The Creation and Practical Use of a Digital Twin of a Conveyor System

SME Conference 2019 – Denver, Colorado

26 February 2019 – Paul Ormsbee – General Manager, Overland Conveyor Company

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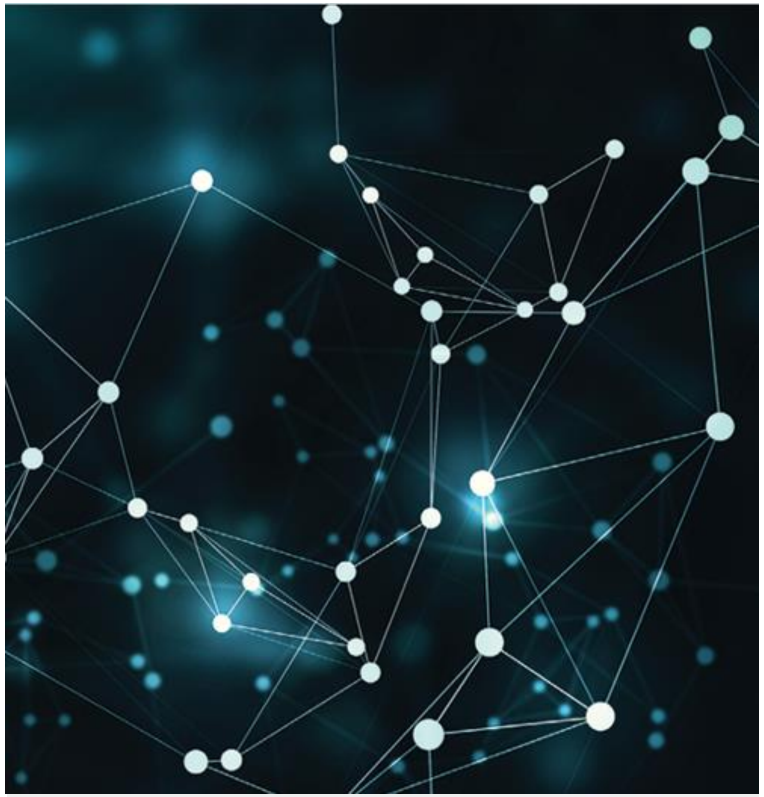
Agenda

- What is a digital twin?
- What makes an effective digital twin?
- Defining a digital twin for a conveyor
- Real-world use cases and examples



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What is a Digital Twin?

A dynamic virtual representation of a physical object or system across its lifecycle, using data to enable understanding, learning and reasoning.[1]

