LiDAR Survey Technology and its application in Transmission Line Engineering

September 20, 2011

Presented by:

Jim Koop
Managing Director – W.I.R.E. Services

Introduction

- Is a T/L Engineering Company Specializing in LiDAR Data Integration
- Provides Utility Solutions through LiDAR Integration

A Division of:

Manitoba Hydro (Parent Company)

- 4th largest Electrical Utility in Canada,
- Produces 98% energy from 14 Hydro Electric Generating Stations
- Total Capacity of 5,490 MW
- Over 11,500 km of Transmission Line
- Major power exporter to U.S.A.
- Lowest rates in North America

Manitoba Hydro International

Manitoba
HYDRO INTERNATIONAL

A wholly owned Subsidiary of Manitoba Hydro and parent company of W.I.R.E. Services

- Utilizes the human resources of Manitoba Hydro
- Assists power utilities in the efficient delivery of electricity
- Has worked in over 60 countries worldwide
- Has offered quality utility services to the international power sector over the past 24 years

Offers **Electric Utility Expertise** in:

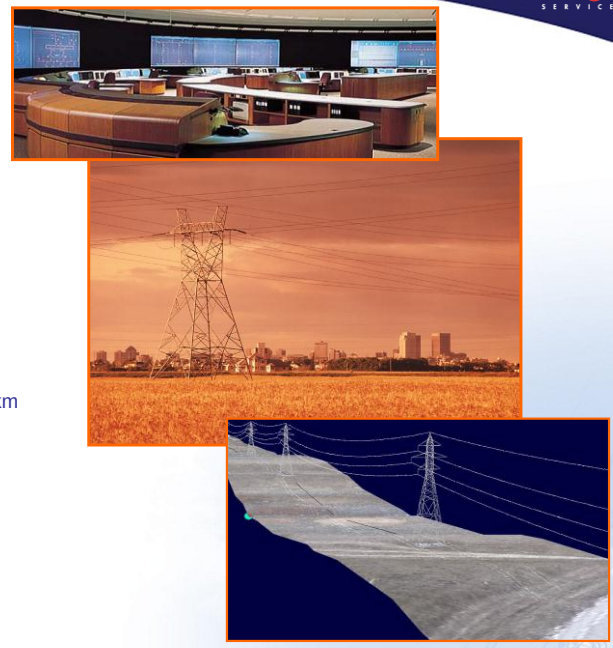
✓Planning, design, construction, operations and management of generation, transmission, and distribution facilities

✓Utility management, consulting, and training services

W.I.R.E. Services

W I R E
SERVICES

- Manitoba Hydro needed better Transmission Line analysis tools
- First LiDAR survey in 1998
- Used LiDAR data for analysis and upgrades since 1999
- W.I.R.E. Services began operations in 2001
- Have Engineering experience on over 30,000 km of LiDAR data
- Have over 30 main clients most of whom are repeat customers



Transmission Line Challenges

Today's Challenges

Transmission Line Issues:

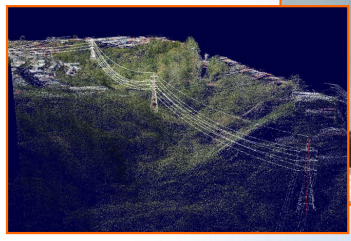
- Increased loading
- Low thermal design limits
- Clearance violations
- Vegetation Management
- Terrain changes
- Sag & Tension uncertainties
- Survey inaccuracies
- Increased crossing requests
- Which span governs line rating

Today's Challenges

Two Distinct Categories

1) Existing Line Rating Analysis
2) New Transmission Line Design

Both categories are unique and have specific requirements

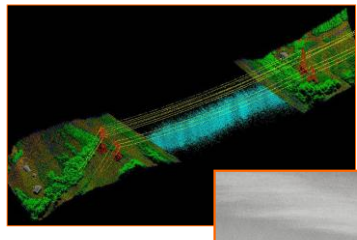


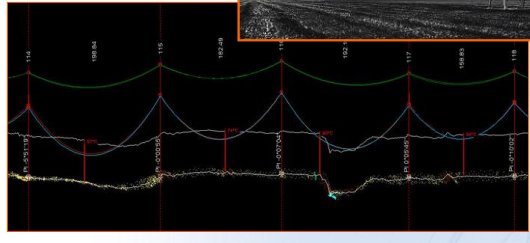
Today's Challenges

Existing Line Rating Analysis

Needs:

- Study the feasibility of upgrade opportunities
- Assemble an up-to-date inventory of lines for GIS, Maintenance, etc.
- Acquire accurate digital imagery record of the line
- Prepare cost and time effective upgrades
- Minimal social and environmental impact
- Determine Maximum Thermal operating limits (wrt minimum ground clearances)



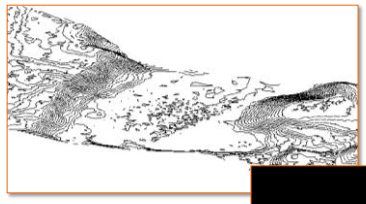


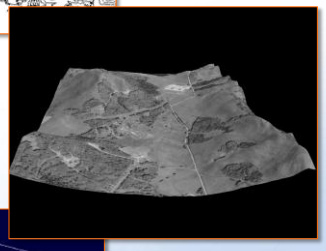
Today's Challenges

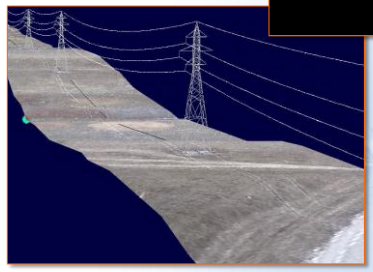
New Transmission Line Design

Needs:

- Study the routing options and obtain preferred route in areas where little survey data in known
- Acquire accurate and up-to-date digital imagery to verify terrain and features on the ground
- Develop information on crossing lines that impact line design







Transmission System

What are the Solutions to these Issues, Challenges and Needs?

