

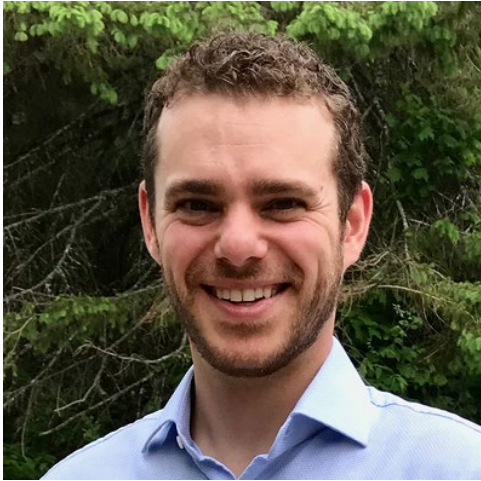


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Transmission Line Conductor Asset Health Assessment with Non- Contact Monitoring Technology

Paper Authors



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Introducing LineVision



Unleashing the full potential of the grid with advanced sensors and analytics

- Patented and proven non-contact sensor technology with systems deployed worldwide
- No outages or specialized equipment required
- Turnkey system for ease of integration



Why Monitor Transmission Line Asset Health?



Do you know the condition of your transmission lines?

Over half of the transmission lines in operation are more than 35 years old¹

Make informed decisions based on the actual line health condition

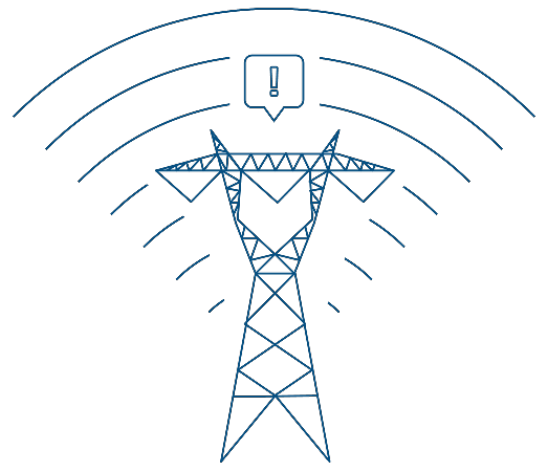
Extend condition-based asset management to conductors for increased grid reliability & safety



1. The Brattle Group, "Investment Trends and Fundamentals in US Transmission and Electricity Infrastructure", July 17, 2015.

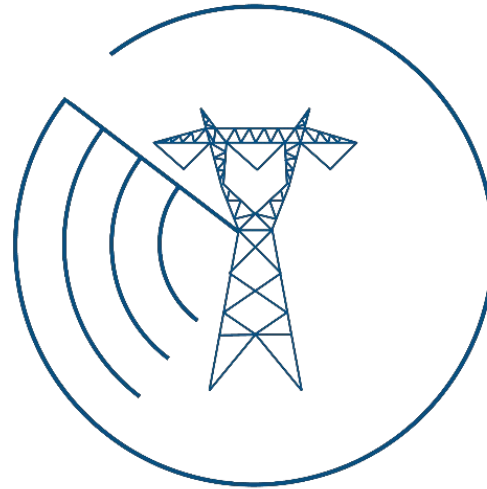
LineAware™

SITUATIONAL AWARENESS



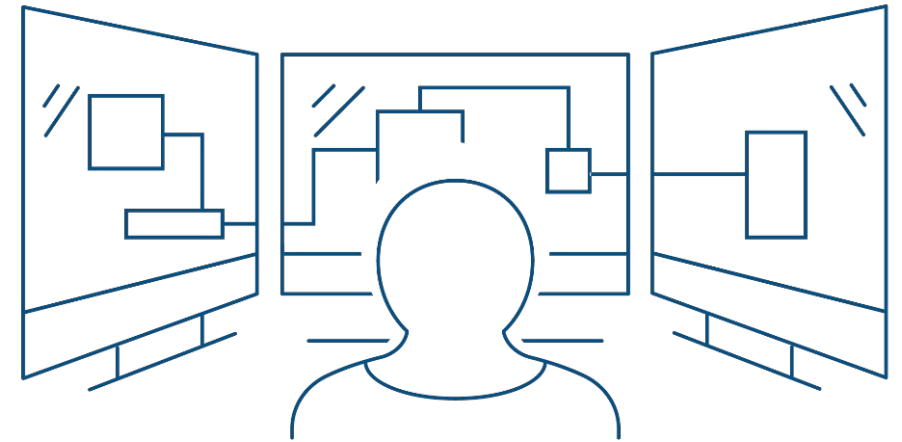
LineRate™

DYNAMIC LINE RATINGS



LineHealth™

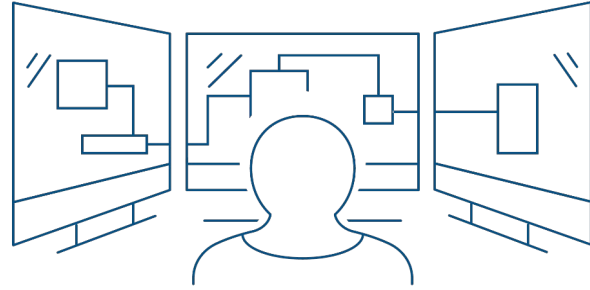
ASSET HEALTH MONITORING



Leveraging the Conductor Digital Twin



LineHealth



Improve asset management strategies by creating a digital twin to determine conductor health.

