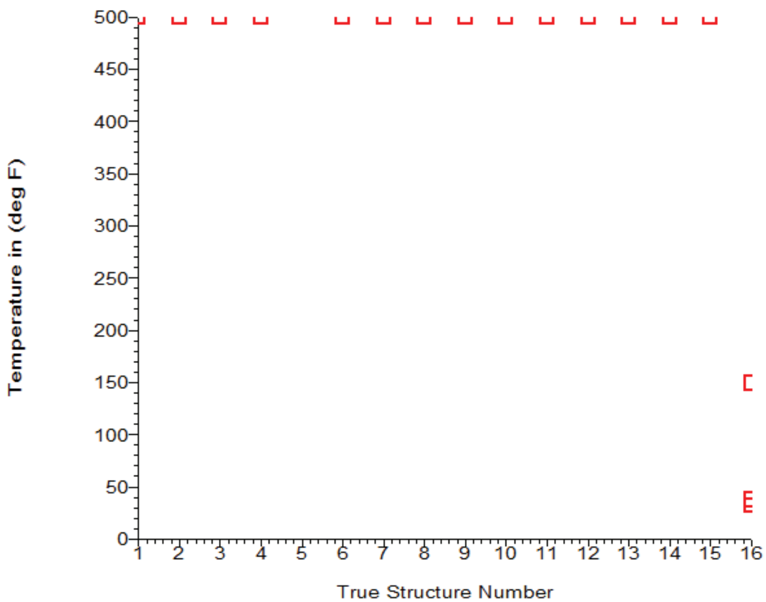
Back Structure Number	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
53	DECATUR_E.MAIN_SUB.	32	3987.43	-11.19	811016.09	1156614.90	656.30	-0.00	NG TIN elevation, Aborted critical point search since wire can't clear point at 32 (deg F)
39	40	500	166.52	8.55	812568.48	1159921.27	669.89	5.00	No violations found at max temp. of 500.00
40	41	500	422.23	11.54	812578.05	1159665.70	669.22	5.85	No violations found at max temp. of 500.00
41	42	500	635.78	5.73	812572.16	1159455.29	670.32	5.91	No violations found at max temp. of 500.00
42	43	500	848.71	10.96	812532.48	1159245.93	670.27	5.48	No violations found at max temp. of 500.00
43	44	500	1121.92	0.99	812455.89	1158988.97	673.22	0.79	No violations found at max temp. of 500.00
44	45	500	1511.55	-6.99	812286.28	1158638.10	671.70	0.02	No violations found at max temp. of 500.00
45	46	500	1855.76	-8.89	812131.83	1158330.53	670.97	0.02	No violations found at max temp. of 500.00
46	47	500	2310.56	-6.39	811924.89	1157925.54	680.66	2.44	No violations found at max temp. of 500.00

47	48	500	2560.35	-13.59	811819.15	1157699.13	669.45	-4.99	No violations found at max temp. of 500.00
48	49	500	2907.19	-6.20	811658.46	1157391.78	668.59	0.04	No violations found at max temp. of 500.00
49	50	500	3202.79	-5.66	811525.61	1157127.61	683.69	-1.25	No violations found at max temp. of 500.00
50	51	500	3361.89	-2.49	811449.53	1156987.81	680.11	1.93	No violations found at max temp. of 500.00
51	52	500	3584.19	0.06	811345.98	1156791.12	674.14	2.20	No violations found at max temp. of 500.00
52	53	500	3809.04	2.64	811188.20	1156664.27	658.83	5.00	No violations found at max temp. of 500.00

Thermal Rating Detail

Note: Temperatures printed are those at which ahead spans get vertical clearance violations

Cable File Name	Back Structure Number	Set No.	Phase No.	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
narcissus_aac.wir	39	3	1	40	500	166.52	8.55	812568.48	1159921.27	669.89	5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	39	3	2	40	500	179.79	2.32	812575.35	1159908.32	669.39	5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	39	3	3	40	500	169.77	8.30	812568.88	1159918.04	669.88	5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	40	3	1	41	500	422.23	11.54	812578.05	1159665.70	669.22	5.85	No violations found at max temp. of 500.00
narcissus_aac.wir	40	3	2	41	500	425.29	5.27	812584.47	1159662.96	668.49	5.73	No violations found at max temp. of 500.00
narcissus_aac.wir	40	3	3	41	500	422.15	10.98	812578.61	1159665.82	669.15	5.76	No violations found at max temp. of 500.00
narcissus_aac.wir	41	3	1	42	500	635.78	5.73	812572.16	1159455.29	670.32	5.91	No violations found at max temp. of 500.00
narcissus_aac.wir	41	3	2	42	500	645.24	10.83	812565.54	1159446.82	671.00	5.68	No violations found at max temp. of 500.00
narcissus_aac.wir	41	3	3	42	500	638.69	10.63	812566.83	1159453.25	670.96	5.79	No violations found at max temp. of 500.00
narcissus_aac.wir	42	3	1	43	500	858.14	5.50	812536.39	1159235.77	670.03	5.71	No violations found at max temp. of 500.00
narcissus_aac.wir	42	3	2	43	500	848.71	10.96	812532.48	1159245.93	670.27	5.48	No violations found at max temp. of 500.00
narcissus_aac.wir	42	3	3	43	500	855.40	10.41	812531.98	1159239.24	670.31	5.56	No violations found at max temp. of 500.00
narcissus_aac.wir	43	3	1	44	500	1121.92	0.99	812455.89	1158988.97	673.22	0.79	No violations found at max temp. of 500.00
narcissus_aac.wir	43	3	2	44	500	1131.79	11.65	812441.92	1158984.98	673.03	5.59	No violations found at max temp. of 500.00
narcissus_aac.wir	43	3	3	44	500	1128.55	0.02	812453.76	1158982.63	673.06	0.64	No violations found at max temp. of 500.00
narcissus_aac.wir	44	3	1	45	500	1511.55	-6.99	812286.28	1158638.10	671.70	0.02	No violations found at max temp. of 500.00
narcissus_aac.wir	44	3	2	45	500	1524.41	13.05	812262.59	1158635.77	671.56	4.94	No violations found at max temp. of 500.00
narcissus_aac.wir	44	3	3	45	500	1511.46	-6.94	812286.28	1158638.20	671.70	0.01	No violations found at max temp. of 500.00
narcissus_aac.wir	45	3	1	46	500	1855.76	-8.89	812131.83	1158330.53	670.97	0.02	No violations found at max temp. of 500.00
narcissus_aac.wir	45	3	2	46	500	1855.38	3.21	812121.20	1158336.32	670.92	-5.06	No violations found at max temp. of 500.00
narcissus_aac.wir	45	3	3	46	500	1855.57	-8.74	812131.78	1158330.76	670.97	0.01	No violations found at max temp. of 500.00
narcissus_aac.wir	46	3	1	47	500	2310.56	-6.39	811924.89	1157925.54	680.66	2.44	No violations found at max temp. of 500.00
narcissus_aac.wir	46	3	2	47	500	2307.15	4.99	811916.26	1157933.71	685.16	-3.49	No violations found at max temp. of 500.00
narcissus_aac.wir	46	3	3	47	500	2310.56	-6.39	811924.89	1157925.54	680.66	2.37	No violations found at max temp. of 500.00
narcissus_aac.wir	47	3	1	48	500	2560.35	-13.59	811819.15	1157699.13	669.45	-4.99	No violations found at max temp. of 500.00
narcissus_aac.wir	47	3	2	48	500	2557.48	13.14	811796.56	1157713.69	669.80	4.57	No violations found at max temp. of 500.00
narcissus_aac.wir	47	3	3	48	500	2553.88	-13.47	811821.95	1157704.96	669.48	-5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	48	3	1	49	500	2907.19	-6.20	811658.46	1157391.78	668.59	0.04	No violations found at max temp. of 500.00
narcissus_aac.wir	48	3	2	49	500	2884.67	7.46	811656.10	1157418.02	669.16	4.90	No violations found at max temp. of 500.00
narcissus_aac.wir	48	3	3	49	500	2907.21	-6.29	811658.53	1157391.73	668.59	0.04	No violations found at max temp. of 500.00
narcissus_aac.wir	49	3	1	50	500	3202.79	-5.66	811525.61	1157127.61	683.69	-1.25	No violations found at max temp. of 500.00
narcissus_aac.wir	49	3	2	50	500	3201.68	-2.53	811523.34	1157130.03	676.64	-4.24	No violations found at max temp. of 500.00
narcissus_aac.wir	49	3	3	50	500	3197.78	-8.79	811530.69	1157130.63	682.87	-3.88	No violations found at max temp. of 500.00
narcissus_aac.wir	50	3	1	51	500	3361.89	-2.49	811449.53	1156987.81	680.11	1.93	No violations found at max temp. of 500.00
narcissus_aac.wir	50	3	2	51	500	3385.05	0.86	811435.82	1156968.85	665.84	-5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	50	3	3	51	500	3361.89	-2.49	811449.53	1156987.81	680.11	2.31	No violations found at max temp. of 500.00
narcissus_aac.wir	51	3	1	52	500	3584.19	0.06	811345.98	1156791.12	674.14	2.20	No violations found at max temp. of 500.00
narcissus_aac.wir	51	3	2	52	500	3584.19	0.06	811345.98	1156791.12	674.14	-3.11	No violations found at max temp. of 500.00
narcissus_aac.wir	51	3	3	52	500	3584.19	0.06	811345.98	1156791.12	674.14	2.45	No violations found at max temp. of 500.00
narcissus_aac.wir	52	3	1	53	500	3809.04	2.64	811188.20	1156664.27	658.83	5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	52	3	2	53	500	3808.73	2.57	811188.52	1156664.27	658.87	5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	52	3	3	53	500	3801.05	-1.96	811197.03	1156661.65	658.23	-5.00	No violations found at max temp. of 500.00
narcissus_aac.wir	**53**	**3**	**1**	**DECATUR_E.MAIN_SUB.**	**32**	**3987.43**	**-11.19**	**811016.09**	**1156614.90**	**656.30**	**-0.00**	**NG TIN elevation, Aborted critical point search since wire can't clear point at 32 (deg F)**
narcissus_aac.wir	53	3	2	DECATUR_E.MAIN_SUB.	149	3990.19	-6.15	811012.49	1156619.37	656.29	-5.00	TIN elevation
narcissus_aac.wir	53	3	3	DECATUR_E.MAIN_SUB.	37	3988.22	4.99	811012.47	1156630.68	656.03	-5.00	TIN elevation


Temperature in (deg F)
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
True Structure Number

PLS-CADD Version 12.50x64 8:50:40 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert. (ft)	0 kV Horiz. (ft)	138 kV Vert. (ft)	138 kV Horiz. (ft)	161 kV Vert. (ft)	161 kV Horiz. (ft)	230 kV Vert. (ft)	230 kV Horiz. (ft)	345 kV Vert. (ft)	345 kV Horiz. (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes:
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN checked at 3.28 (ft) station and offset intervals along wire. Clearances are being checked out to an offset 20.00 (ft) from wire.
Required clearance to TIN is that for feature code 'Interpolated Points' (set in Terrain/Feature Code Data/Feature Code for Ground Clearance and Interpolated TIN Points

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
407	406	230	-4.67	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	1524.27	16.00	832145.79	770356.61	807.91	0.00
405	404	230	-1.37	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	3043.21	15.54	830688.83	770786.04	795.78	0.00
404	403	230	-1.65	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	3831.92	15.42	829932.32	771009.16	784.35	0.00

3 spans with clearance violations NG
8 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 8:54:46 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert. (ft)	0 kV Horiz. (ft)	138 kV Vert. (ft)	138 kV Horiz. (ft)	161 kV Vert. (ft)	161 kV Horiz. (ft)	230 kV Vert. (ft)	230 kV Horiz. (ft)	345 kV Vert. (ft)	345 kV Horiz. (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000

552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 240 241 242 243 244 245 246 247 248 545 546 547 548 549 550 551 552 1241 1242 1243 1244 1245 1246 1247 1248 1545 1546 1547 1548 1549 1550 1551 1552
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wines in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Controlli Weather Case	-Clearance--- ---Margin---- Vert. (ft)	Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
408	407A	230	-3.26	-0.59	NG		42	0		Crossing conductor 69kV/By POWER	489.41	-27.70	832410.09	769612.52	878.32	0.00
407	406	60F 6psf	41.78	15.92	??	Point above wires.	0	76		Crossing shield wire	1258.20	15.14	832400.73	770280.45	900.27	0.00
		60F 6psf	25.54	15.37	??	Point above wires.	0	119		Crossing conductor 69kV	1250.54	15.35	832408.14	770278.48	884.65	0.00

1 spans with clearance violations NG
10 spans without clearance violations (spans without violations excluded from report above)

1 spans with aerial survey points above or between wires. These should be investigated to ensure proper clearance is maintained at all relevant temperatures. ??

SEL-RIV-2_779

Critical Wire Crossing Clearance Report 11/6/2013

PLS-CADD Version 12.50x64   8:59:29 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000

1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 240 241 242 243 244 245 246 247 248 545 546 547 548 549 550 551 552 1241 1242 1243 1244 1245 1246 1247 1248 1545 1546 1547 1548 1549 1550 1551 1552
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
408	407A	230	-2.85	-7.59	NG		20	0		Crossing conductor 69kV/By POWER	489.08	-20.70	832416.94	769611.08	877.91	0.00

1 spans with clearance violations NG
10 spans without clearance violations (spans without violations excluded from report above)

Ahead span of structure 408 and cross section at station 489.08 (ft)

PLS-CADD Version 12.50x64 9:04:34 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 104 110 116 126 255 301 306 321 335 400 405 410 425 1007 1008
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
- **Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.**
- **Point above wires: Aerial obstacle that is above wires for specified criteria.**
  - **Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.**
- **Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.**
  - **Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.**
- **Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.**

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)

0 spans with clearance violations OK
11 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 9:06:32 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000

Feature code used to determine required clearance to ground 100

Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 104 110 116 126 255 301 306 321 335 400 405 410 425 1007 1008
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but
reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).
Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are
indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance
(no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Controlling Point Station (ft)	Controlling Point Offset (ft)	Controlling Point X (ft)	Controlling Point Y (ft)	Controlling Point Z (ft)	Controlling Point Height (ft)

0 spans with clearance violations OK
11 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 9:10:17 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. 0 kV (ft)	Horiz. 0 kV (ft)	Vert. 138 kV (ft)	Horiz. 138 kV (ft)	Vert. 161 kV (ft)	Horiz. 161 kV (ft)	Vert. 230 kV (ft)	Horiz. 230 kV (ft)	Vert. 345 kV (ft)	Horiz. 345 kV (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 131
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).

Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
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Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
405	404	230	-8.23	-1.46	NG		3	0		Vegetation/Tree/Brush	3218.45	34.07	830526.06	770853.54	792.02	23.08

1 spans with clearance violations NG
10 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 9:11:51 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
16	230	0.00256	0	0.0	0.00	0.000	0.00	230	230	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	16	230	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert. (ft)	0 kV Horiz. (ft)	138 kV Vert. (ft)	138 kV Horiz. (ft)	161 kV Vert. (ft)	161 kV Horiz. (ft)	230 kV Vert. (ft)	230 kV Horiz. (ft)	345 kV Vert. (ft)	345 kV Horiz. (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 131
This report is checking clearances to wires between structures ST.Francois_Sub. to 323.
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).

Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Controlling Point Station (ft)	Controlling Point Offset (ft)	Controlling Point X (ft)	Controlling Point Y (ft)	Controlling Point Z (ft)	Controlling Point Height (ft)

0 spans with clearance violations OK
11 spans without clearance violations (spans without violations excluded from report above)

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Obstacle New Rating Report 11/11/2013

PLS-CADD Version 12.50x64 4:05:01 PM Monday, November 11, 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
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Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) Vert. 0 kV	Horiz. 0 kV	Vert. 138 kV	Horiz. 138 kV	Vert. 161 kV	Horiz. 161 kV	Vert. 230 kV	Horiz. 230 kV	Vert. 345 kV	Horiz. 345 kV	Stucture Base/Guy to Spotting Constraint
11	Set Control Point/Instrument Point	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
13	PI (point of intersection)	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
14	New TIN PI (defined by engineer)	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
200	UNKNOWN FEATURE CODE	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
220	Guy wire anchor	No	Yes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	Conductor/shield wire attachment point	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
232	Insulator attachment point at structure	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
236	Shield Wire	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
237	Guy Wire	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
253	Transmission Structure Steel	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
254	Transmission Structure Wood	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
256	Center of Structure	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
275	Conductor splices	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
276	Shield wire splices	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
277	Aerial marker ball	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
468	Comm conductors, cables and messengers	Yes	No	0.000	0.000	9.000	11.000	9.000	11.000	11.000	13.000	13.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1001	Conductor Left/Bottom	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1002	Conductor Center/Middle	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1003	Conductor Right/Top	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
1009	Parallel Line	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1102	?UNKNOWN FEATURE CODE?	No	Yes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Thermal Rating Report Settings

Structure range: ST.Francois_Sub. to 323 Temperature range: 32 (°F) to 500 (°F)
Cable condition: Max Sag FE
Maximum offset from wires 5.00 (ft)
Special Temperature Values:
32 (deg F) indicates that a violation occurs even at the minimum temperature (will be indicated as NG)
500 (deg F) indicates that there is never a violation even at the maximum temperature

Results based on vertical clearances to survey points that are within a 5.00 (ft) offset from wires.
This report includes only survey points that do not have the following feature codes: 131

Results based on clearance to ground calculated at 3.28 (ft) station intervals along span.
If a TIN model is available it is used to calculate the ground level directly below the span and 5.00 (ft) left or right of that point.
If the program is unable to determine the ground elevations at these points from the TIN model then it will try to construct a profile below the wire. This profile consists of line segments created by connecting survey points with known ground elevations within a 3.00 (ft) offset of the wire in order of increasing station. Segments with lengths in excess of 30.00 (ft) are not included.

Thermal Rating Summary

Note: Spans sorted in order of temperature causing vertical clearance violations

Back Structure Number	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
408	**407A**	**32**	**489.08**	**-20.70**	**832416.94**	**769611.08**	**877.91**	**-4.36**	**NG Point Crossing conductor 69kV/By POWER , Aborted critical point search since wire can't clear point at 32 (deg F)**
407	406	143	1470.12	11.08	832196.33	770336.55	809.45	-5.00	TIN elevation
404	403	193	3831.14	20.43	829934.48	771013.74	784.46	5.00	TIN elevation
405	404	197	3045.57	20.54	830687.99	770791.50	795.90	5.00	TIN elevation
403	402	240	4531.50	-20.55	829251.17	771172.70	767.40	-5.00	TIN elevation
406	405	302	2298.01	-20.54	831393.32	770540.40	804.75	-5.00	TIN elevation
407A	407	407	907.05	21.30	832523.75	770017.29	828.01	5.00	TIN elevation
ST.Francois_Sub.	409	500	81.37	15.00	832751.44	769461.57	817.55	1.18	No violations found at max temp. of 500.00
409	408	500	327.27	-15.00	832506.27	769497.10	820.24	0.93	No violations found at max temp. of 500.00
402	401	500	5315.32	-21.48	828499.29	771394.16	745.54	-4.75	No violations found at max temp. of 500.00
401	323	500	5899.34	-0.00	827953.31	771595.71	753.21	4.81	No violations found at max temp. of 500.00

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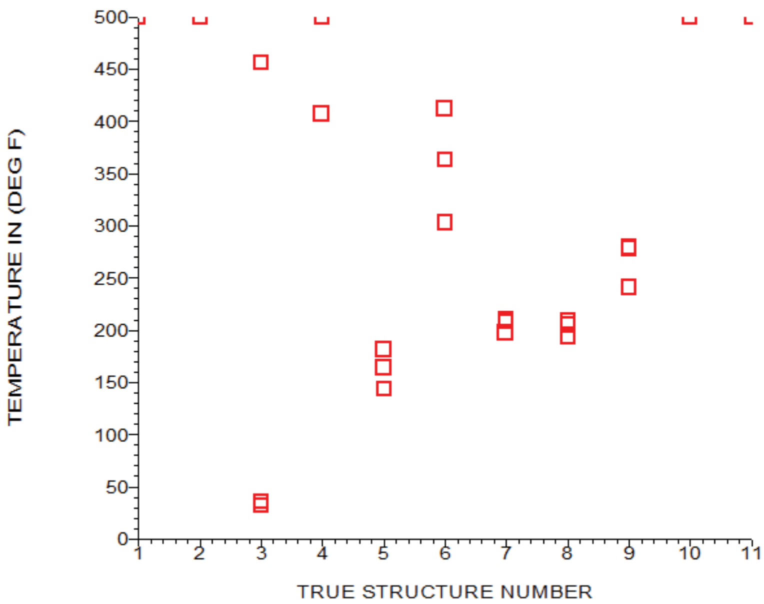
Obstacle New Rating Report 11/11/2013

Thermal Rating Detail

Note: Temperatures printed are those at which ahead spans get vertical clearance violations

Cable File Name	Back Structure Number	Set No.	Phase No.	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
lapwing_acsr.wir	ST.Francois_Sub.	3	1	409	500	6520.57	17.52	832669.91	769447.99	845.96	-4.67	No violations found at max temp. of 500.00
lapwing_acsr.wir	ST.Francois_Sub.	3	2	409	500	158.48	-4.53	832671.90	769462.86	846.20	-4.56	No violations found at max temp. of 500.00
lapwing_acsr.wir	ST.Francois_Sub.	3	3	409	500	81.37	15.00	832751.44	769461.57	817.55	1.18	No violations found at max temp. of 500.00
lapwing_acsr.wir	409	3	1	408	500	327.27	-15.00	832506.27	769497.10	820.24	0.93	No violations found at max temp. of 500.00
lapwing_acsr.wir	409	3	2	408	500	328.39	2.81	832509.88	769514.57	821.20	2.97	No violations found at max temp. of 500.00
lapwing_acsr.wir	409	3	3	408	500	316.55	16.59	832524.94	769524.74	822.02	0.93	No violations found at max temp. of 500.00
lapwing_acsr.wir	**408**	**3**	**1**	**407A**	**32**	**489.08**	**-20.70**	**832416.94**	**769611.08**	**877.91**	**-4.36**	**NG Point Crossing conductor 69kV/By POWER , Aborted critical point search since wire can't clear point at 32 (deg F)**
lapwing_acsr.wir	408	3	2	407A	36	488.34	-4.70	832432.62	769607.77	876.97	-4.46	Point Crossing conductor 69kV/By POWER
lapwing_acsr.wir	408	3	3	407A	456	487.60	11.30	832448.29	769604.47	876.03	-4.42	Point Crossing conductor 69kV/By POWER
lapwing_acsr.wir	407A	3	1	407	500	881.85	-15.00	832483.99	769997.99	826.58	1.29	No violations found at max temp. of 500.00
lapwing_acsr.wir	407A	3	2	407	500	886.55	2.10	832501.62	770000.00	827.46	2.24	No violations found at max temp. of 500.00
lapwing_acsr.wir	407A	3	3	407	407	907.05	21.30	832523.75	770017.29	828.01	5.00	TIN elevation
lapwing_acsr.wir	407	3	1	406	180	1491.12	-21.14	832167.07	770311.60	809.62	-5.00	TIN elevation
lapwing_acsr.wir	407	3	2	406	163	1486.66	-4.78	832175.99	770326.03	809.49	-5.00	TIN elevation
lapwing_acsr.wir	407	3	3	406	143	1470.12	11.08	832196.33	770336.55	809.45	-5.00	TIN elevation
lapwing_acsr.wir	406	3	1	405	302	2298.01	-20.54	831393.32	770540.40	804.75	-5.00	TIN elevation
lapwing_acsr.wir	406	3	2	405	363	2298.23	-4.96	831397.50	770555.40	804.01	-5.00	TIN elevation
lapwing_acsr.wir	406	3	3	405	411	2331.23	10.48	831370.21	770579.54	803.51	-5.00	TIN elevation
lapwing_acsr.wir	405	3	1	404	208	3041.92	-10.53	830682.67	770760.67	794.98	5.00	TIN elevation
lapwing_acsr.wir	405	3	2	404	210	3038.95	5.03	830689.93	770774.75	795.47	5.00	TIN elevation
lapwing_acsr.wir	405	3	3	404	197	3045.57	20.54	830687.99	770791.50	795.90	5.00	TIN elevation
lapwing_acsr.wir	404	3	1	403	205	3850.47	-10.53	829907.19	770989.50	783.36	5.00	TIN elevation
lapwing_acsr.wir	404	3	2	403	208	3827.98	4.96	829933.15	770998.01	784.02	5.00	TIN elevation
lapwing_acsr.wir	404	3	3	403	193	3831.14	20.43	829934.48	771013.74	784.46	5.00	TIN elevation
lapwing_acsr.wir	403	3	1	402	240	4531.50	-20.55	829251.17	771172.70	767.40	-5.00	TIN elevation
lapwing_acsr.wir	403	3	2	402	278	4525.59	-5.04	829261.24	771185.90	767.24	-5.00	TIN elevation
lapwing_acsr.wir	403	3	3	402	279	4525.31	10.45	829265.90	771200.67	766.67	-5.00	TIN elevation
lapwing_acsr.wir	402	3	1	401	500	5315.32	-21.48	828499.29	771394.16	745.54	-4.75	No violations found at max temp. of 500.00
lapwing_acsr.wir	402	3	2	401	500	5306.35	-4.12	828512.81	771408.27	745.21	-4.26	No violations found at max temp. of 500.00
lapwing_acsr.wir	402	3	3	401	500	5332.91	15.00	828492.76	771434.13	743.43	-2.06	No violations found at max temp. of 500.00
lapwing_acsr.wir	401	3	1	323	500	5899.34	-0.00	827953.31	771595.71	753.21	4.81	No violations found at max temp. of 500.00
lapwing_acsr.wir	401	3	2	323	500	5896.73	-0.00	827955.36	771594.09	753.32	-3.29	No violations found at max temp. of 500.00
lapwing_acsr.wir	401	3	3	323	500	5898.12	15.00	827963.56	771606.73	752.39	3.02	No violations found at max temp. of 500.00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PLS-CADD Version 12.50x64 9:14:58 PM Wednesday, November 06, 2013
Power Engineers
Project Name: 'c:\users\mdebeer\documents\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\sel-riv-2-779\sel-riv-2_779.DON'
Line Title: 'New Alignment'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert. (ft)	0 kV Horiz. (ft)	138 kV Vert. (ft)	138 kV Horiz. (ft)	161 kV Vert. (ft)	161 kV Horiz. (ft)	230 kV Vert. (ft)	230 kV Horiz. (ft)	345 kV Vert. (ft)	345 kV Horiz. (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Thermal Rating Report Settings

Structure range: ST.Francois_Sub. to 323 Temperature range: 32 (°F) to 500 (°F)
Cable condition: Max Sag FE
Maximum offset from wires 5.00 (ft)
Special Temperature Values:
32 (deg F) indicates that a violation occurs even at the minimum temperature (will be indicated as NG)
500 (deg F) indicates that there is never a violation even at the maximum temperature

Results based on vertical clearances to survey points that are within a 5.00 (ft) offset from wires.
This report includes only survey points that have the following feature codes: 131

Results based on clearance to ground calculated at 3.28 (ft) station intervals along span.
If a TIN model is available it is used to calculate the ground level directly below the span and 5.00 (ft) left or right of that point.
If the program is unable to determine the ground elevations at these points from the TIN model then it will try to construct a profile below the wire. This profile consists of line segments created by connecting survey points with known ground elevations within a 3.00 (ft) offset of the wire in order of increasing station. Segments with lengths in excess of 30.00 (ft) are not included.

Thermal Rating Summary

Note: Spans sorted in order of temperature causing vertical clearance violations

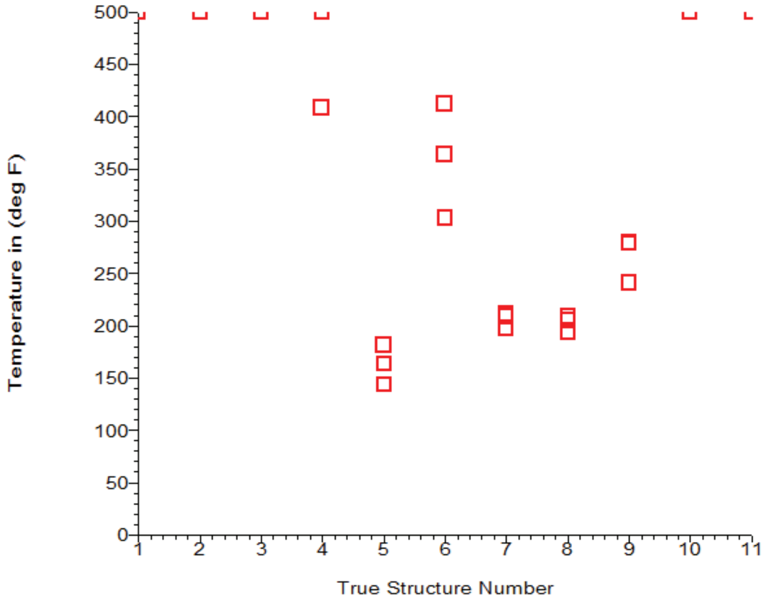
Back Structure Number	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
407	406	143	1470.12	11.08	832196.33	770336.56	809.45	-5.00	TIN elevation
404	403	193	3831.14	20.43	829934.48	771013.74	784.46	5.00	TIN elevation
405	404	197	3045.57	20.54	830687.99	770791.50	795.90	5.00	TIN elevation
403	402	240	4531.50	-20.57	829251.16	771172.68	767.40	-5.02	TIN elevation
406	405	302	2298.05	-20.54	831393.28	770540.41	804.75	-5.01	TIN elevation
407A	407	408	903.77	21.27	832523.22	770014.05	828.05	4.98	TIN elevation
ST.Francois_Sub.	409	500	82.03	18.82	832751.80	769465.43	817.68	5.00	No violations found at max temp. of 500.00
409	408	500	329.63	-10.92	832505.07	769501.65	820.43	5.01	No violations found at max temp. of 500.00
408	407A	500	518.48	-11.17	832431.07	769638.56	827.47	4.90	No violations found at max temp. of 500.00

402	401	500	5298.98	-21.73	828514.90	771389.29	746.35	-5.06	No violations found at max temp. of 500.00
401	323	500	5895.79	-10.87	827949.35	771584.98	753.95	-5.00	No violations found at max temp. of 500.00

Thermal Rating Detail

Note: Temperatures printed are those at which ahead spans get vertical clearance violations

Cable File Name	Back Structure Number	Set No.	Phase No.	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
lapwing_acsr.wir	ST.Francois_Sub.	3	1	409	500	86.96	-8.93	832739.79	769439.93	817.02	5.01	No violations found at max temp. of 500.00
lapwing_acsr.wir	ST.Francois_Sub.	3	2	409	500	84.36	5.03	832745.94	769452.73	817.35	5.00	No violations found at max temp. of 500.00
lapwing_acsr.wir	ST.Francois_Sub.	3	3	409	500	82.03	18.82	832751.80	769465.43	817.68	5.00	No violations found at max temp. of 500.00
lapwing_acsr.wir	409	3	1	408	500	329.63	-10.92	832505.07	769501.65	820.43	5.01	No violations found at max temp. of 500.00
lapwing_acsr.wir	409	3	2	408	500	267.45	4.74	832569.17	769500.36	828.51	4.78	No violations found at max temp. of 500.00
lapwing_acsr.wir	409	3	3	408	500	318.66	20.66	832523.97	769529.22	822.19	4.99	No violations found at max temp. of 500.00
lapwing_acsr.wir	408	3	1	407A	500	518.48	-11.17	832431.07	769638.56	827.47	4.90	No violations found at max temp. of 500.00
lapwing_acsr.wir	408	3	2	407A	500	522.08	-5.22	832437.52	769641.15	827.67	-5.05	No violations found at max temp. of 500.00
lapwing_acsr.wir	408	3	3	407A	500	529.20	20.70	832464.26	769644.02	827.75	4.97	No violations found at max temp. of 500.00
lapwing_acsr.wir	407A	3	1	407	500	895.54	-11.42	832489.65	770010.97	826.65	4.92	No violations found at max temp. of 500.00
lapwing_acsr.wir	407A	3	2	407	500	890.24	4.82	832504.88	770003.22	827.53	4.96	No violations found at max temp. of 500.00
lapwing_acsr.wir	407A	3	3	407	408	903.77	21.27	832523.22	770014.05	828.05	4.98	TIN elevation
lapwing_acsr.wir	407	3	1	406	180	1491.12	-21.15	832167.07	770311.59	809.62	-5.01	TIN elevation
lapwing_acsr.wir	407	3	2	406	163	1486.66	-4.78	832175.98	770326.03	809.49	-5.00	TIN elevation
lapwing_acsr.wir	407	3	3	406	143	1470.12	11.08	832196.33	770336.56	809.45	-5.00	TIN elevation
lapwing_acsr.wir	406	3	1	405	302	2298.05	-20.54	831393.28	770540.41	804.75	-5.01	TIN elevation
lapwing_acsr.wir	406	3	2	405	363	2298.23	-4.96	831397.50	770555.41	804.01	-4.99	TIN elevation
lapwing_acsr.wir	406	3	3	405	411	2334.51	10.50	831367.07	770580.49	803.55	-4.98	TIN elevation
lapwing_acsr.wir	405	3	1	404	208	3041.96	-10.53	830682.63	770760.68	794.98	5.00	TIN elevation
lapwing_acsr.wir	405	3	2	404	210	3038.95	5.02	830689.93	770774.75	795.47	5.00	TIN elevation
lapwing_acsr.wir	405	3	3	404	197	3045.57	20.54	830687.99	770791.50	795.90	5.00	TIN elevation
lapwing_acsr.wir	404	3	1	403	205	3850.48	-10.53	829907.18	770989.50	783.36	5.00	TIN elevation
lapwing_acsr.wir	404	3	2	403	209	3827.98	4.96	829933.14	770998.01	784.02	5.00	TIN elevation
lapwing_acsr.wir	404	3	3	403	193	3831.14	20.43	829934.48	771013.74	784.46	5.00	TIN elevation
lapwing_acsr.wir	403	3	1	402	240	4531.50	-20.57	829251.16	771172.68	767.40	-5.02	TIN elevation
lapwing_acsr.wir	403	3	2	402	279	4525.59	-5.03	829261.23	771185.91	767.24	-4.99	TIN elevation
lapwing_acsr.wir	403	3	3	402	279	4525.31	10.50	829265.91	771200.71	766.67	-4.95	TIN elevation
lapwing_acsr.wir	402	3	1	401	500	5298.98	-21.73	828514.90	771389.29	746.35	-5.06	No violations found at max temp. of 500.00
lapwing_acsr.wir	402	3	2	401	500	5306.67	-4.86	828512.30	771407.65	745.25	-5.00	No violations found at max temp. of 500.00
lapwing_acsr.wir	402	3	3	401	500	5328.51	12.10	828496.16	771430.10	743.61	-4.95	No violations found at max temp. of 500.00
lapwing_acsr.wir	401	3	1	323	500	5895.79	-10.87	827949.35	771584.98	753.95	-5.00	No violations found at max temp. of 500.00
lapwing_acsr.wir	401	3	2	323	500	5896.97	-1.69	827954.12	771592.91	753.41	-5.00	No violations found at max temp. of 500.00
lapwing_acsr.wir	401	3	3	323	500	5897.93	6.90	827958.70	771600.25	752.82	-5.00	No violations found at max temp. of 500.00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True Structure Number