Transmission Solutions

Solutions:

#1 Data Collection:

- LiDAR Survey (Multiple methods available)
- Digital Downward Imagery
- Forward Digital Video

#2 Thermal Rating Analysis:

- Determine the ACTUAL capacity of an existing Transmission Line

Transmission Solutions

Solutions: (Continued)

#3 Upgrade Engineering:

- Increase the existing capacity of a Transmission Line
- Upgrade engineering using innovative technology, techniques and software

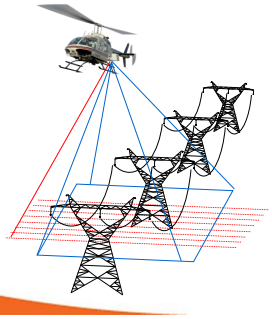
#4 Implementation:

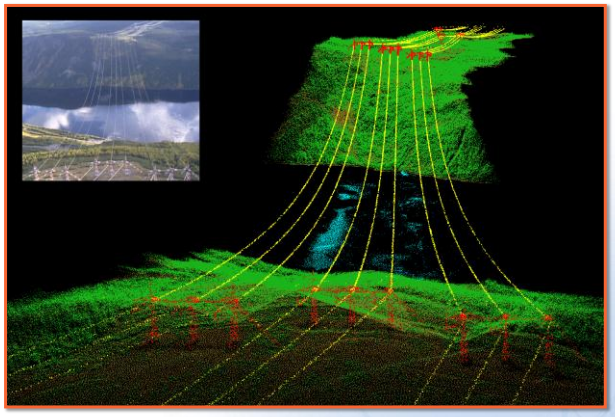
- Use modern construction methods and new technology
- Live line and cold procedures

What is LiDAR?

LiDAR:
Light Detection And Ranging

- Sending a laser pulse to the ground
- Timing the returning reflection from an object
- Calculating the distance
- Integrate with GPS and Inertial data
- Determine x, y, z coordinate of the point

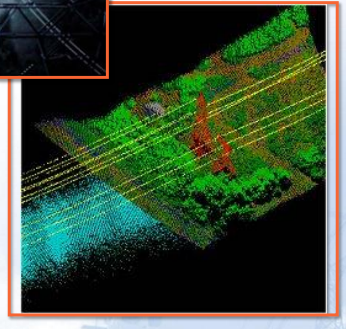




W.I.R.E. Services Capabilities

Experienced in:

- LiDAR Data Support
- Transmission Line Modelling
- Thermal Rating Verification
- Upgrade Solutions
- Transmission Line Engineering
- New Route Surveys
- Danger Tree & Vegetation Studies

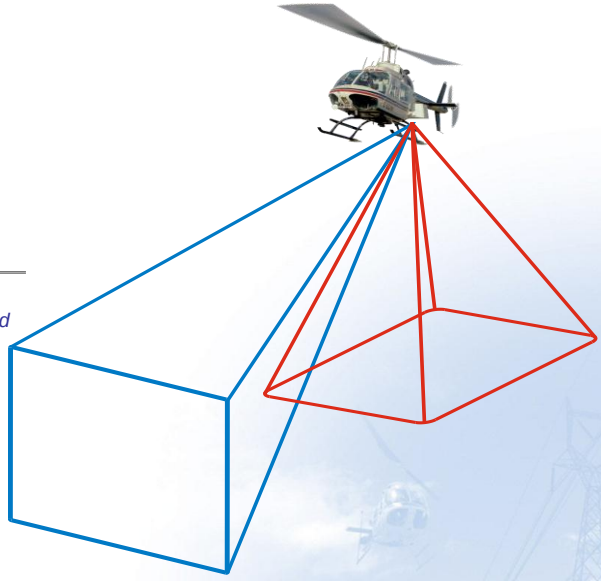


LiDAR Data Support

- Develop technical specifications
- Conduct purchasing tenders
- Digital orthorectified imagery
- Digital streaming forward video
- Tower/Structure imagery
- Meteorological data specifications

Outcome:

- *Create an Inventory of Transmission Lines and Structures for GIS and Mapping*
- *Collect the data necessary for Analysis and Upgrade Engineering*



LiDAR Data Support

Meteorological Recording

Portable Weather Stations record:

- Temperature
- Wind speed
- Wind direction
- Solar indicator or Cloud cover
- Date & time

Data Required (by Utility):

- Line current (amps or MVA)

What's being Collected

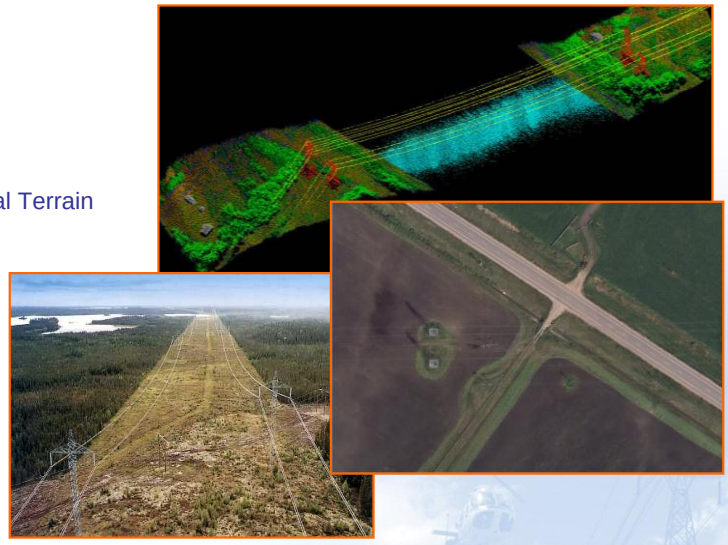
Summary...