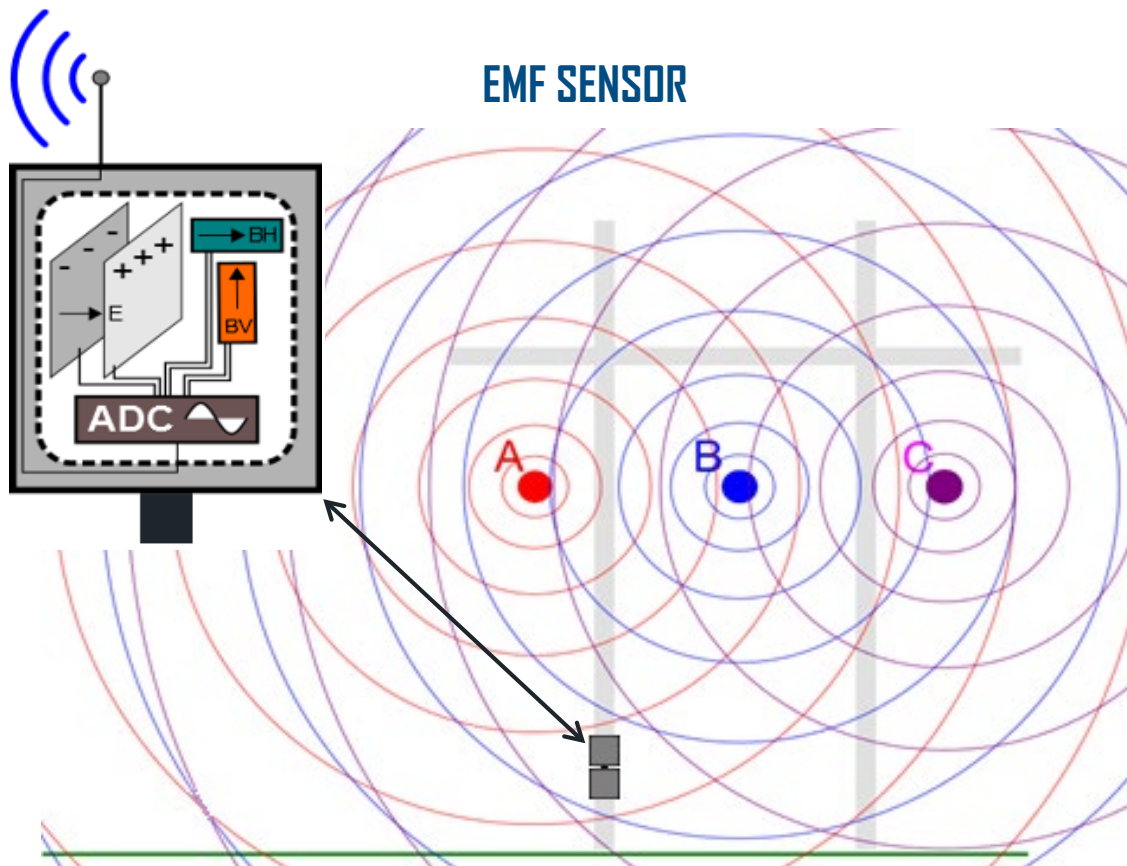
Model analyzes historical loading and weather data to assess previous damage.

Realtime monitored information is used to determine the current health.

Output:

1. Thermal aging analysis from historical high temperature exposure
2. Remaining tensile strength
3. Projected conductor end of life
4. Initial vs actual sag assessment
5. Icing Detection: Ice weight accumulation & maximum tension
6. Galloping Detection: Amplitude, frequency & maximum tension
7. Recommended safe operating limits

V3 Sensor Technologies

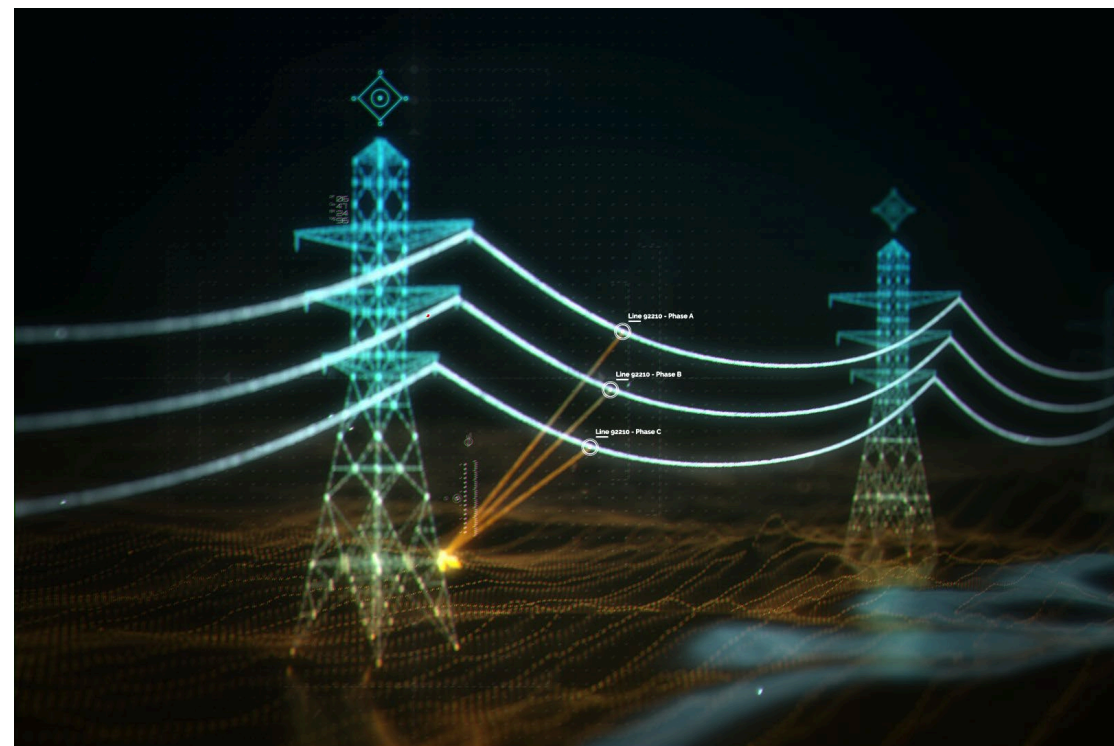


EMF SENSOR

EMF & Optical Sensors Independently Have:

- Edge computing with device health metrics
- Battery power with solar charging
- LTE or satellite data transfer