DPFE-SEL-1-1558
Ground Clearance Report 12/12/2013

PLS-CADD Version 12.50x64 09:15:19 AM 12 December 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	17	248	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. 0 kV (ft)	Horiz. 0 kV (ft)	Vert. 138 kV (ft)	Horiz. 138 kV (ft)	Vert. 161 kV (ft)	Horiz. 161 kV (ft)	Vert. 230 kV (ft)	Horiz. 230 kV (ft)	Vert. 345 kV (ft)	Horiz. 345 kV (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes:
This report is checking clearances to wires between structures 213A to RIVER CEMENT SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN checked at 3.28 (ft) station and offset intervals along wire. Clearances are being checked out to an offset 20.00 (ft) from wire.
Required clearance to TIN is that for feature code 'Interpolated Points' (set in Terrain/Feature Code Data/Feature Code for Ground Clearance and Interpolated TIN Points

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
- **Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.**
- **Point above wires: Aerial obstacle that is above wires for specified criteria.**
  - **Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.**
- **Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.**
  - **Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.**
- **Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.**

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
1223	1224	248	-0.34	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	3004.03	-7.58	859014.91	854880.54	543.57	0.00
1232	1233	248	-2.10	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	5577.18	0.66	860838.00	853231.91	578.93	0.00
1235	1236	248	-0.39	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	6529.45	-0.03	861668.14	852927.38	655.96	0.00
1236	1237	248	-2.44	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	6739.26	-4.00	861843.19	853013.40	668.66	0.00
1237	1238	248	-1.46	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	7066.52	-7.48	862076.82	853238.73	675.36	0.00
1238	1239	248	-0.58	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	7361.88	-7.03	862274.10	853458.59	674.21	0.00
1242	1243	248	-1.61	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	8626.34	-2.23	863167.58	854353.16	639.07	0.00
1243	1244	248	-3.31	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	8795.45	-2.10	863314.58	854404.57	634.98	0.00
1248	1249	248	-1.58	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	10102.02	-7.44	864600.12	854343.15	608.33	0.00
1249	1250	248	-2.48	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	10487.47	1.51	864945.83	854513.86	578.12	0.00
1252	1253	248	-4.25	0.00	NG	Ground clear controls.	0	0	TIN-INTERP	Interpolated Points	11280.96	-7.11	865715.90	854684.17	553.35	0.00

11 spans with clearance violations NG

31 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 03:37:45 PM 10 December 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	17	248	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. 0 kV (ft)	Horiz. 0 kV (ft)	Vert. 138 kV (ft)	Horiz. 138 kV (ft)	Vert. 161 kV (ft)	Horiz. 161 kV (ft)	Vert. 230 kV (ft)	Horiz. 230 kV (ft)	Vert. 345 kV (ft)	Horiz. 345 kV (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000

552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 240 241 242 243 244 245 246 247 248 545 546 547 548 549 550 551 552 1241 1242 1243 1244 1245 1246 1247 1248 1545 1546 1547 1548 1549 1550 1551 1552
This report is checking clearances to wires between structures 213A to RIVER CEMENT SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
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Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)

0 spans with clearance violations OK
42 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 12:22:14 PM 12 December 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	17	248	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. (0 kV) (ft)	Horiz. (0 kV) (ft)	Vert. (138 kV) (ft)	Horiz. (138 kV) (ft)	Vert. (161 kV) (ft)	Horiz. (161 kV) (ft)	Vert. (230 kV) (ft)	Horiz. (230 kV) (ft)	Vert. (345 kV) (ft)	Horiz. (345 kV) (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000