LiDAR Data
- Scanning Laser Data for Digital Terrain Model (DTM)

Downward Digital Imagery
- Orthorectified strip images
- MrSID compressed imagery

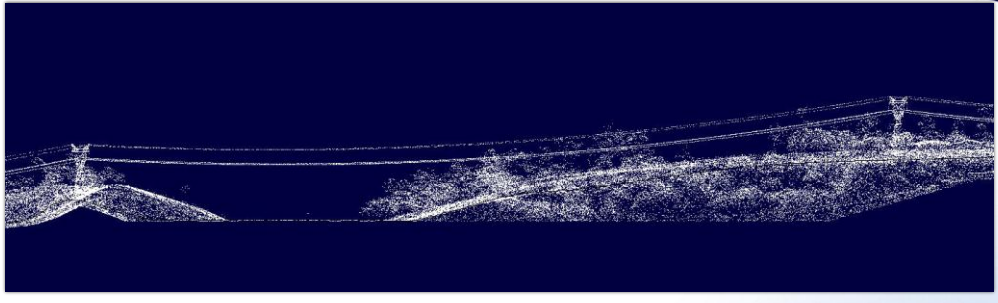
Forward Digital Video
- Structure still shots

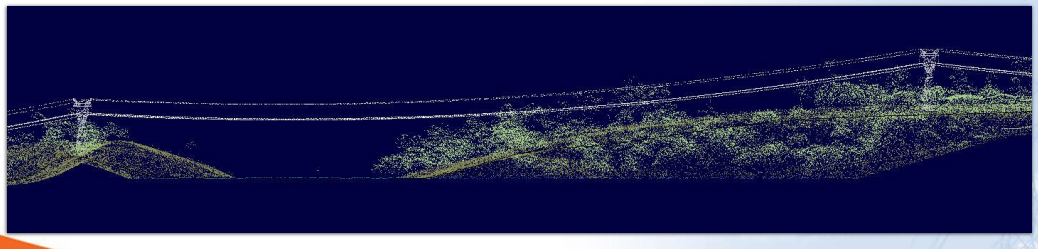
Meteorological Data

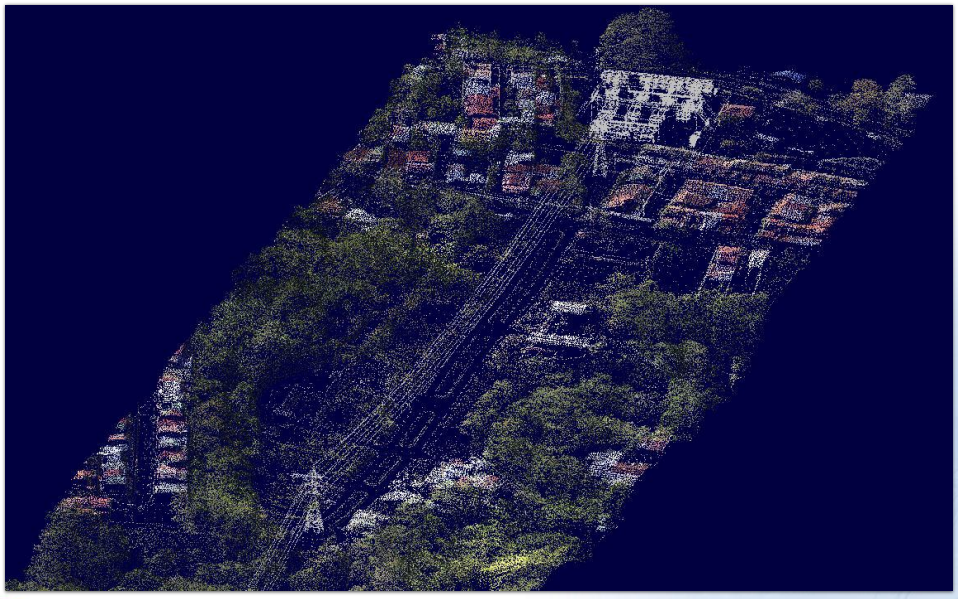


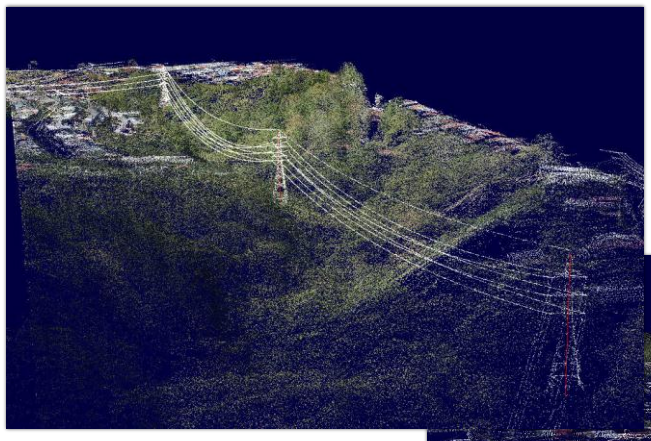
Processing of Data Collection

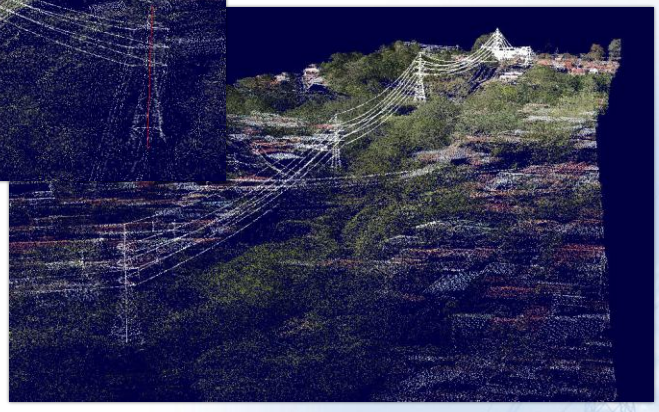
LiDAR Data Samples







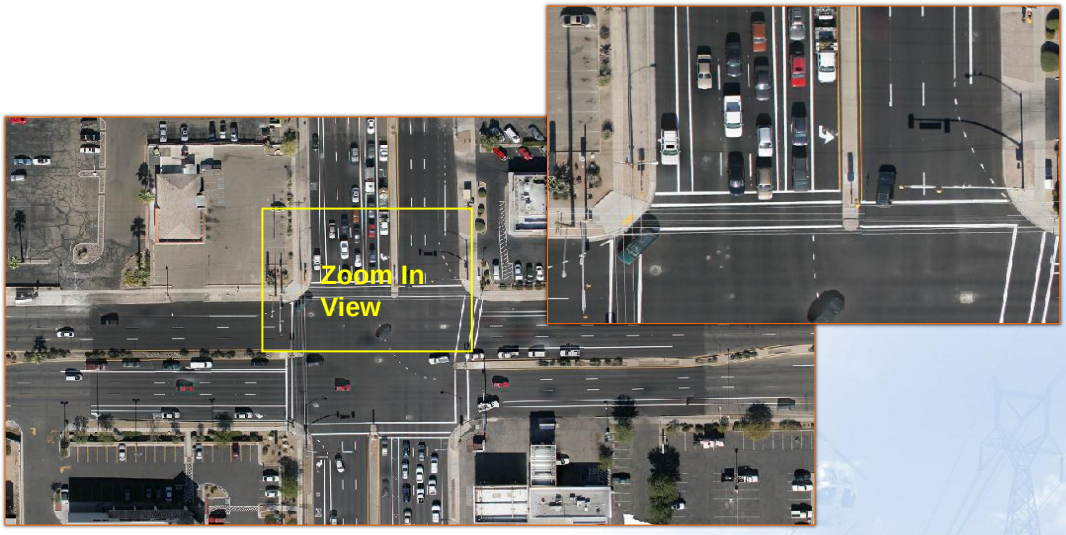