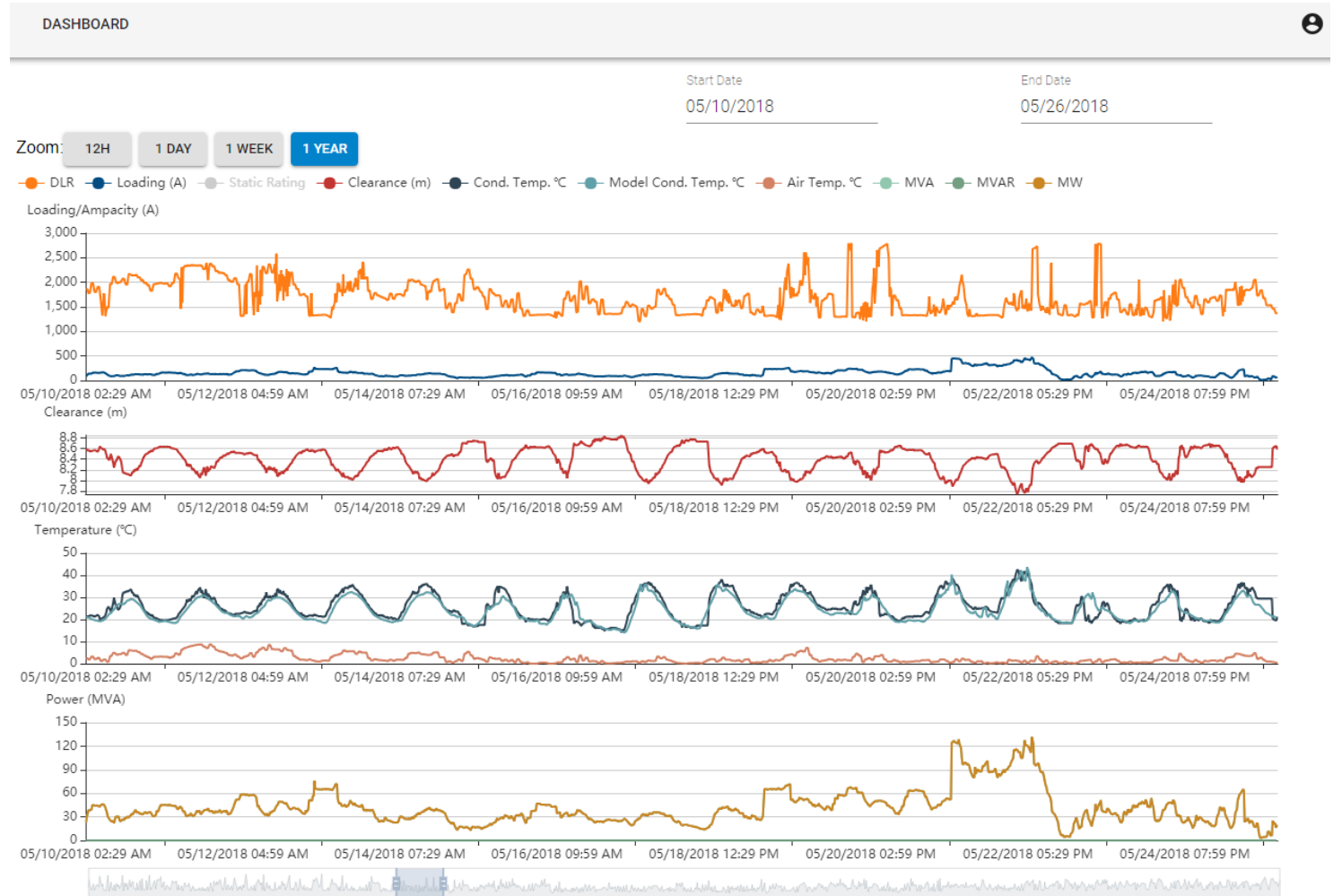
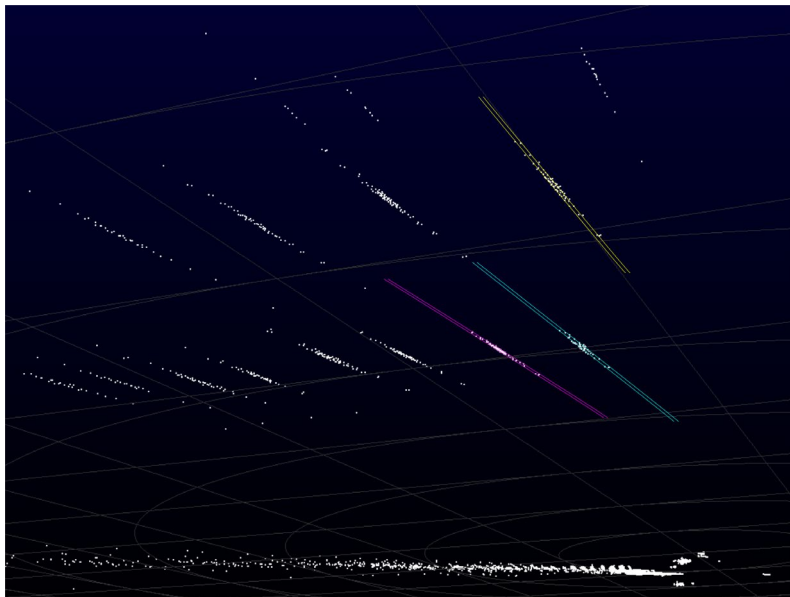
SCANNING OPTICAL SENSOR



Methodology :

1. Measure fixed conductor heights at the insulators
2. Continuously scan in-span position of conductors
3. Reconstruct catenary shape / calculate sag