Data Model

- describe each system asset

Analytics

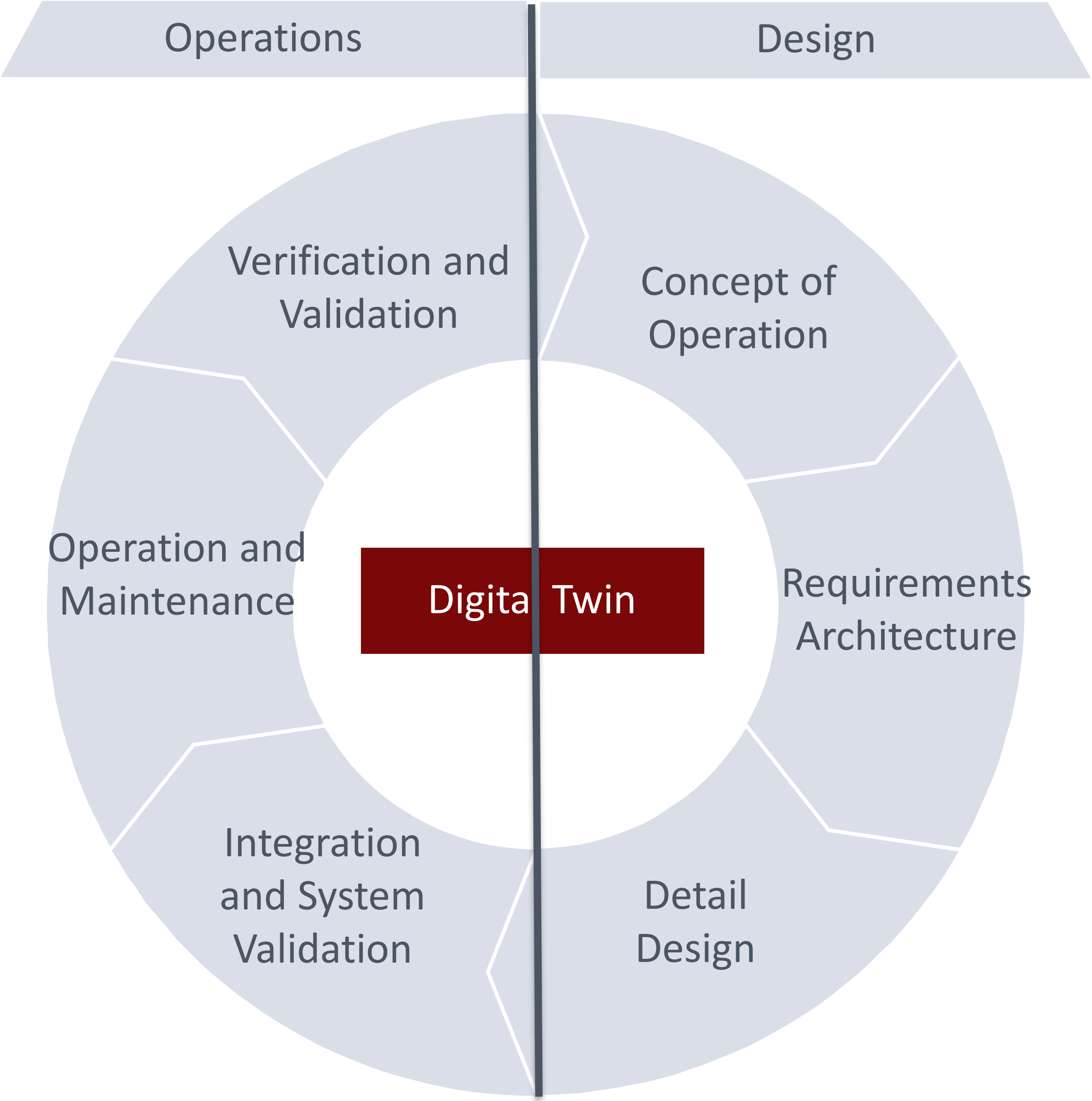
- Physics and AI/ML models

Knowledge Base

- Expertise, data, best practice rule-sets

[1] Bolton, McColl-Kennedy, Cheung, Gallen Orsingher, Witell & Zaki, 2018

An Effective Digital Twin



- An effective digital twin creates a useful link between the design and operations of a machine.
- The design of the machine is continually evaluated and updated to result in improvements towards the operation.
- Create a concrete understanding of the effect that each change to the design has on the operating characteristics of the machine

Digital Twin of a Conveyor System

Build a complete digital representation of the system of the mechanical components of a conveyor and their operation

Customer Value …

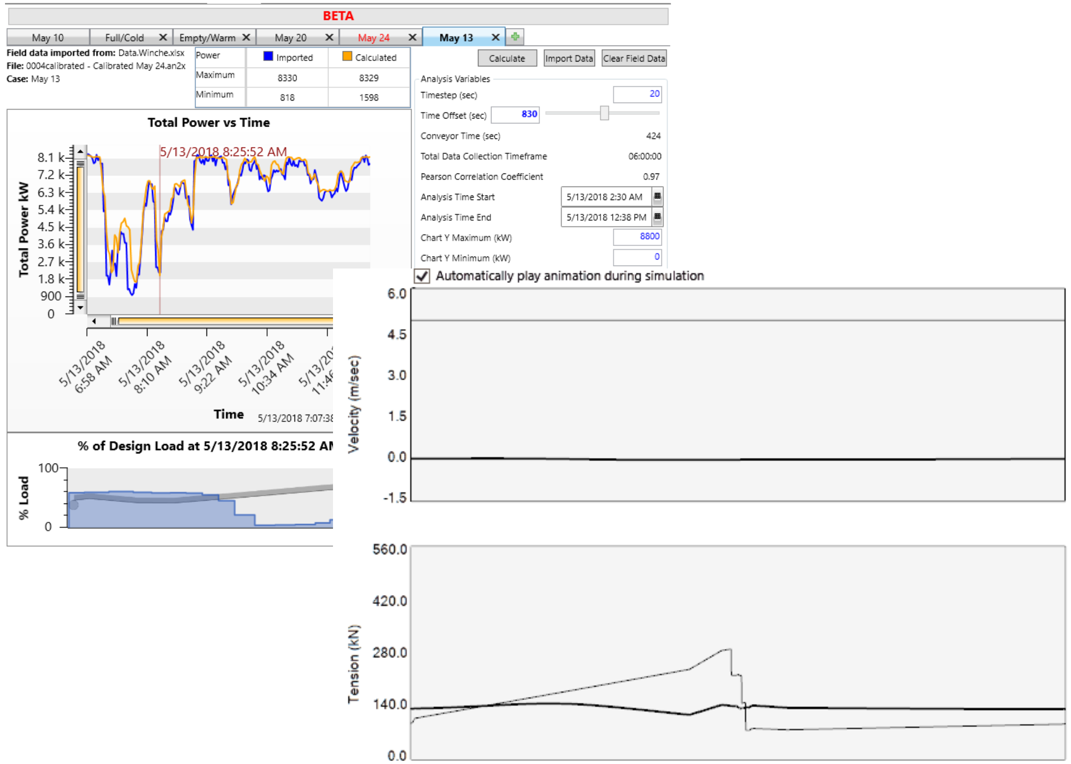
1. Increasing Efficiency / Reducing Power / Reducing CAPEX
2. Reducing UNPLANNED Downtime / Increasing Equipment Availability
3. Increasing Component Life / Reducing Required Maintenance
4. Optimizing Spare Inventory

