BENCH MARK

THE INTERNATIONAL MAGAZINE FOR ENGINEERING DESIGNERS & ANALYSTS FROM **NAFEMS**

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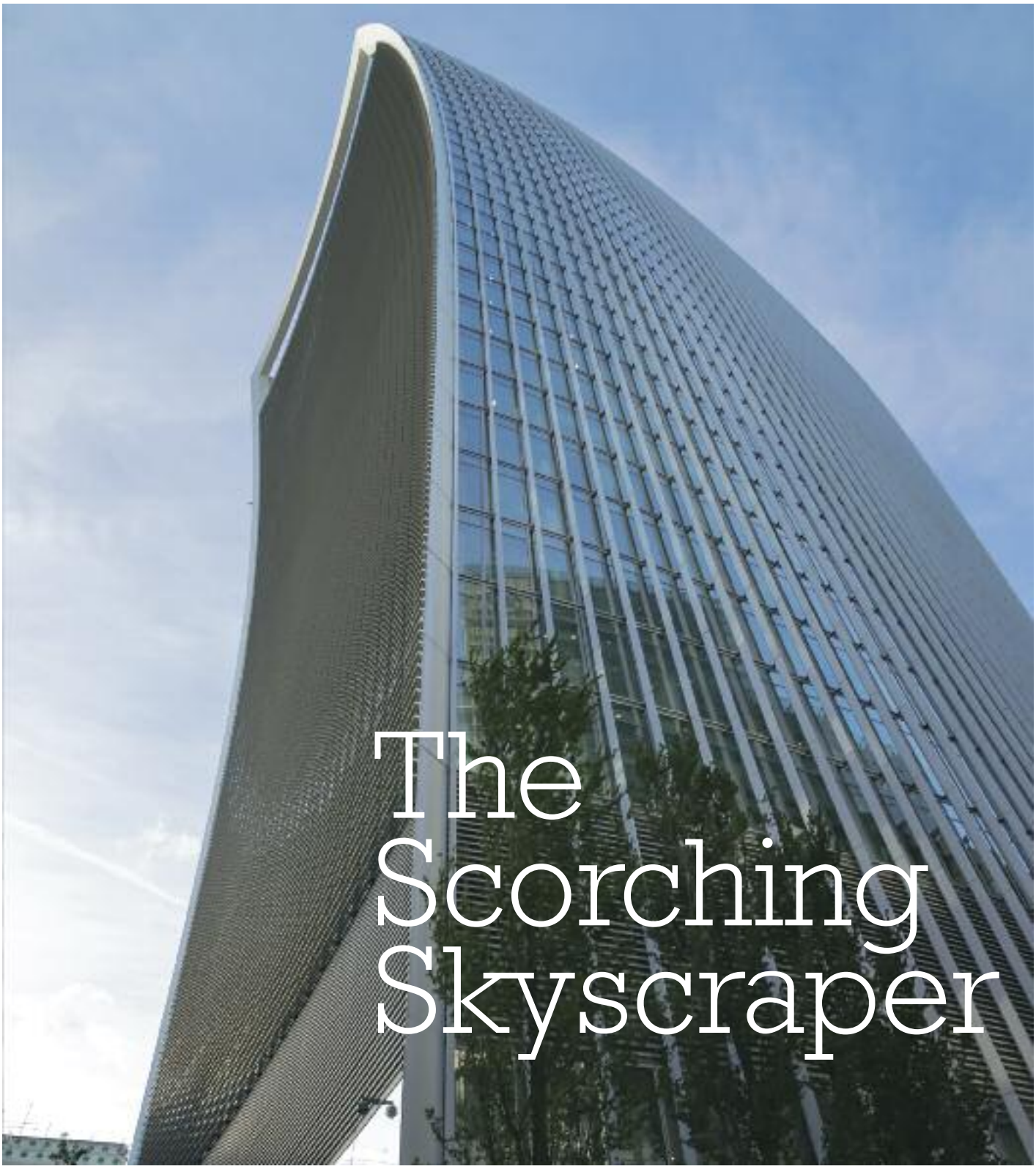

The Scorching Skyscraper

Simulation 20/20: The Next 5 Years

The Business, Technological, and Human Enablers Driving Change Over the Next Five Years

In 2008, NAFEMS Americas held a regional conference with the theme of a "2020 Vision of Engineering Analysis and Simulation." The objective of this event was to bring together the leading visionaries, developers, and practitioners of CAE-related technologies and business processes to share relevant trends and roadmaps, to explore common themes, and to address these issues in an open forum. The goal of this effort was to provide attendees with the best "food for thought and action" to support the industry's evolution over the next several years.

In the seven years that followed, we have witnessed significant advancements in the area of engineering analysis and simulation, the potential of which are not often realized due to a variety of factors, including accessibility, usability, confidence, and financial. However, we are still left with many of the same questions:

What is the future for engineering analysis and simulation?

What factors are constraining growth potential?