Optical Point Cloud Capture and Analysis



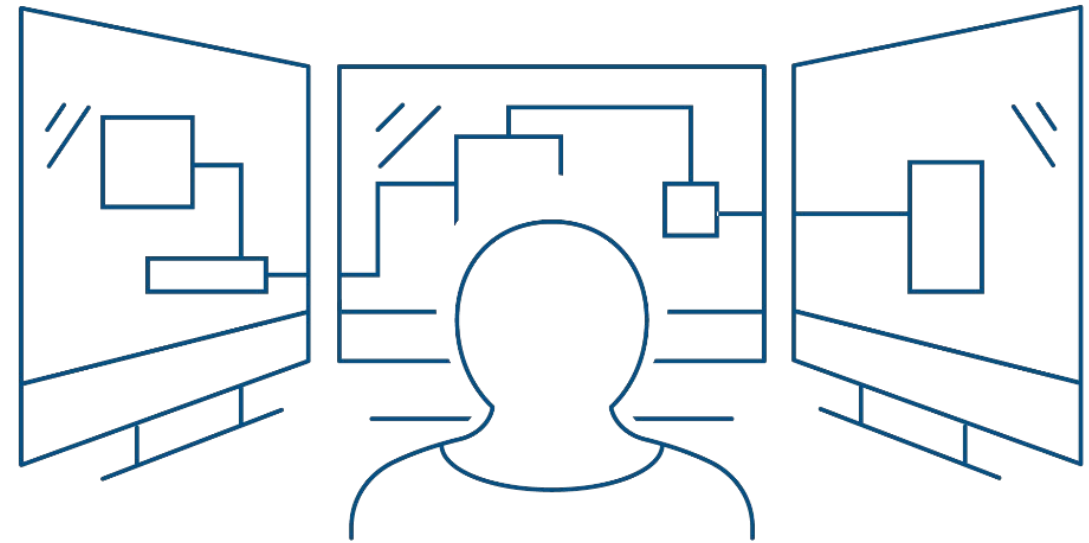


LineHealth – Conductor Asset Health Model



Sub-Models

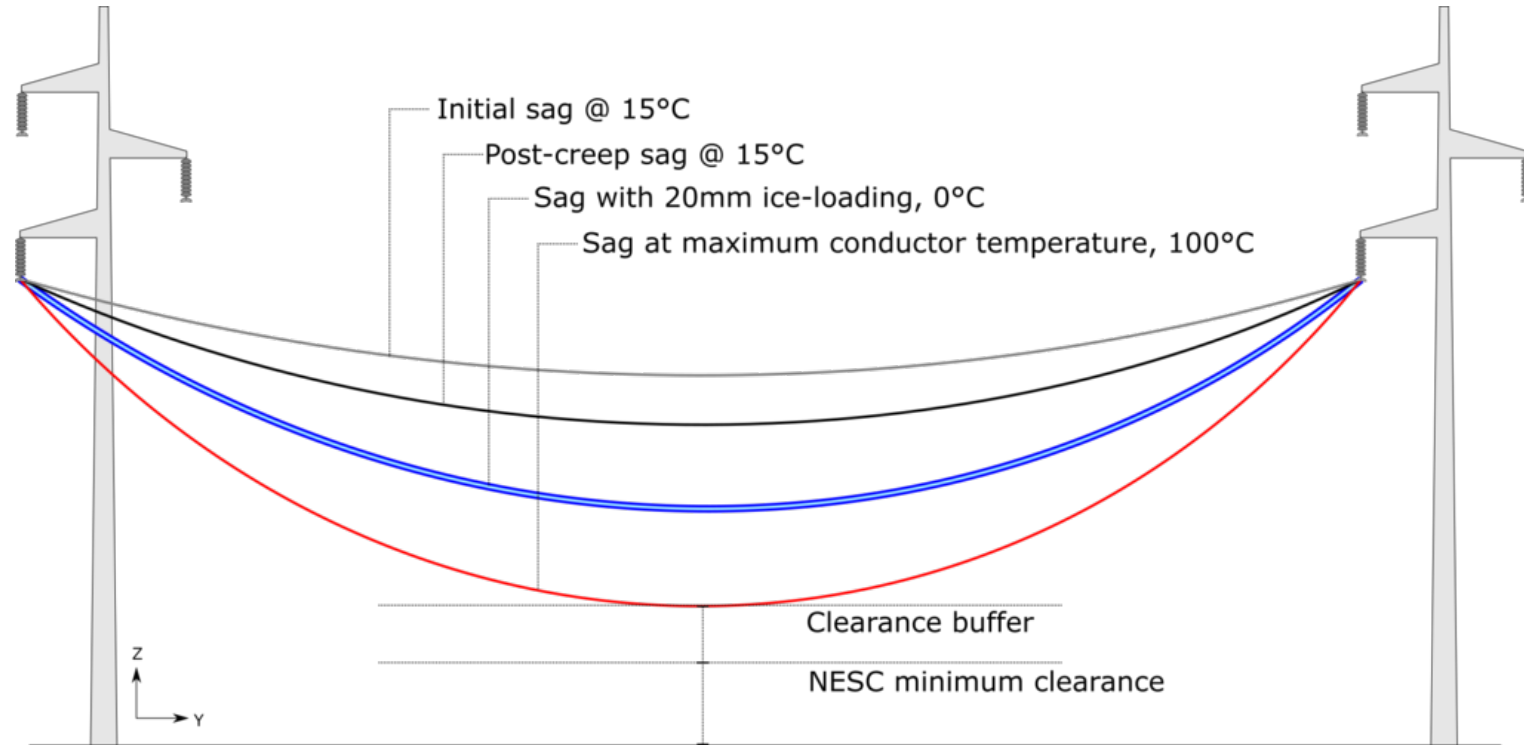
1. Thermal Aging Analysis
2. Historical Sag Estimation
3. Conductor Elongation Evaluation
4. Anomalous Motion Detection
5. Precipitation Overload Detection
6. Galloping Detection



LineHealth - Model Inputs



1. Engineering Design Criteria
e.g. Tension & Sag
2. Historical Loading Data
3. Historical Weather Conditions
4. V3 System Measurements