Digital Twin of a Conveyor System

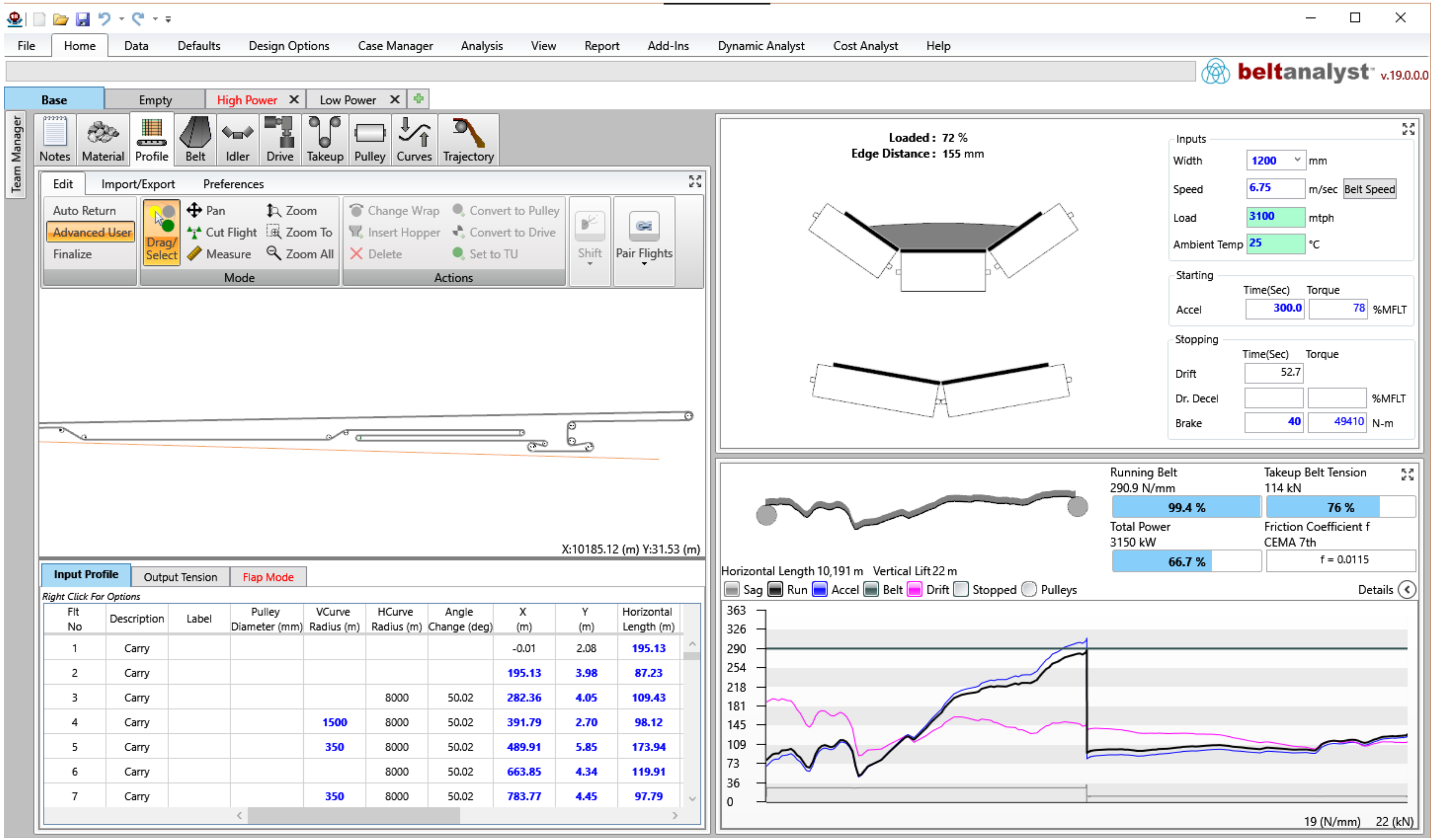
Build a complete digital representation of the system of the mechanical components of a conveyor and their operation

We do this by …

- Mathematical modeling of engineered components and component systems
- Design optimization and component selection for predicted operating conditions
- Active monitoring and continual simulation of calibrated models to ensure design and reality are in-scope