1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 240 241 242 243 244 245 246 247 248 545 546 547 548 549 550 551 552 1241 1242 1243 1244 1245 1246 1247 1248 1545 1546 1547 1548 1549 1550 1551 1552
This report is checking clearances to wires between structures 213A to RIVER CEMENT SUB..
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin). Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as “NG” and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

```
     Back     Ahead Control -Clearance---  OK  Comment Survey Pt.      Aerial --------------------------Controlling----------------------------
Structure Structure Weather ---Margin----              Clearance  Pts. Above -----------------------------Point-------------------------------
   Number    Number Case     Vert. Horiz.             Violations  or Between Point Feature     Station  Offset       X       Y       Z  Height
                              (ft)   (ft)                in Span       Wires    ID Code          (ft)    (ft)    (ft)    (ft)    (ft)    (ft)
                                                                                   Description
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0 spans with clearance violations OK
42 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 03:41:42 PM 10 December 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
2	60F 6psf	0.00256	48	6.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	17	248	Max Sag FE
2	2	60F 6psf	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

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Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	0 kV Vert. (ft)	0 kV Horiz. (ft)	138 kV Vert. (ft)	138 kV Horiz. (ft)	161 kV Vert. (ft)	161 kV Horiz. (ft)	230 kV Vert. (ft)	230 kV Horiz. (ft)	345 kV Vert. (ft)	345 kV Horiz. (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

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0 spans with clearance violations OK
42 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 12:23:46 PM 12 December 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

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1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
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Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. 0 kV (ft)	Horiz. 0 kV (ft)	Vert. 138 kV (ft)	Horiz. 138 kV (ft)	Vert. 161 kV (ft)	Horiz. 161 kV (ft)	Vert. 230 kV (ft)	Horiz. 230 kV (ft)	Vert. 345 kV (ft)	Horiz. 345 kV (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000

Feature code used to determine required clearance to ground 100

Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 104 110 116 126 255 301 306 321 335 400 405 410 425 1007 1008
This report is checking clearances to wires between structures 213A to RIVER CEMENT SUB..
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but
reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).
Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are
indicated as “NG” and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance
(no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Controlling Point Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)

0 spans with clearance violations OK
42 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 09:22:47 AM 12 December 2013
Power Engineers
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Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	17	248	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Vert. 0 kV (ft)	Horiz. 0 kV (ft)	Vert. 138 kV (ft)	Horiz. 138 kV (ft)	Vert. 161 kV (ft)	Horiz. 161 kV (ft)	Vert. 230 kV (ft)	Horiz. 230 kV (ft)	Vert. 345 kV (ft)	Horiz. 345 kV (ft)	Stucture Base/Guy to Spotting Constraint (ft)
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 131
This report is checking clearances to wires between structures 213A to RIVER CEMENT SUB..
This report includes only survey points with a horizontal distance to wire of less than 30.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).

Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
Point above wires: Aerial obstacle that is above wires for specified criteria.
Closer inspection may be required to ensure wires remain below obstacle at colder temperatures.
Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point: Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
1215	1216	248	-12.92	-3.44	NG		9	0		Vegetation/Tree/Brush	662.28	19.91	856831.09	855169.58	631.88	35.64
1219	1220	248	-13.07	-1.22	NG		12	0		Vegetation/Tree/Brush	1993.75	26.29	858162.33	855141.50	561.69	47.30
1220	1221	248	-13.62	-0.37	NG	Nonprojectable.	6	0		Vegetation/Tree/Brush	1993.75	26.29	858162.33	855141.50	561.69	47.30
1221	1222	248	-0.77	-17.67	NG		1	0		Vegetation/Tree/Brush	2592.53	1.45	858761.47	855157.90	547.34	10.25
1222	1223	248	-6.48	-0.33	NG		1	0		Vegetation/Tree/Brush	2743.71	-21.94	858881.16	855086.12	535.25	24.07
1223	1224	248	-14.48	-3.89	NG		13	0		Vegetation/Tree/Brush	3162.98	-23.64	859157.66	854808.79	533.29	26.75
1224	1225	248	-13.47	-4.90	NG		4	0		Vegetation/Tree/Brush	3223.37	-22.61	859208.06	854775.52	529.12	30.62
1225	1226	248	-11.52	-1.99	NG		4	0		Vegetation/Tree/Brush	3667.82	-21.20	859582.34	854535.79	486.20	20.94
1228	1229	248	-3.93	-4.37	NG		4	0		Vegetation/Tree/Brush	4485.02	-21.59	860271.31	854096.42	424.46	32.78
1229	1230	248	-2.40	-19.26	NG		2	0		Vegetation/Tree/Brush	4801.39	-0.82	860527.41	853909.51	451.36	14.50
1239	1240	248	-13.20	-7.66	NG		20	0		Vegetation/Tree/Brush	7783.91	20.14	862581.64	853748.69	651.93	31.29
1240	1241	248	-14.26	-16.73	NG		18	0		Vegetation/Tree/Brush	8039.28	-9.87	862737.97	853952.62	644.49	23.64
1242	1243	248	-7.55	-1.21	NG		3	0		Vegetation/Tree/Brush	8576.35	-22.47	863117.37	854333.46	639.56	14.08
1246	1247	248	-9.72	-3.01	NG		6	0		Vegetation/Tree/Brush	9632.15	-24.49	864149.65	854347.93	614.72	30.22
1247	1248	248	-7.93	-2.25	NG		4	0		Vegetation/Tree/Brush	9828.73	9.93	864342.07	854294.91	617.54	21.47
1248	1249	248	-3.00	-1.35	NG	Nonprojectable.	1	0		Vegetation/Tree/Brush	10310.84	15.27	864795.42	854420.24	584.22	31.50
1249	1250	248	-14.99	-5.06	NG		46	0		Vegetation/Tree/Brush	10311.49	22.19	864799.19	854414.40	583.41	41.24
1250	1251	248	-14.34	-4.34	NG		13	0		Vegetation/Tree/Brush	10637.06	19.51	865084.82	854553.21	564.21	26.61
1251	1252	248	-2.06	-0.56	NG		1	0		Vegetation/Tree/Brush	10899.78	25.98	865345.38	854588.74	543.55	28.87

19 spans with clearance violations NG
23 spans without clearance violations (spans without violations excluded from report above)

PLS-CADD Version 12.50x64 09:25:11 AM 12 December 2013
Power Engineers
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Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Weather Cases Relevant for Terrain Clearances by Span

WC #	Description	Air Density Factor (psf/mph^2)	Wind Vel. (mph)	Wind Pres. (psf)	Wire Ice Thick (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp (deg F)	Ambient Temp (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC HL	0.00256	40	4.0	0.50	57.000	0.00	0	0	1.00	0.30	None	1
5	60	0.00256	0	0.0	0.00	0.000	0.00	60	60	1.00	0.00	None	1
17	248	0.00256	0	0.0	0.00	0.000	0.00	248	248	1.00	0.00	None	1

Weather case for final after creep '60'
Weather case for final after load NESC HL

Survey Point Clearance Criteria

LC #	WC #	Weather Case Description	Cable Condition
1	17	248	Max Sag FE

Survey Point Clearance and Danger Tree Locator functions ARE NOT considering a Continuous Range of wind values from left blowout to right blowout.

Survey Point Clearance functions are treating points with insufficient vertical clearance but adequate horizontal clearance as non violations.

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Terrain Clearances by Span Report

This report includes only survey points that have the following feature codes: 131
This report is checking clearances to wires between structures 213A to RIVER CEMENT SUB..
This report includes only survey points with a horizontal distance to wire of less than 5.00 (ft).

Clearance to ground centerline is not being checked at regular intervals (only being checked at existing survey points) ??
Clearance to TIN is not being checked ??

PLS-CADD analyzes clearances for all of the weather cases specified in Criteria/Survey Point Clearances but reports results only for the weather case it deems the worst case violation (lowest vertical clearance margin).

DPFE-SEL-1-1558

Critical Vegetation Clearance Report 12/12/2013

Detailed results for all weather cases and wind directions can be obtained through Terrain/Clearance if desired.

Explanation of comments printed in this report
Ground clear controls: Constrained by required clearance to ground rather than required clearances for point Feature Code.
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Point between wires: Aerial obstacle that is above some wires and below other wires for specified criteria.
Closer inspection may be required to ensure there are no violations when transitioning from cold to hot temperatures.
Nonprojectable: Point can't be projected onto span. Constrained by clearance to end of span.

Points simultaneously violating both horizontal and vertical clearance requirements are indicated as "NG" and shown in red.

A clearance value of 10000 indicates the program was unable to calculate a clearance (no wires in span, no wires crossing point, unknown ground elevation, no points meeting above criteria...).

Back Structure Number	Ahead Structure Number	Control Weather Case	Clearance Margin Vert. (ft)	Clearance Margin Horiz. (ft)	OK	Comment	Survey Pt. Clearance Violations in Span	Aerial Pts. Above or Between Wires	Controlling Point ID	Feature Code Description	Station (ft)	Offset (ft)	X (ft)	Y (ft)	Z (ft)	Height (ft)
1215	1216	248	-2.32	-17.08	NG		4	0		Vegetation/Tree/Brush	602.54	-8.08	856771.91	855198.75	640.00	15.97
1221	1222	248	-0.77	-17.67	NG		1	0		Vegetation/Tree/Brush	2592.53	1.45	858761.47	855157.90	547.34	10.25
1229	1230	248	-2.40	-19.26	NG		1	0		Vegetation/Tree/Brush	4801.39	-0.82	860527.41	853909.51	451.36	14.50
1239	1240	248	-6.20	-16.69	NG		3	0		Vegetation/Tree/Brush	7778.26	-10.13	862555.82	853765.48	654.18	15.98
1240	1241	248	-14.26	-16.73	NG		6	0		Vegetation/Tree/Brush	8039.28	-9.87	862737.97	853952.62	644.49	23.64
1247	1248	248	-4.45	-17.03	NG		1	0		Vegetation/Tree/Brush	9824.88	-4.86	864339.68	854310.00	614.71	21.11
1249	1250	248	-14.46	-19.65	NG		15	0		Vegetation/Tree/Brush	10376.08	7.45	864849.71	854457.25	581.35	33.16

7 spans with clearance violations NG

35 spans without clearance violations (spans without violations excluded from report above)

DPFE-SEL-1-1558_Obstacle_New_Rating

Obstacle New Rating Report 12/12/2013

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Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) 0 kV Vert.	0 kV Horiz.	138 kV Vert.	138 kV Horiz.	161 kV Vert.	161 kV Horiz.	230 kV Vert.	230 kV Horiz.	345 kV Vert.	345 kV Horiz.	Stucture Base/Guy to Spotting Constraint
11	Set Control Point/Instrument Point	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
13	PI (point of intersection)	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
14	New TIN PI (defined by engineer)	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
104	Water	No	Yes	0.000	0.000	21.000	0.000	21.000	0.000	23.000	0.000	25.000	0.000	0.000
110	Road	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
116	Railroad	No	Yes	0.000	0.000	30.000	17.000	31.000	18.000	32.000	19.000	34.000	21.000	0.000
126	Swimming Pool	No	Yes	0.000	0.000	29.000	31.000	29.000	31.000	31.000	33.000	33.000	35.000	0.000
200	UNKNOWN FEATURE CODE	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
220	Guy wire anchor	No	Yes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	Conductor/shield wire attachment point	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
232	Insulator attachment point at structure	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
236	Shield Wire	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
237	Guy Wire	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
240	Crossing conductor unknown voltage	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
241	Crossing shield wire	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
242	Crossing conductor 345kV	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
243	Crossing conductor 230kV	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
244	Crossing conductor 161kV	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
245	Crossing conductor 138kV	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
246	Crossing conductor 69kV	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
247	Crossing conductor 34kV	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
248	Crossing conductor 12kV/4kV	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
253	Transmission Structure Steel	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
254	Transmission Structure Wood	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
255	Other supporting structures	Yes	No	0.000	0.000	8.000	10.000	9.000	11.000	10.000	12.000	12.000	14.000	0.000
256	Center of Structure	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
275	Conductor splices	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
276	Shield wire splices	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
277	Aerial marker ball	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
301	Building	Yes	No	0.000	0.000	17.000	13.000	18.000	14.000	19.000	15.000	21.000	17.000	0.000
306	Silo/grain bin	Yes	No	0.000	0.000	22.000	24.000	22.000	24.000	24.000	26.000	26.000	28.000	0.000
321	Fence	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
335	Bridge	Yes	No	0.000	0.000	16.000	13.000	17.000	13.000	18.000	15.000	20.000	17.000	0.000
400	Street Light	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
405	Antenna, radio/TV	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
410	Sign	Yes	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
425	Pipeline	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
468	Comm conductors, cables and messengers	Yes	No	0.000	0.000	9.000	11.000	9.000	11.000	11.000	13.000	13.000	15.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
545	Underbuild conductor 138kV - Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
546	Underbuild conductor 69kV - Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
547	Underbuild conductor 34kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
548	Underbuild conductor 12kV/4kV - Ameren Owned	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
549	Underbuild conductor 138kV - Non-Ameren Owned	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
550	Underbuild conductor 69kV - Non-Ameren Owned	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
551	Underbuild conductor 34kV - Non-Ameren Owned	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
552	Underbuild conductor 12kV/4kV - Non-Ameren Owned	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000
1001	Conductor Left/Bottom	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1002	Conductor Center/Middle	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1003	Conductor Right/Top	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1007	Substation	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	12.000	17.000	16.000	22.000	0.000
1008	Temporary Objects	No	No	0.000	0.000	12.000	13.000	12.000	14.000	14.000	15.000	16.000	17.000	0.000
1009	Parallel Line	Yes	No	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1102	?UNKNOWN FEATURE CODE?	No	Yes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1241	Crossing shield wire/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1242	Crossing conductor 345kV/By POWER	Yes	No	0.000	0.000	12.000	18.000	13.000	18.000	14.000	20.000	16.000	22.000	0.000
1243	Crossing conductor 230kV/By POWER	Yes	No	0.000	0.000	10.000	15.000	10.000	16.000	12.000	17.000	14.000	20.000	0.000
1244	Crossing conductor 161kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	9.000	14.000	10.000	16.000	13.000	18.000	0.000
1245	Crossing conductor 138kV/By POWER	Yes	No	0.000	0.000	8.000	14.000	8.000	14.000	10.000	15.000	12.000	18.000	0.000
1246	Crossing conductor 69kV/By POWER	Yes	No	0.000	0.000	6.000	12.000	7.000	13.000	8.000	14.000	11.000	16.000	0.000
1247	Crossing conductor 34kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	12.000	8.000	13.000	10.000	16.000	0.000
1248	Crossing conductor 12kV/4kV/By POWER	Yes	No	0.000	0.000	6.000	11.000	6.000	11.000	8.000	13.000	10.000	15.000	0.000
1545	Underbuild conductor 138kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1546	Underbuild conductor 69kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	10.000	10.000	0.000
1547	Underbuild conductor 34kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	6.000	7.000	7.000	8.000	10.000	10.000	0.000
1548	Underbuild conductor 12kV/4kV - Ameren Owned/By POWER	Yes	No	0.000	0.000	5.000	7.000	5.000	7.000	7.000	8.000	9.000	10.000	0.000
1549	Underbuild conductor 138kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	9.000	7.000	10.000	7.000	11.000	8.000	13.000	10.000	0.000
1550	Underbuild conductor 69kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	8.000	7.000	8.000	7.000	10.000	8.000	12.000	10.000	0.000
1551	Underbuild conductor 34kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	7.000	7.000	7.000	7.000	9.000	8.000	11.000	10.000	0.000
1552	Underbuild conductor 12kV/4kV - Non-Ameren Owned/By POWER	Yes	No	0.000	0.000	6.000	7.000	7.000	7.000	8.000	8.000	11.000	10.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Thermal Rating Report Settings

Structure range: 213A to RIVER CEMENT SUB. Temperature range: 32 (°F) to 500 (°F)
Cable condition: Max Sag FE
Maximum offset from wires 5.00 (ft)
Special Temperature Values:
32 (deg F) indicates that a violation occurs even at the minimum temperature (will be indicated as NG)
500 (deg F) indicates that there is never a violation even at the maximum temperature

Results based on vertical clearances to survey points that are within a 5.00 (ft) offset from wires.
This report includes only survey points that do not have the following feature codes: 131

Results based on clearance to ground calculated at 3.28 (ft) station intervals along span. If a TIN model is available it is used to calculate the ground level directly below the span and 5.00 (ft) left or right of that point. If the program is unable to determine the ground elevations at these points from the TIN model then it will try to construct a profile below the wire. This profile consists of line segments created by connecting survey points with known ground elevations within a 3.00 (ft) offset of the wire in order of increasing station. Segments with lengths in excess of 30.00 (ft) are not included.

Thermal Rating Summary

Note: Spans sorted in order of temperature causing vertical clearance violations

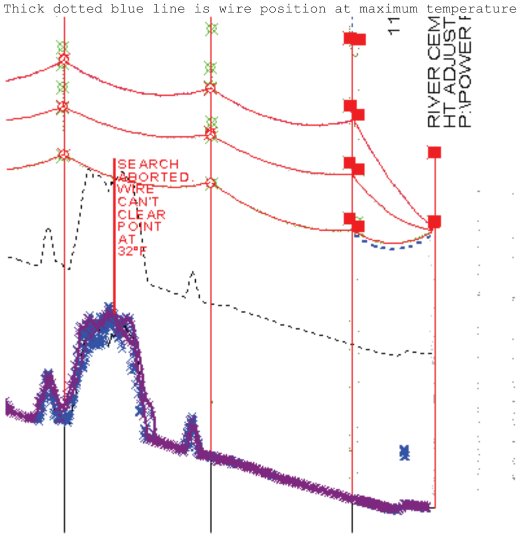
Back Structure Number	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
1252	**1253**	**32**	**11282.73**	**-7.62**	**865717.56**	**854684.97**	**553.40**	**-0.55**	**NG Point Ground , Aborted critical point search since wire can't clear point at 32 (deg F)**
1243	1244	46	8790.51	2.50	863309.23	854400.46	635.36	4.47	Point Ground
1232	1233	63	5577.17	1.91	860836.80	853231.56	579.10	1.25	Point Ground
1236	1237	83	6775.97	-0.64	861874.57	853032.76	670.49	5.05	TIN elevation
1249	1250	89	10482.43	-3.13	864939.22	854515.65	578.83	-5.05	TIN elevation
1242	1243	94	8621.34	2.50	863167.20	854346.29	639.66	4.86	Point Ground
1237	1238	113	7066.79	-12.59	862073.18	853242.33	676.02	-4.80	TIN elevation
1248	1249	127	10101.93	-12.49	864597.68	854347.57	608.56	-4.85	Point Ground
1238	1239	164	7361.66	-12.03	862270.24	853461.77	674.67	-5.00	TIN elevation
1223	1224	172	2988.88	-13.01	859005.04	854893.24	545.21	-5.30	Point Ground
1235	1236	179	6531.18	0.50	861669.73	852926.51	656.32	0.53	Point Ground
1241	1242	196	8261.81	-11.75	862895.79	854110.10	644.84	-5.00	TIN elevation

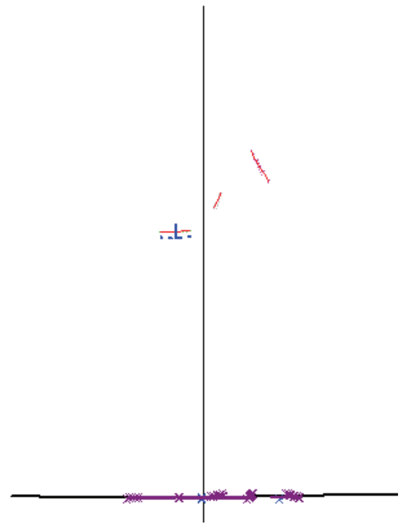
1240	1241	234	8078.71	-8.00	862766.88	853979.49	647.39	-1.44	Point Ground
1231	1232	285	5275.07	1.63	860750.05	853520.93	553.51	1.07	Point Ground
1222	1223	320	2705.70	3.98	858841.22	855108.95	546.49	5.01	TIN elevation
1229	1230	326	4856.05	4.81	860570.50	853875.40	471.97	5.00	TIN elevation
1221	1222	336	2552.18	3.32	858721.09	855156.66	549.24	5.00	TIN elevation
1239	1240	387	7703.71	-11.86	862503.15	853712.69	656.83	-5.00	TIN elevation
1245	1246	388	9358.59	-11.94	863876.18	854361.35	627.41	-5.00	TIN elevation
1251	1252	389	10978.64	-2.66	865418.44	854629.97	547.81	5.00	TIN elevation
1233	1234	438	5850.28	2.33	861002.41	853061.85	595.03	5.00	TIN elevation
1244	1245	440	9114.01	-3.19	863631.84	854375.75	627.88	3.81	Point Ground
1234	1235	448	6213.24	2.81	861357.82	852988.19	616.83	5.00	TIN elevation
1230	1231	448	5075.67	-5.08	860698.45	853713.68	526.78	-5.00	TIN elevation
1217	1218	485	1276.11	1.17	857445.20	855178.46	601.27	5.00	TIN elevation
1226	1227	494	3838.13	-5.71	859717.67	854431.23	467.06	-5.00	TIN elevation
213A	1214	500	132.70	0.00	856301.96	855196.85	698.10	3.05	No violations found at max temp. of 500.00
1214	1215	500	396.40	3.15	856565.61	855190.15	672.63	4.08	No violations found at max temp. of 500.00
1215	1216	500	595.24	-1.74	856764.49	855192.55	642.02	3.34	No violations found at max temp. of 500.00
1216	1217	500	914.47	-7.93	857083.75	855193.47	578.38	-4.14	No violations found at max temp. of 500.00
1218	1219	500	1500.33	-0.00	857669.41	855175.67	598.49	4.29	No violations found at max temp. of 500.00
1219	1220	500	1784.94	1.60	857953.96	855169.65	549.21	4.09	No violations found at max temp. of 500.00
1220	1221	500	2168.98	-4.96	858338.05	855170.50	565.91	1.76	No violations found at max temp. of 500.00
1224	1225	500	3383.79	-8.46	859335.85	854677.52	519.65	-1.10	No violations found at max temp. of 500.00
1225	1226	500	3658.15	-5.36	859565.67	854527.62	485.62	-1.94	No violations found at max temp. of 500.00
1227	1228	500	4231.93	-9.36	860051.59	854222.41	445.98	-2.37	No violations found at max temp. of 500.00
1228	1229	500	4612.62	0.00	860367.56	854009.91	431.59	3.12	No violations found at max temp. of 500.00
1246	1247	500	9592.72	-12.11	864109.23	854339.30	616.47	-4.77	No violations found at max temp. of 500.00
1247	1248	500	9794.00	-3.32	864308.80	854311.48	625.13	4.44	No violations found at max temp. of 500.00
1250	1251	500	10660.19	2.64	865105.00	854573.52	562.80	0.79	No violations found at max temp. of 500.00
1253	1254	500	11458.37	-3.38	865891.87	854708.20	531.91	3.73	No violations found at max temp. of 500.00
1254	RIVER CEMENT SUB.	500	11675.66	-0.00	866108.32	854724.01	525.32	3.98	No violations found at max temp. of 500.00

DPFE-SEL-1-1558_Obstacle_New_Rating
Obstacle New Rating Report

12/12/2013

Ahead span of structure 1254, station 11675.66 (ft)
Maximum wire temperature 500 (deg F), No violations found at max temp. of 500.00
Red line goes from controlling point to required height above it.
Thick dotted blue line is wire position at maximum temperature.





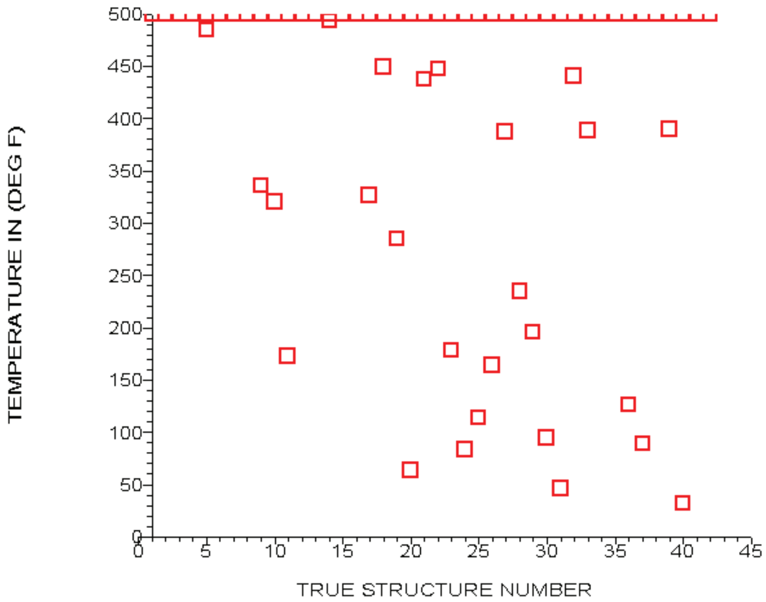
Thermal Rating Detail

Note: Temperatures printed are those at which ahead spans get vertical clearance violations

Cable File Name	Back Structure Number	Set No.	Phase No.	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
linnet_acsr.wir	213A	3	1	1214	500	132.70	0.00	856301.96	855196.85	698.10	3.05	No violations found at max temp. of 500.00
linnet_acsr.wir	213A	3	2	1214	500	149.96	0.00	856319.22	855196.52	697.30	-4.14	No violations found at max temp. of 500.00
linnet_acsr.wir	213A	3	3	1214	500	167.22	0.00	856336.48	855196.18	696.47	3.76	No violations found at max temp. of 500.00
linnet_acsr.wir	1214	3	1	1215	500	396.40	3.15	856565.61	855190.15	672.63	4.08	No violations found at max temp. of 500.00
linnet_acsr.wir	1214	3	2	1215	500	392.77	9.93	856561.94	855183.39	674.57	4.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1214	3	3	1215	500	396.40	3.15	856565.61	855190.15	672.63	4.02	No violations found at max temp. of 500.00
linnet_acsr.wir	1215	3	1	1216	500	595.24	-1.74	856764.49	855192.55	642.02	3.34	No violations found at max temp. of 500.00
linnet_acsr.wir	1215	3	2	1216	500	623.75	5.74	856792.84	855184.51	638.51	4.07	No violations found at max temp. of 500.00
linnet_acsr.wir	1215	3	3	1216	500	599.22	-1.46	856768.46	855192.19	641.24	3.75	No violations found at max temp. of 500.00
linnet_acsr.wir	1216	3	1	1217	500	914.47	-7.93	857083.75	855193.47	578.38	-4.14	No violations found at max temp. of 500.00
linnet_acsr.wir	1216	3	2	1217	500	921.89	0.00	857091.06	855185.44	574.24	-3.83	No violations found at max temp. of 500.00
linnet_acsr.wir	1216	3	3	1217	500	914.47	-7.93	857083.75	855193.47	578.38	-3.87	No violations found at max temp. of 500.00
linnet_acsr.wir	1217	3	1	1218	485	1276.11	1.17	857445.20	855178.46	601.27	5.00	TIN elevation
linnet_acsr.wir	1217	3	2	1218	500	1276.18	7.83	857445.14	855171.81	602.23	4.10	No violations found at max temp. of 500.00
linnet_acsr.wir	1217	3	3	1218	500	1277.27	0.00	857446.39	855179.61	601.22	3.84	No violations found at max temp. of 500.00
linnet_acsr.wir	1218	3	1	1219	500	1500.33	-0.00	857669.41	855175.67	598.49	4.29	No violations found at max temp. of 500.00
linnet_acsr.wir	1218	3	2	1219	500	1502.58	3.66	857671.61	855171.98	598.72	-0.33	No violations found at max temp. of 500.00
linnet_acsr.wir	1218	3	3	1219	500	1508.47	0.46	857677.55	855175.09	596.88	4.66	No violations found at max temp. of 500.00
linnet_acsr.wir	1219	3	1	1220	500	1784.94	1.60	857953.96	855169.65	549.21	4.09	No violations found at max temp. of 500.00
linnet_acsr.wir	1219	3	2	1220	500	1780.88	3.97	857949.86	855167.35	550.55	0.84	No violations found at max temp. of 500.00
linnet_acsr.wir	1219	3	3	1220	500	1784.94	1.60	857953.96	855169.65	549.21	3.98	No violations found at max temp. of 500.00

linnet_acsr.wir	1220	3	1	1221	500	2168.98	-4.96	858338.05	855170.50	565.91	1.76	No violations found at max temp. of 500.00
linnet_acsr.wir	1220	3	2	1221	500	2125.82	12.26	858294.67	855153.83	568.80	4.65	No violations found at max temp. of 500.00
linnet_acsr.wir	1220	3	3	1221	500	2168.98	-4.96	858338.05	855170.50	565.91	1.71	No violations found at max temp. of 500.00
linnet_acsr.wir	1221	3	1	1222	336	2552.18	3.32	858721.09	855156.66	549.24	5.00	TIN elevation
linnet_acsr.wir	1221	3	2	1222	500	2533.61	-0.00	858702.58	855160.27	548.84	-2.61	No violations found at max temp. of 500.00
linnet_acsr.wir	1221	3	3	1222	500	2528.58	-0.00	858697.54	855160.35	548.53	2.51	No violations found at max temp. of 500.00
linnet_acsr.wir	1222	3	1	1223	320	2705.70	3.98	858841.22	855108.95	546.49	5.01	TIN elevation
linnet_acsr.wir	1222	3	2	1223	500	2782.46	0.00	858878.38	855041.67	539.55	3.13	No violations found at max temp. of 500.00
linnet_acsr.wir	1222	3	3	1223	500	2782.46	0.00	858878.38	855041.67	539.55	3.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1223	3	1	1224	172	2988.88	-13.01	859005.04	854893.24	545.21	-5.30	Point Ground
linnet_acsr.wir	1223	3	2	1224	500	3025.08	-4.68	859031.12	854866.79	541.47	-2.92	No violations found at max temp. of 500.00
linnet_acsr.wir	1223	3	3	1224	500	3053.38	-9.77	859057.73	854855.90	539.83	-3.05	No violations found at max temp. of 500.00