How can we realize its full potential?

Where will it lead us in the next decade?

To help address these questions, NAFEMS Americas is partnering with a number of industry thought leaders and end-users companies to host a year-long program of webinars focused on three major topic areas, each with additional key sub-topics:

DEMOCRATIZATION

- Expert Knowledge Capture & Reuse
- Usability
- Accessibility
- Next-Generation Computing Architectures

SIMULATION GOVERNANCE

- Verification & Validation
- Uncertainty Quantification
- Risk Management
- Simulation Deployment

BUSINESS CHALLENGES

- ROI
- Licensing Models
- Communication
- Influence of SMEs
- Vendor & End-User Collaboration

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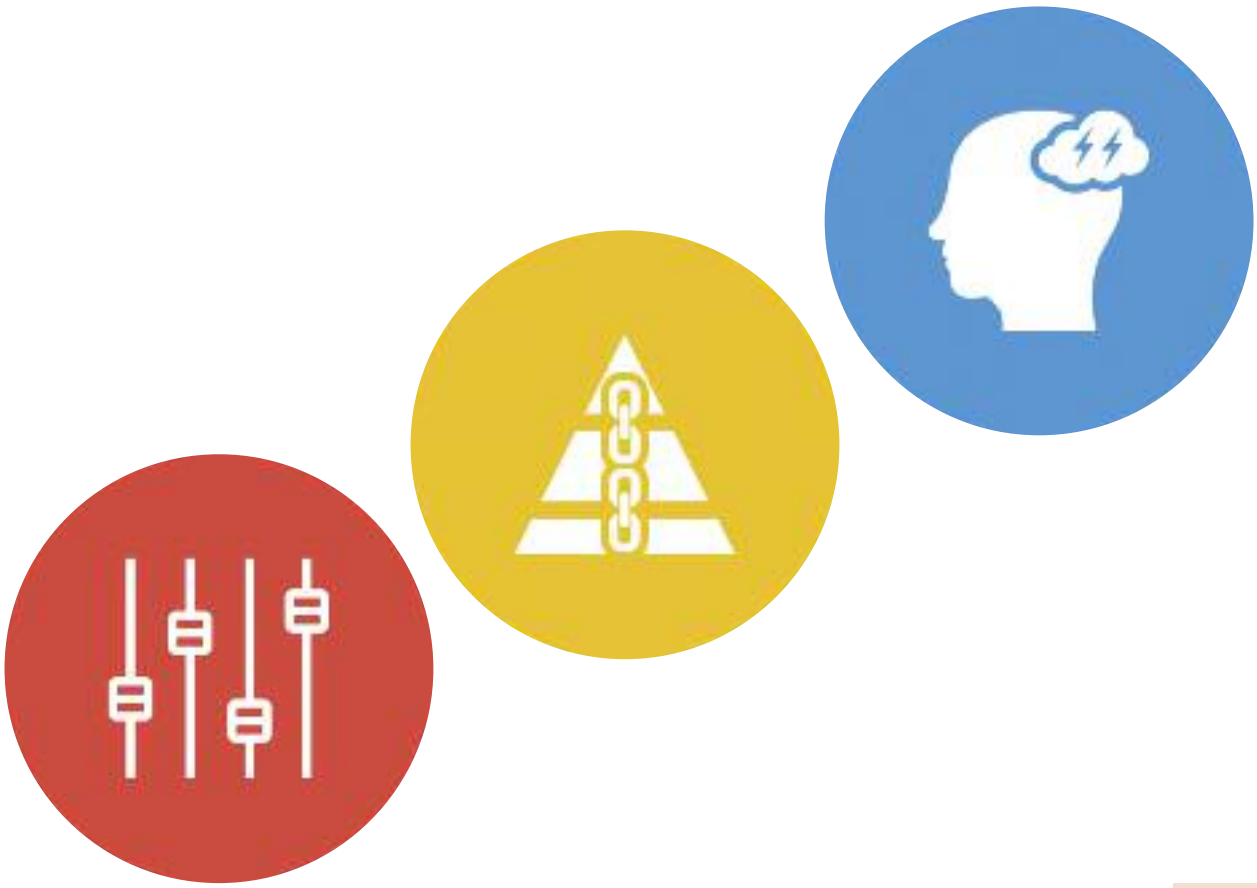
We encourage you to register and attend each of the webinars in the series. To do so, please visit nafems.org/2020

Democratization **Simulation Governance** **Business Challenges**

Democratizing CAE: Simulation Apps offer Potential Hundredfold Growth in CAE Usage

An opinion piece from Bruce Jenkins, President, Ora Research.



"Democratizing CAE" was the topic of a webinar hosted by NAFEMS on August 27, 2015. Presenters explored new technologies and methods to embed CAE experts' "tangible knowledge and intangible judgment into a reusable template, extending this simulation capability throughout the product development team," in NAFEMS' description.