beltanalyst™ As The Framework for The Digital Twin



Data Model

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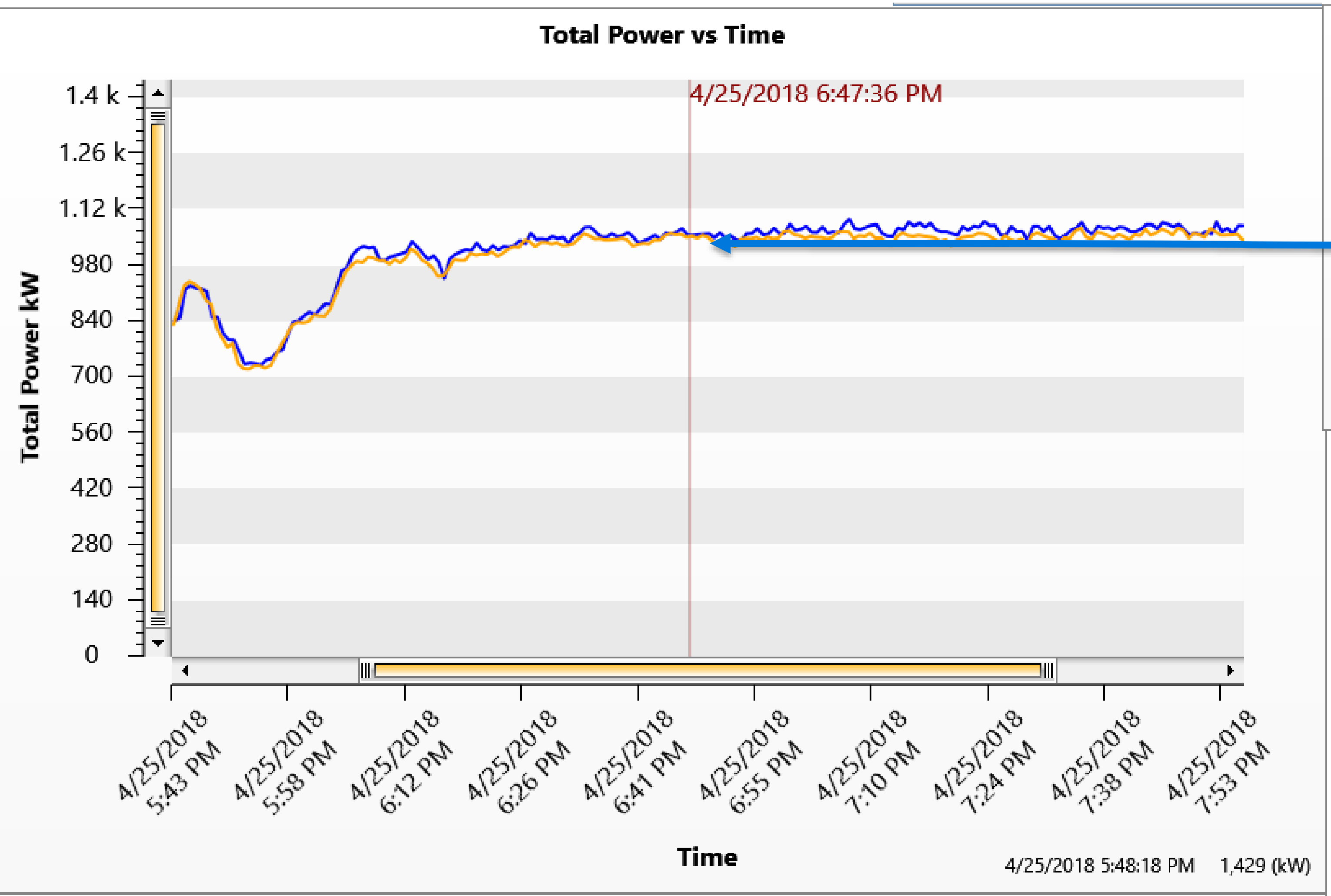
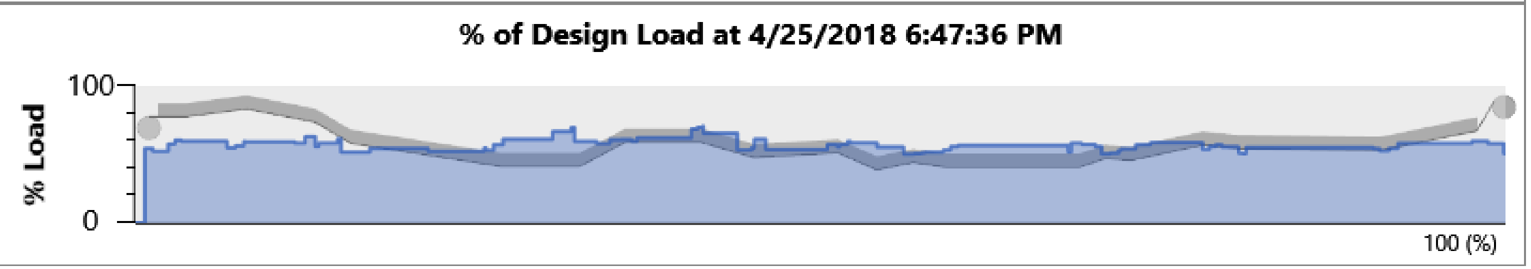
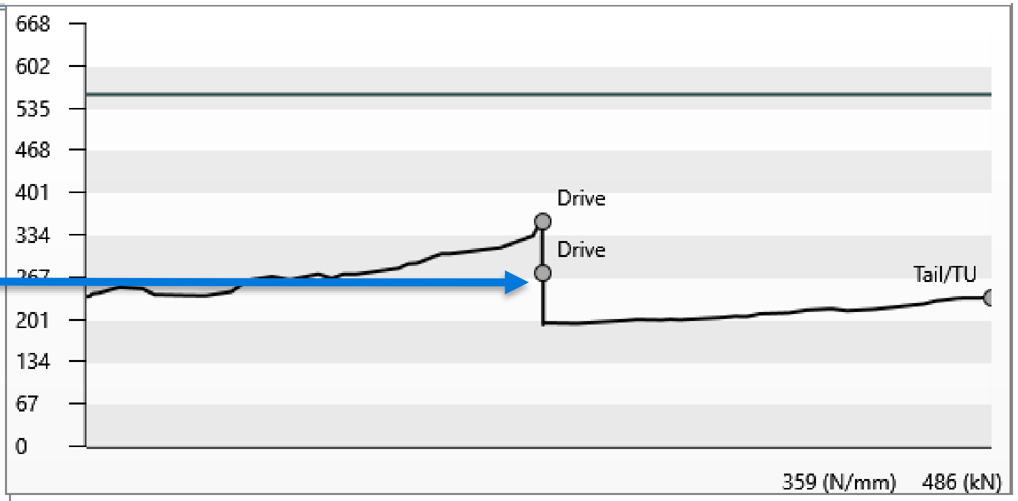