linnet_acsr.wir	1224	3	1	1225	500	3383.79	-8.46	859335.85	854677.52	519.65	-1.10	No violations found at max temp. of 500.00
linnet_acsr.wir	1224	3	2	1225	500	3367.27	2.08	859316.26	854677.49	518.66	-4.87	No violations found at max temp. of 500.00
linnet_acsr.wir	1224	3	3	1225	500	3383.79	-8.46	859335.85	854677.52	519.65	-1.27	No violations found at max temp. of 500.00
linnet_acsr.wir	1225	3	1	1226	500	3658.15	-5.36	859565.67	854527.62	485.62	-1.94	No violations found at max temp. of 500.00
linnet_acsr.wir	1225	3	2	1226	500	3654.90	0.00	859560.05	854524.84	485.21	-3.30	No violations found at max temp. of 500.00
linnet_acsr.wir	1225	3	3	1226	500	3618.96	-9.19	859534.67	854551.90	492.24	-4.89	No violations found at max temp. of 500.00
linnet_acsr.wir	1226	3	1	1227	494	3838.13	-5.71	859717.67	854431.23	467.06	-5.00	TIN elevation
linnet_acsr.wir	1226	3	2	1227	500	3901.68	-2.77	859769.67	854394.58	456.25	-4.86	No violations found at max temp. of 500.00
linnet_acsr.wir	1226	3	3	1227	500	3913.45	-5.92	859781.29	854390.91	453.66	-3.80	No violations found at max temp. of 500.00
linnet_acsr.wir	1227	3	1	1228	500	4231.93	-9.36	860051.59	854222.41	445.98	-2.37	No violations found at max temp. of 500.00
linnet_acsr.wir	1227	3	2	1228	500	4281.14	5.95	860084.76	854182.97	438.73	-1.30	No violations found at max temp. of 500.00
linnet_acsr.wir	1227	3	3	1228	500	4243.62	-10.22	860061.90	854216.83	444.74	-3.41	No violations found at max temp. of 500.00
linnet_acsr.wir	1228	3	1	1229	500	4612.62	0.00	860367.56	854009.91	431.59	3.12	No violations found at max temp. of 500.00
linnet_acsr.wir	1228	3	2	1229	500	4610.85	4.79	860363.50	854006.82	431.68	1.61	No violations found at max temp. of 500.00
linnet_acsr.wir	1228	3	3	1229	500	4598.27	0.56	860355.14	854017.12	431.42	4.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1229	3	1	1230	326	4856.05	4.81	860570.50	853875.40	471.97	5.00	TIN elevation
linnet_acsr.wir	1229	3	2	1230	500	4850.63	-3.20	860570.23	853885.07	470.06	-3.02	No violations found at max temp. of 500.00
linnet_acsr.wir	1229	3	3	1230	500	4850.63	-3.20	860570.23	853885.07	470.06	-2.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1230	3	1	1231	448	5075.67	-5.08	860698.45	853713.68	526.78	-5.00	TIN elevation
linnet_acsr.wir	1230	3	2	1231	500	5079.58	-4.31	860698.87	853709.71	527.44	-4.25	No violations found at max temp. of 500.00
linnet_acsr.wir	1230	3	3	1231	500	5079.58	-4.31	860698.87	853709.71	527.44	-4.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1231	3	1	1232	285	5275.07	1.63	860750.05	853520.93	553.51	1.07	Point Ground
linnet_acsr.wir	1231	3	2	1232	500	5299.34	-3.53	860761.99	853499.18	555.48	-3.88	No violations found at max temp. of 500.00
linnet_acsr.wir	1231	3	3	1232	500	5299.34	-3.53	860761.99	853499.18	555.48	-3.71	No violations found at max temp. of 500.00
linnet_acsr.wir	1232	3	1	1233	63	5577.17	1.91	860836.80	853231.56	579.10	1.25	Point Ground
linnet_acsr.wir	1232	3	2	1233	500	5577.17	1.91	860836.80	853231.56	579.10	1.59	No violations found at max temp. of 500.00
linnet_acsr.wir	1232	3	3	1233	500	5577.17	1.91	860836.80	853231.56	579.10	1.84	No violations found at max temp. of 500.00
linnet_acsr.wir	1233	3	1	1234	438	5850.28	2.33	861002.41	853061.85	595.03	5.00	TIN elevation
linnet_acsr.wir	1233	3	2	1234	500	5889.99	8.71	861040.01	853047.57	598.00	4.71	No violations found at max temp. of 500.00
linnet_acsr.wir	1233	3	3	1234	500	5881.81	0.72	861033.61	853057.05	596.98	4.36	No violations found at max temp. of 500.00
linnet_acsr.wir	1234	3	1	1235	448	6213.24	2.81	861357.82	852988.19	616.83	5.00	TIN elevation
linnet_acsr.wir	1234	3	2	1235	500	6153.05	7.84	861297.85	852995.37	614.06	4.18	No violations found at max temp. of 500.00
linnet_acsr.wir	1234	3	3	1235	500	6136.08	0.00	861282.80	853006.46	613.11	4.18	No violations found at max temp. of 500.00
linnet_acsr.wir	1235	3	1	1236	179	6531.18	0.50	861669.73	852926.51	656.32	0.53	Point Ground
linnet_acsr.wir	1235	3	2	1236	500	6449.63	-4.56	861590.86	852947.87	641.92	-4.38	No violations found at max temp. of 500.00
linnet_acsr.wir	1235	3	3	1236	500	6449.63	-4.56	861590.86	852947.87	641.92	-4.56	No violations found at max temp. of 500.00
linnet_acsr.wir	1236	3	1	1237	83	6775.97	-0.64	861874.57	853032.76	670.49	5.05	TIN elevation
linnet_acsr.wir	1236	3	2	1237	500	6728.71	-0.00	861837.16	853003.87	668.59	2.98	No violations found at max temp. of 500.00
linnet_acsr.wir	1236	3	3	1237	500	6728.71	-0.00	861837.16	853003.87	668.59	3.14	No violations found at max temp. of 500.00
linnet_acsr.wir	1237	3	1	1238	113	7066.79	-12.59	862073.18	853242.33	676.02	-4.80	TIN elevation
linnet_acsr.wir	1237	3	2	1238	500	7082.98	-3.37	862090.83	853248.29	675.36	-5.34	No violations found at max temp. of 500.00
linnet_acsr.wir	1237	3	3	1238	500	7028.20	-11.67	862048.21	853212.89	673.69	-4.74	No violations found at max temp. of 500.00
linnet_acsr.wir	1238	3	1	1239	164	7361.66	-12.03	862270.24	853461.77	674.67	-5.00	TIN elevation
linnet_acsr.wir	1238	3	2	1239	500	7338.10	6.30	862268.12	853431.99	674.19	-0.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1238	3	3	1239	500	7368.68	-5.90	862279.48	853462.89	673.96	0.72	No violations found at max temp. of 500.00
linnet_acsr.wir	1239	3	1	1240	387	7703.71	-11.86	862503.15	853712.69	656.83	-5.00	TIN elevation
linnet_acsr.wir	1239	3	2	1240	500	7677.79	3.64	862496.50	853683.23	656.64	-4.05	No violations found at max temp. of 500.00
linnet_acsr.wir	1239	3	3	1240	500	7701.41	-10.20	862502.77	853709.87	656.77	-3.91	No violations found at max temp. of 500.00
linnet_acsr.wir	1240	3	1	1241	234	8078.71	-8.00	862766.88	853979.49	647.39	-1.44	Point Ground
linnet_acsr.wir	1240	3	2	1241	500	8039.32	4.79	862748.47	853942.39	644.34	-3.14	No violations found at max temp. of 500.00
linnet_acsr.wir	1240	3	3	1241	500	8021.61	-10.20	862725.37	853940.22	644.64	-4.05	No violations found at max temp. of 500.00
linnet_acsr.wir	1241	3	1	1242	196	8261.81	-11.75	862895.79	854110.10	644.84	-5.00	TIN elevation
linnet_acsr.wir	1241	3	2	1242	500	8324.83	11.31	862957.53	854136.38	642.48	3.78	No violations found at max temp. of 500.00
linnet_acsr.wir	1241	3	3	1242	500	8285.01	-11.23	862913.07	854125.59	643.43	-4.74	No violations found at max temp. of 500.00
linnet_acsr.wir	1242	3	1	1243	94	8621.34	2.50	863167.20	854346.29	639.66	4.86	Point Ground
linnet_acsr.wir	1242	3	2	1243	500	8597.25	4.26	863150.93	854328.44	640.22	0.96	No violations found at max temp. of 500.00
linnet_acsr.wir	1242	3	3	1243	500	8591.00	-0.00	863143.46	854327.23	640.05	3.08	No violations found at max temp. of 500.00
linnet_acsr.wir	1243	3	1	1244	46	8790.51	2.50	863309.23	854400.46	635.36	4.47	Point Ground
linnet_acsr.wir	1243	3	2	1244	500	8839.68	0.00	863358.42	854398.30	632.59	-3.19	No violations found at max temp. of 500.00

linnet_acsr.wir	1243	3	3	1244	500	8845.65	-6.42	863364.97	854404.13	632.18	-3.12	No violations found at max temp. of 500.00
linnet_acsr.wir	1244	3	1	1245	440	9114.01	-3.19	863631.84	854375.75	627.88	3.81	Point Ground
linnet_acsr.wir	1244	3	2	1245	500	9118.91	4.12	863636.04	854368.01	627.33	-3.32	No violations found at max temp. of 500.00
linnet_acsr.wir	1244	3	3	1245	500	9114.01	-3.19	863631.84	854375.75	627.88	3.68	No violations found at max temp. of 500.00
linnet_acsr.wir	1245	3	1	1246	388	9358.59	-11.94	863876.18	854361.35	627.41	-5.00	TIN elevation
linnet_acsr.wir	1245	3	2	1246	500	9349.63	5.28	863865.60	854345.08	626.44	-2.19	No violations found at max temp. of 500.00
linnet_acsr.wir	1245	3	3	1246	500	9359.07	-3.38	863875.83	854352.79	627.39	3.44	No violations found at max temp. of 500.00
linnet_acsr.wir	1246	3	1	1247	500	9592.72	-12.11	864109.23	854339.30	616.47	-4.77	No violations found at max temp. of 500.00
linnet_acsr.wir	1246	3	2	1247	500	9636.52	11.05	864150.67	854312.14	621.32	4.50	No violations found at max temp. of 500.00
linnet_acsr.wir	1246	3	3	1247	500	9592.72	-12.11	864109.23	854339.30	616.47	-4.65	No violations found at max temp. of 500.00
linnet_acsr.wir	1247	3	1	1248	500	9794.00	-3.32	864308.80	854311.48	625.13	4.44	No violations found at max temp. of 500.00
linnet_acsr.wir	1247	3	2	1248	500	9794.29	-0.78	864308.84	854308.92	625.52	-3.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1247	3	3	1248	500	9882.97	-4.74	864397.48	854304.23	615.51	2.72	No violations found at max temp. of 500.00
linnet_acsr.wir	1248	3	1	1249	127	10101.93	-12.49	864597.68	854347.57	608.56	-4.85	Point Ground
linnet_acsr.wir	1248	3	2	1249	500	10101.62	-6.68	864600.11	854342.29	608.36	-4.50	No violations found at max temp. of 500.00
linnet_acsr.wir	1248	3	3	1249	500	10117.06	-11.70	864611.43	854353.93	606.62	-4.87	No violations found at max temp. of 500.00
linnet_acsr.wir	1249	3	1	1250	89	10482.43	-3.13	864939.22	854515.65	578.83	-5.05	TIN elevation
linnet_acsr.wir	1249	3	2	1250	500	10435.56	5.95	864901.81	854485.99	580.78	-0.66	No violations found at max temp. of 500.00
linnet_acsr.wir	1249	3	3	1250	500	10446.86	-3.48	864907.49	854499.57	580.78	-2.69	No violations found at max temp. of 500.00
linnet_acsr.wir	1250	3	1	1251	500	10660.19	2.64	865105.00	854573.52	562.80	0.79	No violations found at max temp. of 500.00
linnet_acsr.wir	1250	3	2	1251	500	10660.74	6.02	865106.08	854570.27	562.67	0.04	No violations found at max temp. of 500.00
linnet_acsr.wir	1250	3	3	1251	500	10690.74	-2.67	865134.33	854583.59	557.36	-2.95	No violations found at max temp. of 500.00
linnet_acsr.wir	1251	3	1	1252	389	10978.64	-2.66	865418.44	854629.97	547.81	5.00	TIN elevation
linnet_acsr.wir	1251	3	2	1252	500	10986.03	6.31	865427.21	854622.34	549.52	-0.40	No violations found at max temp. of 500.00
linnet_acsr.wir	1251	3	3	1252	500	10985.28	-2.99	865424.94	854631.39	546.97	4.39	No violations found at max temp. of 500.00
linnet_acsr.wir	**1252**	**3**	**1**	**1253**	**32**	**11282.73**	**-7.62**	**865717.56**	**854684.97**	**553.40**	**-0.55**	**NG Point Ground , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	1252	3	2	1253	500	11274.75	10.63	865712.70	854665.65	554.35	3.54	No violations found at max temp. of 500.00
linnet_acsr.wir	1252	3	3	1253	500	11282.73	-7.62	865717.56	854684.97	553.40	-0.53	No violations found at max temp. of 500.00
linnet_acsr.wir	1253	3	1	1254	500	11458.37	-3.38	865891.87	854708.20	531.91	3.73	No violations found at max temp. of 500.00
linnet_acsr.wir	1253	3	2	1254	500	11511.30	0.00	865944.81	854711.33	530.16	-0.61	No violations found at max temp. of 500.00
linnet_acsr.wir	1253	3	3	1254	500	11458.37	-3.38	865891.87	854708.20	531.91	3.75	No violations found at max temp. of 500.00
linnet_acsr.wir	1254	3	1	RIVER CEMENT SUB.	500	11675.66	-0.00	866108.32	854724.01	525.32	3.98	No violations found at max temp. of 500.00
linnet_acsr.wir	1254	3	2	RIVER CEMENT SUB.	500	11687.27	0.00	866119.93	854723.80	525.23	-1.64	No violations found at max temp. of 500.00
linnet_acsr.wir	1254	3	3	RIVER CEMENT SUB.	500	11688.16	11.09	866120.61	854712.69	525.18	1.93	No violations found at max temp. of 500.00


TEMPERATURE IN (DEG F)
500
450
400
350
300
250
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45
TRUE STRUCTURE NUMBER

PLS-CADD Version 12.50x64 09:29:39 AM 12 December 2013
Power Engineers
Project Name: 'p:\power projects\128387 ameren missouri 2013\dd (design & drawing)\pls-cadd\projects\128387\dpfe-sel-1-1558\dpfe-sel-1-1558.DON'
Line Title: 'gg'

Criteria Notes:
Ameren NERC Rating Criteria
Revision 0 - 6/27/11

Required Clearances

Feature Code	Feature Description	Aerial Obstacle	Point is on Ground	Required Clearance (ft) ----0 kV----- Vert.	Horiz.	---138 kV---- Vert.	Horiz.	---161 kV---- Vert.	Horiz.	---230 kV---- Vert.	Horiz.	---345 kV---- Vert.	Horiz.	Stucture Base/Guy to Spotting Constraint
100	Ground	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000
131	Vegetation/Tree/Brush	Yes	No	0.000	0.000	15.000	20.000	15.000	20.000	15.000	30.000	15.000	30.000	0.000
500	Interpolated Points	No	Yes	0.000	0.000	22.000	0.000	23.000	0.000	24.000	0.000	26.000	0.000	0.000

Feature code used to determine required clearance to ground 100
Feature code used for interpolated TIN points 500

Thermal Rating Report Settings

Structure range: 213A to RIVER CEMENT SUB. Temperature range: 32 (°F) to 500 (°F)
Cable condition: Max Sag FE
Maximum offset from wires 5.00 (ft)
Special Temperature Values:
32 (deg F) indicates that a violation occurs even at the minimum temperature (will be indicated as NG)
500 (deg F) indicates that there is never a violation even at the maximum temperature

Results based on vertical clearances to survey points that are within a 5.00 (ft) offset from wires.
This report includes only survey points that have the following feature codes: 131

Results based on clearance to ground calculated at 3.28 (ft) station intervals along span.
If a TIN model is available it is used to calculate the ground level directly below the span and 5.00 (ft) left or right of that point.
If the program is unable to determine the ground elevations at these points from the TIN model then it will try to construct a profile below the wire. This profile consists of line segments created by connecting survey points with known ground elevations within a 3.00 (ft) offset of the wire in order of increasing station. Segments with lengths in excess of 30.00 (ft) are not included.

Thermal Rating Summary

Note: Spans sorted in order of temperature causing vertical clearance violations

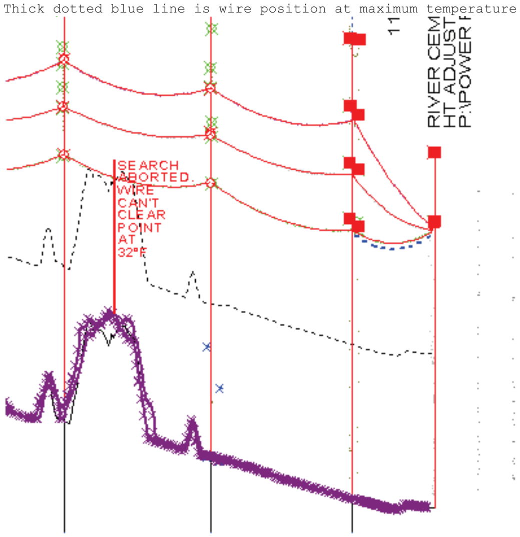
Back Structure Number	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
1229	**1230**	**32**	**4801.39**	**-0.82**	**860527.41**	**853909.51**	**465.86**	**-0.74**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
1239	**1240**	**32**	**7778.26**	**-10.13**	**862555.82**	**853765.48**	**670.16**	**-3.39**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
1240	**1241**	**32**	**8039.28**	**-9.87**	**862737.97**	**853952.62**	**668.13**	**-3.40**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
1247	**1248**	**32**	**9824.88**	**-4.86**	**864339.68**	**854310.00**	**635.82**	**3.19**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
1249	**1250**	**32**	**10383.53**	**2.49**	**864854.04**	**854465.09**	**604.27**	**4.82**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
1252	**1253**	**32**	**11281.87**	**-7.08**	**865716.80**	**854684.29**	**553.28**	**0.00**	**NG TIN elevation, Aborted critical point search since wire can't clear point at 32 (deg F).**
1215	1216	32	602.54	-8.08	856771.91	855198.75	655.97	-2.94	Point Vegetation/Tree/Brush
1243	1244	46	8768.99	3.55	863287.71	854401.46	636.04	5.00	TIN elevation
1232	1233	69	5636.38	0.74	860854.96	853175.19	583.63	-0.00	TIN elevation

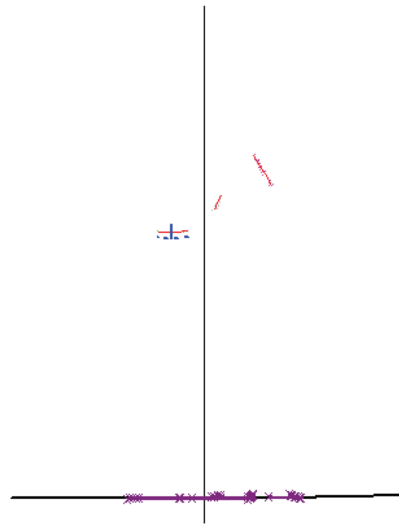
1236	1237	85	6775.97	-1.19	861874.24	853033.20	670.45	4.49	TIN elevation
1242	1243	99	8607.54	2.25	863157.01	854336.97	639.93	5.01	TIN elevation
1237	1238	110	7066.82	-13.25	862072.70	853242.79	676.11	-5.46	TIN elevation
1248	1249	128	10101.29	-12.91	864596.92	854347.65	608.58	-5.27	TIN elevation
1221	1222	156	2592.53	1.45	858761.47	855157.90	557.59	2.33	Point Vegetation/Tree/Brush
1238	1239	164	7361.67	-12.01	862270.25	853461.76	674.67	-4.98	TIN elevation
1223	1224	175	2988.55	-13.16	859004.84	854893.55	545.21	-5.45	TIN elevation
1235	1236	183	6529.66	-0.03	861668.35	852927.34	656.00	-0.00	TIN elevation
1241	1242	197	8261.81	-11.63	862895.87	854110.01	644.82	-4.88	TIN elevation
1231	1232	296	5274.66	0.56	860750.96	853521.64	553.39	-0.00	TIN elevation
1222	1223	325	2705.72	3.77	858841.41	855109.03	546.46	4.81	TIN elevation
1251	1252	384	10978.64	-2.55	865418.46	854629.86	547.88	5.11	TIN elevation
1245	1246	388	9358.59	-11.93	863876.18	854361.35	627.41	-4.99	TIN elevation
1233	1234	438	5850.28	2.35	861002.40	853061.82	595.03	5.03	TIN elevation
1244	1245	445	9113.42	-1.94	863631.14	854374.56	627.86	5.07	TIN elevation
1234	1235	447	6213.25	2.83	861357.82	852988.17	616.83	5.02	TIN elevation
1230	1231	449	5075.67	-5.08	860698.45	853713.68	526.78	-5.00	TIN elevation
1217	1218	485	1276.11	1.19	857445.20	855178.45	601.27	5.01	TIN elevation
1226	1227	494	3838.13	-5.71	859717.67	854431.23	467.06	-5.00	TIN elevation
213A	1214	500	125.09	2.21	856294.31	855194.79	698.67	5.02	No violations found at max temp. of 500.00
1214	1215	500	404.83	4.54	856574.03	855188.70	671.57	5.02	No violations found at max temp. of 500.00
1216	1217	500	942.96	-7.27	857112.23	855192.42	584.64	-4.01	No violations found at max temp. of 500.00
1218	1219	500	1501.39	0.75	857670.46	855174.90	598.41	5.02	No violations found at max temp. of 500.00
1219	1220	500	1873.18	-5.61	858042.31	855175.39	551.54	-1.35	No violations found at max temp. of 500.00
1220	1221	500	2168.19	-1.66	858337.21	855167.22	566.51	5.05	No violations found at max temp. of 500.00
1224	1225	500	3338.85	-12.40	859300.04	854704.95	522.69	-5.00	No violations found at max temp. of 500.00
1225	1226	500	3660.62	-8.35	859569.36	854528.81	485.62	-4.99	No violations found at max temp. of 500.00
1227	1228	500	4232.35	-1.91	860047.92	854215.92	446.31	5.08	No violations found at max temp. of 500.00
1228	1229	500	4507.70	-6.02	860282.14	854071.13	439.49	-0.56	No violations found at max temp. of 500.00
1246	1247	500	9646.20	-12.17	864162.48	854334.35	632.84	-4.61	No violations found at max temp. of 500.00
1250	1251	500	10658.28	3.92	865103.31	854571.95	562.90	1.97	No violations found at max temp. of 500.00
1253	1254	500	11524.90	-2.30	865958.02	854715.28	529.58	5.06	No violations found at max temp. of 500.00
1254	RIVER CEMENT SUB.	500	11679.00	-9.52	866111.84	854733.47	525.33	-5.00	No violations found at max temp. of 500.00

DPFE-SEL-1-1558
Vegetation New Rating Report

12/12/2013

Ahead span of structure 1254, station 11679.00 (ft)
Maximum wire temperature 500 (deg F), No violations found at max temp. of 500.00
Red line goes from controlling point to required height above it.
Thick dotted blue line is wire position at maximum temperature.





Thermal Rating Detail

Note: Temperatures printed are those at which ahead spans get vertical clearance violations

Cable File Name	Back Structure Number	Set No.	Phase No.	Ahead Structure Number	Maximum Wire Temp. (deg F)	Critical Station (ft)	Critical Offset (ft)	Critical X (ft)	Critical Y (ft)	Critical Z (ft)	Offset From Wire (ft)	Notes
linnet_acsr.wir	213A	3	1	1214	500	125.09	2.21	856294.31	855194.79	698.67	5.02	No violations found at max temp. of 500.00
linnet_acsr.wir	213A	3	2	1214	500	155.17	9.24	856324.24	855187.17	697.68	4.98	No violations found at max temp. of 500.00
linnet_acsr.wir	213A	3	3	1214	500	160.90	1.46	856330.13	855194.85	696.87	5.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1214	3	1	1215	500	404.83	4.54	856574.03	855188.70	671.57	5.02	No violations found at max temp. of 500.00
linnet_acsr.wir	1214	3	2	1215	500	395.25	10.89	856564.41	855182.42	674.27	4.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1214	3	3	1215	500	398.12	4.24	856567.32	855189.05	672.58	5.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1215	3	1	1216	32	602.54	-8.08	856771.91	855198.75	655.97	-2.94	Point Vegetation/Tree/Brush
linnet_acsr.wir	1215	3	2	1216	500	735.33	1.53	856904.49	855186.51	630.31	-5.02	No violations found at max temp. of 500.00
linnet_acsr.wir	1215	3	3	1216	500	620.34	-8.57	856789.72	855198.88	653.61	-3.06	No violations found at max temp. of 500.00
linnet_acsr.wir	1216	3	1	1217	500	942.96	-7.27	857112.23	855192.42	584.64	-4.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1216	3	2	1217	500	918.74	1.07	857087.89	855184.41	584.38	-2.82	No violations found at max temp. of 500.00
linnet_acsr.wir	1216	3	3	1217	500	942.96	-7.27	857112.23	855192.42	584.64	-3.75	No violations found at max temp. of 500.00
linnet_acsr.wir	1217	3	1	1218	485	1276.11	1.19	857445.20	855178.45	601.27	5.01	TIN elevation
linnet_acsr.wir	1217	3	2	1218	500	1241.54	3.56	857410.59	855176.77	602.03	0.66	No violations found at max temp. of 500.00
linnet_acsr.wir	1217	3	3	1218	500	1276.42	1.20	857445.51	855178.43	601.31	5.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1218	3	1	1219	500	1501.39	0.75	857670.46	855174.90	598.41	5.02	No violations found at max temp. of 500.00
linnet_acsr.wir	1218	3	2	1219	500	1497.65	9.12	857666.60	855166.59	599.69	4.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1218	3	3	1219	500	1504.67	0.70	857673.74	855174.91	597.72	5.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1219	3	1	1220	500	1873.18	-5.61	858042.31	855175.39	551.54	-1.35	No violations found at max temp. of 500.00
linnet_acsr.wir	1219	3	2	1220	500	1937.66	4.26	858106.62	855164.46	561.12	-2.11	No violations found at max temp. of 500.00

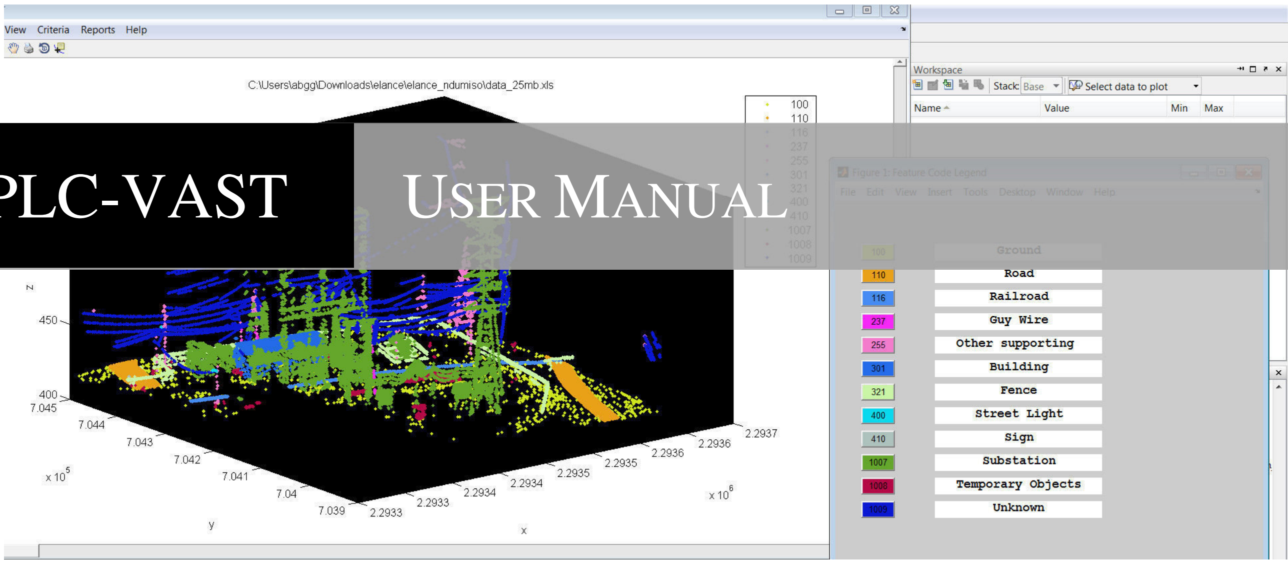
linnet_acsr.wir	1219	3	3	1220	500	1873.18	-5.61 858042.31	855175.39	551.54	-1.49	No violations found at max temp. of 500.00
linnet_acsr.wir	1220	3	1	1221	500	2168.19	-1.66 858337.21	855167.22	566.51	5.05	No violations found at max temp. of 500.00
linnet_acsr.wir	1220	3	2	1221	500	2154.63	12.56 858323.48	855153.16	569.23	4.96	No violations found at max temp. of 500.00
linnet_acsr.wir	1220	3	3	1221	500	2164.57	-1.64 858333.59	855167.23	566.50	5.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1221	3	1	1222	156	2592.53	1.45 858761.47	855157.90	557.59	2.33	Point Vegetation/Tree/Brush
linnet_acsr.wir	1221	3	2	1222	500	2592.53	1.45 858761.47	855157.90	557.59	0.11	No violations found at max temp. of 500.00
linnet_acsr.wir	1221	3	3	1222	500	2592.53	1.45 858761.47	855157.90	557.59	2.77	No violations found at max temp. of 500.00
linnet_acsr.wir	1222	3	1	1223	325	2705.72	3.77 858841.41	855109.03	546.46	4.81	TIN elevation
linnet_acsr.wir	1222	3	2	1223	500	2781.28	1.17 858876.82	855042.23	539.77	4.27	No violations found at max temp. of 500.00
linnet_acsr.wir	1222	3	3	1223	500	2781.42	1.41 858876.66	855041.99	539.83	4.40	No violations found at max temp. of 500.00
linnet_acsr.wir	1223	3	1	1224	175	2988.55	-13.16 859004.84	854893.55	545.21	-5.45	TIN elevation
linnet_acsr.wir	1223	3	2	1224	500	3055.07	-6.23 859057.25	854852.01	539.23	-5.81	No violations found at max temp. of 500.00
linnet_acsr.wir	1223	3	3	1224	500	3054.18	-12.34 859059.78	854857.63	539.87	-5.61	No violations found at max temp. of 500.00
linnet_acsr.wir	1224	3	1	1225	500	3338.85	-12.40 859300.04	854704.95	522.69	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1224	3	2	1225	500	3346.06	1.85 859298.48	854689.05	520.37	-5.08	No violations found at max temp. of 500.00
linnet_acsr.wir	1224	3	3	1225	500	3341.82	-12.23 859302.45	854703.21	522.45	-4.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1225	3	1	1226	500	3660.62	-8.35 859569.36	854528.81	485.62	-4.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1225	3	2	1226	500	3653.85	-1.69 859560.07	854526.84	485.48	-5.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1225	3	3	1226	500	3660.33	-8.37 859569.12	854528.99	485.64	-4.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1226	3	1	1227	494	3838.13	-5.71 859717.67	854431.23	467.06	-5.00	TIN elevation
linnet_acsr.wir	1226	3	2	1227	500	4079.48	7.27 859914.19	854290.52	459.11	1.54	No violations found at max temp. of 500.00
linnet_acsr.wir	1226	3	3	1227	500	4099.86	-2.45 859936.60	854287.76	454.12	3.25	No violations found at max temp. of 500.00
linnet_acsr.wir	1227	3	1	1228	500	4232.35	-1.91 860047.92	854215.92	446.31	5.08	No violations found at max temp. of 500.00
linnet_acsr.wir	1227	3	2	1228	500	4242.53	12.16 860048.90	854198.57	445.81	4.90	No violations found at max temp. of 500.00
linnet_acsr.wir	1227	3	3	1228	500	4248.49	-1.69 860061.40	854207.02	444.33	5.12	No violations found at max temp. of 500.00
linnet_acsr.wir	1228	3	1	1229	500	4507.70	-6.02 860282.14	854071.13	439.49	-0.56	No violations found at max temp. of 500.00
linnet_acsr.wir	1228	3	2	1229	500	4505.26	9.75 860271.64	854059.12	432.83	4.18	No violations found at max temp. of 500.00
linnet_acsr.wir	1228	3	3	1229	500	4507.70	-6.02 860282.14	854071.13	439.49	-0.65	No violations found at max temp. of 500.00
linnet_acsr.wir	**1229**	**3**	**1**	**1230**	**32**	**4801.39**	**-0.82 860527.41**	**853909.51**	**465.86**	**-0.74**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	1229	3	2	1230	500	4801.39	-0.82 860527.41	853909.51	465.86	-0.75	No violations found at max temp. of 500.00
linnet_acsr.wir	1229	3	3	1230	500	4801.39	-0.82 860527.41	853909.51	465.86	-0.69	No violations found at max temp. of 500.00
linnet_acsr.wir	1230	3	1	1231	449	5075.67	-5.08 860698.45	853713.68	526.78	-5.00	TIN elevation
linnet_acsr.wir	1230	3	2	1231	500	5072.44	-5.09 860697.52	853716.76	526.08	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1230	3	3	1231	500	5072.44	-5.32 860697.74	853716.83	526.14	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1231	3	1	1232	296	5274.66	0.56 860750.96	853521.64	553.39	-0.00	TIN elevation
linnet_acsr.wir	1231	3	2	1232	500	5300.96	-4.65 860763.52	853497.96	555.56	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1231	3	3	1232	500	5300.93	-4.82 860763.68	853498.03	555.55	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1232	3	1	1233	69	5636.38	0.74 860854.96	853175.19	583.63	-0.00	TIN elevation
linnet_acsr.wir	1232	3	2	1233	500	5577.35	0.33 860838.37	853231.85	578.92	0.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1232	3	3	1233	500	5577.38	0.07 860838.62	853231.89	578.89	0.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1233	3	1	1234	438	5850.28	2.35 861002.40	853061.82	595.03	5.03	TIN elevation
linnet_acsr.wir	1233	3	2	1234	500	5889.64	8.94 861039.62	853047.42	597.98	4.94	No violations found at max temp. of 500.00
linnet_acsr.wir	1233	3	3	1234	500	5879.83	1.44 861031.53	853056.74	596.91	5.04	No violations found at max temp. of 500.00
linnet_acsr.wir	1234	3	1	1235	447	6213.25	2.83 861357.82	852988.17	616.83	5.02	TIN elevation
linnet_acsr.wir	1234	3	2	1235	500	6135.00	9.10 861279.91	852997.76	614.81	4.94	No violations found at max temp. of 500.00
linnet_acsr.wir	1234	3	3	1235	500	6137.89	0.91 861284.39	853005.20	613.25	5.05	No violations found at max temp. of 500.00
linnet_acsr.wir	1235	3	1	1236	183	6529.66	-0.03 861668.35	852927.34	656.00	-0.00	TIN elevation
linnet_acsr.wir	1235	3	2	1236	500	6447.62	-5.18 861589.01	852948.89	641.49	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1235	3	3	1236	500	6447.63	-5.00 861588.99	852948.70	641.48	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1236	3	1	1237	85	6775.97	-1.19 861874.24	853033.20	670.45	4.49	TIN elevation
linnet_acsr.wir	1236	3	2	1237	500	6739.79	0.50 861846.31	853010.13	669.00	3.73	No violations found at max temp. of 500.00
linnet_acsr.wir	1236	3	3	1237	500	6736.56	0.40 861843.68	853008.26	668.89	3.75	No violations found at max temp. of 500.00
linnet_acsr.wir	1237	3	1	1238	110	7066.82	-13.25 862072.70	853242.79	676.11	-5.46	TIN elevation
linnet_acsr.wir	1237	3	2	1238	500	7063.20	-4.97 862076.48	853234.58	674.90	-6.11	No violations found at max temp. of 500.00
linnet_acsr.wir	1237	3	3	1238	500	7066.89	-12.96 862072.97	853242.65	676.08	-6.05	No violations found at max temp. of 500.00
linnet_acsr.wir	1238	3	1	1239	164	7361.67	-12.01 862270.25	853461.76	674.67	-4.98	TIN elevation
linnet_acsr.wir	1238	3	2	1239	500	7341.69	2.26 862267.52	853437.36	674.21	-5.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1238	3	3	1239	500	7361.86	-11.60 862270.69	853461.63	674.63	-4.97	No violations found at max temp. of 500.00