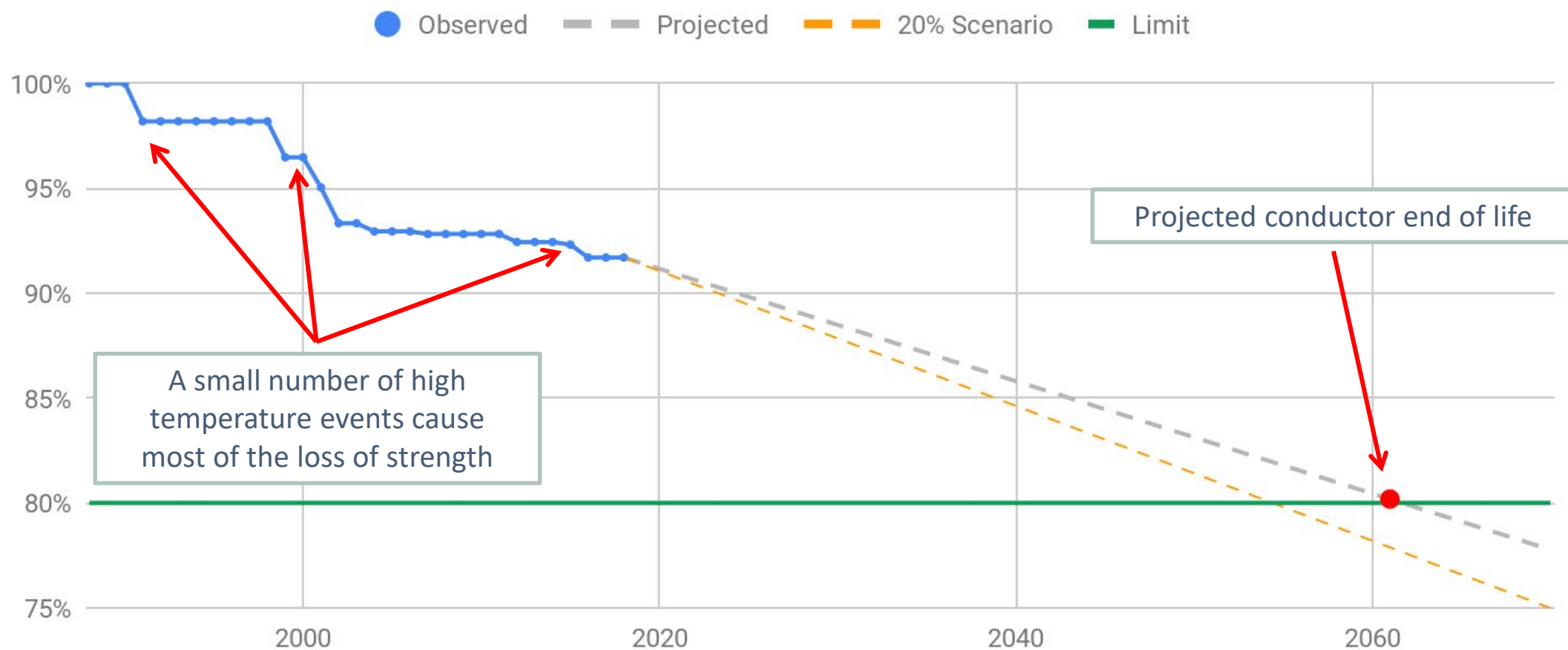


Thermal Aging Analysis



Elevated conductor temperatures cause annealing, resulting in loss of conductor strength.

Using industry standards, LineHealth computes the conductor strength loss over its lifetime and the end of life can be projected based on thermal aging history.



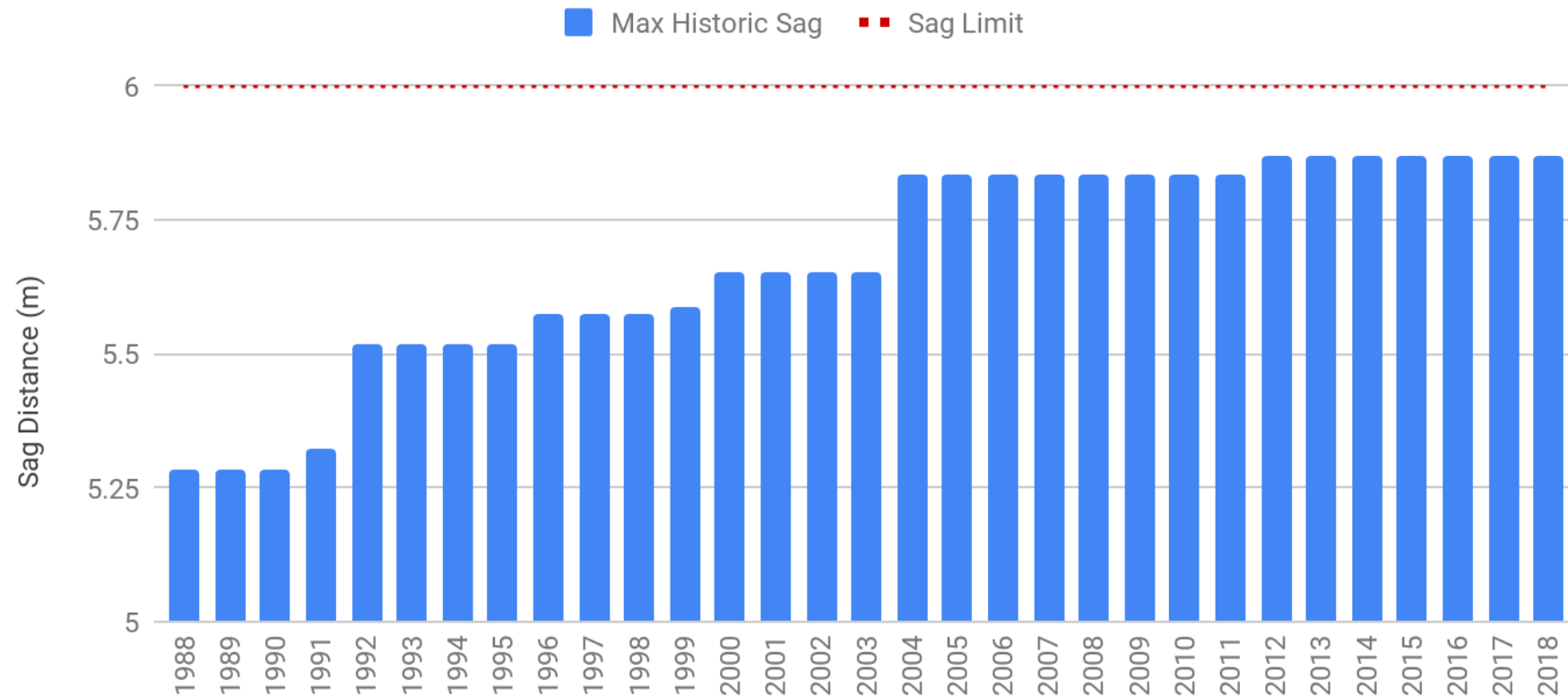
Historical Sag Estimation



Estimate the historical maximum sags from high temperature events.