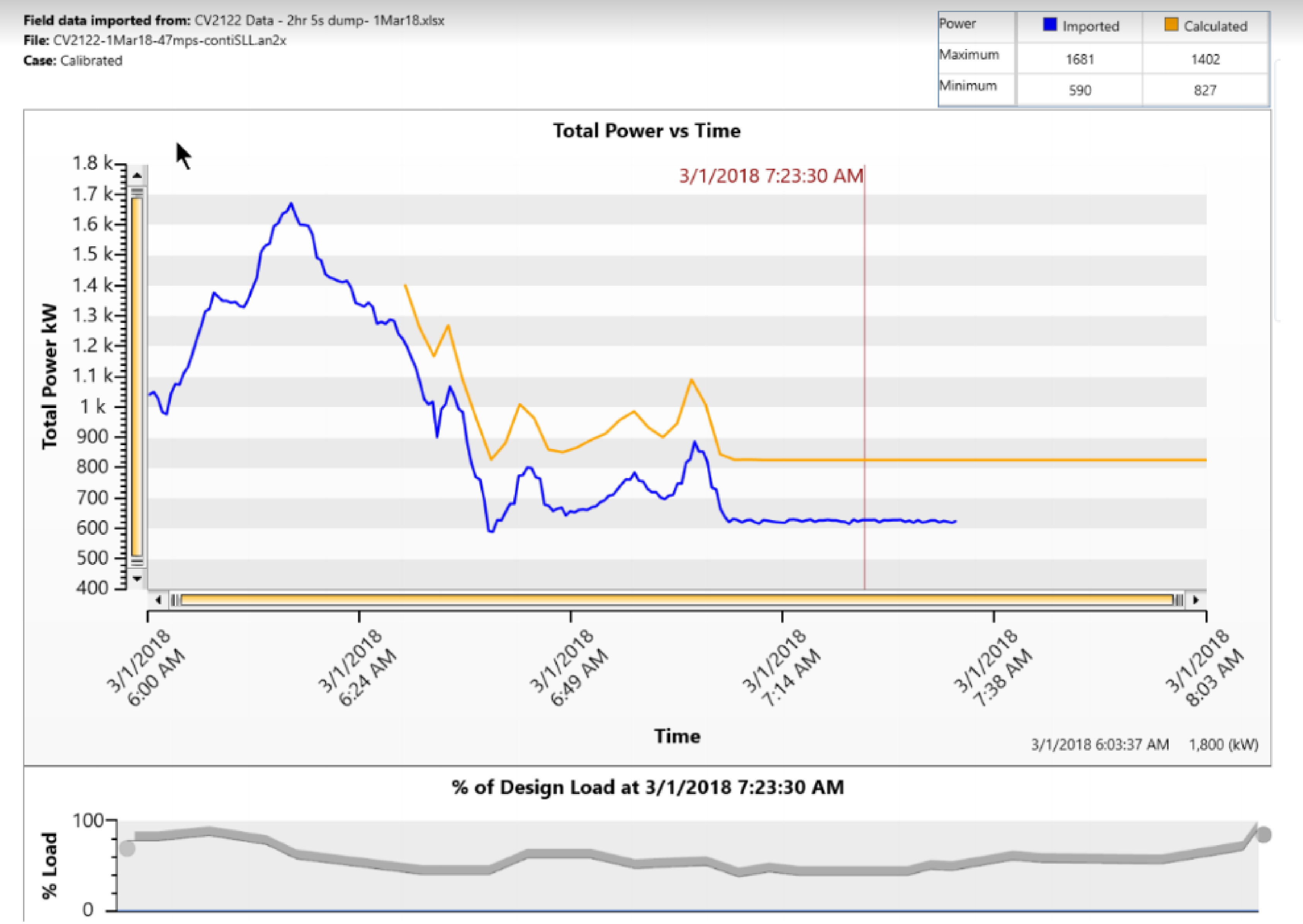
Belt Tension Diagram



- Field Data Can be Imported into the digital twin.
  - Power Demand/Torque over time
  - Conveyor Load/Belt Scale over time
  - More…
- The link between power demand, belt tension, and loads on all components of the conveyor can be determined
- Knowledge base can be used for evaluation