linnet_acsr.wir	**1239**	**3**	**1**	**1240**	**32**	**7778.26**	**-10.13 862555.82**	**853765.48**	**670.16**	**-3.39**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	1239	3	2	1240	500	7681.05	2.78 862498.12	853686.18	656.51	-4.92	No violations found at max temp. of 500.00
linnet_acsr.wir	1239	3	3	1240	500	7778.26	-10.13 862555.82	853765.48	670.16	-3.91	No violations found at max temp. of 500.00
linnet_acsr.wir	**1240**	**3**	**1**	**1241**	**32**	**8039.28**	**-9.87 862737.97**	**853952.62**	**668.13**	**-3.40**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	1240	3	2	1241	500	7970.10	13.03 862705.95	853887.16	646.60	5.13	No violations found at max temp. of 500.00
linnet_acsr.wir	1240	3	3	1241	187	8039.28	-9.87 862737.97	853952.62	668.13	-3.75	Point Vegetation/Tree/Brush
linnet_acsr.wir	1241	3	1	1242	197	8261.81	-11.63 862895.87	854110.01	644.82	-4.88	TIN elevation
linnet_acsr.wir	1241	3	2	1242	500	8323.82	12.56 862957.65	854134.78	642.48	5.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1241	3	3	1242	500	8281.50	-11.35 862910.43	854123.28	643.65	-4.87	No violations found at max temp. of 500.00
linnet_acsr.wir	1242	3	1	1243	99	8607.54	2.25 863157.01	854336.97	639.93	5.01	TIN elevation

linnet_acsr.wir	1242	3	2	1243	500	8591.05	8.43	863149.30	854321.14	640.48	4.97	No violations found at max temp. of 500.00
linnet_acsr.wir	1242	3	3	1243	500	8591.05	1.95	863144.84	854325.85	640.16	5.03	No violations found at max temp. of 500.00
linnet_acsr.wir	1243	3	1	1244	46	8768.99	3.55	863287.71	854401.46	636.04	5.00	TIN elevation
linnet_acsr.wir	1243	3	2	1244	500	8830.99	7.93	863349.02	854391.22	633.15	4.97	No violations found at max temp. of 500.00
linnet_acsr.wir	1243	3	3	1244	500	8844.28	-3.21	863363.30	854401.06	632.24	0.06	No violations found at max temp. of 500.00
linnet_acsr.wir	1244	3	1	1245	445	9113.42	-1.94	863631.14	854374.56	627.86	5.07	TIN elevation
linnet_acsr.wir	1244	3	2	1245	500	9102.80	2.40	863620.16	854371.22	628.12	-5.04	No violations found at max temp. of 500.00
linnet_acsr.wir	1244	3	3	1245	500	9113.22	-1.80	863630.92	854374.43	627.86	5.08	No violations found at max temp. of 500.00
linnet_acsr.wir	1245	3	1	1246	388	9358.59	-11.93	863876.18	854361.35	627.41	-4.99	TIN elevation
linnet_acsr.wir	1245	3	2	1246	500	9348.25	2.47	863864.50	854348.01	626.59	-5.01	No violations found at max temp. of 500.00
linnet_acsr.wir	1245	3	3	1246	500	9358.38	-11.82	863875.95	854361.26	627.39	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1246	3	1	1247	500	9646.20	-12.17	864162.48	854334.35	632.84	-4.61	No violations found at max temp. of 500.00
linnet_acsr.wir	1246	3	2	1247	500	9637.29	11.47	864151.40	854311.65	621.30	4.92	No violations found at max temp. of 500.00
linnet_acsr.wir	1246	3	3	1247	500	9646.20	-12.17	864162.48	854334.35	632.84	-4.46	No violations found at max temp. of 500.00
linnet_acsr.wir	**1247**	**3**	**1**	**1248**	**32**	**9824.88**	**-4.86**	**864339.68**	**854310.00**	**635.82**	**3.19**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	1247	3	2	1248	355	9825.53	0.45	864339.81	854304.66	638.19	-1.13	Point Vegetation/Tree/Brush
linnet_acsr.wir	1247	3	3	1248	500	9824.88	-4.86	864339.68	854310.00	635.82	2.88	No violations found at max temp. of 500.00
linnet_acsr.wir	1248	3	1	1249	128	10101.29	-12.91	864596.92	854347.65	608.58	-5.27	TIN elevation
linnet_acsr.wir	1248	3	2	1249	500	10101.26	-8.15	864599.11	854343.43	608.42	-5.95	No violations found at max temp. of 500.00
linnet_acsr.wir	1248	3	3	1249	500	10121.24	-12.55	864614.74	854356.63	605.94	-5.72	No violations found at max temp. of 500.00
linnet_acsr.wir	**1249**	**3**	**1**	**1250**	**32**	**10383.53**	**2.49**	**864854.04**	**854465.09**	**604.27**	**4.82**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	**1249**	**3**	**2**	**1250**	**32**	**10324.06**	**9.72**	**864804.60**	**854431.26**	**619.20**	**2.46**	**NG Point Vegetation/Tree/Brush , Aborted critical point search since wire can't clear point at 32 (deg F)**
linnet_acsr.wir	1249	3	3	1250	491	10383.53	2.49	864854.04	854465.09	604.27	5.70	Point Vegetation/Tree/Brush
linnet_acsr.wir	1250	3	1	1251	500	10658.28	3.92	865103.31	854571.95	562.90	1.97	No violations found at max temp. of 500.00
linnet_acsr.wir	1250	3	2	1251	500	10656.41	11.71	865102.70	854563.97	572.84	5.74	No violations found at max temp. of 500.00
linnet_acsr.wir	1250	3	3	1251	500	10690.05	-3.13	865133.57	854583.93	557.50	-3.44	No violations found at max temp. of 500.00
linnet_acsr.wir	1251	3	1	1252	384	10978.64	-2.55	865418.46	854629.86	547.88	5.11	TIN elevation
linnet_acsr.wir	1251	3	2	1252	500	10901.92	6.04	865344.20	854608.76	551.26	-0.50	No violations found at max temp. of 500.00
linnet_acsr.wir	1251	3	3	1252	500	10985.07	-2.31	865424.85	854630.68	547.53	5.08	No violations found at max temp. of 500.00
linnet_acsr.wir	**1252**	**3**	**1**	**1253**	**32**	**11281.87**	**-7.08**	**865716.80**	**854684.29**	**553.28**	**0.00**	**NG TIN elevation, Aborted critical point search since wire can't clear point at 32 (deg F).**
linnet_acsr.wir	1252	3	2	1253	500	11416.25	2.97	865850.99	854696.58	548.47	-4.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1252	3	3	1253	500	11281.82	-7.06	865716.75	854684.26	553.28	0.04	No violations found at max temp. of 500.00
linnet_acsr.wir	1253	3	1	1254	500	11524.90	-2.30	865958.02	854715.28	529.58	5.06	No violations found at max temp. of 500.00
linnet_acsr.wir	1253	3	2	1254	500	11434.18	2.99	865868.64	854698.91	542.63	-2.99	No violations found at max temp. of 500.00
linnet_acsr.wir	1253	3	3	1254	500	11515.37	-2.32	865948.56	854714.14	529.92	5.07	No violations found at max temp. of 500.00
linnet_acsr.wir	1254	3	1	RIVER CEMENT SUB.	500	11679.00	-9.52	866111.84	854733.47	525.33	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1254	3	2	RIVER CEMENT SUB.	500	11682.49	-3.23	866115.21	854727.12	525.28	-5.00	No violations found at max temp. of 500.00
linnet_acsr.wir	1254	3	3	RIVER CEMENT SUB.	500	11685.28	13.94	866117.68	854709.89	525.31	5.00	No violations found at max temp. of 500.00

D. APPENDIX D: USER MANUAL

December 2013

PLC-VAST User Manual



Rev. 0 | Ndumiso Mabuza

Note From The Developer

For the latest information regarding PLC-VAST, send me an email at ndumisosm@gmail.com or call me on (+27)72 489 4142 letting me know which country you're from, what industry you work in and how the software has helped you in your line of work. You can also send me suggestions on any other improvements or added functionality that you think could be useful for users of the software package.

Disclaimer

PLC-VAST is Freeware (even for commercial use), and as such, no monetary cost is involved in obtaining this program. You may redistribute PLC-VAST as long as it is not modified in any way. Any modification should be discussed with me beforehand.

PLC-VAST is provided "as is" and the developer cannot be responsible for any damage or inaccurate calculations that may occur as a result of using this software. This includes the information contained within it. It is not intended to replace industry design software packages such as PLSCADD which are recommended for the design of high voltage transmission lines. The program is meant to rather serve as a simple clearance violation checking tool for short line designs and single isolated spans.

Program Description

PLC-VAST, short for Power Line Clearance Violation Assessment Software Tool, is a MATLAB based power line analysis software program which was developed for educational as well as commercial purposes. It uses the graphical user interface development environment (GUIDE) to provide a graphical interface from which analysis of power lines can take place. The program provides individual users, consulting firms and utilities alike with the opportunity to analyse clearance violations on high voltage (HV) transmission power lines based on a set input criteria against which it checks the minimum allowable distances between the main power line and other impeding objects such as ground points, crossing conductors, vegetation points and buildings.

A Laser Imaging, Detection and Ranging (LIDAR) data input file with the various survey points is imported into the program in .xlsx or .csv format and the data is then displayed on the GUI. The user can then view and edit the survey data as well as run reports which will show which survey points on the main transmission power line conductors are in violation of the set criteria.

Contents

1 Minimum System Requirements

The PLC-VAST program is designed for intensive data processing and as such, high level system requirements are necessary to successfully run the program. The minimum system requirements specified below have been determined through a trial and error process on different computers with varying system specifications. A minimum system configuration based on program testing on systems of different configuration levels is therefore given herein.

The program has not been tested on any other operating system thus far and therefore its compatibility and functionality on other operating system platforms cannot be confirmed.

Processor: Intel i5 core processor

Operating System: Windows 7

RAM: 3GB

Matlab version: R2012a full version

Disk Space: At least 1 GB for MATLAB only, 3–4 GB for a typical installation and an additional 1GB for the PLC-VAST program.

No graphics support is required for operation of the software.

2 Running the Program

The PLC-VAST software can be operated in one of two ways. The first method is to run the independent plc-vast.exe file. The only pre-requisite for this method to work is for a MATLAB R2012a compiler to be pre-installed on the computer. Both the 32-bit and 64-bit compilers are freely available on the Mathworks website (www.mathworks.com).

The second method is to launch the program from within MATLAB. In order to run the program within MATLAB, a user should ensure that all the program files are stored in the same folder. The LIDAR data file need not be stored in the same folder, only the MATLAB code files.

Upon opening MATLAB, the user should change the directory to the corresponding location of these MATLAB code files. The program can then be opened in the following ways;

1. Typing guide in the MATLAB command window will bring up the GUIDE tool window that allows the user to create or edit GUIs interactively. The PLC-VAST program can then be opened by opening the PLC_VAST.fig file.

2. Opening the PLC_VAST.m file from the MATLAB main command window (File > Open) will open the MATLAB code for the program. The program can then be opened by clicking on the run icon  or pressing F5.

3 Main Menu Bar

This section will give highlights of the main menu items and explain each of the sub-menu items briefly. The main menu (as shown in Figure 3-1) consists of the following six items:

1. File
2. Edit
3. View
4. Criteria
5. Reports
6. Help

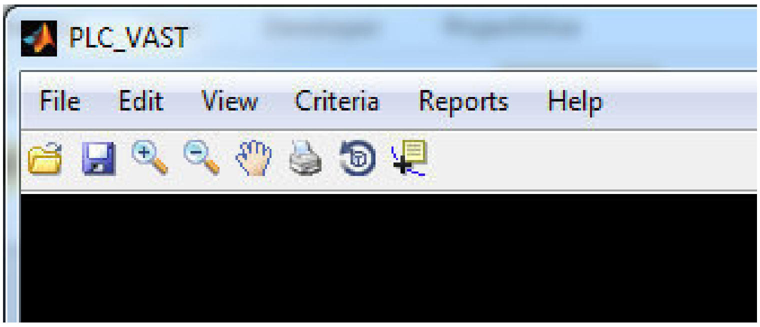


Figure 3-1: Main menu of the PLC_VAST program

The icons below the main menu items are shortcuts to several sub-menu items for performing quick functions. The menu items and their sub-menu items are explained below.

3.1 File Menu

The File Menu deals with user I/O options as shown in Figure 3-2.

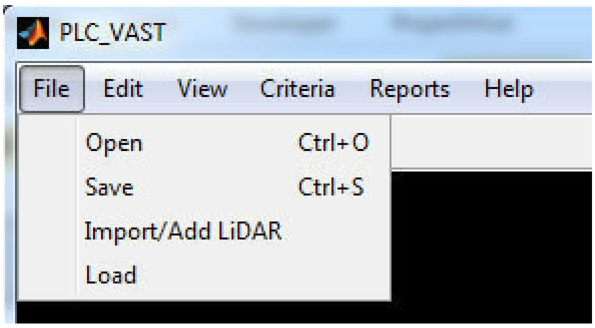


Figure 3-2: File menu options

Each of the sub-menu options are discussed in the next sub-sections.

3.1.1 File - Open

This option opens a dialog-box (as shown in Figure 3-2) which allows a user to browse and select the input data file in ".csv" and ".xlsx" formats.

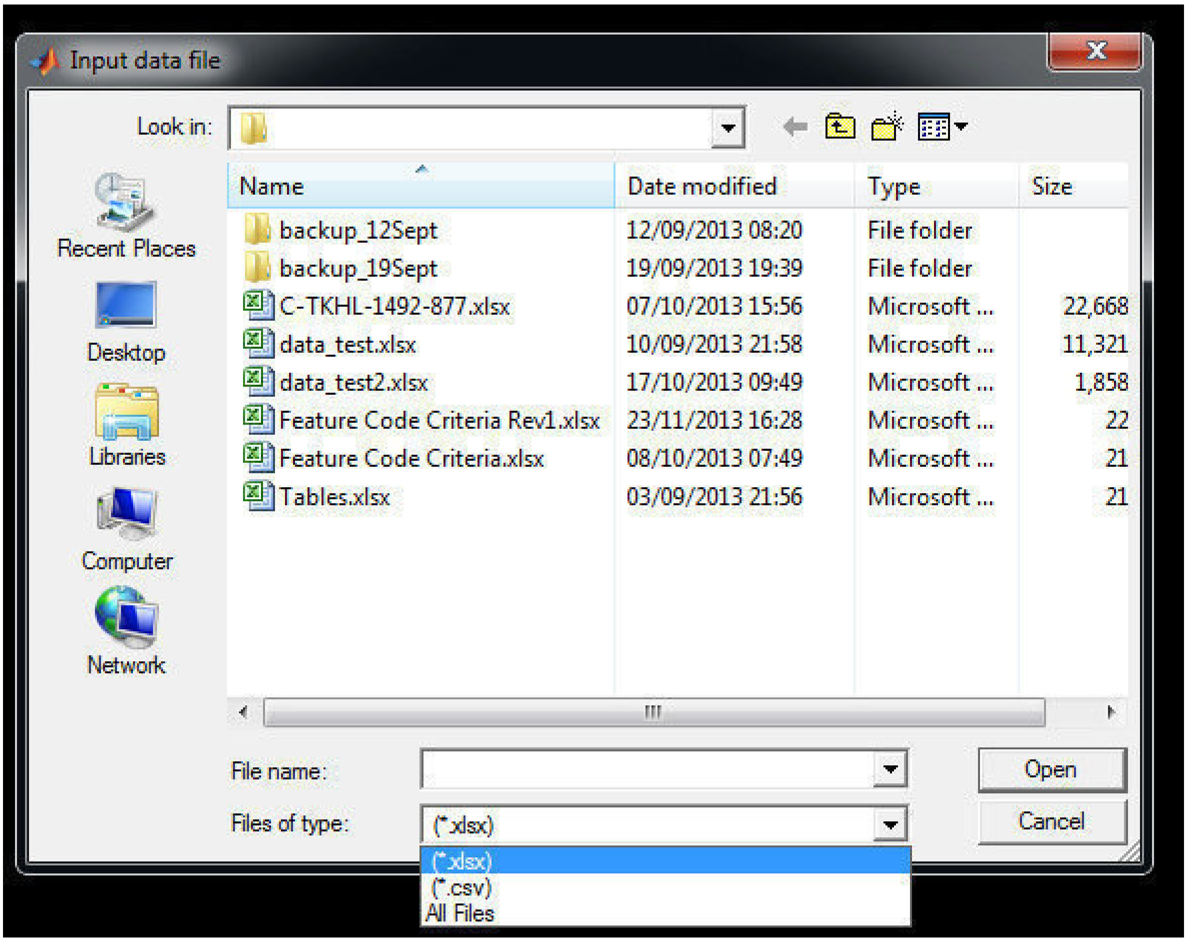


Figure 3-2: Browse and select file to open

The input data file must contain only 4 columns in order (from left to right): Feature Code, X(ft), Y(ft) and Z(ft) as shown in Figure 3-2 below. An additional requirement is that each column must contain only numeric data and no unit symbols.

Feature Code	X (ft)	Y (ft)	Z (ft)
100	2293574.45	704431.5	415.87
100	2293575.37	704431.2	415.84
1009	2293577.27	704396.8	497.93
1009	2293577.34	704395.8	497.96
321	2293548.5	704397.1	424.7
321	2293549.42	704396.8	424.63

Figure 3-4: Example of Input Data File

If no file is chosen or the user chooses to cancel or close the dialog-box, an error message will be displayed as shown in Figure 3-5.

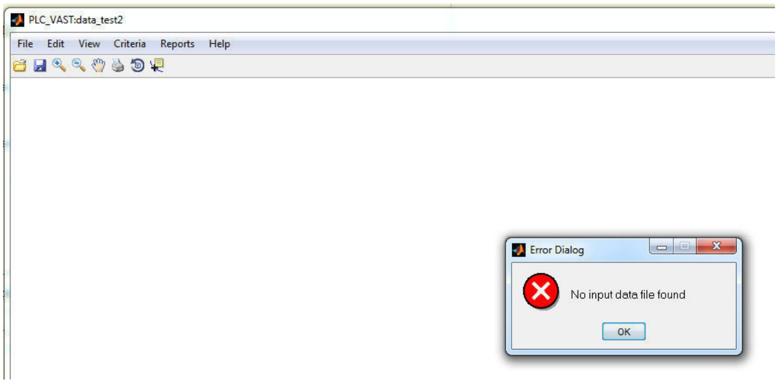


Figure 3-5: No file to open error message

On selecting an input data file, the program will read the data and display a dialog-box to select the feature codes to display as shown in Figure 3-6. This function will reduce the processing time and make the program run smooth in case a huge amount of data is to be handled by the program. Furthermore, the name of the input data file chosen will be shown on the top-left corner of the main program window as shown in the red coloured oval in Figure 3-6.

To select any feature code, the user has to click on the corresponding coloured icon in the dialog-box. Multiple feature codes can be selected by clicking on their respective icons. Once all feature codes have been selected, the user needs to close the dialog-box and the program will display the data points corresponding to the selected feature codes as read from the input file. This functionality is illustrated in Figure 3-7. The points will also be coloured according to their corresponding feature codes in the display plot.

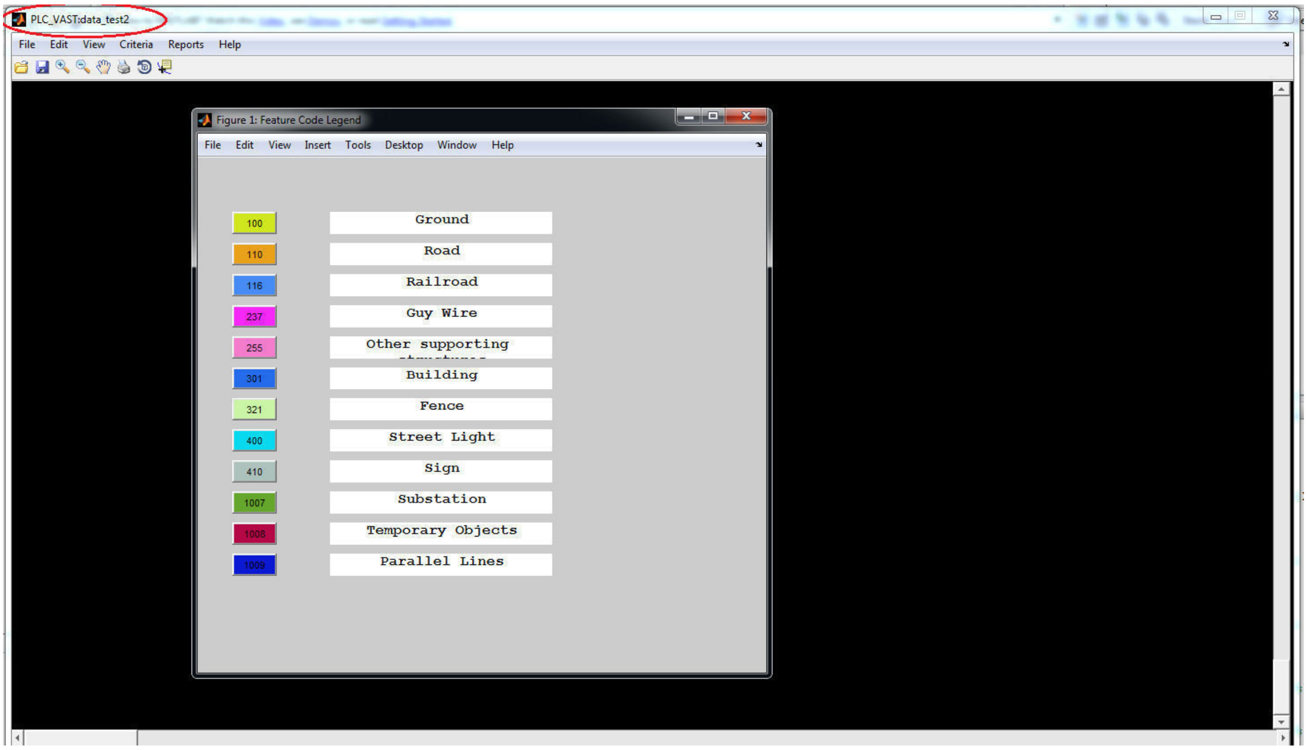


Figure 3-6: Select feature code(s) to display

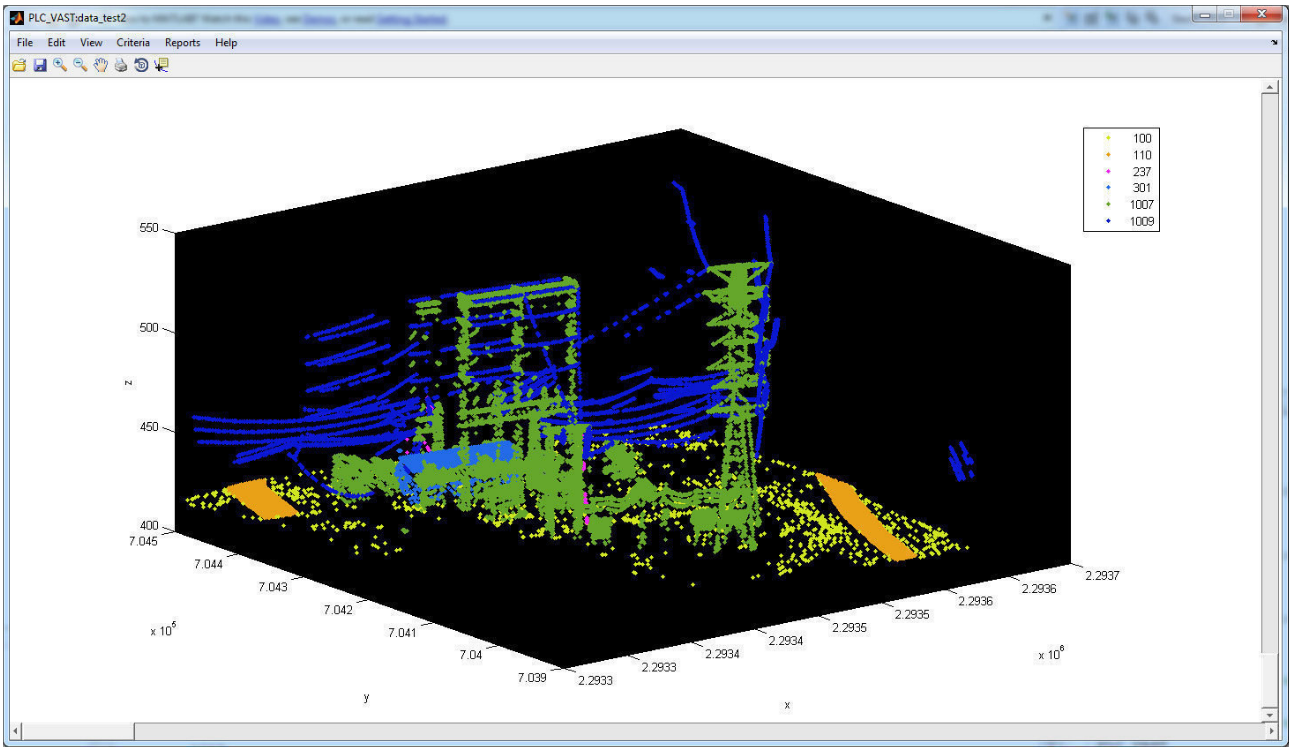


Figure 3-7: Display of selected feature code points in program main window

3.1.2 File –Save

This option allows the user to save the input-data file in ".mat" format which is the standard MATLAB format to save any data. Saving the same data in ".mat" format will make it faster to read the same data when required to be loaded to this program the next time. This option will open a dialog-box (as shown in Figure 3-8) which will ask the user to enter a file name by which the user wants to save the input file data.

When no filename is entered by the user to save the input data, the program will show an error message saying "File not saved" as shown in Figure 3-9.

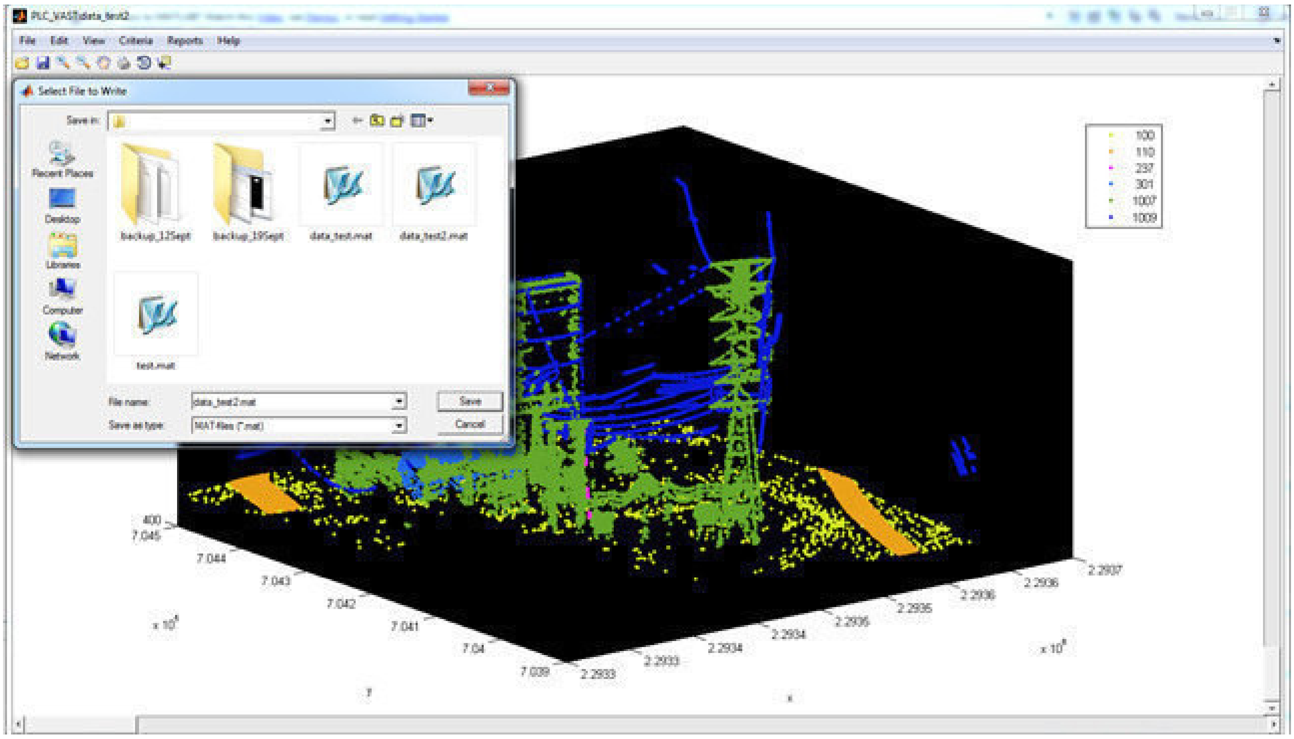


Figure 3-8: Save input data as ".mat" format

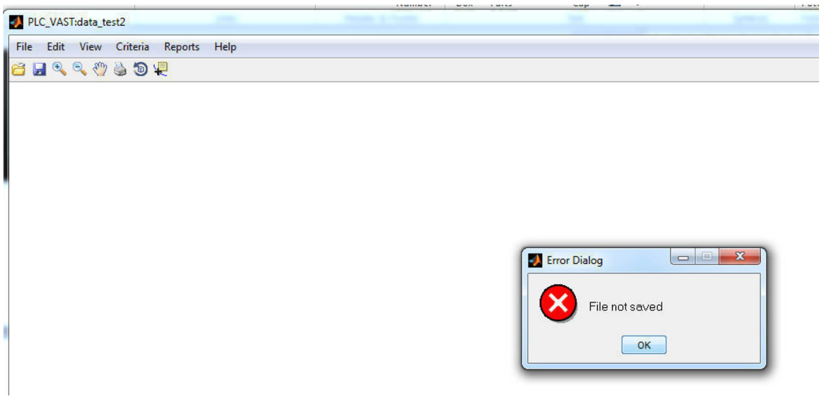


Figure 3-9: File not saved error message

3.1.3 File – Load

This option allows user to load a ".mat" data file saved earlier. On selecting this option, a dialog-box will appear as shown in Figure 3-10 and the user can browse to the file of interest. This will also clear the current displayed plot in the Main Window area. An error message with the text "No mat data file found" will be displayed if the user closes the dialog-box without selecting any file or chooses to press "Cancel". On selecting a file, the program will proceed in the same manner as it does when a file is chosen via File – Open option. The program will then display a legend dialog-box to select the feature codes to display in the program Main Window.

3.1.4 File – Import/Add LIDAR

This option is meant to allow users to import data from other file(s) and add it to the current dataset. An example of this functionality is when a revised LIDAR data file is meant to be merged with a previous data set. Instead of opening the new revised file, only the desired points may be imported from the desired file and added to the current file. The reason for this may be due to the fact that the older data set has been modified and replacing it with a totally new file would result in the modifications being lost.

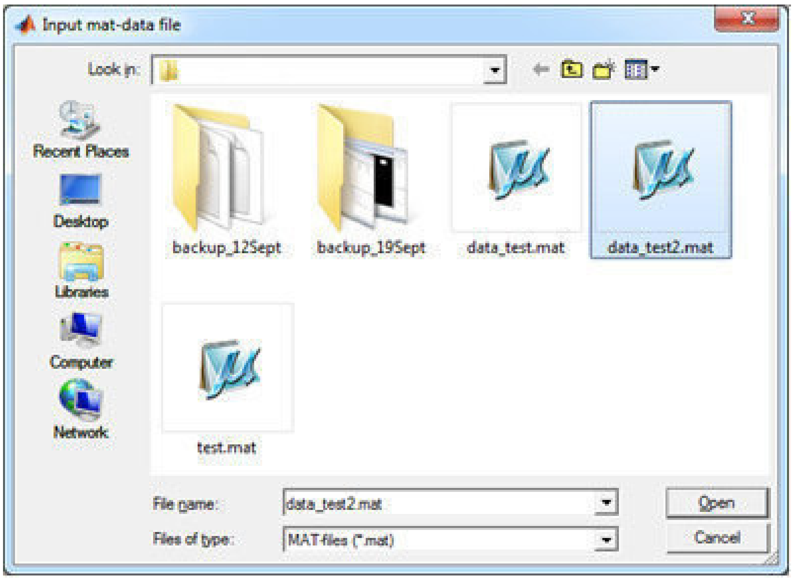


Figure 3-10: Input ".mat" data file dialog-box

3.2 Edit Menu

This menu deals with the options to delete/select the data loaded to the program or read by the program as per the File – Menu options. The two sub-menu items under this menu are shown in Figure 3-11. These sub-menu items are discussed in the next sub-sections.

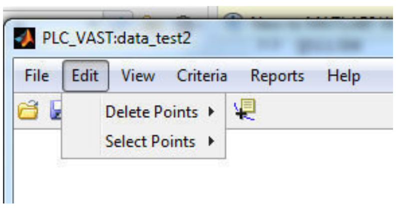


Figure 3-11: Edit menu items

3.2.1 Edit – Delete

This option allows the user to delete data points in the following two ways as shown in Figure 3-12.

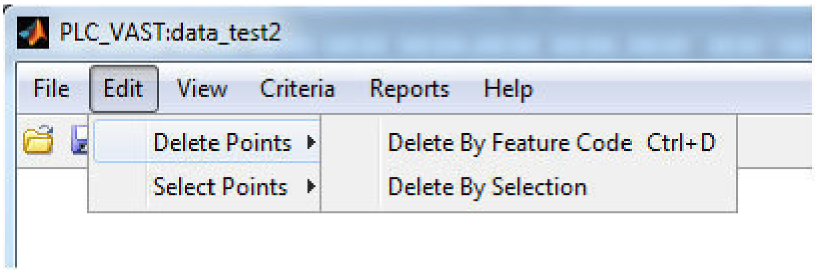


Figure 3-12: Delete points

1. Delete by Feature Code: This option allows the user to select the feature code(s) which need to be removed from the dataset in the program memory. This option can be accessed as shown in Figure 3-13. The deleted points will also be removed from the display window if visible in the display as per the user's initial display preferences. To view the remaining points, go to View → Initial View (Fit Model) as shown in Figure 3-18. The plots shown in Figure 3-15 (a) and (b) shows that the view before and after the feature code 255 (Other Supporting Structures) had been deleted from the viewable points deleted.

2. Delete by Selection: This option allows the user to select point(s) displayed in the program main window. The selected points are then removed from the dataset in the program memory as well as from the program display window. To select the points, go to Edit → Select Points as shown in Figure 3-13 and proceed as explained in the next sub-section. To view the remaining points, go to View → Initial View (Fit Model) as shown in Figure 3-18. The plots shown in Figure 3-15 (a) and (b) shows that the points outside the selection range i.e. between Z = 467.23 and Z = 548.22 are retained and the remaining ones are deleted.

3.2.2 Edit – Select Points

This option allows the user to select points in two ways as shown in Figure 3-13. The selected points can then be viewed on Google Earth via View → Google Earth or can be deleted using the Delete by Selection feature as discussed previously.

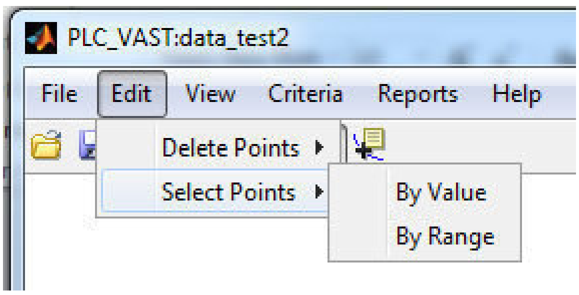
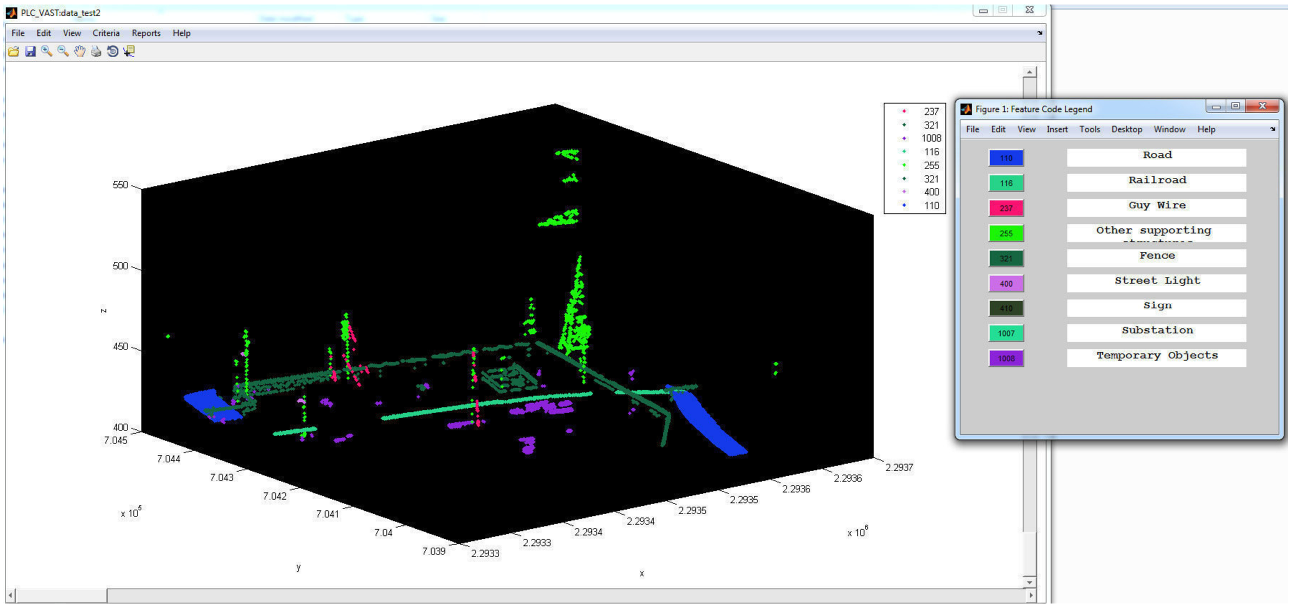


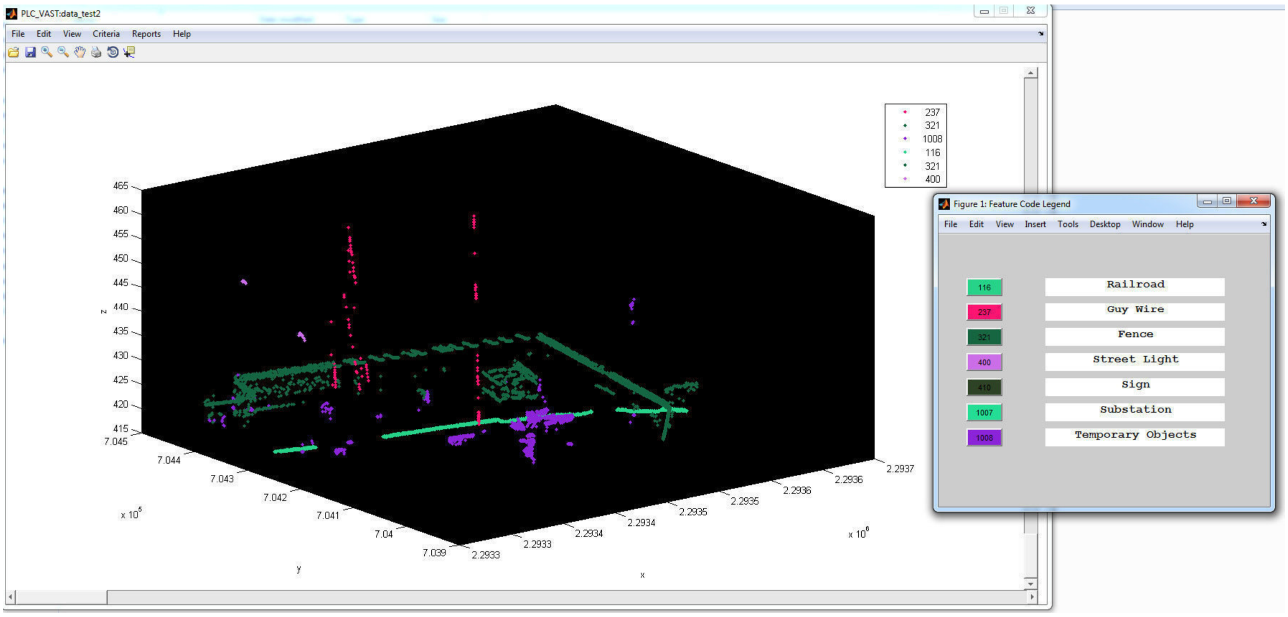
Figure 3-13: Select points

1. Select points by value: This option requires the user to enter the values of Feature Code, X(ft), Y(ft) and Z(ft) coordinates of the desired point to be selected. On choosing this option, a dialog-box appears as shown in Figure 3-16 where the user can enter the values of the coordinates. The nearest point will be selected if the values of the entered coordinates do not match exactly with any of the points for the corresponding feature code.

2. Select points by range: This option requires the user to enter the range of X(ft), Y(ft) and Z(ft) coordinates to simultaneously select multiple points. On choosing this option, a dialog-box appears as shown in Figure 3-17 where the user can then enter minimum and maximum values for X, Y and Z. All the points within this range of coordinates will then be selected.

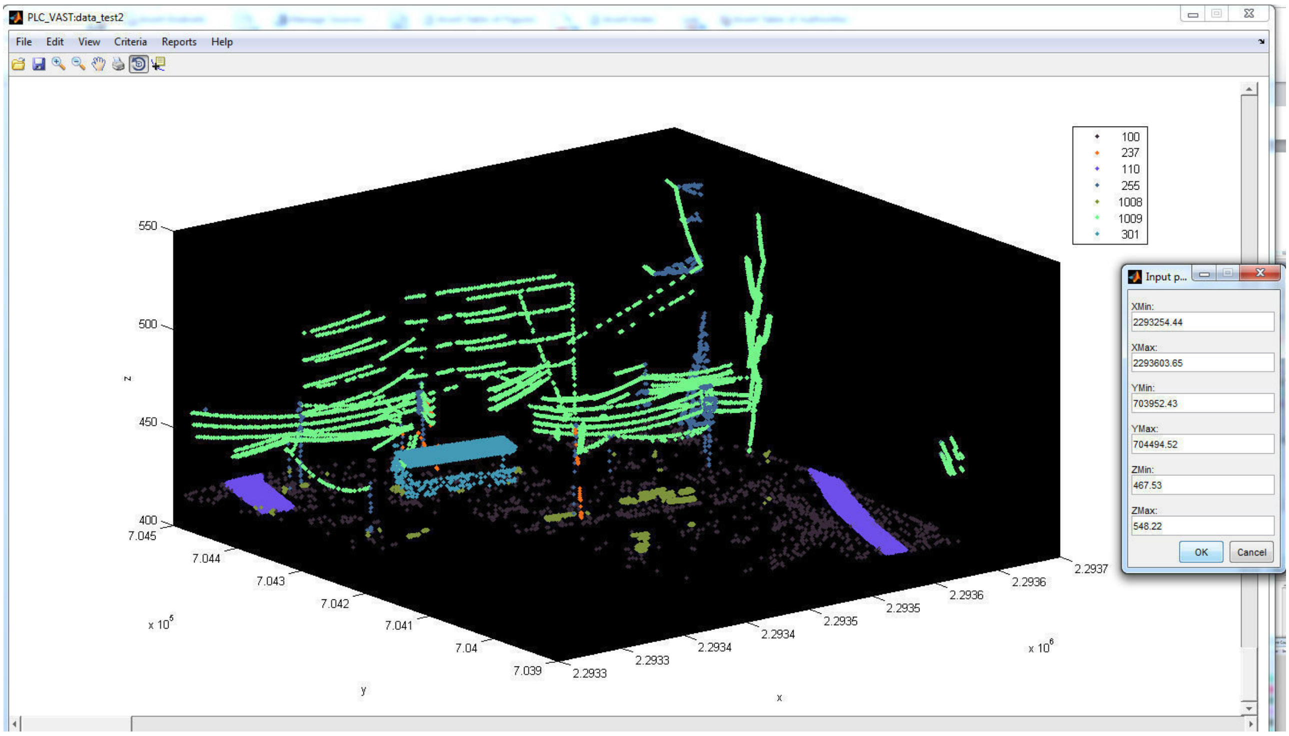


(a) View before deleting points

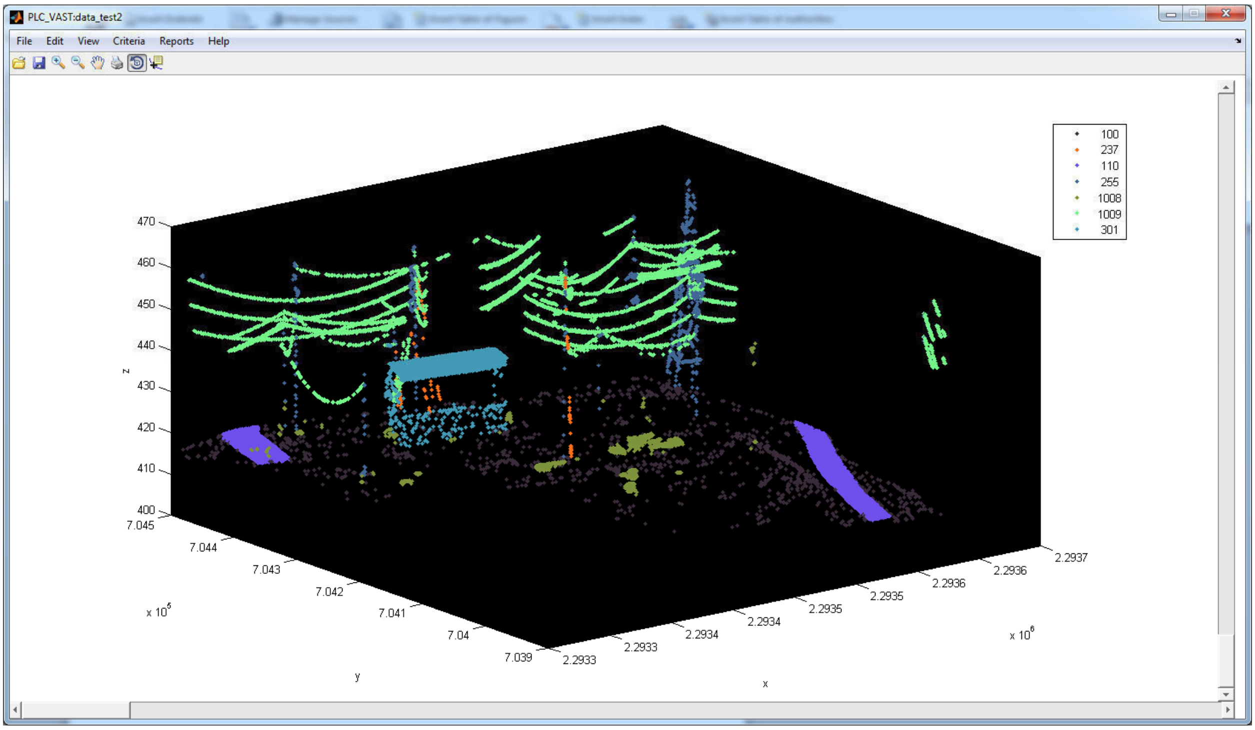


(b) View after deleting Road and Other Supporting Structures points

Figure 3-14: Delete points by feature code



(a) Points selected by range between Z = 467.23 and Z = 548.22 for deleting



(b) Selected points are absent from the updated view

Figure 3-15: Delete points by selection

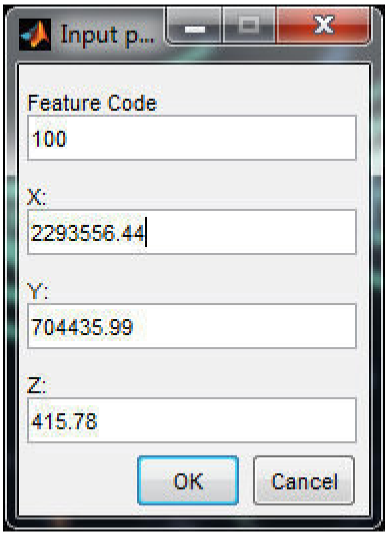


Figure 3-16: Select point by value

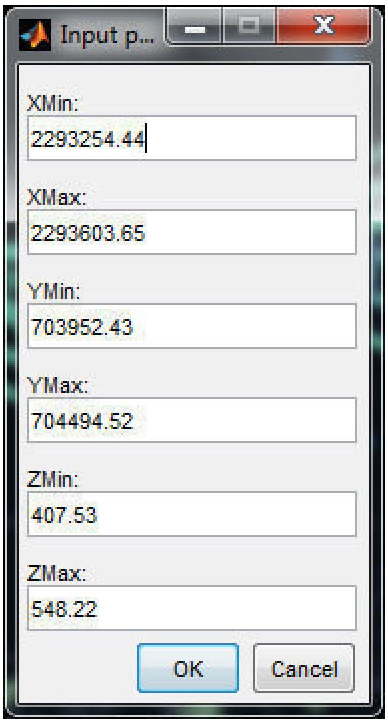


Figure 3-17: Select points by range

3.3 View – Menu

This menu shows the various viewing options provided by the program. The different sub-menu items are shown in Figure 3-18.

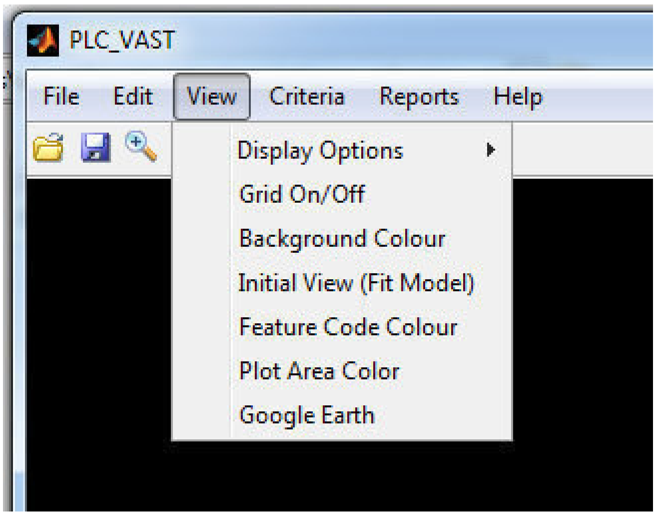


Figure 3-18: View menu items

Each menu item is discussed elaborately in the following sub-sections.

3.3.1 View – Display Options

The display options (Figure 3-19) allow users to view the legend, choose plot symbols and choose feature codes to plot in the main window. It allows the user to measure the distance between two coordinates.

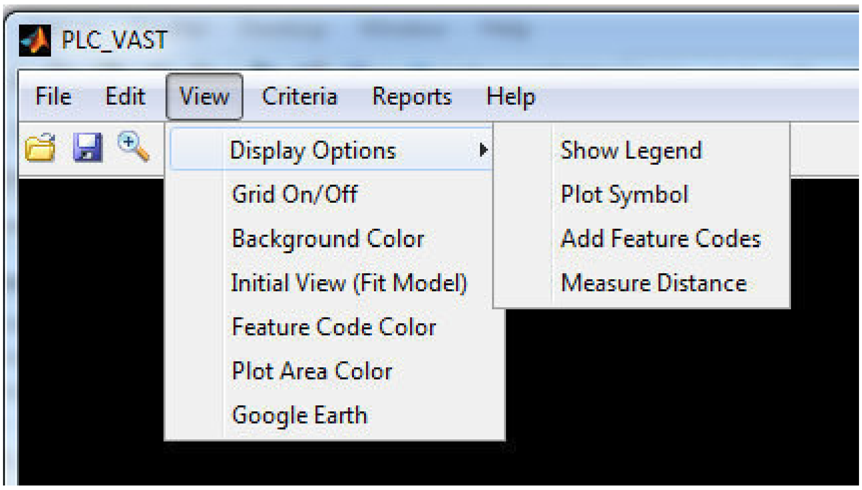


Figure 3-19: View - Display options

1. Show Legend: This option displays the legend of the current data in a separate window as shown in Figure 3-20.

2. Plot Symbol: On choosing this option, a dialog-box will appear as shown in Figure 3-21. This option will let the user select one of the various available symbols to plot the data points in the main display window.

3. Add Feature Codes: This option works in a similar manner to the one described in the File – Open menu. On choosing this option, a dialog-box appears as shown in Figure 3-6. This dialog box allows the user to select multiple feature codes to be plotted in the main display window.

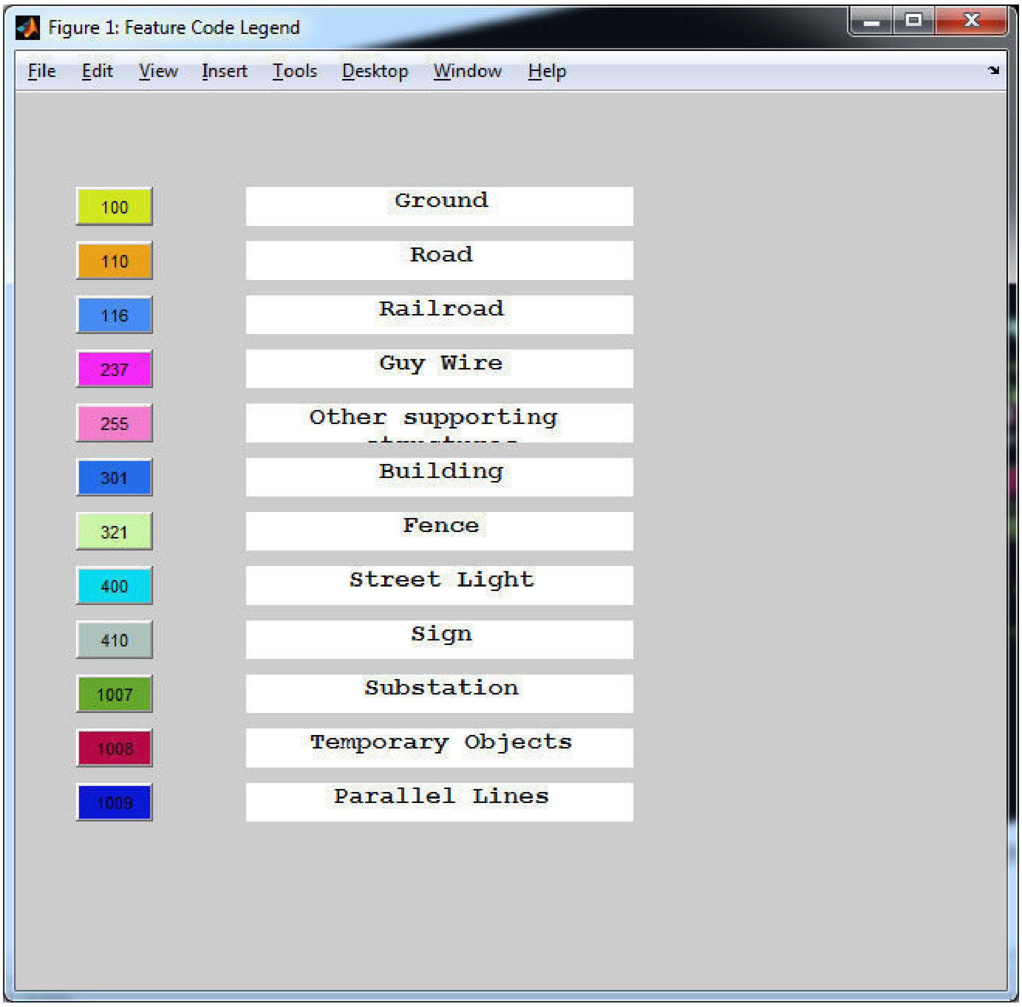


Figure 3-20: View feature code legend

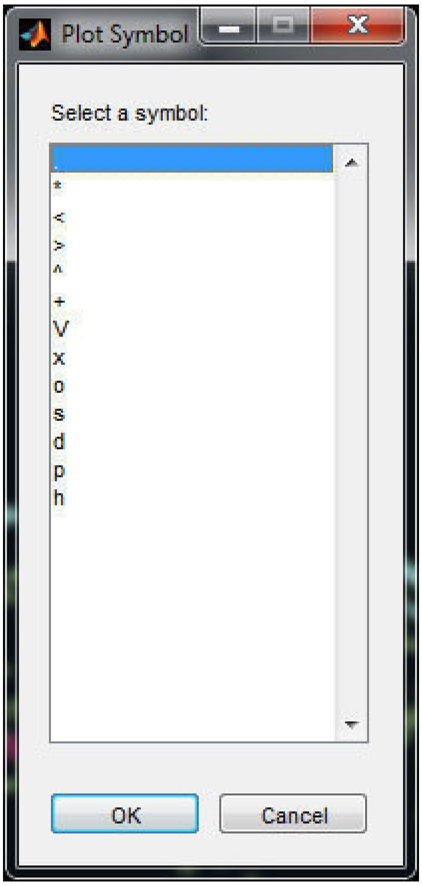


Figure 3-21: Choose plot symbol

3. Compute Distance: The distance measurement function allows the user to measure the distance between two coordinates. It allows for the simultaneous measurement of distance between multiple sets of coordinates. For example, if six points are selected, the program will return three distance measurements between the 3 sets of points (points 1 and 2, 3 and 4, 5 and 6). Once the 'measure distance' option has been selected, the user then clicks on the desired points and presses enter. The distance will then appear on the screen above the line connecting the 2 points, as shown in Figure 3-23 below.

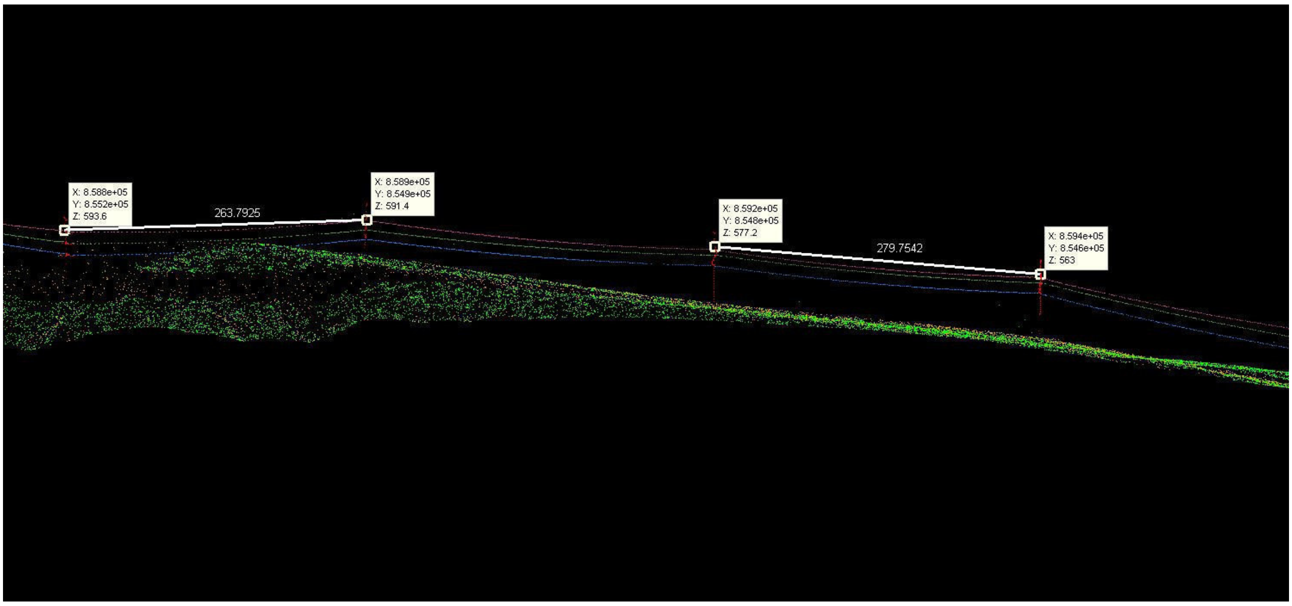


Figure 3-22: Distance measurement function

3.3.2 View – Grid On/Off

This option toggles between the appearance and disappearance of the grid lines in the main window display plot. The visibility of the grid lines in the display depends upon the background colour of the plot area.

3.3.3 View – Background Colour

This option lets users select the colour of the background i.e. the main window area behind the plot display. The user can choose a colour using the dialog-box shown in Figure 3-23. The default background colour set in the program is white.

3.3.4 View – Initial View (Fit Model)

This option changes the current plot in the main window to its original view undoing all the effects caused by zoom, pan or rotation movements or any other changes in the program.

3.3.5 View - Feature Code Colour

On loading a dataset to the program, it randomly assigns different set of colours to the different feature codes present in the loaded dataset. This option allows the user to assign colours to each of the feature code. This option opens a dialog-box similar to the one shown in Figure 3-6. To change the colour of any feature code(s), the user needs to press the button/icon corresponding to the feature code and it will open up a dialog-box shown in Figure 3-23. When the user has changed the colour(s) corresponding to all desired feature code(s) and closes the legend dialog-box, the colour(s) chosen by the user will be assigned to the corresponding feature code from there onwards. The corresponding changes will then take effect on the displayed feature codes as well.

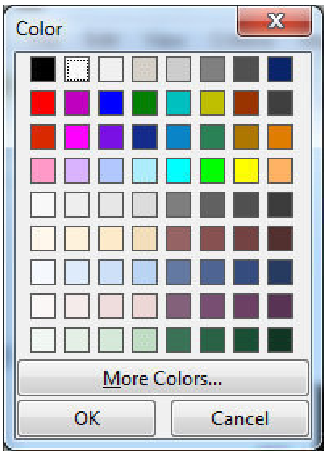


Figure 3-23: Choose feature code colour

3.3.6 View – Plot Area Colour

This option allows the user to change the colour of the plot area of the main window display. This is done in the same way as changing the background colour. The default plot area colour is black.

3.3.7 View – Google Earth

This option allows the user to view the selected point(s) in Google Earth. If no point is selected and the user chooses this option then an error message will be displayed as shown in Figure 3-24. The program will create a ".kml" file for each point selected to be viewed in Google Earth. These ".kml" files will be loaded simultaneously in Google Earth so that all the points can be viewed at once.

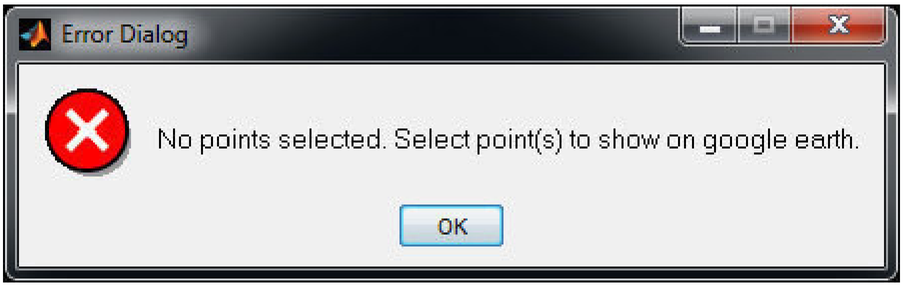


Figure 3-24: Google Earth option error message

3.4 Criteria – Menu

This menu item provides options (as shown in Figure 3-25) for modifying the criterion of safe clearance distances from the main power line conductors to other feature codes. This clearance criteria is used to generate evaluation reports for conductors of different voltages. These options are discussed in the next sub-sections.

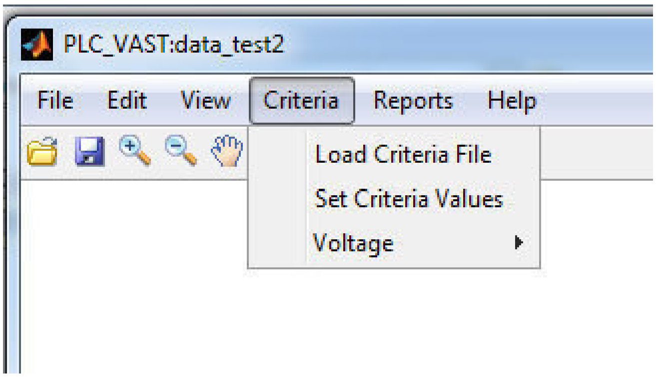


Figure 3-25: Criteria menu items

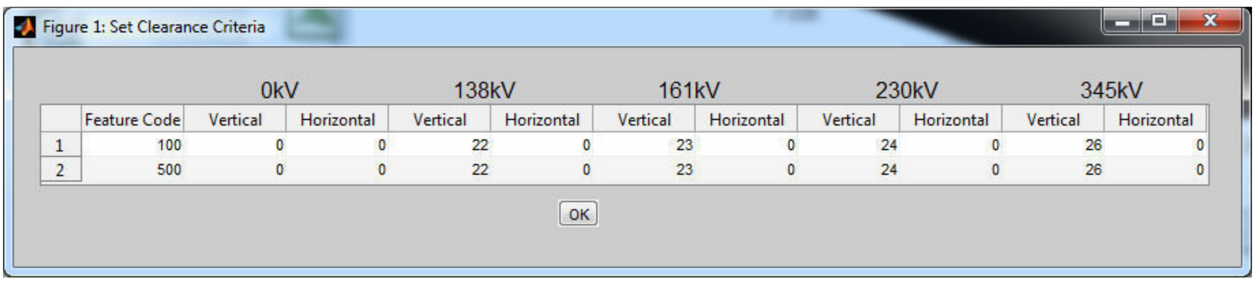
3.4.1 Criteria – Load Criteria File

This function lets the user choose a ".mat" format criteria file provided with the program with default values. The criteria file caters for 5 sets of 3-phase line voltages, namely, 0 kV, 138 kV, 161 kV, 230 kV and 345 kV. The criteria file and target feature codes are fixed for different clearance checks such as Ground Clearance, Wire Clearance and Structure Clearance etc. The criteria file consists of minimum vertical and horizontal distance required between a conductor point and the target point for violation clearance.

On choosing this option, a dialog-box will appear which will be similar to the one used for loading the ".mat" data input file (as shown in Figure 3-10). The user can browse and select a criteria file to load into the program. If no file is selected then an error message will be displayed on-screen saying `"No criteria file loaded"`.

3.4.2 Criteria – Set Criteria Values

This option will display the criteria values read from the input criteria file to the user in a tabular form as shown in Figure 3-26. The user is then allowed to edit the values for vertical and horizontal distances.



		0kV		138kV		161kV		230kV		345kV	
	Feature Code	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
1	100	0	0	22	0	23	0	24	0	26	0
2	500	0	0	22	0	23	0	24	0	26	0

Figure 3-26: Table for editing criteria values

3.5 Reports – Menu

This menu item provides options (as shown in Figure 3-27) to create different types of clearance reports for the data points loaded or read by the program. Each report will be written to a text file in the format shown in Figure 3-28. The report will include values of Voltage for the main power line conductors for which safety criteria is applied. It will also include the feature code of the type of structure like ground, buildings, vegetation etc. for which the program will be computing distances from the main power line conductor points.

Only those conductor point(s) that violate the set safety criteria are mentioned in the report, together with the values of the vertical and horizontal distance for the closest main power line conductor point. For each conductor-clearance feature code pair, the safe vertical and horizontal distances are mentioned in the beginning of the report for each structure as shown in Figure 3-28.

The obstacle line rating and vegetation line rating reports measure are used to determine the maximum current and subsequently the maximum power that can be transferred on a particular conductor, given a specific set of weather conditions before a violation occurs to the wire, structure and vegetation points. For this report, the user is prompted to enter the weather data for the test scenario on the batch thermal calculator. The batch thermal calculator will then calculate the average conductor temperature along that line. The sag of the conductor catenary curve is then modelled based on these new conductor temperature using the initial LIDAR data catenary curve as a base for the extrapolation.

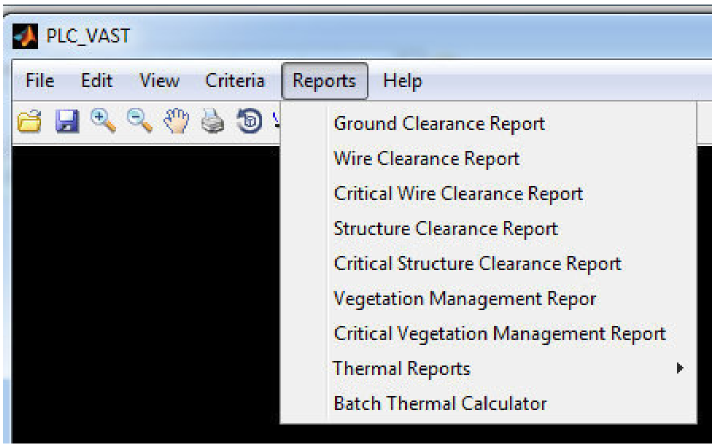


Figure 3-27: Reports menu items

