Generation Digital Transformation Update

Presented by: John Yale, Hydro Plant Engineering

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Information Only – No Action Needed

Why Are We Here Today?

Discuss Digital Transformation
- The ability to access and utilize data to improve business processes and drive decision making.
- Expected Outcomes: Accelerate decisions, improve O&M efficiencies, reduce forced outages
- Key components: Data, tools, culture

Review of ongoing efforts
- Stator temperature predictive model
- Anomaly detection
- Rotor mounted data system
- Turbine runner hub sensor
- Data acquisition, communication and analysis

Stator Temperature Predictive Model

Develop a Model to Predict Stator Temperature

- Part of a family of unit models

- Predicts temperature as a function of operations

- Developed using big data techniques combined with engineering knowledge

Better manage - stator temperature, cooling systems, maintenance, and stator life
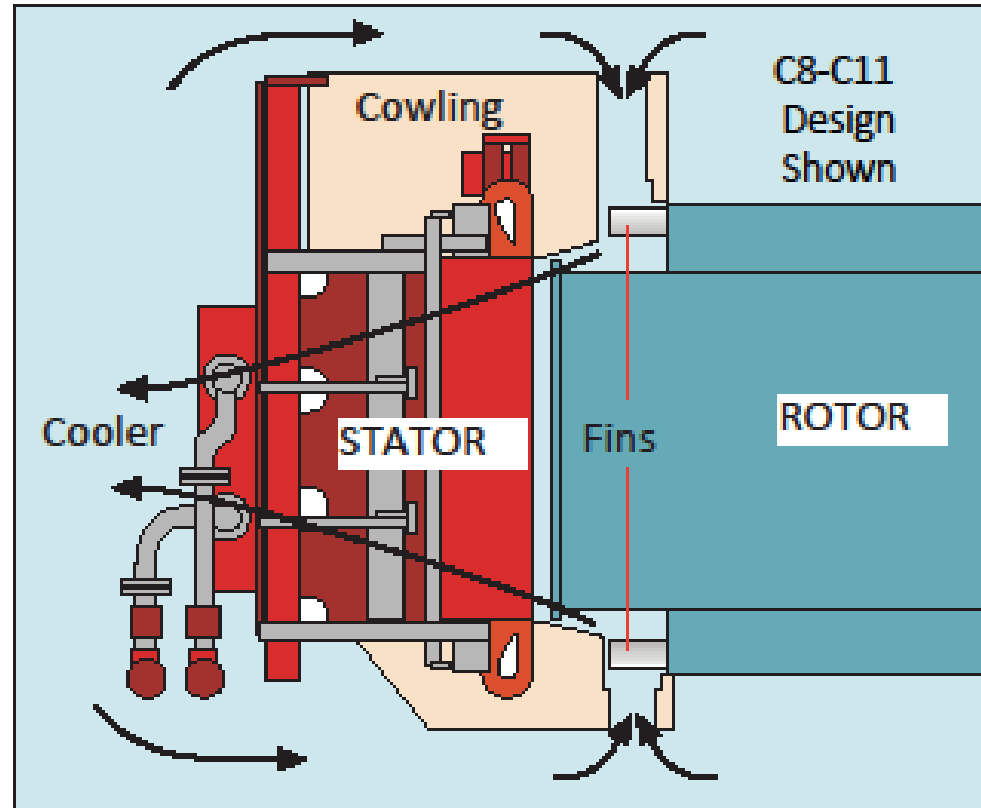
Stator Temperature Predictive Model

Inputs:

- Cooling water temperature
- Cooling water flow
- Stator current
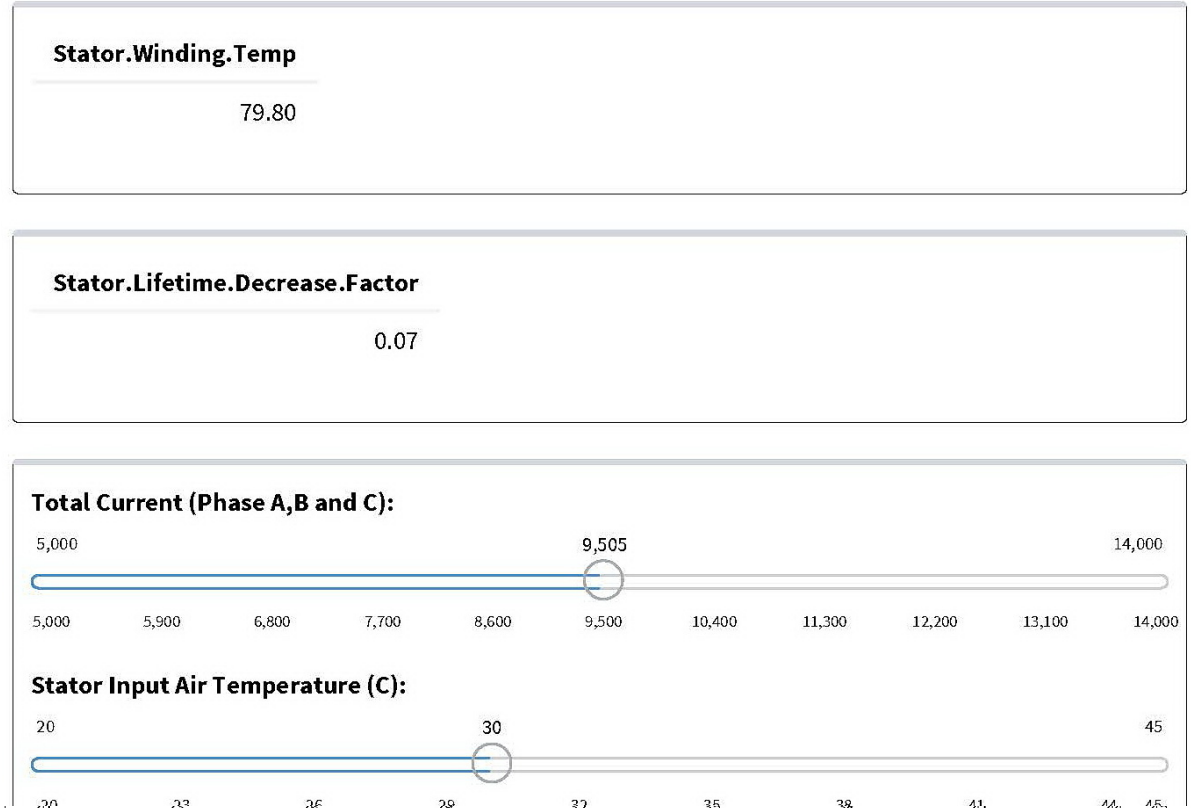- Ambient air temperature

Outputs:

- Stator winding temperature
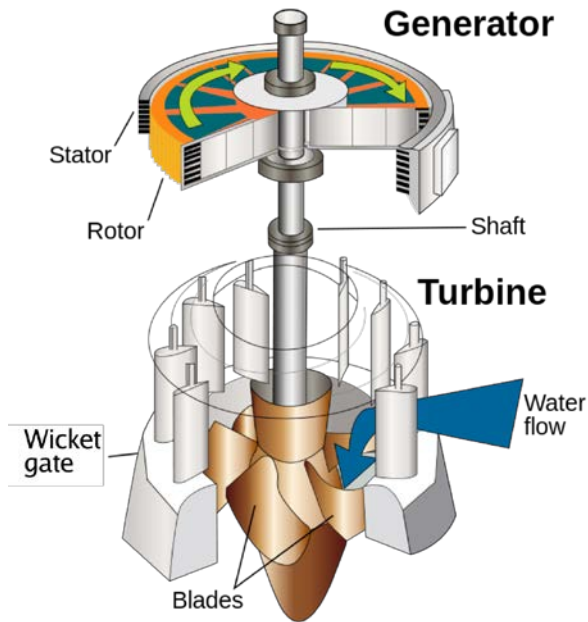- Cooler cleaning maintenance

Stator Temperature Predictive Model

Temperature Prediction Tool

A current increase of 500A will reduce the remaining life of the unit by 7%!

Stator.Winding.Temp

79.80

Stator.Lifetime.Decrease.Factor

0.07

Total Current (Phase A,B and C):

5,000					9,505				14,000
5,000	5,900	6,800	7,700	8,600	9,500	10,400	11,300	12,200	13,100	14,000

Stator Input Air Temperature (C):

20			30						45
20	23	26	29	32	35	38	41	44	45

Stator Temperature Predictive Model - What's Next?