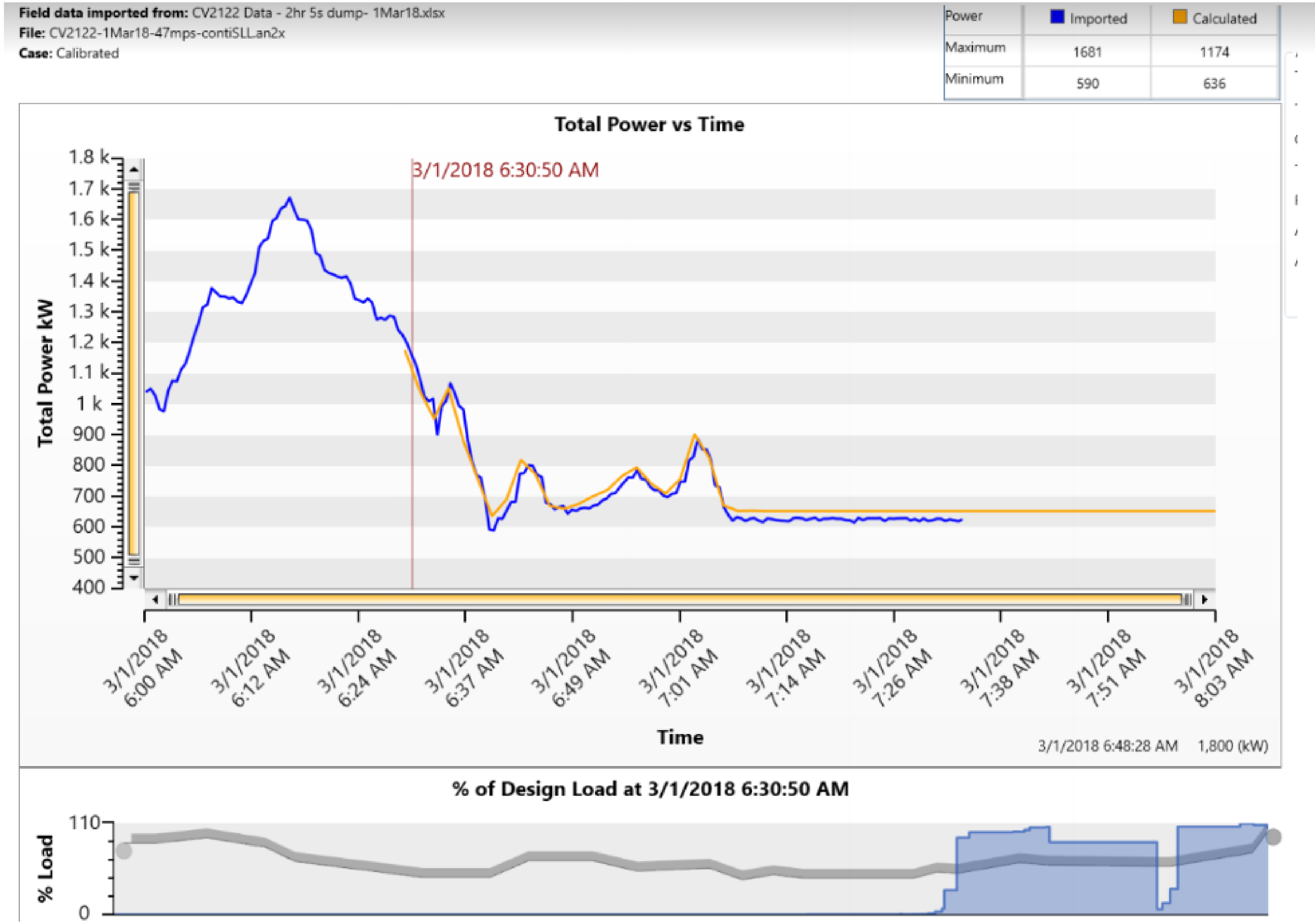
Use Case of a Conveyor Digital Twin- **Design Confirmation / Optimization**

- **Example of Design Confirmation**
  - 8.6 km / 1350mm BW / 4615 TPH / 6.0 m/s
  - 15,700 Rollers / 5,550 Frames to be aligned
  - ST3150 13x6 (Super Low Rolling Resistant Rubber)
- **Digital Twin**
  - **Design vs. Actual Comparison of Total Demand Power**
  - Data Collected 1 Mar 2018 6:00AM to 8:00AM
  - YELLOW LINE- Predicted Power
  - BLUE LINE- Actual Collected Data



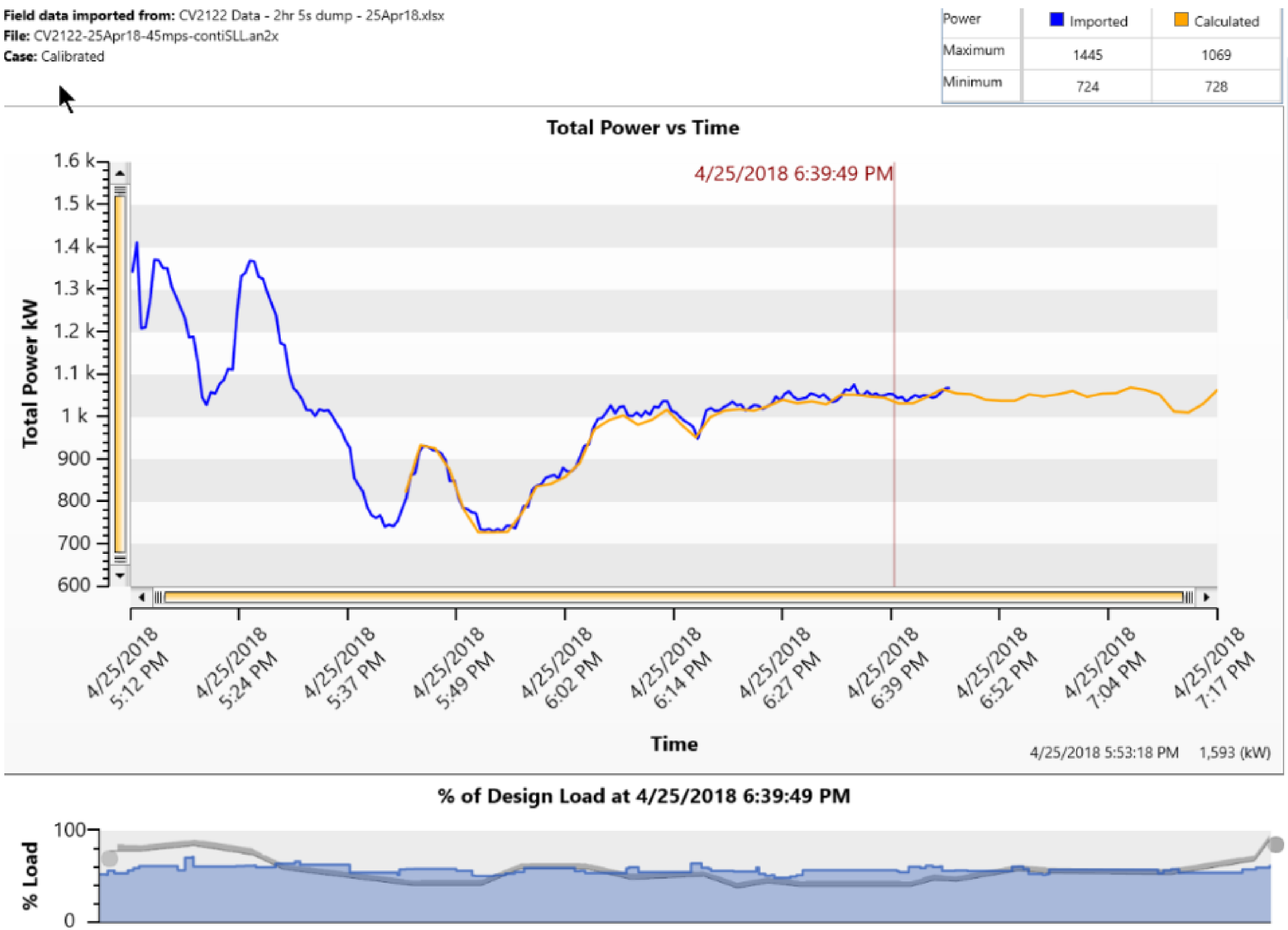
Use Case of a Conveyor Digital Twin- **Design Confirmation / Optimization**