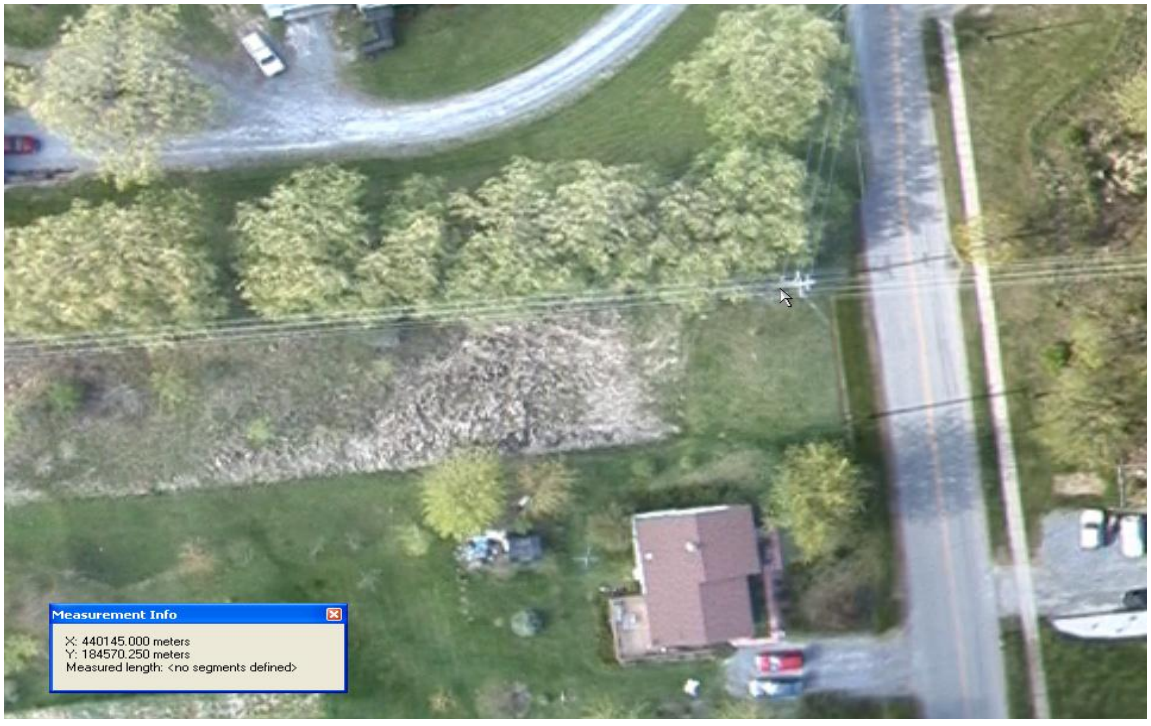
Orthorectified Imagery

- Typical 10 - 15 cm pixel size

Orthorectified Imagery



Compressed Imagery


Measurement Info
X: 440145.000 meters
Y: 184570.250 meters
Measured length: <no segments defined>


Measurement Info
X: 440143.000 meters
Y: 184548.550 meters
Measured Length: 22.074 meters

Structure Still Imagery

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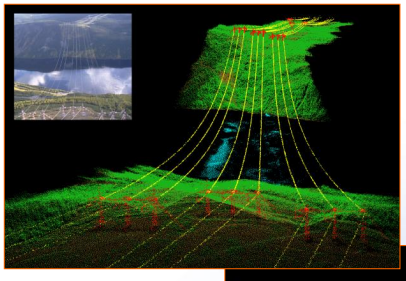
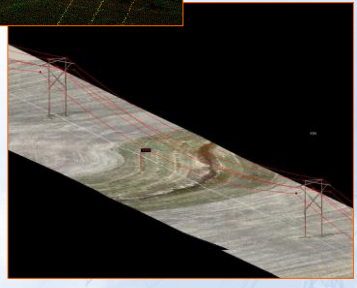