Generator

Stator

Rotor

Shaft

Turbine

Wicket gate

Water flow

Blades

- Try model with Hydropower Research Institute data - completely different units, similar units, more data

- Patent applied for

- Work with others

- Develop other predictive models – bearings, excitation, turbine

P.U.D.
CHELAN COUNTY

Anomaly Detection

Find When Things are "Not Normal"

- We monitor +/- 300 analog signals for each unit
- Alarm just before it is too late!
- Use data analytics to create a tool to:
    - Define "normal"
    - Create notifications

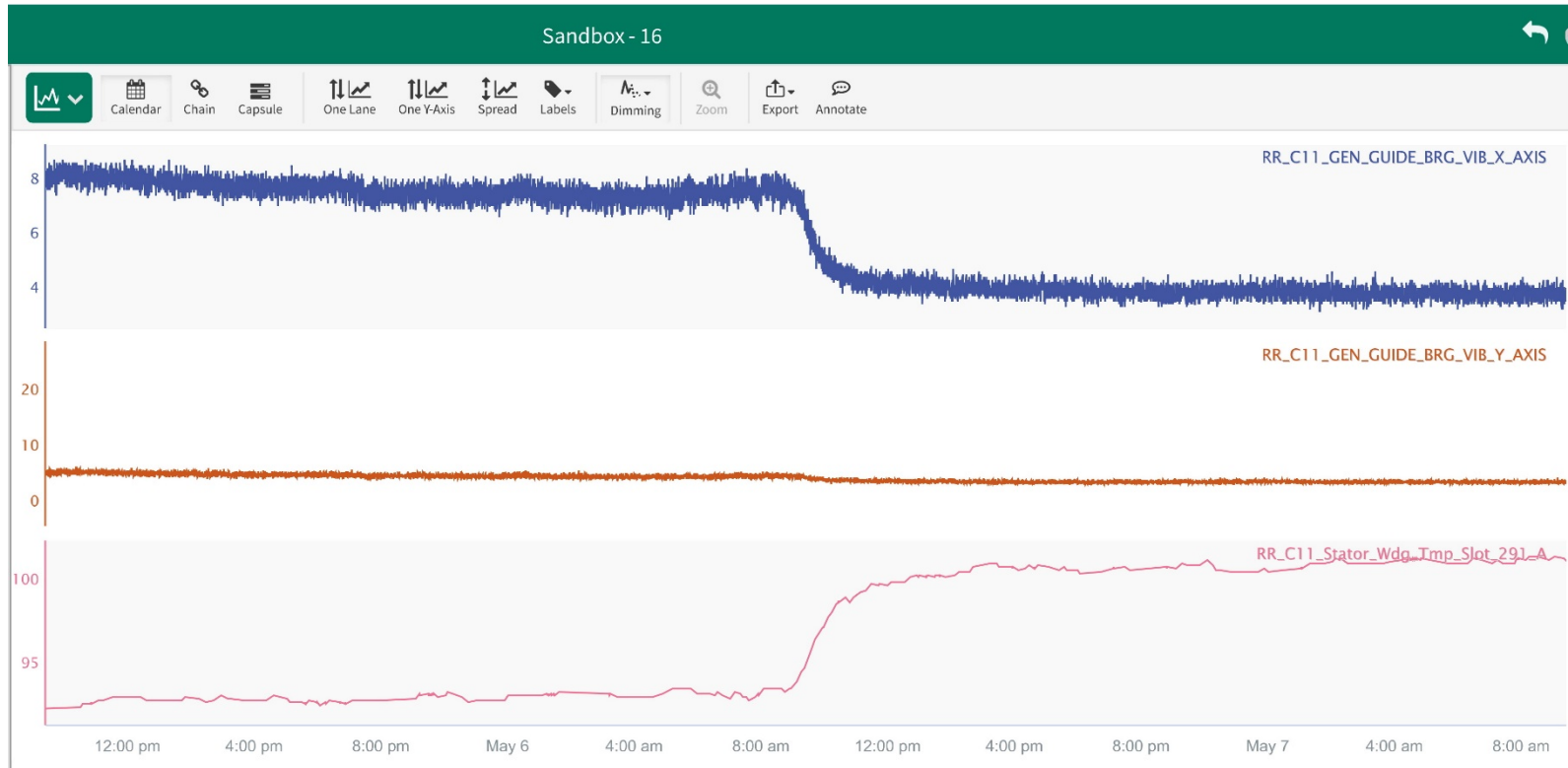Better equipment management, faster response, reduced forced outages