- **Example of Design Confirmation**
  - Digital Twin
    - **Calibrated Total Demand Power**
  - Data Collected 1 Mar 2018 6:00AM to 8:00AM
  - YELLOW LINE- Predicted Power
  - BLUE LINE- Actual Collected Data



Use Case of a Conveyor Digital Twin- **Design Confirmation / Optimization**

- **Example of Design Confirmation**
  - Digital Twin
    - **Calibration Confirmed with Additional Data Analysis**
  - Data Collected 25 Apr 2018 5:12PM to 7:17PM (60% Loaded)
  - YELLOW LINE- Predicted Power
  - BLUE LINE- Actual Collected Data



Use Case of a Conveyor Digital Twin- **Design Confirmation / Optimization**

- **Example** **of Design Confirmation**
  - **Comparison of Design vs. Actual**
  - ***Worst Case***
    - Components Operating at 66% of Limits @ Design Tonnage
  - ***Typical Operation***
    - Components Operating at 62% of Limits @ Design Tonnage

	Design		Actual from Data	Projected Worst Case Current Operation
	High Estimate (0 Deg C)	Low Estimate (50 Deg C)	4.7 mps / 3600TPH 27 Deg C	6.0 mps / 4615 TPH 0 Deg C
Idler Drag (kN)	149.2	63.6	86.4	94.1
Belt Indentation (kN)	262.0	215.0	149.5	149.5
Alignment (kN)	84.0	47.2	40.5	40.5
Flexure (Sag) (kN)	4.8	5.8	5.7	5.6
Lift (kN)	13.8	13.8	13.8	13.8
Secondary (kN)	38.5	33.9	32.5	35.6
Composite “f”	0.0167	0.0111	0.0095	0.0097
% Nmpl kW	100%	73%	62%	66%