Process Overview

Transmission Line Modelling

- Catenary
- Profile
- Structures

Thermal Rating Procedure

- Weather Study
- Cond. Temp
- Simulation
- Determine Rating

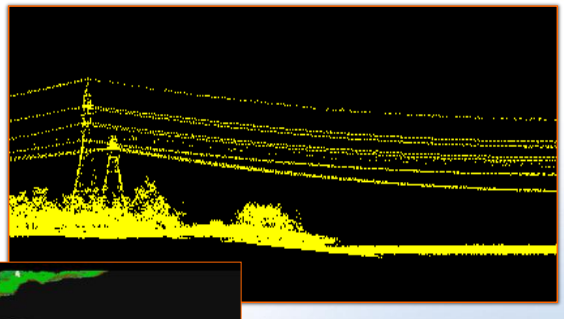
Upgrade Engineering

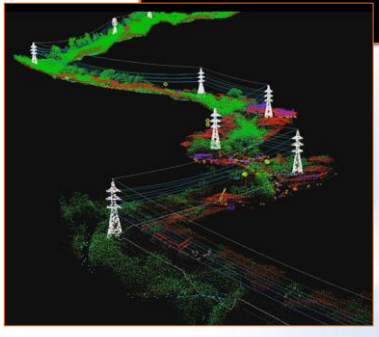
- Locate clearance encroachments
- Solve using Nip&Tuck™
- Implosive Splices
- Develop upgrade method
- Solve span by span or globally

Transmission Line Modelling

"As Built" model of existing transmission line

- Extract various features from LiDAR data
- Separate each component
- Create layers for Wire (catenary), structures, vegetation, bare earth, etc.
- Sag wire to match LiDAR point catenary
- Import Imagery

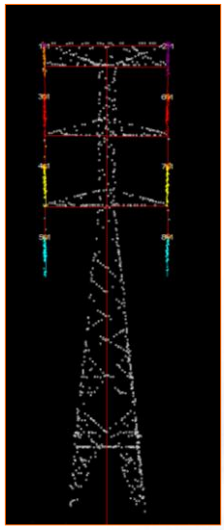


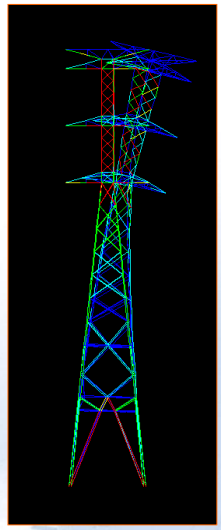


Transmission Line Modelling

PLS-CADD Structure Modelling

- Method 1 Structures (stick frame)
  - Sized to LiDAR Points
  - Insulator Weight, Wind Area, Length
  - Wire Set Convention
  - Structure Center
  - Naming
- Optional Method 4 Structures

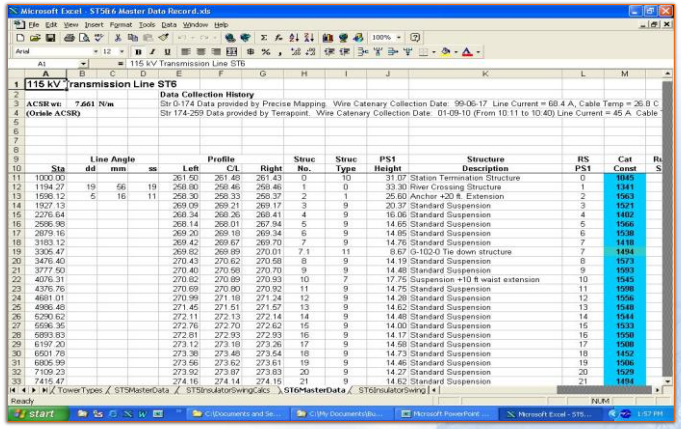




Transmission Line Modelling

"As-Built" Model provides data for a Complete T/L Analysis

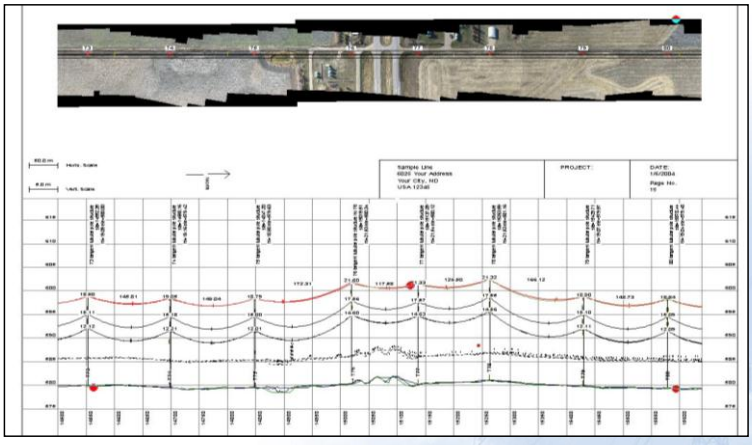
- Support Height
- Catenary Constant
- Span Tension
- Tension Variance
- Insulator Swing
- Wind / Weight Span