Anomaly Detection
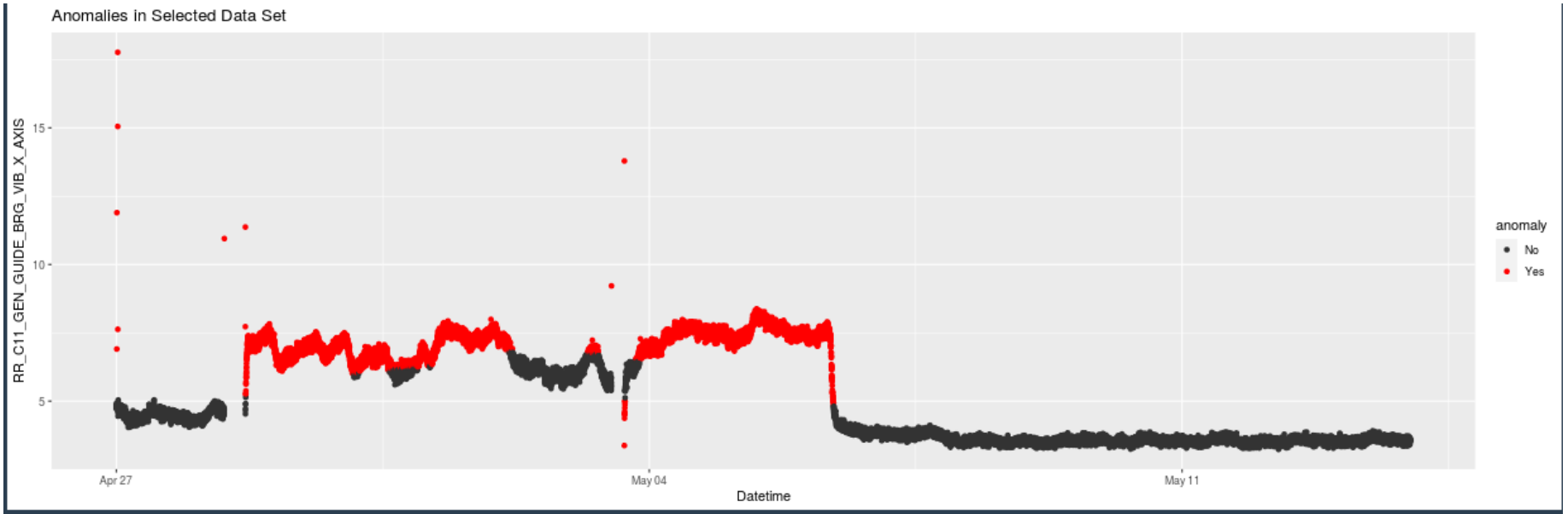
"No, I was not aware of this issue."

Anomaly Detection & Other Data Tools

16 - Sandbox - Seeq

Used SEEQ, a data tool for our PI data, to analyze what the anomaly tool identified

Anomaly Detection - What's Next?

- Working on the next generation of the tool
- Integrate engineering knowledge with anomaly screening
- Use multiple factors based on engineering knowledge
- Move the "normal" definition to our operating data system
- Create alerts to engineers when operating outside of "normal"