Use Case of a Conveyor Digital Twin- **Design Confirmation / Optimization**

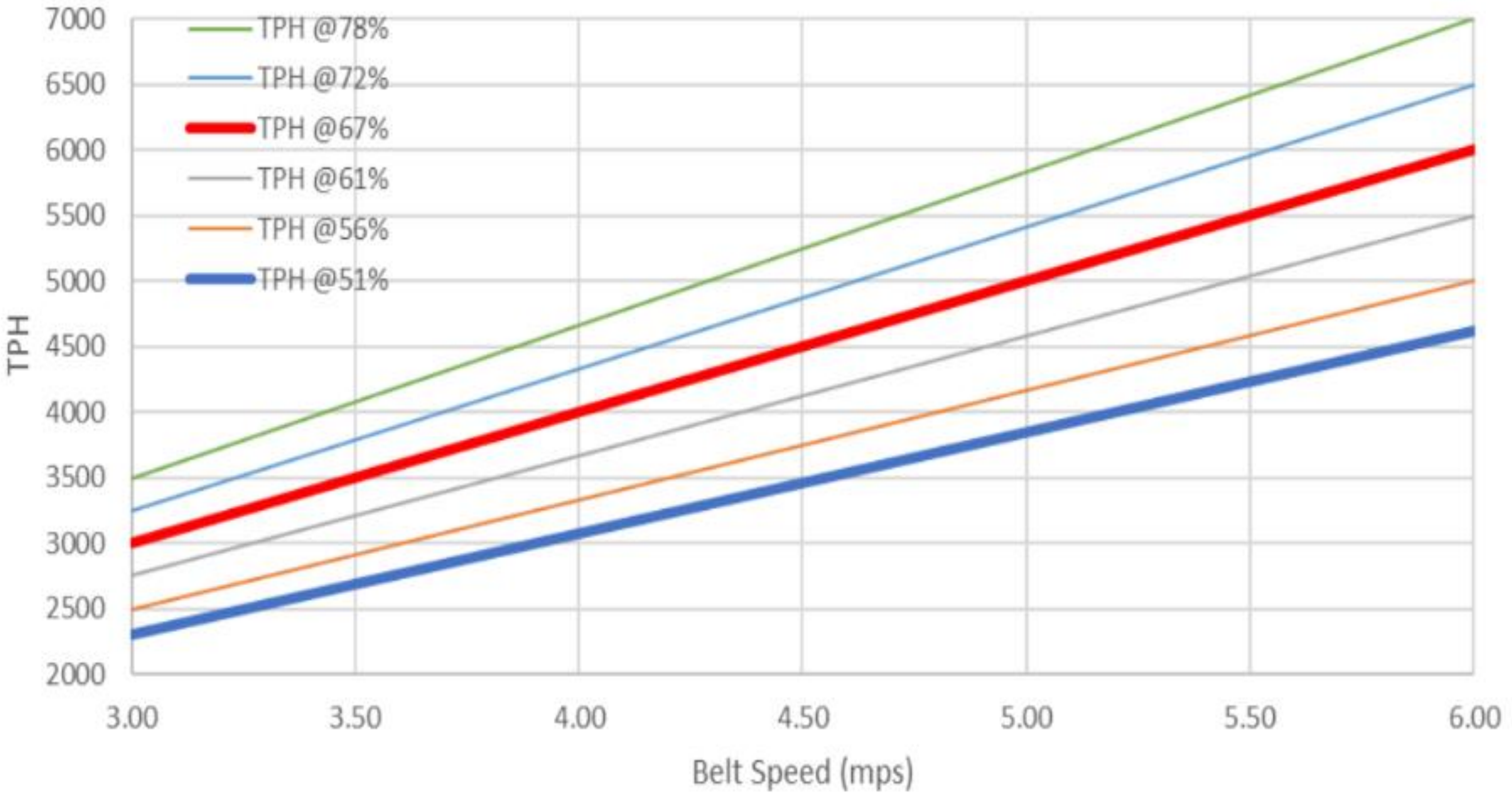
- **Example of Design Confirmation**

  1. **Used Digital Twin to Optimize Operation using Variable Speed**
  2. **Used Digital Twin to Find Optimal Tonnage Capacity with Existing Components**

  – ***Recommendations***

    – Speed can be varied between 50-100% (3.0 to 6.0 m/s) **(IMPLEMENTED)**

    – Maximum Throughout can be safely increased from 4615 (Blue line) to 6000 (Red line) TPH (**+30%**) without changing any components **(PLANNING TO IMPLEMENT)**



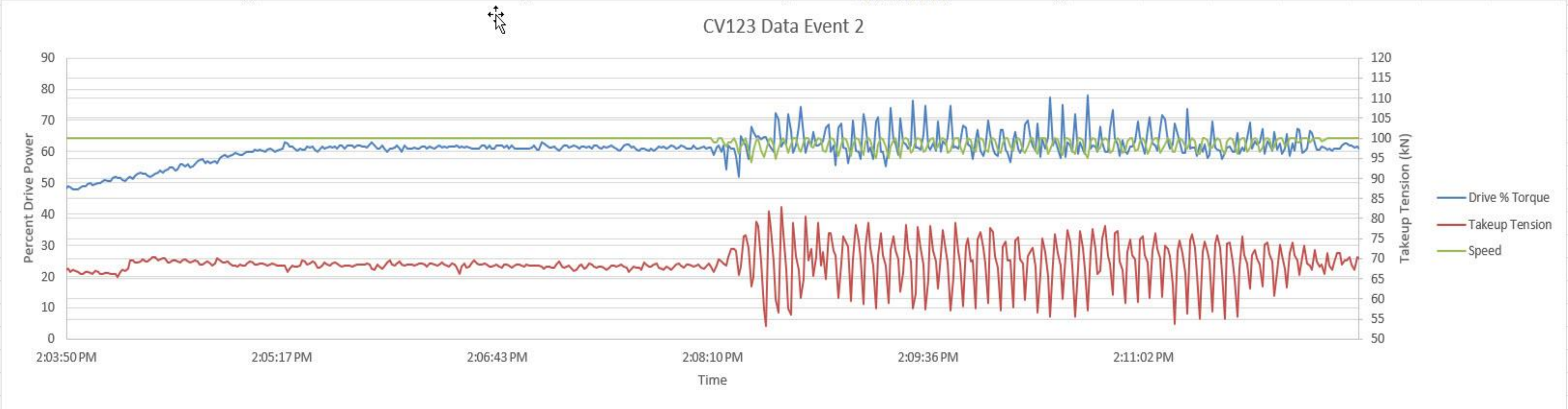
Use Case of a Conveyor Digital Twin- **Anomaly Detection**

- **Anomaly Detection by**
  - Condition Monitoring of Components (Predictive Maintenance)
    - Vibration Analysis
    - Oil Analysis
    - Acoustic Analysis
    - Thermal Analysis / Imaging
    - Etc
  - **Digital Twin (Pro-Active Maintenance)**
    - **Power Analysis**

Maintenance Strategy	Methods	Relative Cost
Reactive	Replace Components When Broken	Highest
Preventative	Replace Components Periodically	Medium
Predictive	**Vibration, Thermal, Acoustic, Oil Analysis, Etc**	**Low**
Pro-Active	**Correct Behavior, Estimate life and Predict Failures using Digital Twin**	**Lowest**

Use Case of a Conveyor Digital Twin- **Anomaly Detection**

- **Example of Anomaly Detection by Digital Twin**
  - “Unforeseen” Power Oscillations Caused by Drive Slip
    - Possible “Root Causes”
      - Worn Lagging
      - High Power Demand
      - Improper Take-up Settings or Behavior



Questions?

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