```
Ground Clearance Report:

Feature code: 1001
Voltage: 345
Horizontal Clearance Dist: 0
Vertical Clearance Dist:26

Point Coordinates Dist. from Ground

    X             Y             Z             Vert.        Horiz.
2.293334e+06 7.035326e+05 4.432500e+02 2.590000e+01     0
2.293343e+06 7.035320e+05 4.438100e+02 2.577000e+01     0
2.293343e+06 7.035324e+05 4.436800e+02 2.564000e+01     0
2.293344e+06 7.035319e+05 4.439000e+02 2.586000e+01     0
2.293344e+06 7.035323e+05 4.436800e+02 2.564000e+01     0
2.293345e+06 7.035321e+05 4.439000e+02 2.586000e+01     0
2.293346e+06 7.035318e+05 4.439700e+02 2.593000e+01     0
2.293347e+06 7.035322e+05 4.438400e+02 2.580000e+01     0
2.293335e+06 7.035325e+05 4.434100e+02 2.537000e+01     0
2.293337e+06 7.035324e+05 4.434800e+02 2.544000e+01     0
2.293337e+06 7.035324e+05 4.434500e+02 2.541000e+01     0
```

Figure 3-28: Report file format

3.6 Help – Menu

This menu item provides various help options (as shown in Figure 3-29) that may be required by the user to know more about the program, techniques used. It will also direct the user to various links and tools on related information on the Internet. The various sub-menu items are discussed in the next sub-sections.

3.6.1 Help – About

This option displays a dialog-box showing the name and contact of the developer of this program. There is also a disclaimer notice under this section.

3.6.2 Help – User Manual

This option will open this program User Manual in ".pdf" format so that the user can familiarize themselves with the various aspects of the program and how to use the GUI. It will help the user to troubleshoot if and when the need arise.

3.6.3 Help – Research Papers

This option will give a list of the research papers that were used to create different functionalities of this program. The research papers are available from various sources on the internet or on request from the developer.

3.6.4 Help – MATLAB

This option will open the help webpage of the Mathworks website in the default browser of the user's computer. This link is meant to assist users with MATLAB coding techniques should they feel the need to further develop or customize this software tool for their own purposes.

3.6.5 Help – PLS-CADD

This option will open the link to the homepage of the "PowLine" in the default browser of the user's computer. This link is meant to assist users to understand the PLS-CADD software package upon which this PLC_VAST program is based.

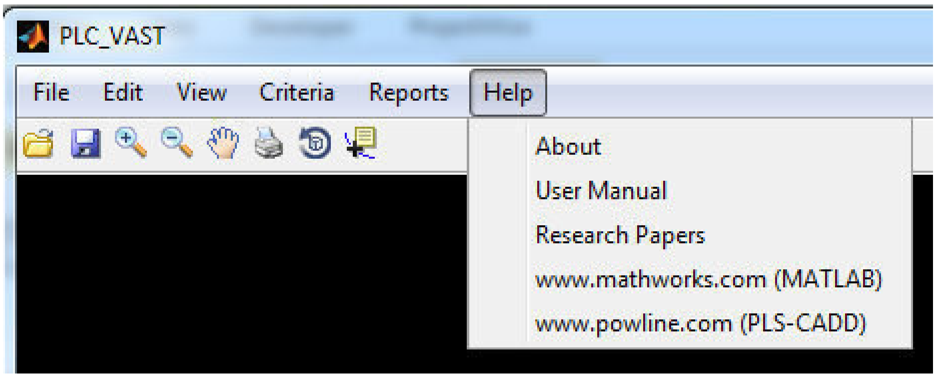


Figure 3-29: Help menu items

4 Icon Bar

Apart from the main menu bar, there are few icons available (as shown in Figure 4-1) for quick access to some of the features of the main menu bar and some new features. These icons are discussed in the following sections.

Figure 4-1: Icon bar

4.1 Open Icon 

This is the first icon from the left in the icon bar. Its function is similar to that of the Open option in the File Menu. This will let the user browse to the data file which is to be processed by the program. As mentioned before, only ".xlsx" and ".csv" files are allowed as inputs to the PLC-VAST program.

4.2 Save Icon 

This is the second icon from left in the icon bar and is used to save the data in the program memory as ".mat" format in a directory of the user's choice. Its function is similar to that of the Save option in the File Menu.

4.3 Zoom In/ Zoom Out Icons 

These related icons allow the user to zoom in and zoom out, respectively, in the display of data on the main program window. To roll back to the original display use: View → Initial View (Fit Model).

4.4 Hand Icon 

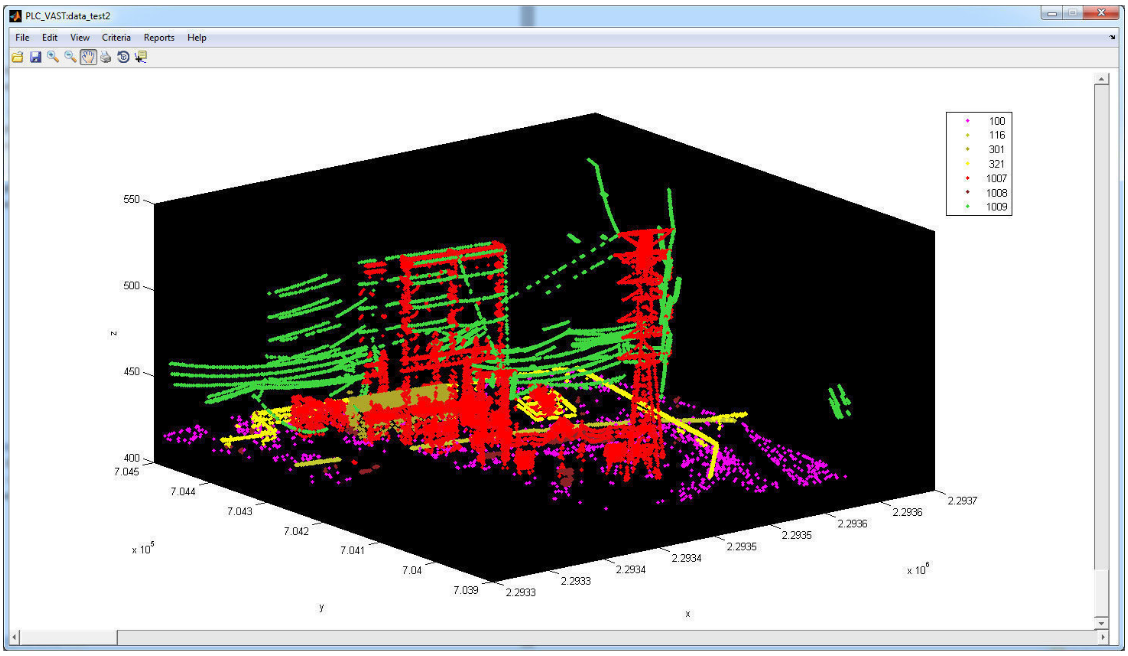
The hand icon is used for pan movements across the display window in the main program.

4.5 Print Icon 

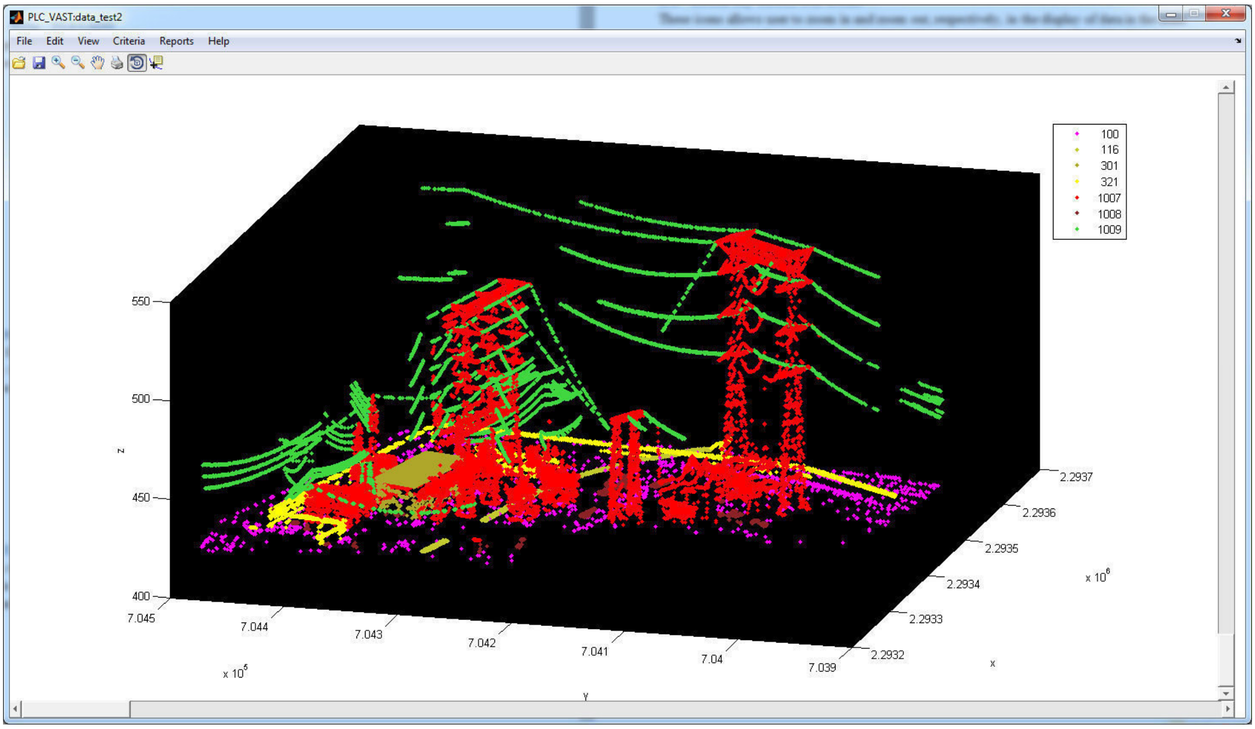
This icon is used to print the data displayed on the main window.

4.6 Rotate Icon 

This icon allows user to rotate the view of the data display in the main program window. Few examples are shown in Figure 4-2.



(a)



(b)

Figure 4-2: (a) Normal view, (b) Rotated view

4.7 Data-tip Icon

This is the last icon from left in the icon bar. It is used to see the coordinates of the individual data point(s) as shown in Figure 4-3.

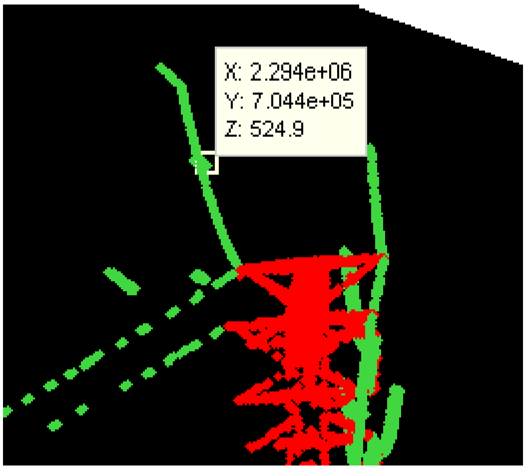


Figure 4-3: Data tip showing coordinates of selected data point

5 Shortcuts

Only the following 3 short cuts are available to users;

File Open – Ctrl+O

File Save – Ctrl+S

Delete Feature Code – Ctrl+D

These shortcuts can be easily re-configured to suit the needs of each user on the GUIDE Menu editor. Other shortcuts can be added similarly for each of the functions.

E. APPENDIX E: MATLAB SOURCE CODE

```matlab
function feature_color = assign_random_color_to_feature(feature_code)

feature_color = zeros(size(feature_code,1),3);

color_repeat = 0;

for i = 1:size(feature_code,1)
    temp_color = rand(1,3);

    if(i==1)
        feature_color(i,:)=temp_color;
    end

    for j = 1:i-1
        if(~isequal(temp_color, feature_color(j,:)))
            feature_color(i,:) = temp_color;
        else
            color_repeat = 1;
            break
        end
    end

    if(color_repeat == 1)
        i = i-1;
        color_repeat = 0;
    end
end
```

```
function varargout = PLC_VAST(varargin)
% PLC_VAST MATLAB code for PLC_VAST.fig
%      PLC_VAST, by itself, creates a new PLC_VAST or raises the existing
%      singleton*.
%
%      H = PLC_VAST returns the handle to a new PLC_VAST or the handle to
%      the existing singleton*.
%
%      PLC_VAST('CALLBACK',hObject,eventData,handles,...) calls the local
%      function named CALLBACK in PLC_VAST.M with the given input arguments.
%
%      PLC_VAST('Property','Value',...) creates a new PLC_VAST or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before PLC_VAST_OpeningFcn gets called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to PLC_VAST_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help PLC_VAST

% Last Modified by GUIDE v2.5 10-Jan-2014 07:27:38

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @PLC_VAST_OpeningFcn, ...
                   'gui_OutputFcn',  @PLC_VAST_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT
end

% --- Executes just before PLC_VAST is made visible.
function PLC_VAST_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to PLC_VAST (see VARARGIN)

% Choose default command line output for PLC_VAST
handles.output = hObject;
```

```
handles.dataMat = [];


% Update handles structure
guidata(hObject, handles);

% UIWAIT makes PLC_VAST wait for user response (see UIRESUME)
% uiwait(handles.PLC_VAST);

global feature_color datCell dMat dMat_main volt feature_code
current_feature_code ...
       sel_data_point feature_code_str plot_symbol feature_code_names
input_fname ...
       sel_feature_code mainFig Legend_handle axes_color back_color
criteria...
       criteria_fname prg_status default_figName
dMat = [];
dMat_main = [];
sel_data_point = [];
feature_code_str = {13 'PI'; 100 'Ground'; 104 'Water'; 110 'Road'; 116
'Railroad'; 126 'Swimming Pool';...
    131 'Vegetation'; 230 'Conductor/Shield wire attachment point'; 232
'Insulator attachment point at structure';...
    236 'Shield wire'; 237 'Guy Wire'; 241 'Crossing shield wire'; 245
'Crossing conductor 138kV';...
    246 'Crossing conductor 69kV'; 247 'Crossing conductor 34kV'; 248
'Crossing conductor 12/4kV'; ...
    253 'Transmission structure steel'; 254 'Transmission structure wood';
255 'Other supporting structures';...
    256 'Center of Structure'; 301 'Building'; 306 'Silo/ grain bin'; 321
'Fence'; 335 'Bridge';...
    400 'Street Light'; 410 'Sign'; 425 'Pipeline'; 468 'Comm conductors,
cables and messengers';...
    500 'Interpolated Points'; 545 'Underbuild conductor 138kV - Ameren
Owned'; 547 'Underbuild conductor 34kV - Ameren Owned';...
    548 'Underbuild conductor 12kV/4kV - Ameren Owned'; 549 'Underbuild
conductor 138kV - Non-Ameren Owned';...
    550 'Underbuild conductor 69kV - Non-Ameren Owned'; 551 'Underbuild
conductor 34kV - Non-Ameren Owned';...
    552 'Underbuild conductor 12kV/4kV - Non-Ameren Owned'; 1001 'Conductor
Left/Bottom'; 1002 'Conductor Center/Middle';...
    1003 'Conductor Right/Top'; 1007 'Substation'; 1008 'Temporary Objects';
1009 'Parallel Lines';1241 'Crossing shield wire/By Engineer';...
    1242 'Crossing conductor 345kV/By Engineer'; 1243 'Crossing conductor
230kV/By Engineer'; 1244 'Crossing conductor 161kV/By Engineer';...
    1245 'Crossing conductor 138kV/By Engineer'; 1246 'Crossing conductor
69kV/By Engineer'; 1247 'Crossing conductor 34kV/By Engineer';...
    1248 'Crossing conductor 12/4kV/By Engineer'; 1545 'Underbuild conductor
138kV - Ameren Owned/By Engineer';...
    1546 'Underbuild conductor 69kV - Ameren Owned/By Engineer'; 1547
'Underbuild conductor 34kV - Ameren Owned/By Engineer';...
    1548 'Underbuild conductor 12/4kV - Ameren Owned/By Engineer'; 1549
'Underbuild conductor 138kV - Non-Ameren Owned/By Engineer';...
    1550 'Underbuild conductor 69kV - Non-Ameren Owned/By Engineer'; 1551
'Underbuild conductor 34kV - Non-Ameren Owned/By Engineer';...
    1552 'Underbuild conductor 12/4kV - Non-Ameren Owned/By Engineer';
```

```
};

prg_status = 0;
plot_symbol = '.';
axes_color = [0 0 0];
back_color = [1 1 1];
sel_feature_code = [];
volt = 0;
criteria = [];
input_fname = [];
criteria_fname = [];
default_figName = get(gcf,'Name');

end


% --- Outputs from this function are returned to the command line.
function varargout = PLC_VAST_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;
end

%%
function feature_color = assign_random_color_to_feature(feature_code)

feature_color = zeros(size(feature_code,1),3);

color_repeat = 0;

for i = 1:size(feature_code,1)
    temp_color = rand(1,3);

    if(i==1)
        feature_color(i,:)=temp_color;
    end

    for j = 1:i-1
        if(~isequal(temp_color, feature_color(j,:)))
            feature_color(i,:) = temp_color;
        else
            color_repeat = 1;
            break
        end
    end

    if(color_repeat == 1)
        i = i-1;
        color_repeat = 0;
    end
```

```
end
end

%%
function viewLegend()

global feature_code_names feature_code feature_color

% scrsz = get(0,'ScreenSize');
L = length(feature_code);
% Legend_Handle = figure('Name','Feature Code Legend','Position',[scrsz(4)/2
scrsz(4)/15 scrsz(3)/3 40*L-100],'MenuBar','none');
% FigP = get(Legend_Handle,'Position');
Legend_Handle = figure('Name','Feature Code
Legend','Units','normalized','Position',[0.3 0.05 0.25
0.9],'MenuBar','none');
H = [];
T = [];

% for i = 1:L
%     H(i) =
uicontrol(Legend_Handle,'Style','pushbutton','String',feature_code_names{i,1}
,'Tag',['pushbutton_legend_'
num2str(i)],'BackgroundColor',feature_color(i,:),...
%               'Position',[40,-10+(FigP(4)-
35*i),50,25],'Callback',@legendButton_Callback);
%     pos = [150,-10+(FigP(4)-35*i),450,25];
%     T(i) =
uicontrol(Legend_Handle,'Style','text','String',feature_code_names{i,2},'Tag'
,['text_legend_' num2str(i)],'BackgroundColor',[ 1 1 1],'Position',pos,...
%          'FontWeight','Bold','FontSize',12,'FontName','FixedWidth');
% end

for i = 1:L
    % pos = [40,-20+(FigP(4)-35*i),50,25];
    H(i) =
uicontrol('Parent',Legend_Handle,'Style','pushbutton','String',feature_code_n
ames{i,1},'Tag',['pushbutton_legend_' num2str(i)],'BackgroundColor',...

feature_color(i,:),'Units','normalized','Position',[0.05,1-
0.035*i,0.1,0.035],'Callback',@legendButton_Callback);  %40L-120-35*i = 0 =>
i = (8L-24)/7
    % pos = [150,-20+(FigP(4)-35*i),450,25];
    pos = [0.15,1-0.035*i,0.6,0.035];
    T(i) =
uicontrol('Parent',Legend_Handle,'Style','text','String',feature_code_names{i
,2},'Tag',['text_legend_' num2str(i)],'BackgroundColor',[1 1
1],'Units','normalized',...

'Position',pos,'FontSize',12,'FontWeight','Bold','FontName','FixedWidth');
end

if ishandle(Legend_Handle)
    uiwait(Legend_Handle);
end
```

```
end

function legendButton_Callback(hObject, eventdata, handles)

global sel_feature_code

sel_feature_code = [sel_feature_code; str2double(get(hObject, 'String'))];

end


function plotSelected()

global sel_feature_code feature_code feature_color datCell plot_symbol

temp_fig = figure('Name', 'Selected Features');

for i=1:size(sel_feature_code,1)
    color_ind = find(sel_feature_code(i,1) == feature_code)

plot3(datCell{color_ind}(:,2),datCell{color_ind}(:,3),datCell{color_ind}(:,4)
,plot_symbol,'Color', feature_color(color_ind,:),'MarkerSize',3);
    hold on
    axis off
end

xlabel('x')
ylabel('y')
zlabel('z')
axis on
set(gca,'Color',[0 0 0]);
hold off
axis equal
waitfor(temp_fig);

delete(temp_fig);


end


%%
% --------------------------------------------------------------------
function File_Menu_Callback(hObject, eventdata, handles)
% hObject    handle to File_Menu (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

end

% --------------------------------------------------------------------
function File_Open_Callback(hObject, eventdata, handles)
```

```
% hObject    handle to File_Open (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global feature_color datCell dMat_main feature_code current_feature_code ...
       feature_code_str feature_code_names plot_symbol input_fname ...
       sel_feature_code mainFig Legend_handle feature_code_mat back_color...
       axes_color prg_status default_figName infnm

% sel_feature_code = [];
%
% delete(gca);
% delete(gco);

[infil, inpathnam] = uigetfile({'*.xlsx';'*.csv'}, 'Input data file');
if infil == 0
    errordlg('No input data file found');
    return
end
[first,second] = strtok(infil,'.');

disp(['input file name: ' first]);

set(gcf,'Name',[default_figName ':' first]);

input_fname = [inpathnam,infil];

infnm = first;

if(strcmp(second,'.xlsx')==1)
   dMat_main = xlsread([inpathnam,infil]);
end

if(strcmp(second,'.csv')==1)
   dMat_main = csvread([inpathnam,infil]);
end

if(size(dMat_main,2)~=4)
    errordlg('Input file format is not supported by the program. Please check
input file');
    return
end


feature_code = unique(dMat_main(:,1))

% put data corresponding to feature codes in respective cells
datCell = cell(size(feature_code,1),1);

h = waitbar(0,'Please wait .... Reading data');

for i=1:size(dMat_main,1)
    ind = find(dMat_main(i,1)==feature_code);
    datCell{ind,1} = [datCell{ind,1}; dMat_main(i,:)];
```

```
    waitbar(i/size(dMat_main,1),h,['Please wait .... Reading data '
num2str(i*100/size(dMat_main,1)) '% complete']);
end

delete(h);

save([inpathnam first '.mat'], 'dMat_main', 'datCell')

current_feature_code = feature_code(1)

for i=1:size(feature_code_str,1)
    feature_code_mat(i) = feature_code_str{i};
end

for i=1:size(feature_code,1)
    ind = find(feature_code_mat==feature_code(i));
    i
    ind
    feature_code_names{i,1} = feature_code_mat(ind);
    feature_code_names{i,2} = feature_code_str{ind,2};
end

disp('feature codes included in input data:')
disp(feature_code_names)

% assign colors to each feature code
feature_color = assign_random_color_to_feature(feature_code)

mainFig = gcf;

% view legend to select feature codes
viewLegend();

waitfor(Legend_handle);

disp('selected feature codes:')

disp(sel_feature_code)

for i=1:size(sel_feature_code,1)
    color_ind = find(sel_feature_code(i,1) == feature_code);
    if(~isempty(color_ind))

plot3(datCell{color_ind}(:,2),datCell{color_ind}(:,3),datCell{color_ind}(:,4)
,plot_symbol,'Color', feature_color(color_ind,:),'MarkerSize',3);
        hold on
        axis off
    end
end

xlabel('x')
ylabel('y')
zlabel('z')
axis on
```

```
set(gca,'Color',axes_color);
axis equal
hold off

set(gcf,'Color',back_color);

prg_status = 1;
end


% ------------------------------------------------------------------
function File_Save_Callback(hObject, eventdata, handles)
% hObject    handle to File_Save (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global dMat_main datCell prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

[save_fpath, save_fname] = uiputfile('*.mat');

if(save_fname~=0)
    save([save_fpath,save_fname], 'dMat_main', 'datCell')
else
    errordlg('File not saved');
    return
end
end


%%
% read data from .mat file
% ------------------------------------------------------------------
function File_Load_Callback(hObject, eventdata, handles)
% hObject    handle to File_Load (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global feature_color datCell dMat_main feature_code current_feature_code ...
       feature_code_str feature_code_names plot_symbol input_fname ...
       sel_feature_code mainFig Legend_handle back_color axes_color...
       feature_code_mat prg_status infnm

sel_feature_code = [];
set(gcf,'Name','PLC_VAST');
delete(gca);
delete(gco);

[infil, inpathnam] = uigetfile({'*.mat'}, 'Input mat-data file');
if infil == 0
```

```
    errordlg('No mat data file found');
    return
end
[first,second] = strtok(infil,'.');

disp(['input file name: ' first]);

figName = get(gcf,'Name');

set(gcf,'Name',[figName ':' first]);

input_fname = [inpathnam,infil];
infnm = first;
S = load(input_fname);

dMat_main = S.dMat_main;
datCell = S.datCell;

feature_code = unique(dMat_main(:,1))

current_feature_code = feature_code(1);

for i=1:size(feature_code_str,1)
    feature_code_mat(i) = feature_code_str{i};
end

feature_code_mat

for i=1:size(feature_code,1)
    ind = find(feature_code_mat==feature_code(i));
    feature_code_names{i,1} = feature_code_mat(ind);
    feature_code_names{i,2} = feature_code_str{ind,2};
end


disp('feature codes included in input data:')
disp(feature_code_names)

% assign colors to each feature code
feature_color = assign_random_color_to_feature(feature_code)

mainFig = gcf;

% view legend to select feature codes
viewLegend();

waitfor(Legend_handle);

disp('selected feature codes:')

disp(sel_feature_code)

for i=1:size(sel_feature_code,1)
```

```
    color_ind = find(sel_feature_code(i,1) == feature_code);
    if(~isempty(color_ind))

plot3(datCell{color_ind}(:,2),datCell{color_ind}(:,3),datCell{color_ind}(:,4)
,plot_symbol,'Color', feature_color(color_ind,:),'MarkerSize',3);
        hold on
        axis off
    end
end

xlabel('x')
ylabel('y')
zlabel('z')
axis on
set(gca,'Color',axes_color);
axis equal
hold off

set(gcf,'Color',back_color);

prg_status = 1;

end


% --------------------------------------------------------------------
function File_Import_Add_Callback(hObject, eventdata, handles)
% hObject    handle to File_Import_Add (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end



% --- Executes on mouse press over figure background.
function PLC_VAST_ButtonDownFcn(hObject, eventdata, handles)
% hObject    handle to PLC_VAST (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end

%%
% % --------------------------------------------------------------------
function File_Edit_Callback(hObject, eventdata, handles)
% hObject    handle to File_Edit (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end


% --------------------------------------------------------------------
function Edit_Delete_Points_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Delete_Points (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
```

```
% handles    structure with handles and user data (see GUIDATA)

end


% --------------------------------------------------------------------
function Edit_Delete_By_Feature_Code_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Delete_By_Feature_Code (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global Legend_handle del_feature_code datCell feature_code feature_color
feature_code_names ...
       feature_code_mat feature_code_str sel_feature_code prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

del_feature_code = [];

% view legend to select feature codes to be deleted from the input data
selFeatureCodeToDel

waitfor(Legend_handle);

disp('selected feature codes to delete:')

disp(del_feature_code)

disp('Feature codes')
disp(feature_code)

temp_feature_code = zeros(size(feature_code,1)-size(del_feature_code,1),1);
temp_feature_color = zeros(size(feature_code,1)-size(del_feature_code,1),3);
temp_datCell = cell(size(feature_code,1)-size(del_feature_code,1),1);
ind_count = 1;

for i=1:length(feature_code)
    ind = find(del_feature_code==feature_code(i),1);
    if(isempty(ind))
        temp_feature_code(ind_count) =  feature_code(i);
        temp_feature_color(ind_count,:) =  feature_color(i,:);
        temp_datCell{ind_count} = datCell{i};
        ind_count = ind_count + 1;
    end
end

feature_code = temp_feature_code;
feature_color = temp_feature_color;
datCell = temp_datCell;

disp('After deleting selected feature codes');
```

```
disp('feature codes')
disp(feature_code)
disp(' ');
disp('feature code color')
disp(feature_color)

for i=1:size(feature_code_str,1)
    feature_code_mat(i) = feature_code_str{i};
end

disp(feature_code_mat)

temp_sel_feature_code = [];
for i = 1:length(sel_feature_code)
    if(isempty(find(sel_feature_code(i)==del_feature_code,1)))
        temp_sel_feature_code = [temp_sel_feature_code; sel_feature_code(i)];
    end
end
sel_feature_code = temp_sel_feature_code;

feature_code_names = cell(size(feature_code,1),2);

for i=1:size(feature_code,1)
    ind = find(feature_code_mat==feature_code(i));
    feature_code_names{i,1} = feature_code_mat(ind);
    feature_code_names{i,2} = feature_code_str{ind,2};
end

end

function selFeatureCodeToDel()
global feature_code_names feature_code feature_color

L = length(feature_code);
Legend_Handle = figure('Name','Feature Code
Legend','Units','normalized','Position',[0.3 0.05 0.25
0.9],'MenuBar','none');
H = [];
T = [];

for i = 1:L
    H(i) =
uicontrol(Legend_Handle,'Style','pushbutton','String',feature_code_names{i,1}
,'Tag',['pushbutton_legend_'
num2str(i)],'BackgroundColor',feature_color(i,:),...
            'Units','normalized','Position',[0.05,1-
0.035*i,0.1,0.035],'Callback',@delByFeatureCode);
    pos = [0.15,1-0.035*i,0.6,0.035];
    T(i) =
uicontrol(Legend_Handle,'Style','text','String',feature_code_names{i,2},'Tag'
,['text_legend_' num2str(i)],'BackgroundColor',[ 1 1
1],'Units','normalized',...