- Excessive sag could indicate plastic deformation
- Data driven corrective actions *i.e.* re-tension
- Continuously monitor for new changes

Max Historical Sag

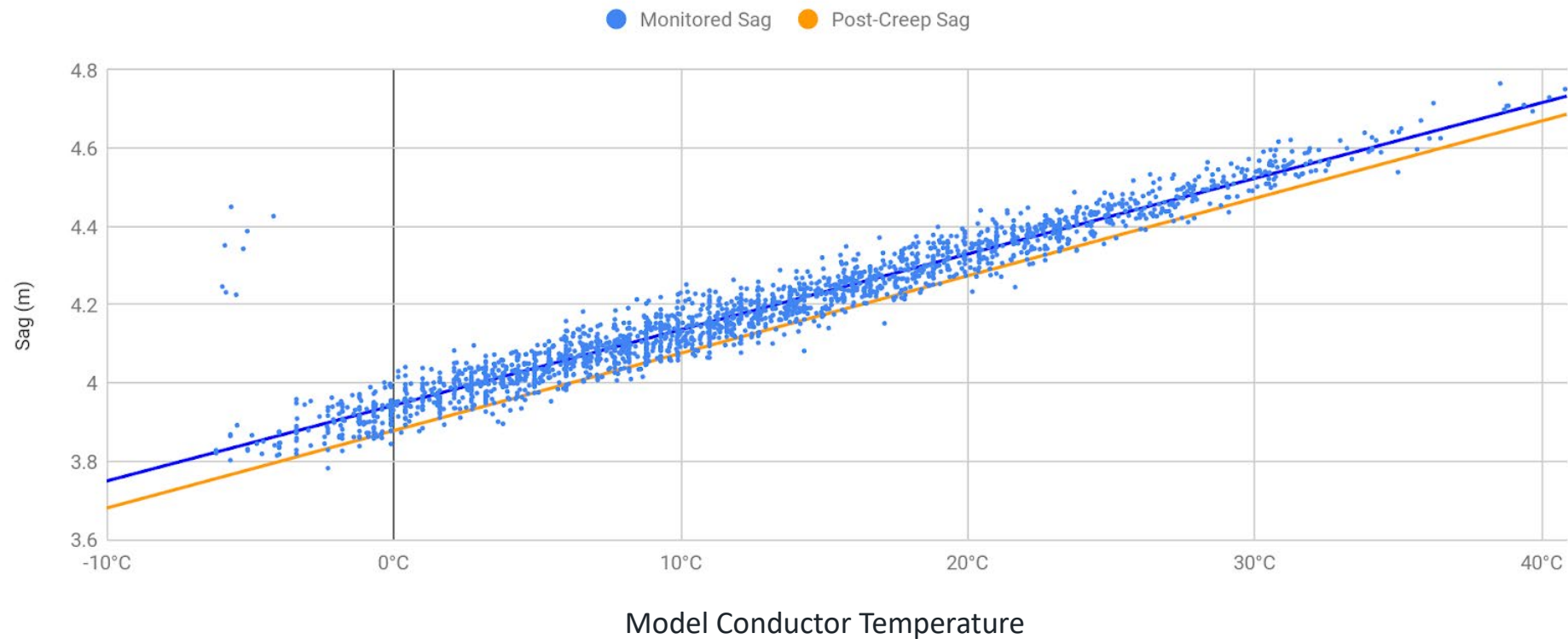


Conductor Elongation Evaluation



Monitoring reveals deviation from design sag-temperature, suggesting elongation.

