

CONVERSATION

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What are your duties with Sentient Science?

I'm the chief digital officer responsible for turning our customers' hard assets like wind turbines into DigitalClone models that we can run computational tests on and ultimately make money for our customers from the data coming off those machines. We don't only work with operators, though. We do the same for the gearbox, component, and lubrication suppliers that want to serve the operator base, as we calculate the components and services needed over time to extend asset life. I am responsible for engaging the operators and suppliers in a new digital business model to lower the cost of O&M.

Tell us about Sentient Science and its core philosophy.

Sentient Science's goal is to help opera-

tors lower their operations and maintenance costs, to reduce the risk of failure of their assets and ultimately lower the cost of energy through the life extension of operator assets.

Sentient does this by applying a material science-based approach to machine failure developed under DoD contracts for the world's largest operators — Army, Navy, Airforce — in an initiative to lower their cost of service. We applied these learnings under request by DoE to wind-turbine gearboxes. The rest is history. We now have 18,000 assets under contract and expect to get to 50,000 assets within those existing customers.

What are the problems with standard diagnostics vs. advanced prognostics?

What business problem do you want to solve? If you want better planning of your O&M budgets over 18 months, or if you want to extend the life of your assets, you need the forward visibility from advanced prognostics. We see things that sensors will never see, and we can alert the operator when we see problems occurring in bearings and gears before anyone thought possible. This gives us the ability to affect inventory carrying costs and lower warranty costs. We provide the foresight needed for better financing for new development, for negotiating better T&Cs, and insight into alternative supplier options. These are not the problems that can be solved with diagnostics.

Sentient Science has developed DigitalClone to help better predict failure rates. How does DigitalClone work?

We look closely at the overall system, the gearbox, and the critical components within the system, bearings, and gears. Our system simulations provide a list of critical components from worst to best. At that point, we take a deep dive into those components to look at their material properties, the metals used by the supplier, the loading conditions on that component for each specific asset, and the potential impact of component failure on surrounding components. We generate the lifing predictions for the components and the gearbox. Now, we have the information to make an action list: What components should be replaced up-tower? What assets should be de-rated to avoid damage propagation? What assets need gearbox exchanges, where and when? This is all provided within a SaaS, but we work closely with our operators to look at the data, correlate it against other input they have, and finally to provide the business decisions to extend the asset, site, or fleet life.

How do you create a predictive model for critical component failure?

We build a DigitalClone model of the asset and its critical components that

we want to simulate and affect. That model is based on 13 years of research and development, \$25 million in investment and validation tests to prove our approach. It's a computational systems and component-computational model that looks at rotating components, material quality, tribological effects, and design variables. We run our models using 8,000 processors to simulate remaining useful life. The model is loaded with the operating conditions of the individual machine that we're trying to affect. We take the SCADA, the wind loads, the maintenance history, and what we know of the bill of materials and run individual simulations for each individual gearbox. It's a lot of processing we throw at a fleet of wind turbines to assess remaining life and the options to extend life. This is new for the wind industry but not new for the defense and aerospace industries.

What are the advantages of the "Buy on Life" feature in DigitalClone?

Imagine you knew the real life of a component, not the supplier assessment, but the actual life as calculated in your individual asset. That means you could make strategic choices between supplier offerings based on life and price of the components. It could enable you to move to a new "Power by the Hour" business model or lead you to plan your supply and inventory management differently.

Today, operators buy on price based on the components the OEM recommends. But what if that component has a shorter life? It might have failed prematurely, and you replace it with the same component. The outcomes will be the same.

Many of the critical components in today's fleet have been designed and installed 10 years back with older modeled components. There may have been improvements in the component offer-

ings from your current suppliers. The Buy on Life feature allows you to simulate how the different offerings would affect the life of the asset and make strategic decisions based on that.

You can compare components and suppliers and buy based on asset management and extended asset life.

Explain what "automation" is and how it works with the wind industry.

Simply put, we create a forecast of actions to extend the life of wind assets including the ROI for each action. That forecast includes both up-tower and down-tower actions, operational changes and GBX changes, where it's located, and when it will fail. For the first time, operators now have multi-year forecasts by asset including the component-replacement schedule needed to minimize gearbox replacements and to extend life.

Now with that information, we've built a supplier portal where operators can automatically push that information to their approved suppliers. The operators can disclose as much or as little information to the suppliers as they want — including multiyear requirements — in order to negotiate the best terms possible. The supplier can drop-ship inventory where and when it's needed instead of storing inventory and tying up capital.

This level of supply-chain automation is proven in other industries. Now we're bringing that automation and effectiveness into the wind markets in order to lower the cost of energy specifically by improving supply and inventory-chain automation.

How does automation reduce energy costs?

O&M efficiencies can be taken directly to the bottom line or to new investments. The problem has been variable O&M costs causing unbalanced pro-

formas. The variable costs of O&M are eating away at the slim profit margins many operators live by. However, by lowering the risk of failure and gaining a better understanding of asset life, operators can now plan for fewer gearbox replacements and extend asset life beyond 20 years. We've seen examples of repowering, gearbox-life extension, component and supplier optimization, new additives, and lubrications all simulated with Sentient's DigitalClone Live system, so that operators have the information they need to make the best financial decisions possible.

Our goal as a company is to significantly reduce the cost-of-energy equation by looking at all areas of the organization that would benefit from knowing more about their assets, not just operational and asset management, but new development, business strategy, and risk management. It's a goal and a long road for us. But the savings will either allow our customers to hedge against the PTC or to take that savings as a direct reduction in energy cost.

What future developments are in the works at Sentient Science that will be beneficial to the wind-power industry?

By knowing future failure rates, we're now powering other business decisions made by the operator including risk management, new development, and supply-chain automation. What started as a pure O&M benefit is clearly affecting other areas of the company, so we can achieve our goal for reduced cost of energy. What you'll see from Sentient now is more automation covering the full asset and more applications providing asset health information to other areas in the organization. I expect we'll get to 50,000 assets under contract soon, so it will be exciting to see what happens. ↵