Rotor Mounted Data System
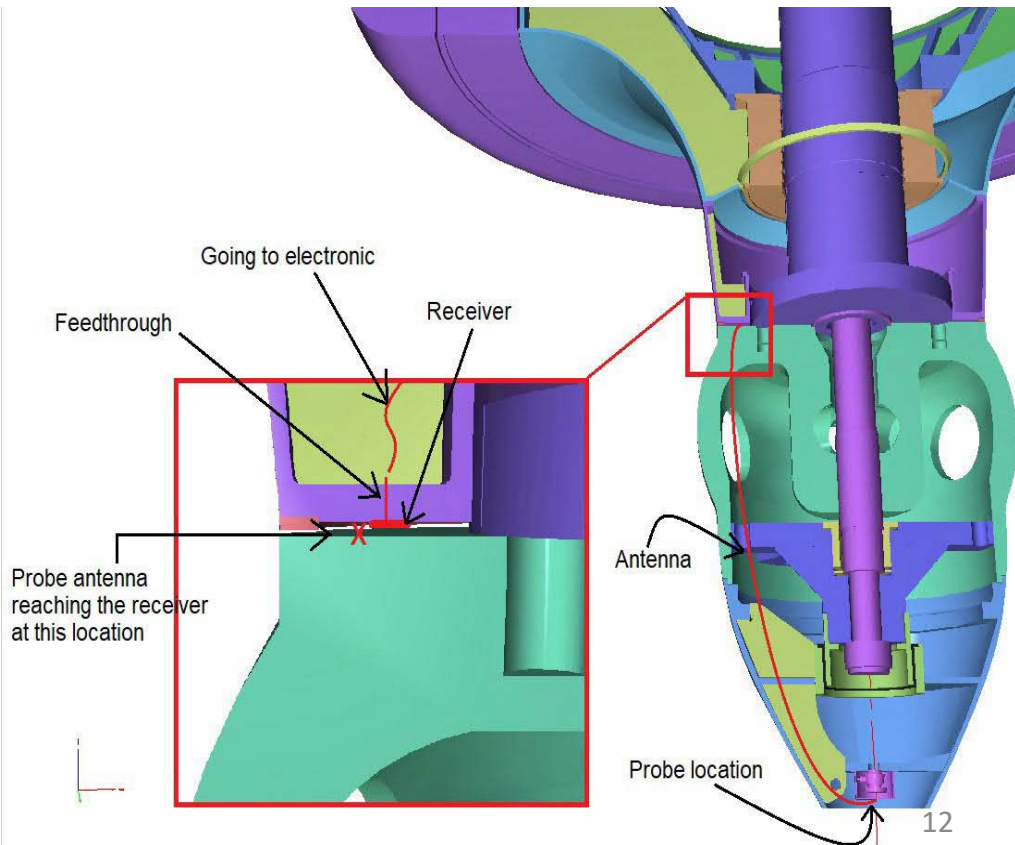
Monitor the rotating parts of the units

- Based on senior teams' projects
- Working to develop commercial application
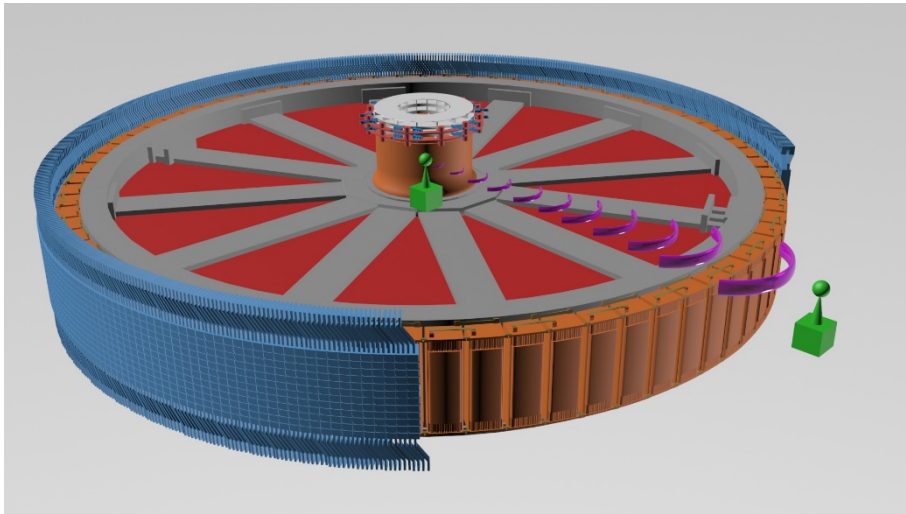
Hub Water Sensor

Enable us to detect water in turbine hubs

- Trunnion seal leakage
- Oil management

Working on a prototype

Know if we have trunnion seal leakage without an outage

Obtaining Useful Data

The challenge is to collect the right data, at the right time, at the right resolution

- We cannot reasonable collect everything at high resolution
- How to collect what we need, when it is needed
- Event recorder function
- Providing data to PI, our archive

Will provide high resolution data when needed, without unnecessary storage burdens

Upgrading Our Data Sources – governor/controls

Technology has changed, we can now collect more data more efficiently

- Current governor/control systems were installed in the 1980s-1990s
- Obsolete hardware and software
- New generations allow more data to be collected, more efficiently and at lower cost

Will provide more data, more analytic tools, and better ability to control the units

Living the Dream!

Ongoing continuous improvement
- Continuing these efforts is included in the 2021 budget
- Dreaming big for new ideas
- Leveraging technology to do things better

Help ensure the Best for the Most for the Longest

**A dream doesn't become reality through magic;
it takes sweat, determination and hard work.**
Colin Powell