Monitored Sag vs Design Sag



Sag has increased 17cm @ 15°C, compared to post-creep sag

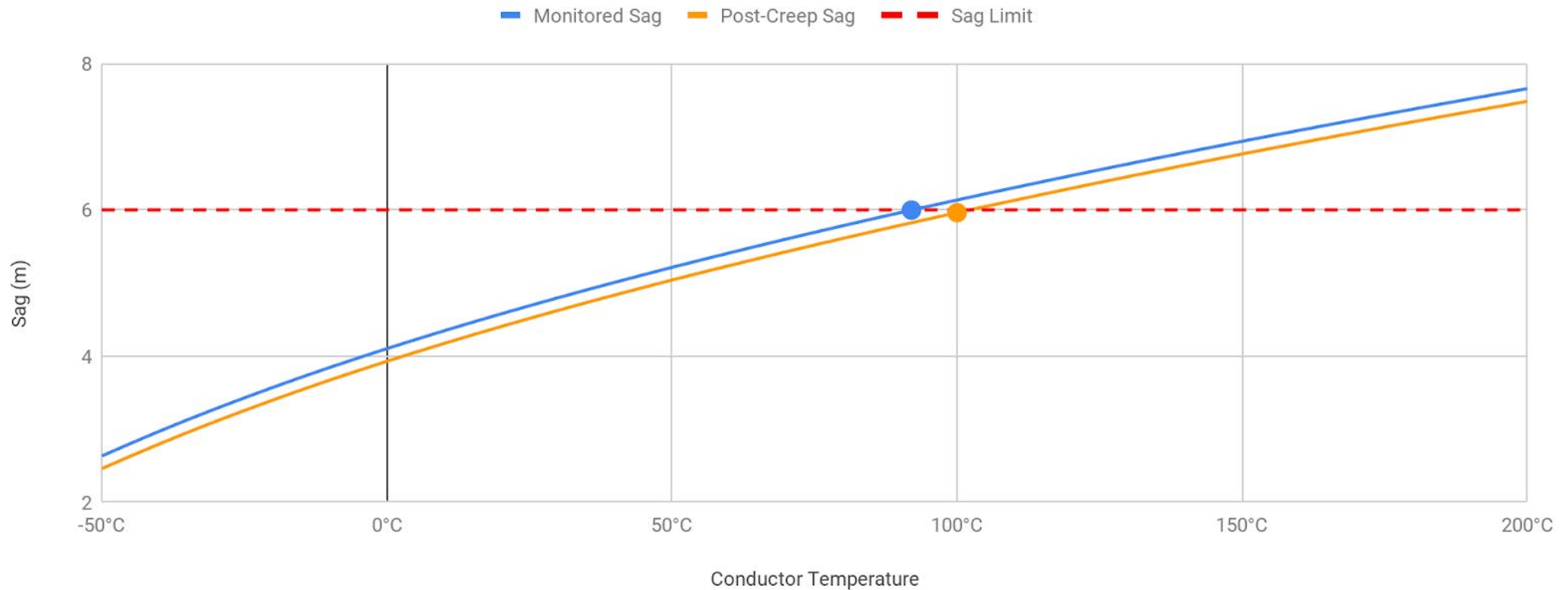
Conductor Elongation Evaluation



Operating Limit Recharacterization

If the line is limited by clearance, we can calculate the *new* limiting conductor temperature. Sag Limit of 6m will be reached at 92 degrees vs the design of 100 degrees.

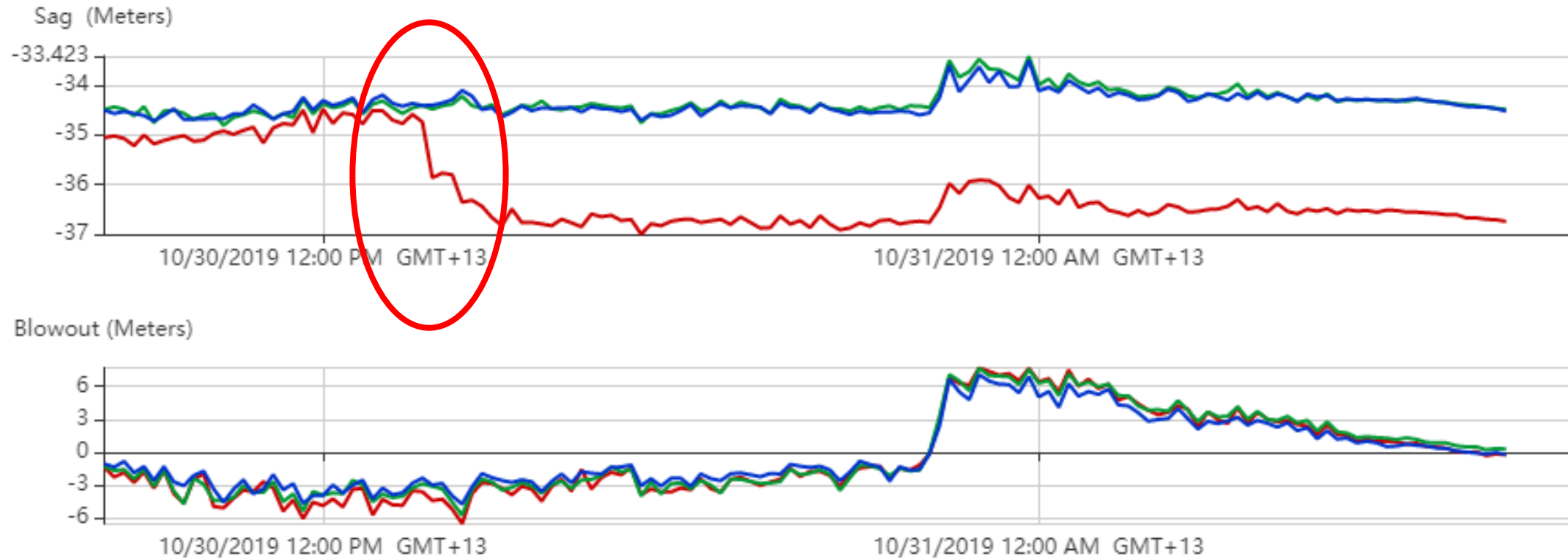
Monitored Sag Extrapolated vs Design



Anomalous Motion Detection



Digital twin model computes the expected conductor position and alerts upon discrepancies.



Anomalous motion of a single phase detected.

Alerts sent to operators.