Transmission Line Modelling

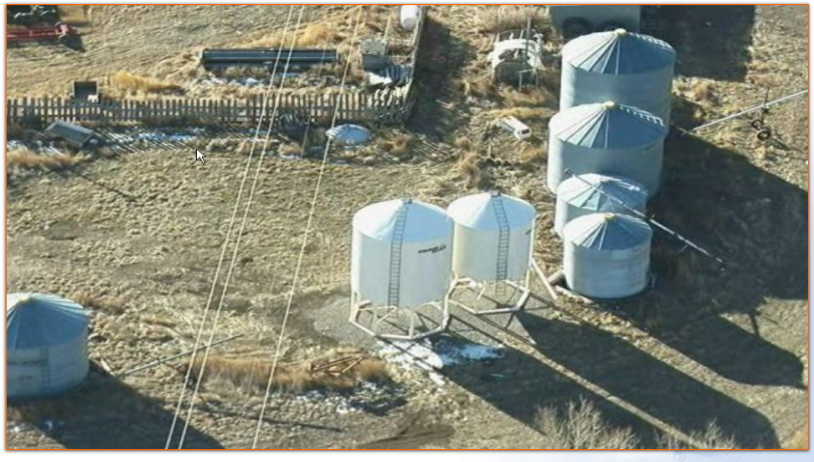
An "As Built" Plan & Profile showing actual:

- Up to date terrain
- Wire sag & tension
- Tower locations
- Suspension heights
- New aerial photographs



Transmission Line Modelling

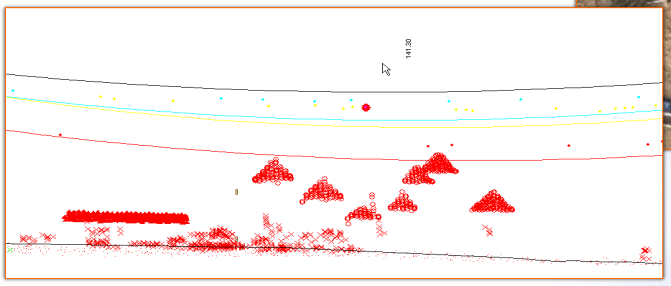
Unknown Issues Become Evident



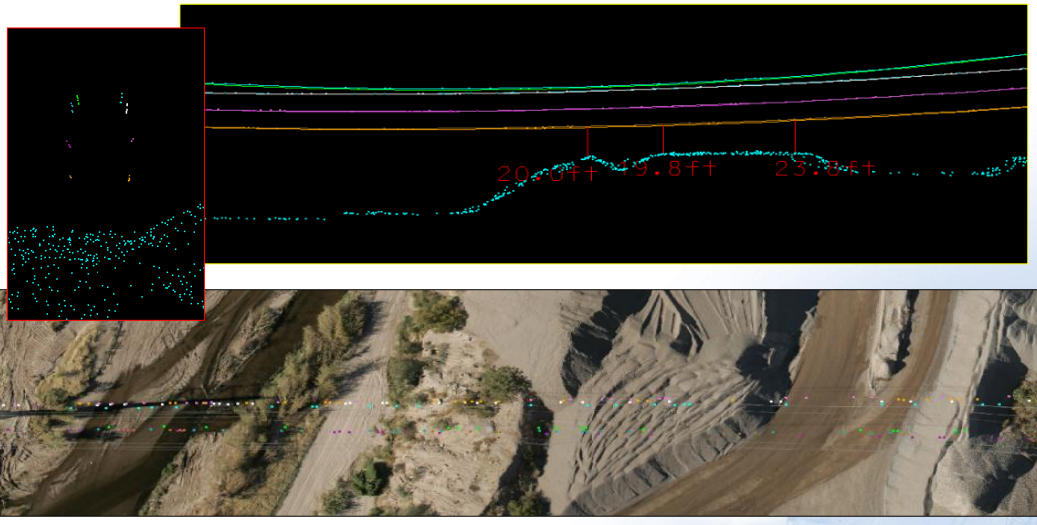
Transmission Line Modelling

Encroachment

- Farm Silos encroach within limits for 138 kV lines
  - 5.6 m vertical
  - 3.6 m horizontal



Transmission Line Modelling



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- Danger Tree & Vegetation Studies

Process Overview of Thermal Rating Analysis

Transmission Line Modelling

- Catenary
- Profile
- Structures

Thermal Rating Procedures

- Verification Engineering
- Weather Study
- Cond. Temp
- Simulation
- Determine Rating

Upgrade Engineering

- Locate clearance encroachments
- Solve using Nip&Tuck™
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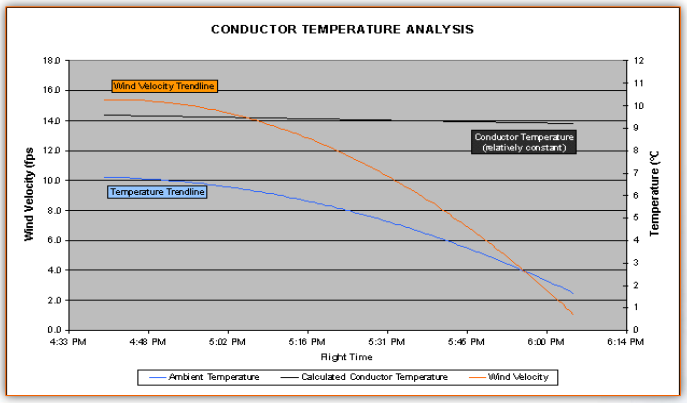
Thermal Rating Procedures

Verification Engineering

Determine the ACTUAL capacity and design of an existing Transmission Line



Calculate:
Using ANSI / IEEE Standard 738-2006 “Bare Overhead Conductor Temperature And Ampacity Under Steady-State Conditions”

Result:
Accurate conductor temperature of model within 1°or 2°C

Thermal Rating Procedures

Conductor Temperature Study

Purpose:

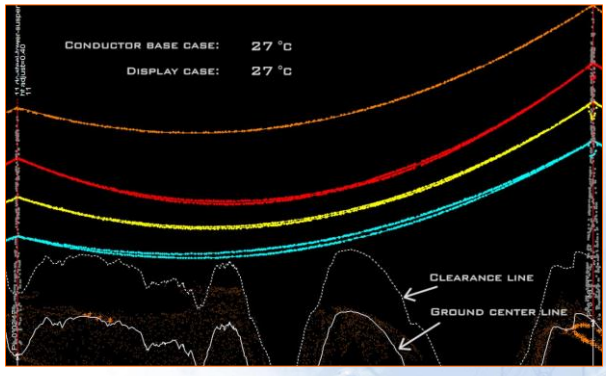
- Establish accurate conductor base temperature at time of data collection