'Position',pos,'FontWeight','Bold','FontSize',12,'FontName','FixedWidth');
end
```

```
if ishandle(Legend_Handle)
    uiwait(Legend_Handle);
end
end

function delByFeatureCode(hObject,eventdata, handles)

global del_feature_code

del_feature_code = [del_feature_code; str2double(get(hObject, 'String'))];

end


% --------------------------------------------------------------------
function Edit_Delete_By_Selection_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Delete_By_Selection (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global sel_data_point dMat dMat_main datCell feature_code prg_status


if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

if(isempty(sel_data_point))
    errordlg('No points selected. Please select points to delete.');
else
    j = 1;
    dMat = [];
    for i=1:size(dMat_main,1)
        if(isequal(dMat_main(i,2:4),sel_data_point(j,:)))
            j=j+1;
            if(j>size(sel_data_point,1))
                break;
            end
        else
            dMat = [dMat; dMat_main(i,:)];
        end
    end

    % put data corresponding to feature codes in respective cells
    datCell = cell(size(feature_code,1),1);

    for i=1:size(dMat,1)
        ind = find(dMat(i,1)==feature_code);
        datCell{ind,1} = [datCell{ind,1}; dMat(i,:)];
    end

end
```

```
end


% --------------------------------------------------------------------
function Edit_Select_Points_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Select_Points (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end


% --------------------------------------------------------------------
function Edit_Select_Value_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Select_Value (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global sel_data_point datCell feature_code prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

feature_code_ind = [];

prompt = {'Feature Code','X:','Y:','Z:'};
dlg_title = 'Input point coordinates';
num_lines = 1;
def =
{num2str(feature_code(1)),num2str(datCell{1,1}(1,2)),num2str(datCell{1,1}(1,3
)),num2str(datCell{1,1}(1,4))};
selection = inputdlg(prompt,dlg_title,num_lines,def);
if(isempty(selection))
    errordlg('No points selected');
    waitforbuttonpress
    return
end

feature_code_ind = find(str2num(selection{1})==feature_code);

if(isempty(feature_code_ind))
    errordlg('Wrong feature code entered');
    waitforbuttonpress
    return
end

sel_data_point = [str2double(selection{2}) str2double(selection{3})
str2double(selection{4})];

% select nearest point
[dist,ind] =
pdist2(datCell{feature_code_ind}(:,2:4),sel_data_point,'euclidean','Smallest'
,1);
```

```
sel_data_point = datCell{feature_code_ind}(ind,:);

format long
disp('selected points by value:')
disp(sel_data_point)
end


% --------------------------------------------------------------------
function Edit_Select_Range_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Select_Range (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global sel_data_point dMat_main prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

sel_data_point = [];

prompt = {'XMin:','XMax:','YMin:','YMax:','ZMin:','ZMax:'};
dlg_title = 'Input point coordinates range';
num_lines = 1;
def =
{num2str(min(dMat_main(:,2))),num2str(max(dMat_main(:,2))),num2str(min(dMat_m
ain(:,3))),num2str(max(dMat_main(:,3))),num2str(min(dMat_main(:,4))),...
       num2str(max(dMat_main(:,4)))};

selection = inputdlg(prompt,dlg_title,num_lines,def);

if(isempty(selection))
    errordlg('No range selected');
    waitforbuttonpress
    return
end

xmin = str2double(selection{1}); xmax = str2double(selection{2});
ymin = str2double(selection{3}); ymax = str2double(selection{4});
zmin = str2double(selection{5}); zmax = str2double(selection{6});

size(dMat_main)

for i=1:size(dMat_main,1)
    x = dMat_main(i,2);
    y = dMat_main(i,3);
    z = dMat_main(i,4);
    if(x >= xmin && x <= xmax)
        if(y >= ymin && y <= ymax)
            if(z >= zmin && z <= zmax)
                sel_data_point = [sel_data_point; x y z];
```

```
            end
        end
    end
end
format long
disp('selected points by range:')
disp(sel_data_point)
end


% --------------------------------------------------------------------
function Edit_Select_Mouse_Click_Callback(hObject, eventdata, handles)
% hObject    handle to Edit_Select_Mouse_Click (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global sel_data_point prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

datacursormode on

dcm_obj = datacursormode(gcf);

set(dcm_obj,'DisplayStyle','datatip',...
    'SnapToDataVertex','on','Enable','on')

c_info = getCursorInfo(dcm_obj);

disp('Points selected by mouse click: ')
c_info.Position

for i=1:length(c_info)
    sel_data_point(i,:) = c_info.Position;
end

end


%%
% --------------------------------------------------------------------
function View_Menu_Callback(hObject, eventdata, handles)
% hObject    handle to View_Menu (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

end

% --------------------------------------------------------------------
function View_Display_Options_Callback(hObject, eventdata, handles)
% hObject    handle to View_Display_Options (see GCBO)
```

```
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end

% --------------------------------------------------------------------
function View_Display_Legend_Callback(hObject, eventdata, handles)
% hObject    handle to View_Display_Legend (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global feature_code feature_color Legend_Handle prg_status feature_code_names

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

% scrsz = get(0,'ScreenSize');
L = length(feature_code);

Legend_Handle = figure('Name','Feature Code
Legend','Units','normalized','Position',[0.3 0.05 0.25
0.9],'MenuBar','none');

H = [];
T = [];


for i = 1:L
    H(i) =
uicontrol('Parent',Legend_Handle,'Style','pushbutton','String',feature_code_n
ames{i,1},'Tag',['pushbutton_legend_' num2str(i)],'BackgroundColor',...

feature_color(i,:),'Units','normalized','Position',[0.05,1-
0.035*i,0.1,0.035],'Enable','inactive');

    pos = [0.15,1-0.035*i,0.6,0.035];
    T(i) =
uicontrol('Parent',Legend_Handle,'Style','text','String',feature_code_names{i
,2},'Tag',['text_legend_' num2str(i)],'BackgroundColor',[1 1
1],'Units','normalized',...

'Position',pos,'FontSize',12,'FontWeight','Bold','FontName','FixedWidth');
end

if ishandle(Legend_Handle)
    uiwait(Legend_Handle);
end

end



% --------------------------------------------------------------------
```

```
function View_Display_Symbol_Callback(hObject, eventdata, handles)
% hObject    handle to View_Display_Symbol (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global plot_symbol prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

S = {'.';'*';'<';'>';'^';'+';'V';'x';'o';'s';'d';'p';'h'};

[s,v] = listdlg('Name', 'Plot Symbol','PromptString','Select a symbol:',...
                'SelectionMode','single', 'ListString',S);

if(v==0)
    return
end

plot_symbol = S{s};

disp('chosen plot symbol:')
disp(plot_symbol)

end

% --------------------------------------------------------------------
function View_Display_Add_Feature_Codes_Callback(hObject, eventdata, handles)
% hObject    handle to View_Display_Add_Feature_Codes (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global sel_feature_code feature_code feature_color datCell plot_symbol
prg_status


if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

init_sz = length(sel_feature_code);

viewLegend();

sel_sz = length(sel_feature_code);

if(init_sz == sel_sz)
    return
end
```

```
for i=1:size(sel_feature_code,1)
    color_ind = find(sel_feature_code(i,1) == feature_code);

plot3(datCell{color_ind}(:,2),datCell{color_ind}(:,3),datCell{color_ind}(:,4)
,plot_symbol,'Color', feature_color(color_ind,:),'MarkerSize',3);
    hold on
    axis off
end

legend(gca,num2str(sel_feature_code),'location','NorthEastOutside');
xlabel('x')
ylabel('y')
zlabel('z')
axis on
set(gca,'Color',[0 0 0]);

hold off

end


% --------------------------------------------------------------------
function View_Display_Measure_Distance_Callback(hObject, eventdata, handles)
% hObject    handle to View_Display_Measure_Distance (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

datacursormode on

dcm_obj = datacursormode(gcf);

set(dcm_obj,'DisplayStyle','datatip',...
    'SnapToDataVertex','on','Enable','on')


c_info = getCursorInfo(dcm_obj);

disp('Points selected: ')
c_info.Position

if(length(c_info)<=1)
    errordlg('Not enough points selected')
    return
end

j = 0;
```

```
disp('computing distance between points')
i = 1;

if(mod(length(c_info),2)==0)
    dist = zeros(length(c_info)/2);
else
    dist = zeros((length(c_info)-1)/2);
end

while(i <= length(c_info))
    x1 = c_info(i).Position(1);
    y1 = c_info(i).Position(2);
    z1 = c_info(i).Position(3);

    x2 = c_info(i+1).Position(1);
    y2 = c_info(i+1).Position(2);
    z2 = c_info(i+1).Position(3);

    disp(['Distance between Point-' num2str(i) ' and Point-' num2str(i+1) '
is: '])
    line([x1;x2],[y1;y2],[z1;z2],'LineWidth',2,'Color',[1 1 1]);

    j = j+1;
    dist(j) = sqrt((x1-x2)^2 + (y1-y2)^2 + (z1-z2)^2);

    i = i+2;
    disp(dist(j));
    text((x1+x2)/2, (y1+y2)/2, (z1+z2+20)/2,num2str(dist(j)),'Color',[1 1
1]);
    if(i>=length(c_info))
        break
    end
end

set(dcm_obj,'Enable','off')

end


% --------------------------------------------------------------------
function View_Grid_On_Off_Callback(hObject, eventdata, handles)
% hObject    handle to View_Grid_On_Off (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end


grid
```

```matlab
end


% --------------------------------------------------------------------
function View_Back_Color_Callback(hObject, eventdata, handles)
% hObject    handle to View_Back_Color (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global back_color prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

back_color = uisetcolor;

set(gcf,'Color',back_color);
end


% --------------------------------------------------------------------
function View_Fit_Callback(hObject, eventdata, handles)
% hObject    handle to View_Fit (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global feature_color datCell feature_code plot_symbol sel_feature_code
back_color axes_color prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

disp('feature code colors for view fit')
disp(feature_color);

for i=1:size(sel_feature_code,1)
    color_ind = find(sel_feature_code(i,1) == feature_code);
    if(~isempty(color_ind))

plot3(datCell{color_ind}(:,2),datCell{color_ind}(:,3),datCell{color_ind}(:,4)
,plot_symbol,'Color', feature_color(color_ind,:),'MarkerSize',3);
        hold on
        axis off
    end
end

xlabel('x')
ylabel('y')
zlabel('z')
axis equal
```

```
set(gca,'Color',axes_color);

hold off

set(gcf,'Color',back_color);
end


% --------------------------------------------------------------------
function View_Set_Feature_Color_Callback(hObject, eventdata, handles)
% hObject    handle to View_Set_Feature_Color (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global datCell feature_color feature_code plot_symbol sel_feature_code
axes_color back_color feature_code_names prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

temp_color = feature_color;

L = length(sel_feature_code);
Legend_Handle = figure('Name','Feature Code
Legend','Units','normalized','Position',[0.3 0.05 0.25
0.9],'MenuBar','none');

H = [];
T = [];

for i = 1:L
    ind = find(feature_code == sel_feature_code(i));
    H(i) =
uicontrol(Legend_Handle,'Style','pushbutton','String',feature_code_names{ind,
1},'Tag',['pushbutton_legend_'
num2str(i)],'BackgroundColor',feature_color(ind,:),...
            'Units','normalized','Position',[0.05,1-
0.035*i,0.1,0.035],'Callback',@assign_feature_color);
    pos = [0.15,1-0.035*i,0.6,0.035];
    T(i) =
uicontrol(Legend_Handle,'Style','text','String',feature_code_names{ind,2},'Ta
g',['text_legend_' num2str(i)],'BackgroundColor',[ 1 1
1],'Units','normalized',...
                    'Position',pos,
'FontWeight','Bold','FontSize',12,'FontName','FixedWidth');
end

if ishandle(Legend_Handle)
    uiwait(Legend_Handle);
end

count = 0;
```

```
for i=1:length(feature_color)
    if(~isequal(temp_color(i,:),feature_color(i,:)))
        count = count+1;
    end
end

if(count==0)
    return
end


% plot changed feature color

for i=1:size(sel_feature_code,1)
    color_ind = find(sel_feature_code(i,1) == feature_code);
    if(~isempty(color_ind))

plot3(datCell{color_ind}(:,2),datCell{color_ind}(:,3),datCell{color_ind}(:,4)
,plot_symbol,'Color', feature_color(color_ind,:),'MarkerSize',3);
        hold on
        axis off
    end
end

xlabel('x')
ylabel('y')
zlabel('z')
axis on
set(gca,'Color',axes_color);
axis equal
hold off

set(gcf,'Color',back_color);



end

function assign_feature_color(hObject,eventdata, handles)

global feature_color feature_code

feature_code_to_set_color = str2double(get(hObject, 'String'));

feature_ind = find(feature_code == feature_code_to_set_color);

initial_color = feature_color(feature_ind,:);

temp_color = initial_color;

while(isequal(initial_color,temp_color))
    temp_color = uisetcolor;
```

```matlab
end

feature_color(feature_ind,:) = temp_color;

end


% --------------------------------------------------------------------
function View_Plot_Area_Color_Callback(hObject, eventdata, handles)
% hObject    handle to View_Plot_Area_Color (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global axes_color prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

axes_color = uisetcolor;

set(gca,'Color',axes_color);
end


% --------------------------------------------------------------------
function View_Google_Earth_Callback(hObject, eventdata, handles)
% hObject    handle to View_Google_Earth (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global sel_data_point prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

if(~isempty(sel_data_point))
    lat_lon = convertToLatLon(sel_data_point)
    for i=1:size(sel_data_point)
        fname = ['test' num2str(i) '.kml'];
        kmlwrite(fname,lat_lon(i,1), lat_lon(i,2));
        winopen(fname);
    end
else
    errordlg('No points selected. Select point(s) to show on google earth.');
end
end

%%
% --------------------------------------------------------------------
function Criteria_Menu_Callback(hObject, eventdata, handles)
```

```matlab
% hObject    handle to Criteria_Menu (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end

% --------------------------------------------------------------------
function Criteria_Voltage_Callback(hObject, eventdata, handles)
% hObject    handle to Criteria_Voltage (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end

% --------------------------------------------------------------------
function Criteria_Voltage_0kV_Callback(hObject, eventdata, handles)
% hObject    handle to Criteria_Voltage_0kV (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global volt prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

volt = 0;
end

% --------------------------------------------------------------------
function Criteria_Voltage_138kV_Callback(hObject, eventdata, handles)
% hObject    handle to Criteria_Voltage_138kV (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global volt prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

volt = 138;
end


% --------------------------------------------------------------------
function Criteria_Voltage_161kV_Callback(hObject, eventdata, handles)
% hObject    handle to Criteria_Voltage_161kV (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global volt prg_status

if(prg_status==0)
```

```matlab
    errordlg('No input data found. Please input data.')
    return
end

volt = 161;
end


% --------------------------------------------------------------------
function Criteria_Voltage_230kV_Callback(hObject, eventdata, handles)
% hObject    handle to Criteria_Voltage_230kV (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global volt prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

volt = 230;
end


% --------------------------------------------------------------------
function Criteria_Voltage_345kV_Callback(hObject, eventdata, handles)
% hObject    handle to Criteria_Voltage_345kV (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global volt prg_status

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end

volt = 345;
end




%%
% --------------------------------------------------------------------
function Reports_Callback(hObject, eventdata, handles)
% hObject    handle to Reports (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

end
```

```
function generateReport(report_type)

global datCell feature_code volt target_fc critical_vdist_mat
critical_hdist_mat...
       criteria_fname input_fname infnm crfnm feature_code_names


target_index = [];
for i = 1:length(target_fc)
    temp_index = find(feature_code==target_fc(i));
    if(temp_index~=0)
        target_index = [target_index; temp_index];
    end
end


if(isempty(target_index))
    errordlg('No target point found for checking')
    return
end

cond_fc = [1001 1002 1003];
cond_index = [];
for i = 1:3
    temp_ind = find(feature_code==cond_fc(i));
    if(temp_ind~=0)
        cond_index = [cond_index; temp_ind];
    end
end

if(isempty(cond_index))
    errordlg('No conductor point found for checking')
    return
end

if(volt==0)
    ind = 1;
elseif(volt == 138)
    ind = 2;
elseif(volt == 161)
    ind = 3;
elseif(volt == 230)
    ind = 4;
elseif(volt == 345)
    ind = 5;
end

crfid = fopen([strtok(crfnm,'.') '_' infnm '_report.txt'],'w');
fprintf(crfid,'%s\n\n',report_type);
fprintf(crfid,'%s',['Input file: ' input_fname]);
fprintf(crfid,'\n');
fprintf(crfid,'%s',['Clearance file:' criteria_fname]);
fprintf(crfid,'\n\n');
```

```
count = 0;

l = 0;
t1 = cputime;
h = waitbar(l,'Finding violations ... Please wait','Name',report_type);
violMat = [];

for k=1:length(cond_index)
    for p=1:length(target_index)
        waitbar(l,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
        disp(['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))])
        critical_vdist = critical_vdist_mat(p,ind);
        critical_hdist = critical_hdist_mat(p,ind);

        fprintf(crfid,'%s%d','Conductor Feature code:
',feature_code(cond_index(k)));
        fprintf(crfid,'\n');
        fprintf(crfid,'%s',['Voltage: ' num2str(volt) 'kV']);
        fprintf(crfid,'\n');
        fprintf(crfid,'%s%d','Target Feature code:
',feature_code(target_index(p)));
        fprintf(crfid,'\n');
        fprintf(crfid,'%s',['Target Feature name: '
feature_code_names{target_index(p),2}]);
        fprintf(crfid,'\n');
        fprintf(crfid,'%s%d','Horizontal Clearance Dist: ',critical_hdist);
        fprintf(crfid,'\n');
        fprintf(crfid,'%s%d','Vertical Clearance Dist: ',critical_vdist);
        fprintf(crfid,'\n\n');

        t = cputime;
        if(critical_vdist > 0 || critical_hdist > 0)
            violMat = [];
            for i = 1:size(datCell{cond_index(k)},1)
                cond_pt = datCell{cond_index(k)}(i,2:4);
                targetMat = datCell{target_index(p)};

                [S,in] = sort(targetMat(:,4),'descend');

                sorted_targetMat = targetMat(in,:);

                temp_ind1 = find(abs(sorted_targetMat(:,2)-
cond_pt(1))<=critical_hdist);
                sorted_targetMat = sorted_targetMat(temp_ind1,:);

                temp_ind2 = find(abs(sorted_targetMat(:,3)-
cond_pt(2))<=critical_hdist);
                sorted_targetMat = sorted_targetMat(temp_ind2,:);
```

```
                tmp_ind = find((sorted_targetMat(:,4)>cond_pt(3)-
critical_vdist));

                if(isempty(tmp_ind))
                    l1 =
(i/(length(cond_index)*length(target_index)*length(datCell{cond_index(k)})))+
l;
                    waitbar(l1,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
                    continue
                end

                tmp_targetMat = sorted_targetMat(tmp_ind,:);

                for j = 1:size(tmp_targetMat,1)
                    target_pt = tmp_targetMat(j,2:4);
                    hdist = sqrt((cond_pt(1)-target_pt(1))^2+(cond_pt(2)-
target_pt(2))^2);

                    if((hdist < critical_hdist))
                        count = count+1;
                        violMat = [violMat; cond_pt(1) cond_pt(2) cond_pt(3)
(cond_pt(3) - target_pt(3)) hdist];
                        break
                    end
                end
                l1 =
(i/(length(cond_index)*length(target_index)*length(datCell{cond_index(k)})))+
l;
                waitbar(l1,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
            end
            disp('time taken:')
            disp(cputime - t);
        end
        disp('total number of violations found:')
        disp(size(violMat))
        fprintf(crfid,'%s%d%s%d\n\n','The following lists the coordinates of
point violating for conductor feature code-', feature_code(cond_index(k)),...
            ' and target feature code-',feature_code(target_index(p)));
        fprintf(crfid,'%s%d','Total number of violations found: ',
length(violMat));
        fprintf(crfid,'\n\n');
        fprintf(crfid,'\t\t%s\t\t\t\t\t\t\t\t%s','Conductor Point
Coordinates','Distances (ft.)');
        fprintf(crfid,'\n\n');
        fprintf(crfid,'%s\t\t\t%s','     X                 Y
Z ','Vertical               Horizontal');
        fprintf(crfid,'\n\n');

        for r=1:size(violMat,1)
            fprintf(crfid,'%8.3f%s%8.3f%s%6.2f%s%5.2f%s%5.2f\n',violMat(r,1),
'          ', violMat(r,2),'         ', violMat(r,3),'             ',
violMat(r,4),...
```

```
                  '                  ',violMat(r,5));
        end

        fprintf(crfid,'\n\n');
        violMat = [];

        if(count==0)
            fprintf(crfid,'%s','--------------No violations found------------
-');
            fprintf(crfid,'\n\n');
        end
        count = 0;
    end

    l = k/length(cond_index);
end

disp('total time taken to report ground violations:')
disp(cputime-t1)

delete(h)
fclose(crfid);

open([strtok(crfnm,'.') '_' infnm '_report.txt'])

end



% --------------------------------------------------------------------
function Reports_Ground_Clearance_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Ground_Clearance (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Ground Clearance Criteria';
criteria_fname = 'Ground Clearance Criteria.xlsx';

if(exist('Ground Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Ground Clearance');
    return
end

target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';
```

```
criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = 22.*ones(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
    end
end

generateReport('Ground Clearance');

end


% --------------------------------------------------------------------
function Reports_Wire_Clearance_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Wire_Clearance (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Wire Clearance Criteria';
criteria_fname = 'Wire Clearance Criteria.xlsx';

if(exist('Wire Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Wire Clearance');
    return
end

target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';

criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = zeros(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
        critical_hdist_mat(i,j) = criteria_mat(i,2*j);
    end
end
```

```
generateReport('Wire Clearance');

end

% --------------------------------------------------------------------
function Reports_Critical_Wire_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Critical_Wire (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Wire Clearance Criteria';
criteria_fname = 'Wire Clearance Criteria.xlsx';

if(exist('Wire Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Wire Critical Clearance');
    return
end

target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';

criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = 5.*ones(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
    end
end

generateReport('Wire Critical Clearance');

end

% --------------------------------------------------------------------
function Reports_Structure_Clearance_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Structure_Clearance (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat
```

```matlab
if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Structure Clearance Criteria';
criteria_fname = 'Structure Clearance Criteria.xlsx';

if(exist('Structure Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Structure Clearance');
    return
end

target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';

criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = zeros(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
        critical_hdist_mat(i,j) = criteria_mat(i,2*j);
    end
end

generateReport('Structure Clearance');
end

% --------------------------------------------------------------------
function Reports_Critical_Structure_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Critical_Structure (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Structure Critical Clearance Criteria';
criteria_fname = 'Structure Critical Clearance Criteria.xlsx';

if(exist('Structure Critical Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Structure Critical Clearance');
    return
end
```

```
target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';

criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = 5.*ones(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
    end
end

generateReport('Structure Critical Clearance');

end

% --------------------------------------------------------------------
function Reports_Vegetation_Management_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Vegetation_Management (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Vegetation Management Criteria';
criteria_fname = 'Vegetation Clearance Criteria.xlsx';

if(exist('Vegetation Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Vegetation Management Clearance');
    return
end

target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';

criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = zeros(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
        critical_hdist_mat(i,j) = criteria_mat(i,2*j);
```

```
    end
end

generateReport('Vegetation Management Clearance');
end


% --------------------------------------------------------------------
function Reports_Critical_Vegetation_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Critical_Vegetation (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global criteria_fname prg_status crfnm target_fc critical_vdist_mat
critical_hdist_mat

if(prg_status==0)
    errordlg('No input data found. Please input data.')
    return
end
crfnm = 'Vegetation Critical Clearance Criteria';
criteria_fname = 'Vegetation Critical Clearance Criteria.xlsx';

if(exist('Vegetation Critical Clearance Criteria.xlsx','file')==0)
    errordlg('Criteria file not found. Please create criteria
file.','Name','Vegetation Management Critical Clearance');
    return
end

target_data = xlsread(criteria_fname, -1);

target_fc = target_data(:,1)';

criteria_mat = target_data(:,3:end);

critical_vdist_mat = zeros(length(criteria_mat),5);
critical_hdist_mat = 5.*ones(length(criteria_mat),5);

for i = 1:size(criteria_mat,1)
    for j = 1:5
        critical_vdist_mat(i,j) = criteria_mat(i,2*j-1);
    end
end

generateReport('Vegetation Management Critical Clearance');
end




% --------------------------------------------------------------------
function Thermal_Obstacle_Callback(hObject, eventdata, handles)
% hObject    handle to Thermal_Obstacle (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
```

```
% handles    structure with handles and user data (see GUIDATA)
end

% --------------------------------------------------------------------
function Thermal_Veg_Callback(hObject, eventdata, handles)
% hObject    handle to Thermal_Veg (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end

% --------------------------------------------------------------------
function Reports_Thermal_Menu_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Thermal_Menu (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end


% --------------------------------------------------------------------
function Reports_Batch_Thermal_Callback(hObject, eventdata, handles)
% hObject    handle to Reports_Batch_Thermal (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
end


%%
% % --------------------------------------------------------------------
function HELP_MATLAB_CreateFcn(hObject, eventdata, handles)
% hObject    handle to View_Display_Symbol (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

end


% --------------------------------------------------------------------
function Help_Menu_Callback(hObject, eventdata, handles)
% hObject    handle to Help_Menu (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

end


% --------------------------------------------------------------------
function Help_About_PLC_VAST_Callback(hObject, eventdata, handles)
% hObject    handle to Help_About_PLC_VAST (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


open('About_PLC_VAST.pdf')
```

```
end


% --------------------------------------------------------------------
function Help_User_Manual_Callback(hObject, eventdata, handles)
% hObject    handle to Help_User_Manual (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

open('PLC-VAST User Manual-updated.docx')

end

% --------------------------------------------------------------------
function Help_Research_Papers_Callback(hObject, eventdata, handles)
% hObject    handle to Help_Research_Papers (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

open('References.pdf')

end


% --------------------------------------------------------------------
function HELP_MATLAB_Callback(hObject, eventdata, handles)
% hObject    handle to HELP_MATLAB (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

web  http://www.mathworks.com -browser
end


% --------------------------------------------------------------------
function Help_PLS_CADD_Callback(hObject, eventdata, handles)
% hObject    handle to Help_PLS_CADD (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

web  http://www.powline.com -browser

end





% global datCell feature_code volt criteria criteria_fname input_fname
prg_status infnm crfnm
%
% if(prg_status==0)
```

```
%     errordlg('No input data found. Please input data.')
%     return
% end
%
% if(isempty(criteria_fname))
%     errordlg('No criteria file found. Please load criteria file.');
%     return
% end
%
% target_index = [];
% for i = 1:length(criteria.target_fc)
%     temp_index = find(feature_code==criteria.target_fc(i));
%     if(temp_index~=0)
%         target_index = [target_index; temp_index];
%     end
% end
%
%
% if(isempty(target_index))
%     errordlg('No target point found for checking')
%     return
% end
%
% cond_fc = [1001 1002 1003];
% cond_index = [];
% for i = 1:3
%     temp_ind = find(feature_code==cond_fc(i));
%     if(temp_ind~=0)
%         cond_index = [cond_index; temp_ind];
%     end
% end
%
% if(isempty(cond_index))
%     errordlg('No conductor point found for checking')
%     return
% end
%
% if(volt==0)
%     ind = 1;
% elseif(volt == 138)
%     ind = 2;
% elseif(volt == 161)
%     ind = 3;
% elseif(volt == 230)
%     ind = 4;
% elseif(volt == 345)
%     ind = 5;
% end
%
% crfid = fopen([strtok(crfnm,'.') '_' infnm '_report.txt'],'w');
% fprintf(crfid,'%s\n\n','Ground Clearance Report');
% fprintf(crfid,'%s',['Input file: ' input_fname]);
% fprintf(crfid,'\n');
% fprintf(crfid,'%s',['Clearance file:' criteria_fname]);
% fprintf(crfid,'\n\n');
%
% count = 0;
```

```
%
% l = 0;
% t1 = cputime;
% h = waitbar(l,'Finding violations ... Please wait','Name','Ground Clearance
Report');
% violMat = [];
% for k=1:length(cond_index)
%     for p=1:length(target_index)
%         waitbar(l,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
%         disp(['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))])
%         critical_vdist = criteria.critical_vdist(p,ind);
%         critical_hdist = criteria.critical_hdist(p,ind);
%
%         fprintf(crfid,'%s%d','Conductor Feature code:
',feature_code(cond_index(k)));
%         fprintf(crfid,'\n');
%         fprintf(crfid,'%s',['Voltage: ' num2str(volt) 'kV']);
%         fprintf(crfid,'\n');
%         fprintf(crfid,'%s%d','Target Feature code:
',feature_code(target_index(p)));
%         fprintf(crfid,'\n');
%         fprintf(crfid,'%s%d','Horizontal Clearance Dist: ',critical_hdist);
%         fprintf(crfid,'\n');
%         fprintf(crfid,'%s%d','Vertical Clearance Dist: ',critical_vdist);
%         fprintf(crfid,'\n\n');
%
%         t = cputime;
%         if(critical_vdist > 0 || critical_hdist > 0)
%             violMat = [];
%             for i = 1:size(datCell{cond_index(k)},1)
%                 cond_pt = datCell{cond_index(k)}(i,2:4);
%                 targetMat = datCell{target_index(p)};
%
%                 [S,in] = sort(targetMat(:,4),'descend');
%
%                 sorted_targetMat = targetMat(in,:);
%
%                 tmp_ind = find((sorted_targetMat(:,4)>cond_pt(3)-
critical_vdist) & abs(sorted_targetMat(:,2)-cond_pt(1))<30 &
abs(sorted_targetMat(:,3)-cond_pt(2))<30);
%
%                 if(isempty(tmp_ind))
%                     l1 =
(i/(length(cond_index)*length(target_index)*length(datCell{cond_index(k)})))+
l;
%                     waitbar(l1,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
%                     continue
%                 end
%
%                 tmp_targetMat = sorted_targetMat(tmp_ind,:);
%
```