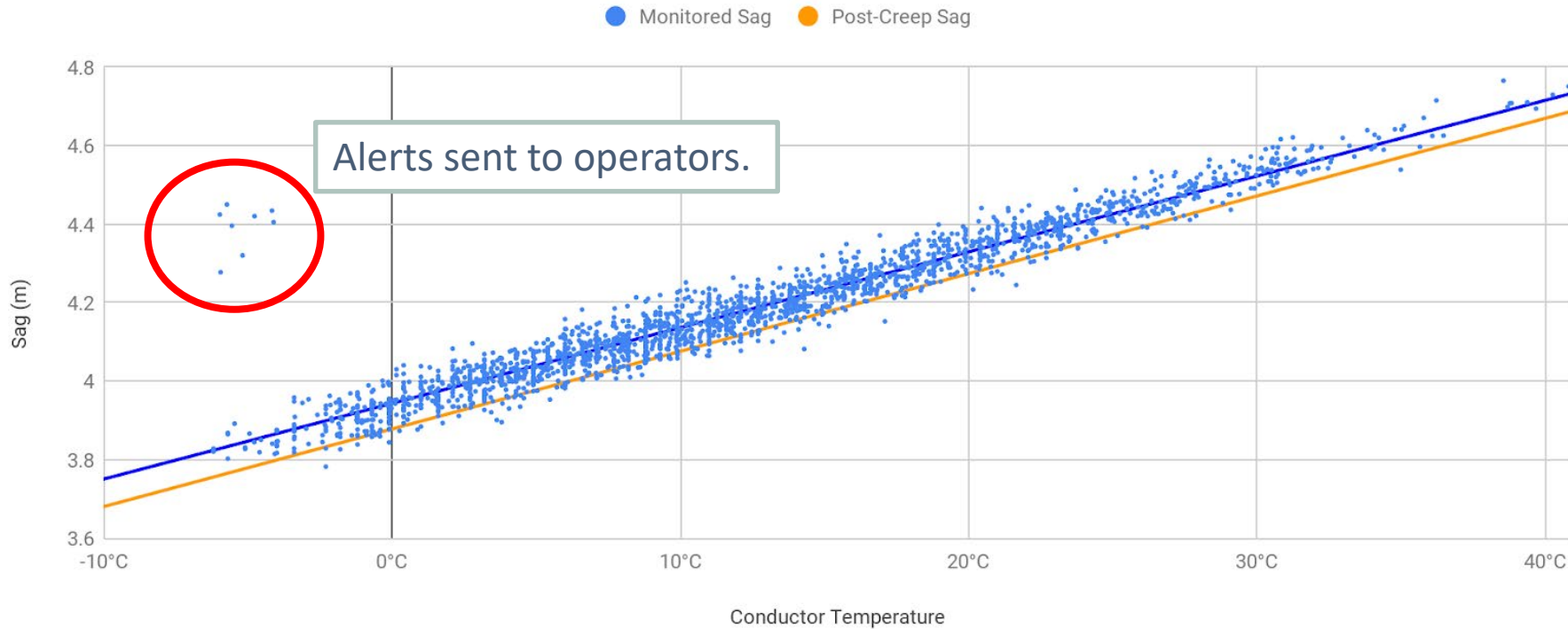
Precipitation Overload Detection



V3 Monitoring has identified the following precipitation overload events in the last 6 months:

Date/time	Duration	Max Observed Sag	Expected Sag	Sag Deviation	Ice Weight / meter	Event Tension (N)	Conductor Temperature
1/20/2019	2hrs	4.45 m	3.97 m	0.48 m	14.58 N/m	26,514.40 N	-5 Degree C

Monitored Sag vs Design Sag



Icing weight per meter & maximum tension calculated.

Shield / ground wire icing is also detected.

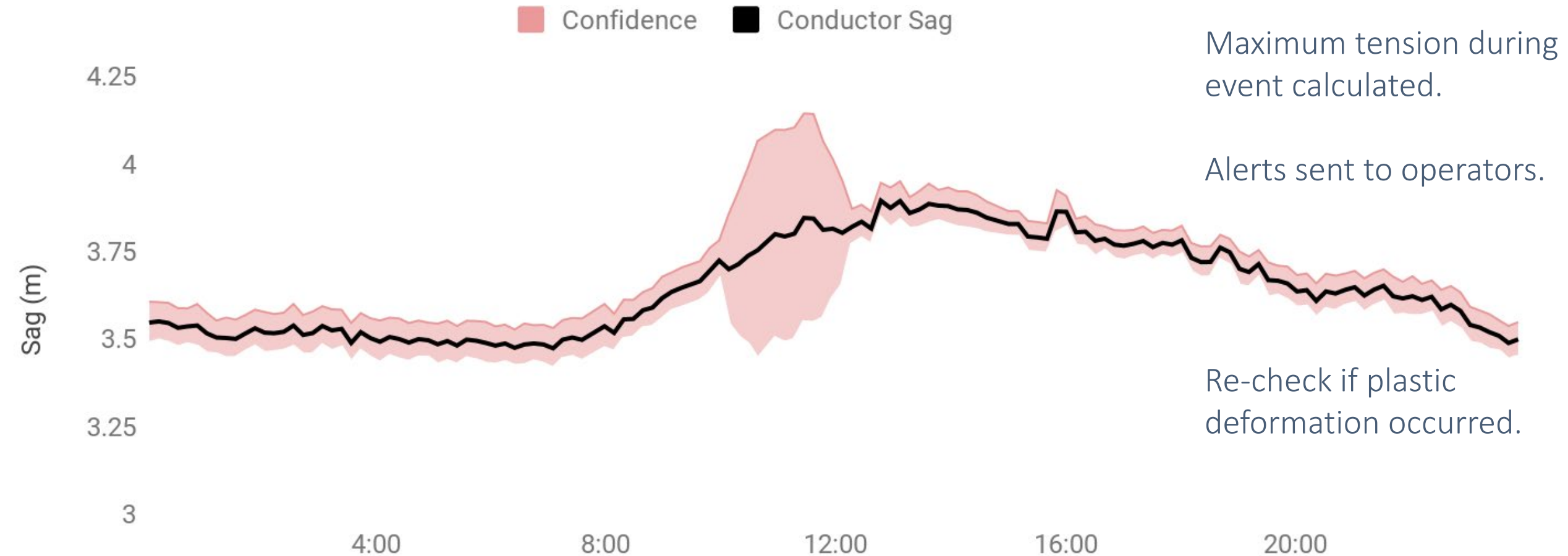
Re-check if plastic deformation occurred.



Galloping Detection

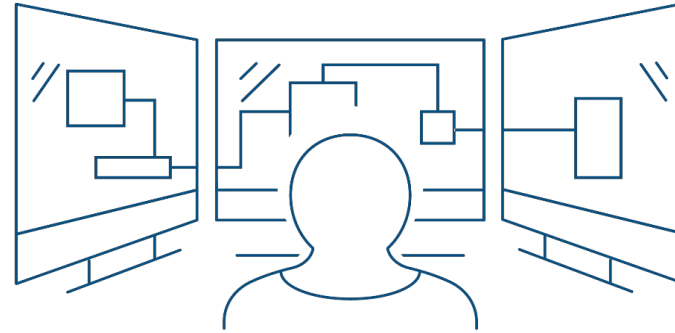


Variation in max and min observed sag in short periods of time that coincide with periods of elevated wind speeds indicates galloping could be occurring.



LineHealth

Utilizing digital twin technology to improve transmission reliability.



Questions welcome!

For further information contact:
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