Reasons:

- Wire sag varies greatly with temperature
- Wire temperature affected by weather conditions and load
- Link catenary shape of the LiDAR data to the temperature of the wire model

Considerations:

- Effect of elevation change
- Wind incidence angle

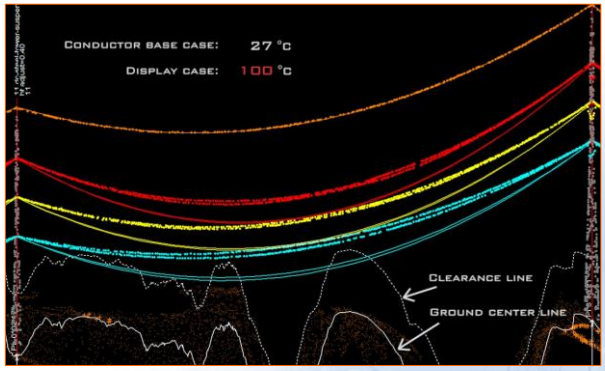


Thermal Rating Procedures

Conduct rating analysis to verify the
Maximum Thermal Operating Capacity

- Increase conductor temperature until first clearance violation(s) occurs
- Create violation reports at various temperatures
- Conduct vegetation encroachment assessment
- Examine encroachments to other man made structures (buildings, signs, etc.)
- Provide upgrade recommendations
- Develop digital drawings

Prepare and Deliver Final Thermal Rating Report to Client



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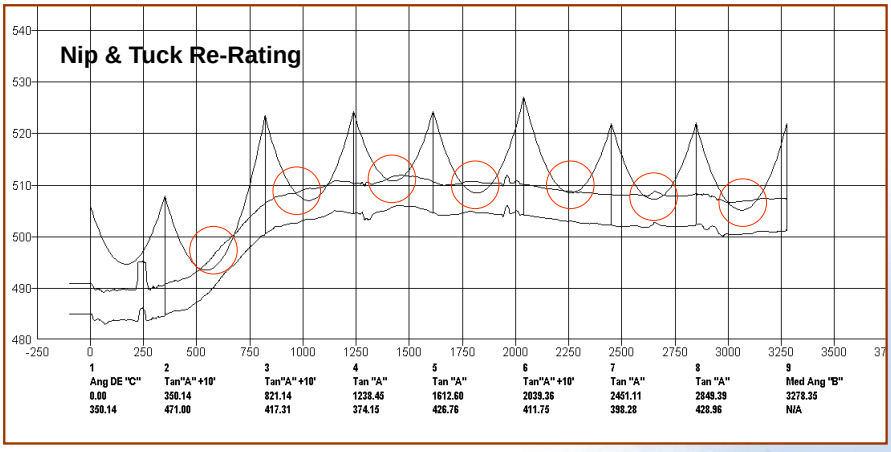
Upgrade Engineering

Several methods in the "Tool Box"

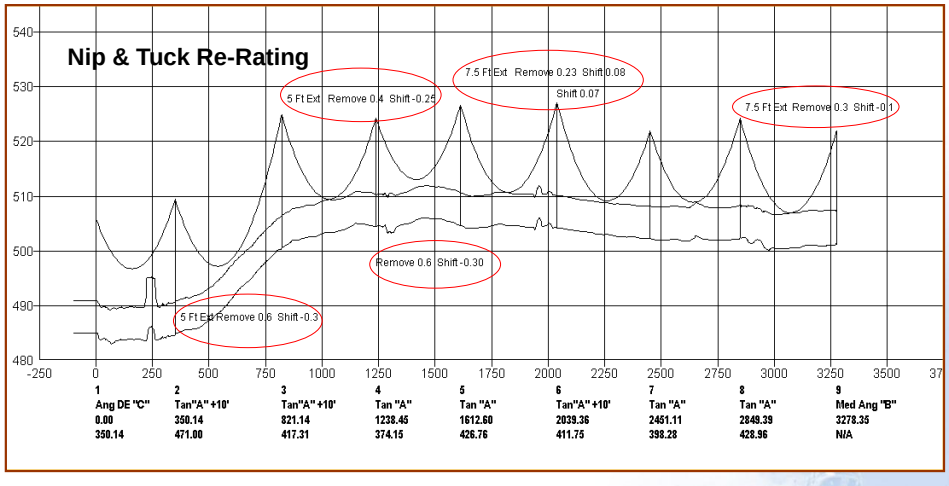
1. Nip&Tuck™ Method where violations are eliminated by span-by-span re-sagging
2. Wire re-tensioning
3. Structure Modifications
   1. Steel – Tower Extension
   2. Wood – Phase Raiser
4. Structure additions
5. Conductor replacement

Upgrade Engineering



Sample section violates clearances in 7 of 8 spans at 100°C rating

Upgrade Engineering



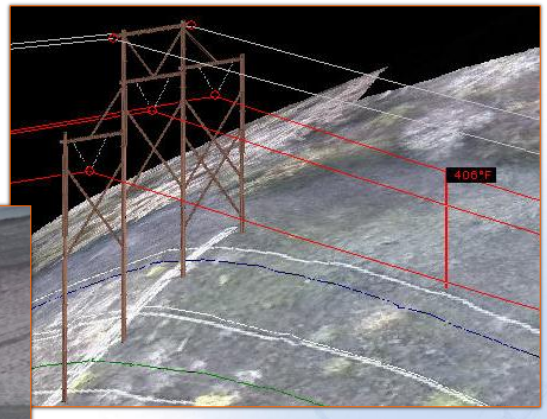
Section upgraded to 100°C temperature with 6 Nip&Tuck operations and 4 tower extensions on strategic structures to regain clearance