```
%                  for j = 1:size(tmp_targetMat,1)
%                      target_pt = tmp_targetMat(j,2:4);
%                      hdist = sqrt((cond_pt(1)-target_pt(1))^2+(cond_pt(2)-
target_pt(2))^2);
%
%                      if((hdist < 22))
%                          count = count+1;
%                          violMat = [violMat; cond_pt(1) cond_pt(2)
cond_pt(3) (cond_pt(3) - target_pt(3)) hdist];
%                          break
%                      end
%                  end
%                  l1 =
(i/(length(cond_index)*length(target_index)*length(datCell{cond_index(k)})))+
l;
%                  waitbar(l1,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
%              end
%              disp('time taken:')
%              disp(cputime - t);
%          end
%          disp('total number of violations found:')
%          disp(length(violMat))
%          fprintf(crfid,'%s%d%s%d\n\n','The following lists the coordinates
of point violating for conductor feature code-',
feature_code(cond_index(k)),...
%              ' and target feature code-',feature_code(target_index(p)));
%          fprintf(crfid,'%s%d','Total number of violations found: ',
length(violMat));
%          fprintf(crfid,'\n\n');
%          fprintf(crfid,'\t\t%s\t\t\t\t\t\t\t\t%s','Conductor Point
Coordinates','Distances (ft.)');
%          fprintf(crfid,'\n\n');
%          fprintf(crfid,'%s\t\t\t%s','     X                 Y
Z ','Vertical               Horizontal');
%          fprintf(crfid,'\n\n');
%
%          for r=1:length(violMat)
%
fprintf(crfid,'%8.3f%s%8.3f%s%6.2f%s%5.2f%s%5.2f\n',violMat(r,1), '
', violMat(r,2),'         ', violMat(r,3),'            ', violMat(r,4),...
%                  '                   ',violMat(r,5));
%          end
%
%          fprintf(crfid,'\n\n');
%          violMat = [];
% %          l = (k/length(cond_index));
%          if(count==0)
%              fprintf(crfid,'%s','--------------No violations found----------
---');
%              fprintf(crfid,'\n\n');
%          end
%          count = 0;
%      end
%
%      l = k/length(cond_index);
```

```
% %     waitbar(l,h,['Finding violations for conductor '
num2str(feature_code(cond_index(k))) ' and target '
num2str(feature_code(target_index(p)))]);
% end
%
% disp('total time taken to report ground violations:')
% disp(cputime-t1)
%
% delete(h)
% fclose(crfid);
%
% open([strtok(crfnm,'.') '_' infnm '_report.txt'])
```

F. APPENDIX F: PLS CADD SCREENSHOTS

APPENDIX F

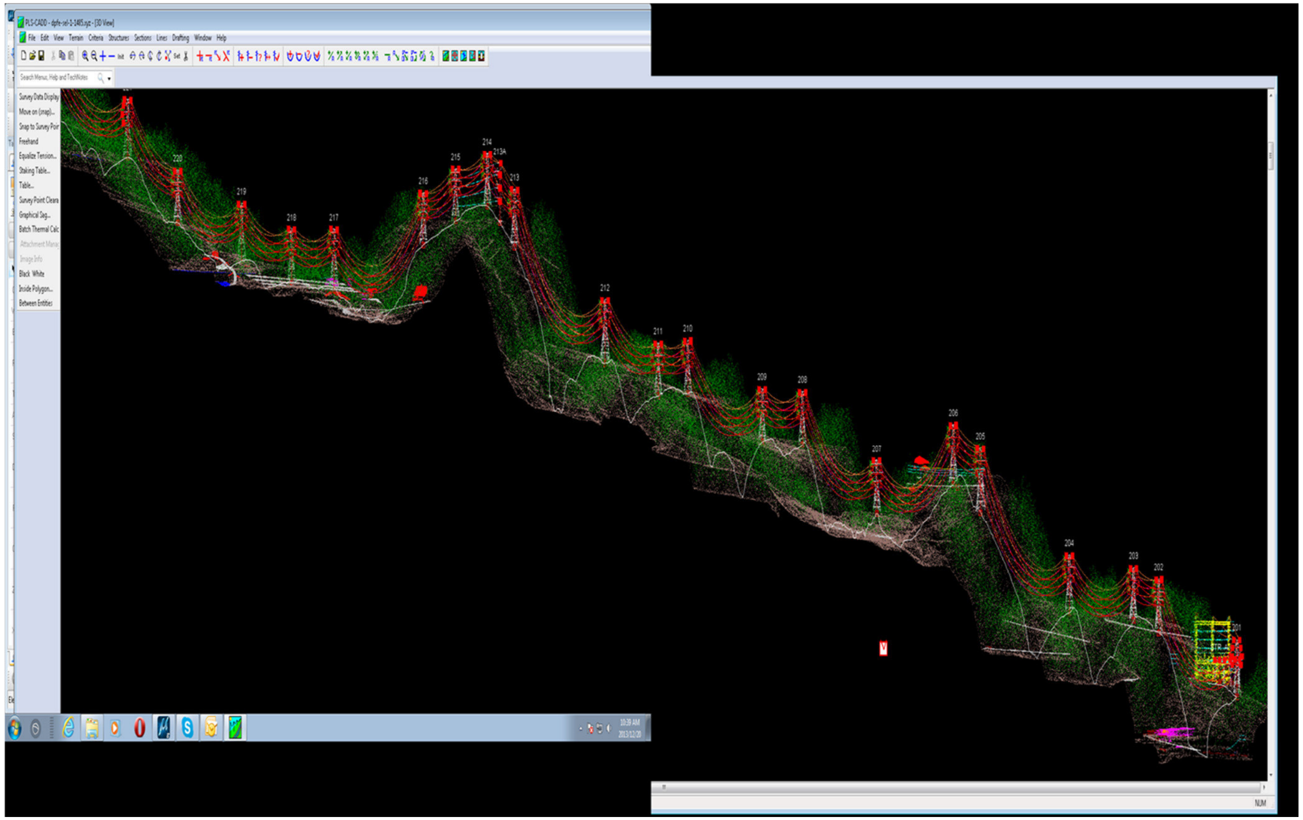


Figure F-1: PLS-CADD Screenshot for DPFE-SEL-1-1485 Transmission Line

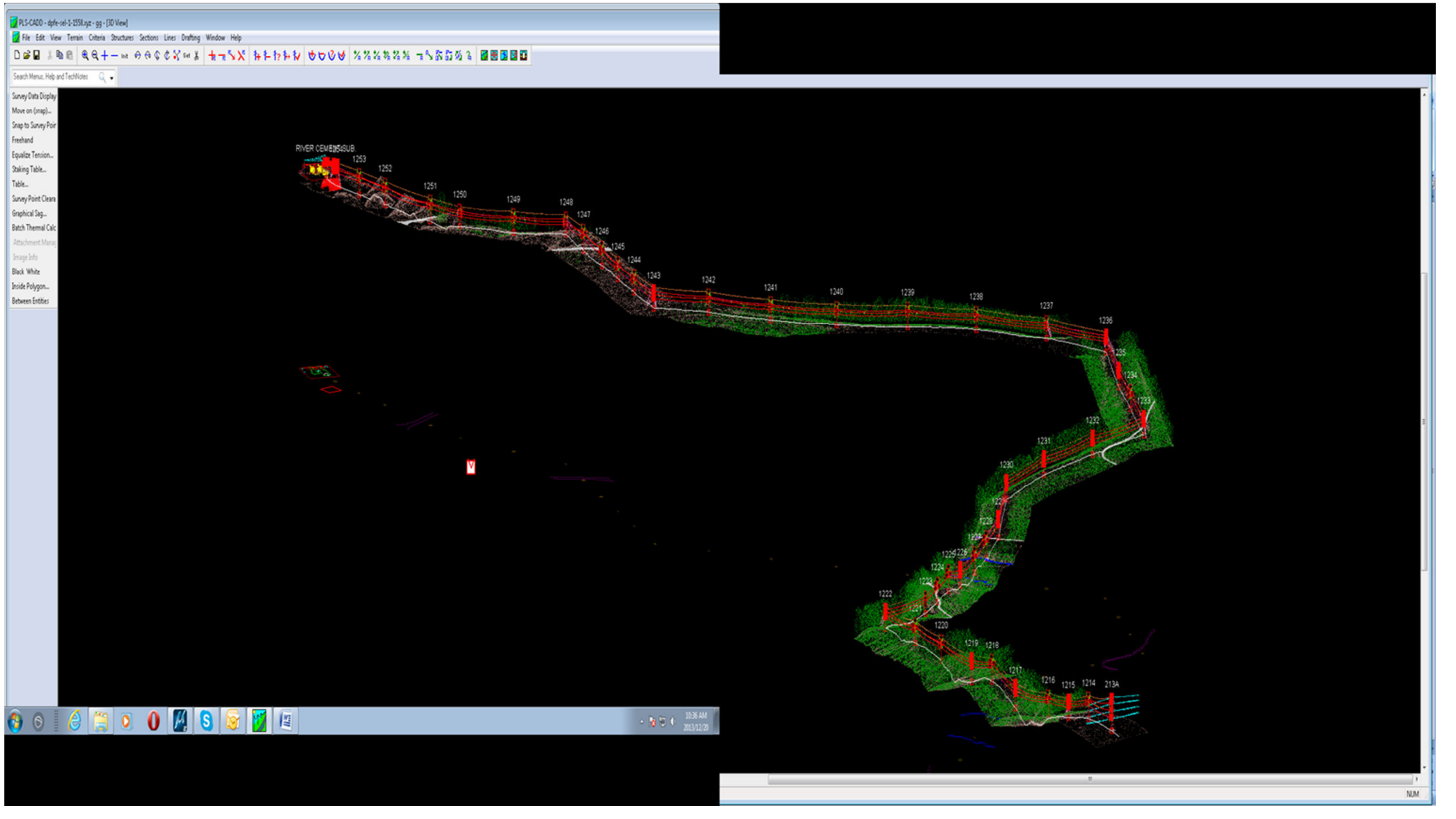


Figure F-2: PLS-CADD Screenshot for DPFE-SEL-1-1558 Transmission Line

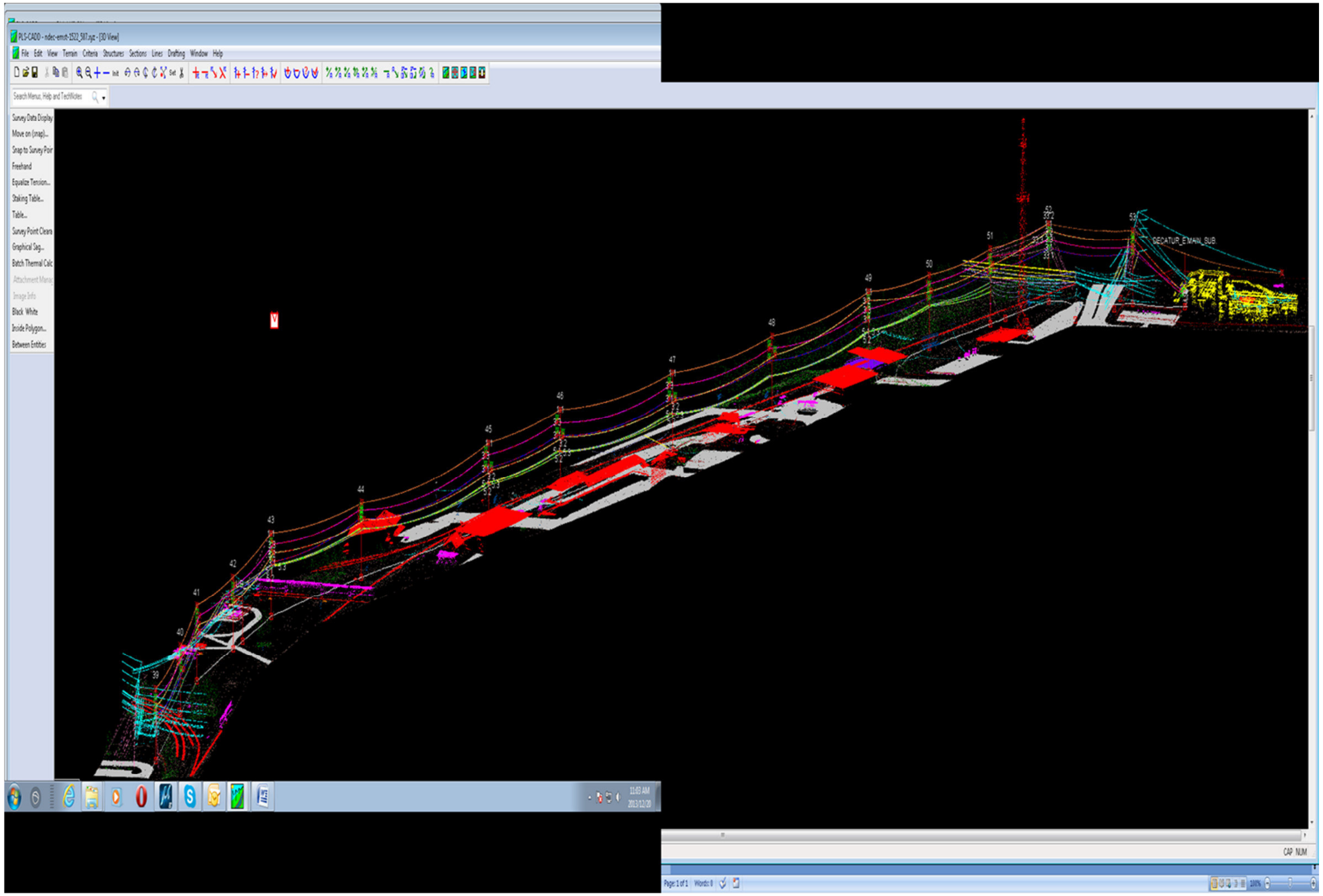


Figure F-3: PLS-CADD Screenshot for NDEC-EMST-1522-587 Transmission Line

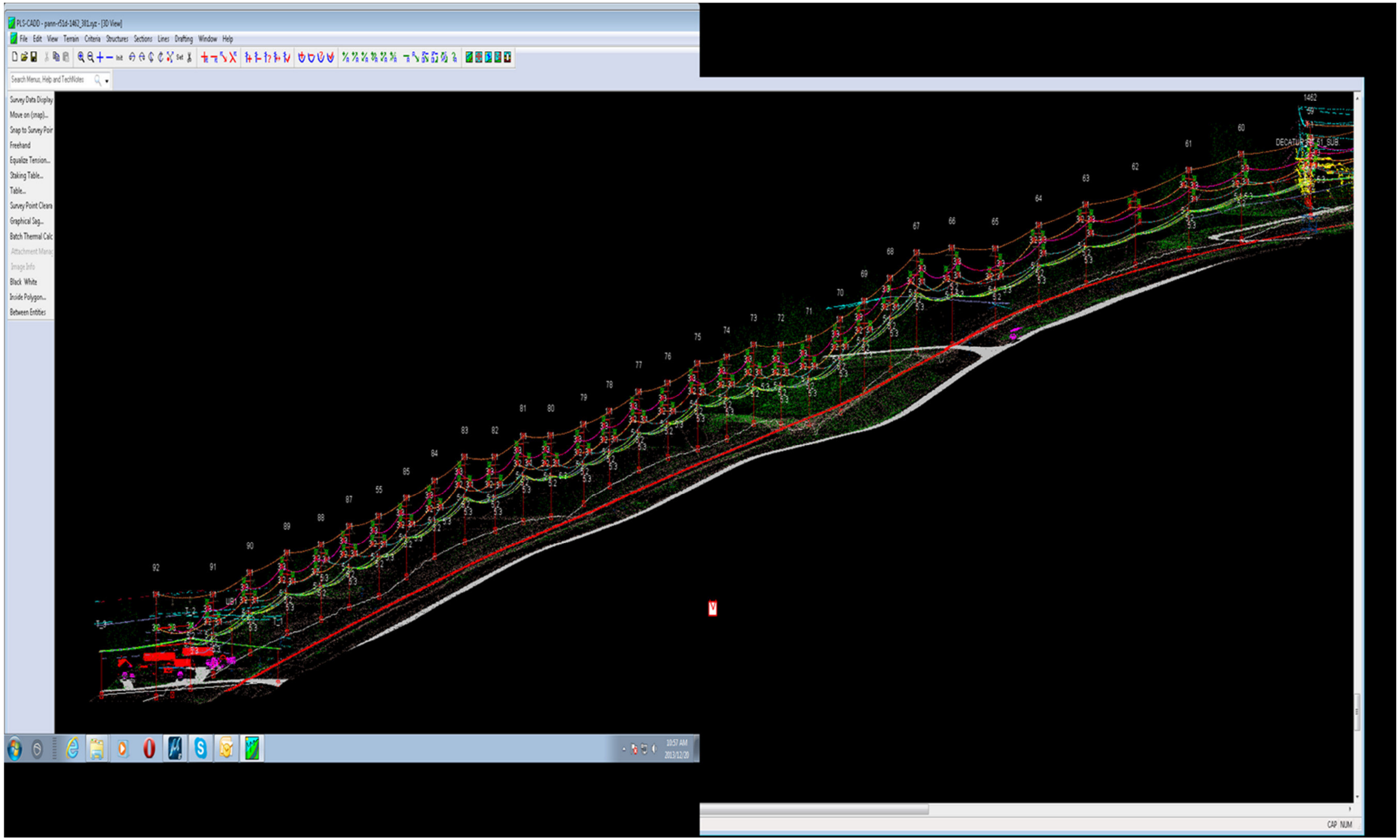


Figure F-4: PLS-CADD Screenshot for PANN-R51D-1462-381 Transmission Line

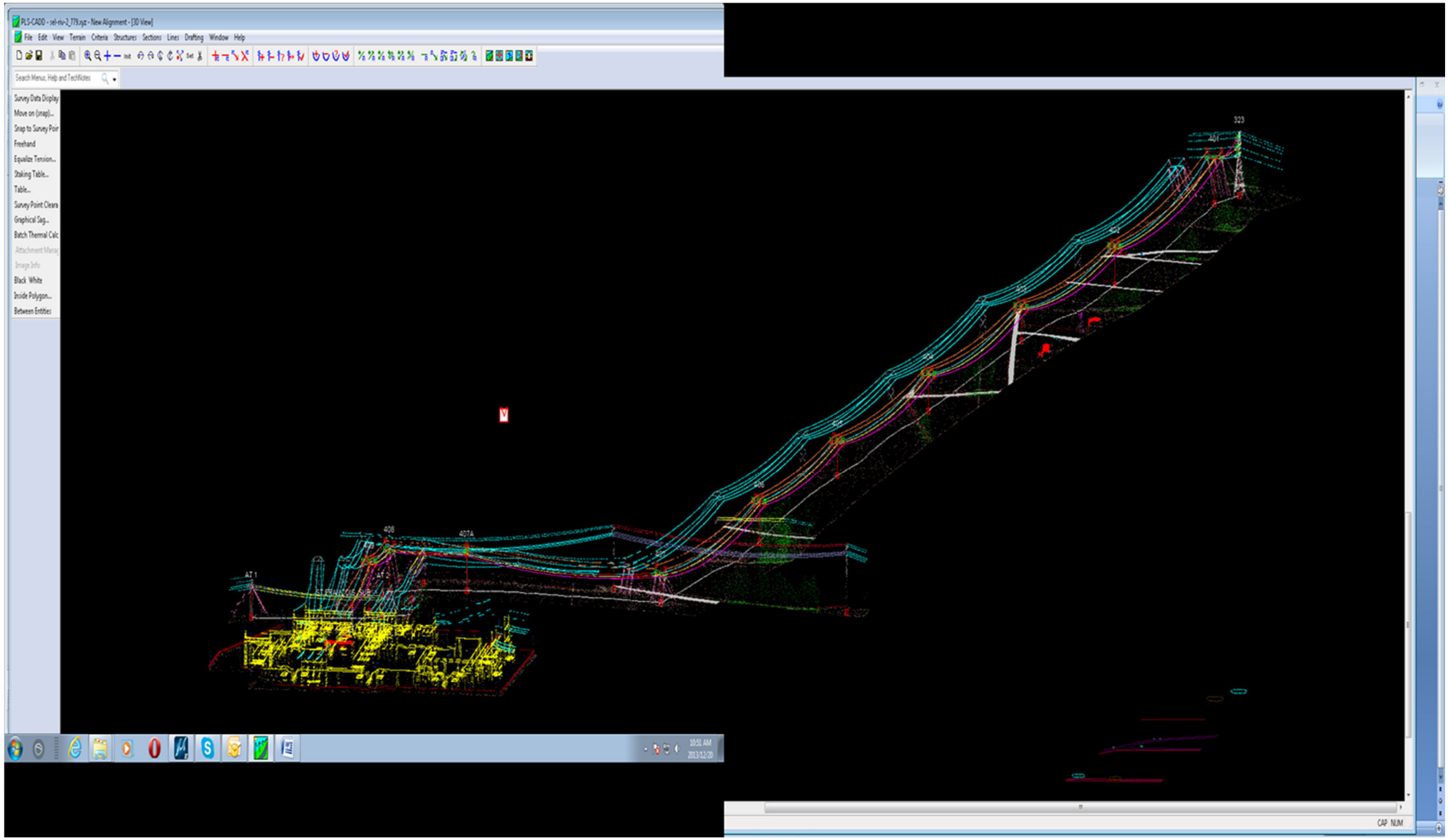


Figure F-5: PLS-CADD Screenshot for SEL-RIV-2-779 Transmission Line

G. APPENDIX G: PLC-VAST SCREENSHOTS

APPENDIX G

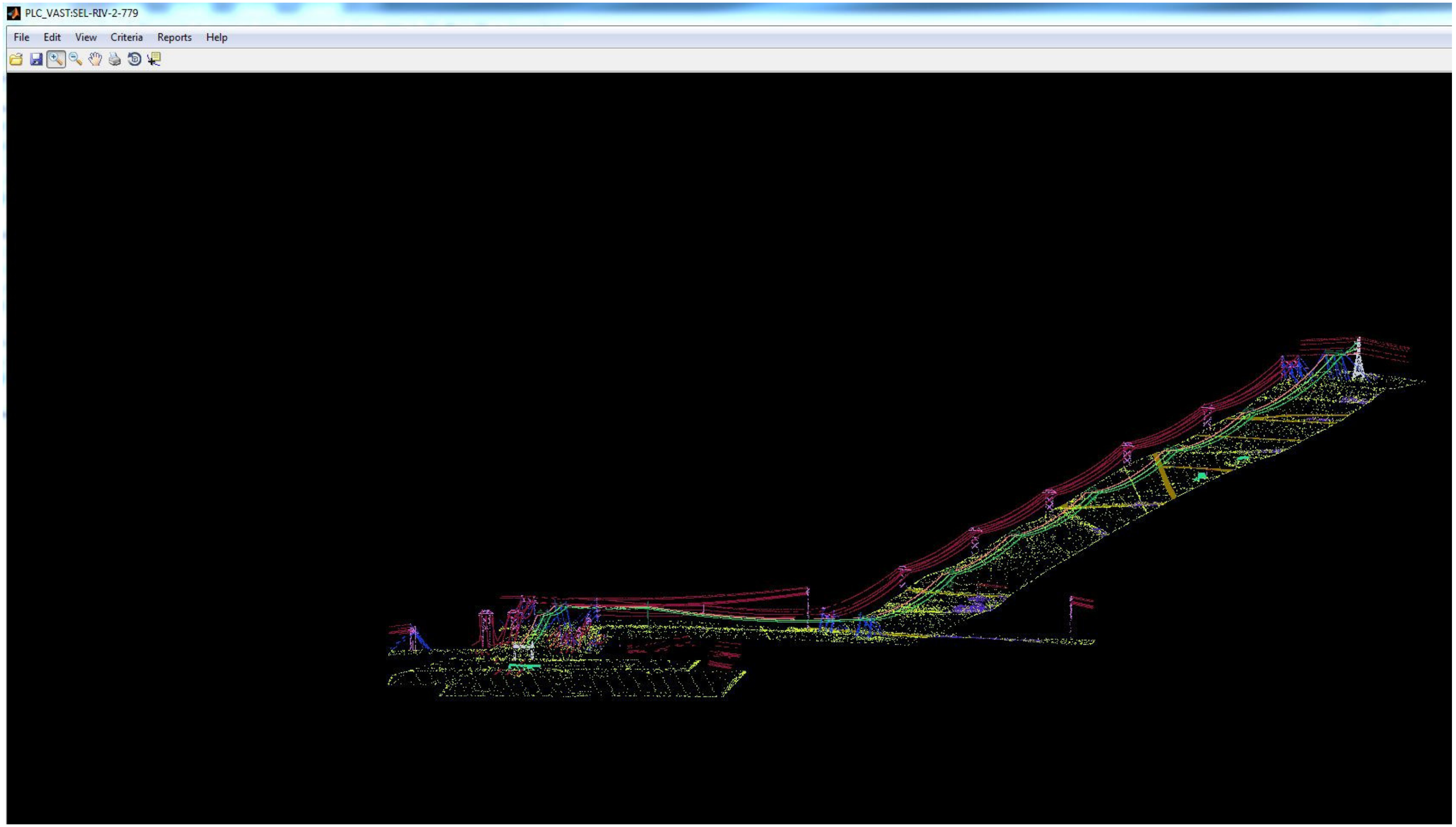


Figure F-1: PLC_VAST Screenshot for SEL-RIV-2-779 Transmission Line

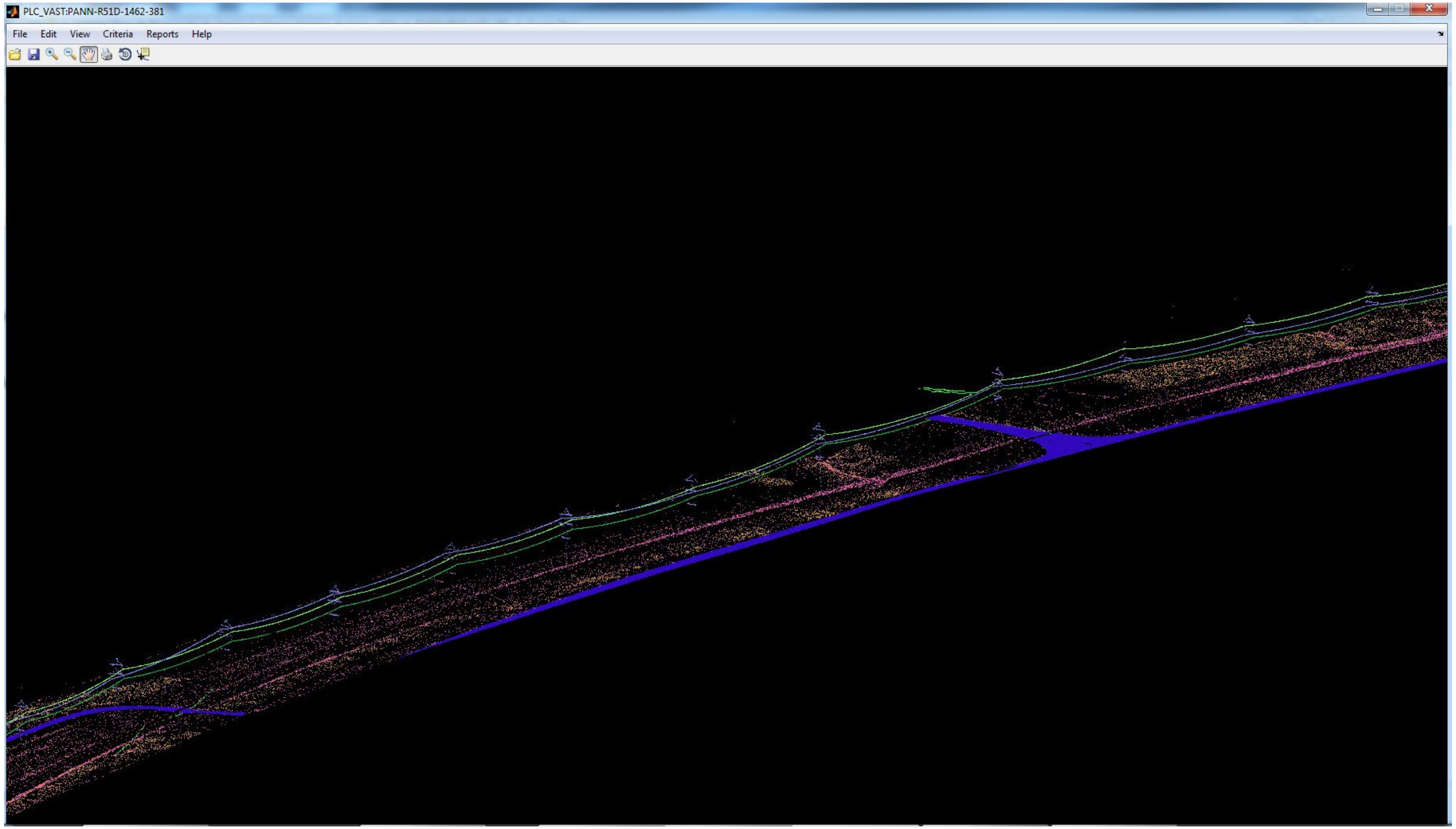


Figure F-2: PLC-VAST Screenshot for PANN-R51D-1462-381 Transmission Line

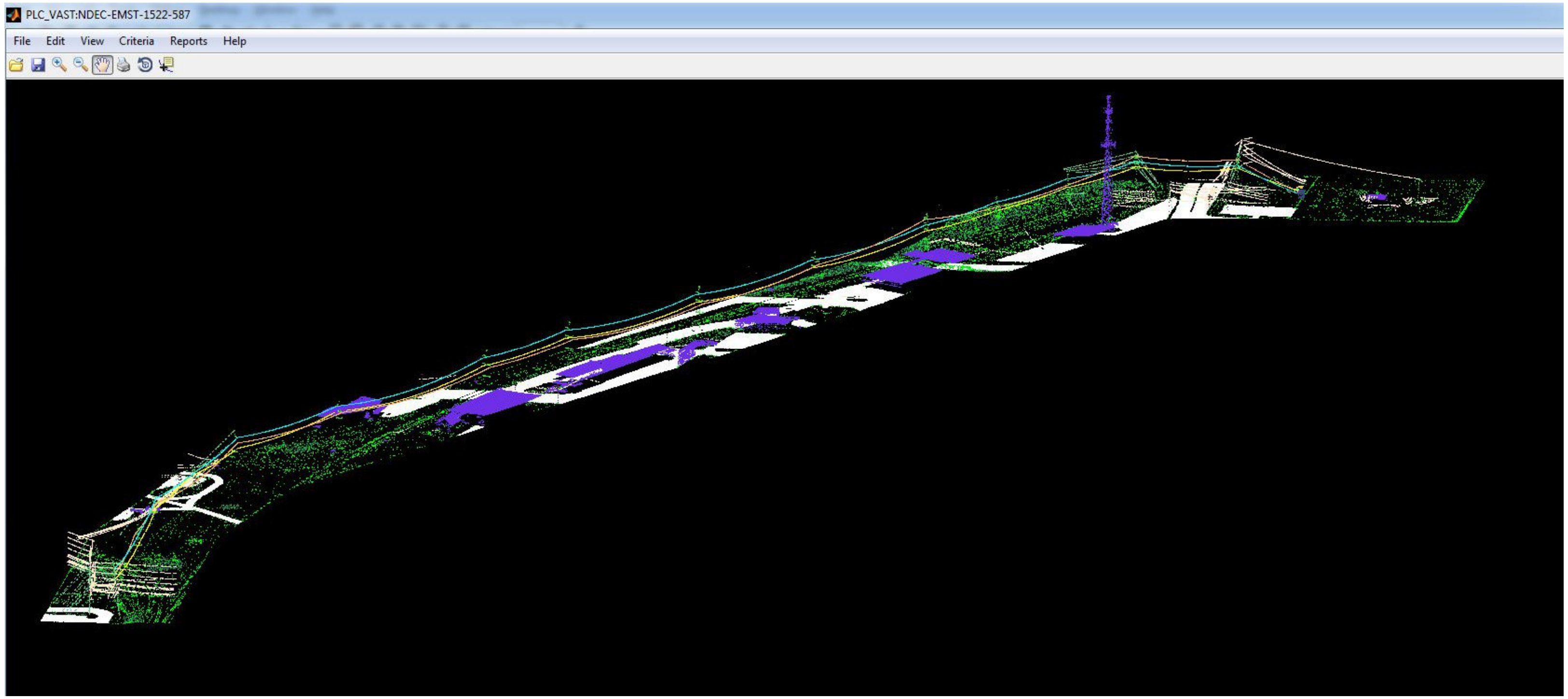


Figure F-3: PLC-VAST Screenshot for NDEC-EMST-1522-587 Transmission Line