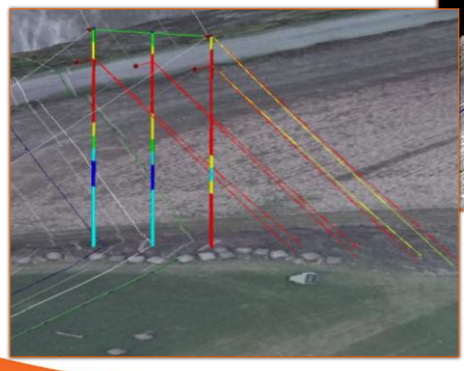
Upgrade Engineering

Re-Rating

- Develop criteria for optimum re-rating opportunity

IE: Conductor tension, structural & foundation loads, etc.





Upgrade Engineering

Structural Modifications

- Phase Raisers®

Upgrade Engineering

Structural Modifications

- Tower Extensions

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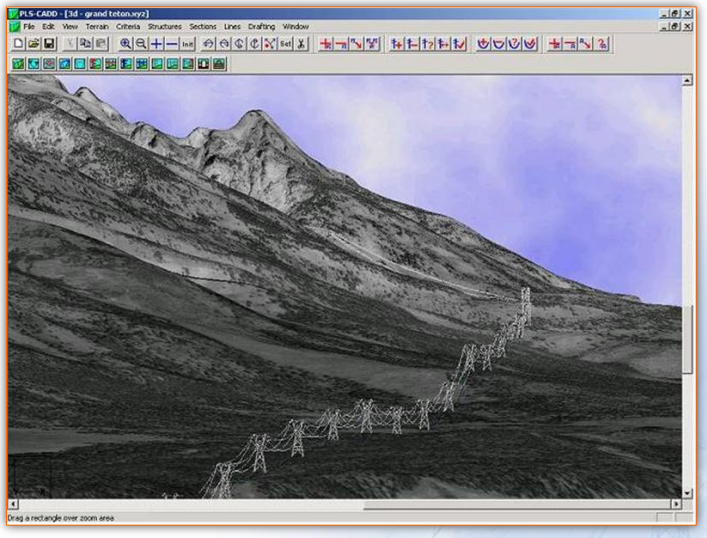
- Environmental Applications
- Danger Tree & Vegetation Studies

Transmission Line Engineering

Transmission Line Design

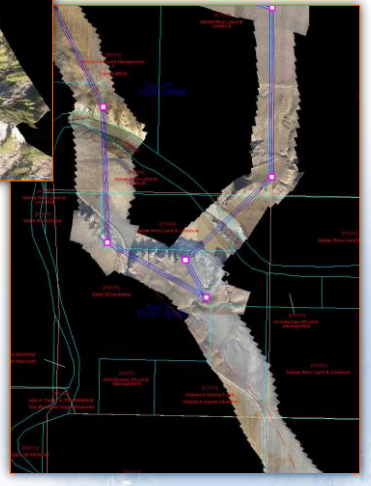
- Complete design, survey, optimization package. Brings all technologies together.
- Optimal structure locating module
- Provides lowest cost transmission solution
- Multiple route analysis and presentation

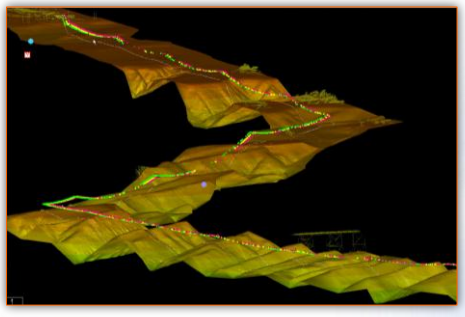


New Route Surveys

Transmission Line Layout

- Highly Accurate Terrain Model
- Flexible layout tool
- Facilitates route changes
- Allows use of optimization tools in PLS-CADD



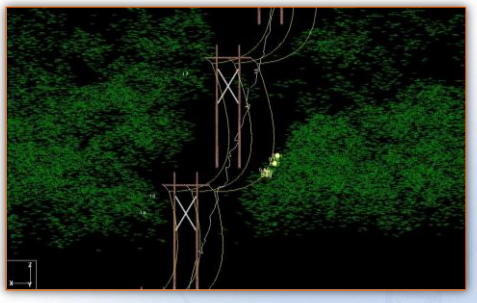


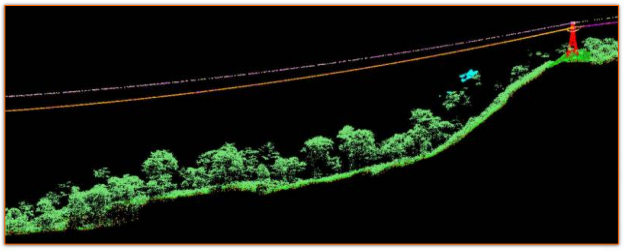
Overlaid Ortho Imagery and Parcel Mapping

Danger Tree & Vegetation Study

Vegetation Assessment

- NERC Standards FAC-008, 003 and NERC Facilities Alert
- Height of vegetation along ROW
- Proximity of vegetation to O/H wires
- Identify and locate Danger Trees
- ROW clearing management





EXPERIENCE:
Using LiDAR since 1998
Using a variety of LiDAR providers
PLS-CADD & TL-PRO

EXPERTISE:
Creating "As-Built" line model
Re-Rating Analysis
Transmission Line Design
Upgrade Solutions

BENEFITS:
Experienced Engineers
Tried & Proven Solutions
World Wide Project Experience

WIRE SERVICES

Providing Utility Solutions from a Utility Perspective

WIRE SERVICES

Questions?