This webinar, the first in a series of five NAFEMS webinars on democratization of CAE, was followed on September 17 by a webinar on Expert Knowledge Capture & Reuse. Future webinars in the series will look at Usability, Accessibility, and Next-Generation Architectures. The webinars are part of a year-long series entitled 'Simulation 20/20: The Next 5 Years'. More information: www.nafems.org/2020

Workflow Capture, App Creation, and Democratization

Juan Betts, managing director of Front End Analytics, began by examining "Workflow Capture, App Creation, and Democratization." Front End Analytics develops "intelligent fit-for-purpose applications" that it calls SmartApps to automate simulation processes.

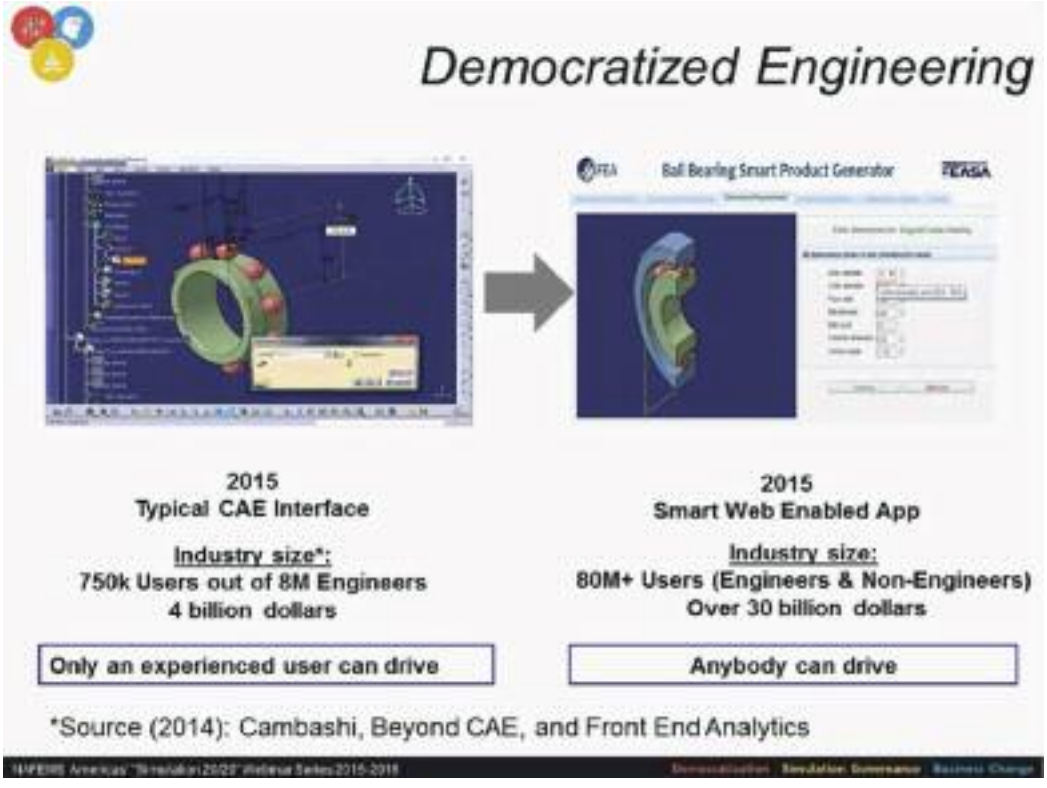
Betts opened by comparing today's CAE industry to the auto industry at the start of the twentieth century. "In the early 1900s, there was this new platform called the automobile," he said. "It was coming of age, but it had a significant problem which was that, in order to use it, you needed to be an expert. You needed to know about changing oil, about the transmission; every few miles you would drive, you would need to go back and turn on the engine - essentially the users of this platform had to be experts on the platform."

"Fast-forward to 2015 - this is a $1.5 trillion industry in no small part because someone who has no clue how a car works can actually drive a car," he continued. "You don't need to know anything about driving dynamics, combustion theory - all of that is embedded into the platform, allowing someone who has no clue how the car works to be able to use it."

Why use this analogy? Because "today CAE is the purview of experts," said Betts. A study by Cambashi, Beyond CAE and Front End Analytics showed that today's CAE industry has about 750,000 users (out of a total of 8 million engineers around the world) and software revenue on order of $4 billion annually. "In essence, you have to be an expert to be able to use these tools. On average, a company spends about $20,000 per user for one of these tools," and at the high end, $100,000 to $150,000 per user. "It's extremely expensive, small/medium enterprises are priced out of this market, and it's very hard to penetrate in part because it's so hard [to use] and you need to have expertise to be able to use these tools."

But today "a revolution is occurring," Betts declared. "These intelligent, web-enabled apps are embedding that intelligence into the platform itself, allowing engineers and non-engineers to potentially benefit." The result, according to Betts, will be to expand the addressable market to more than 80 million users - engineers and non-engineers both - and over $30 billion annually.

"It's going to revolutionize the way you do business in ways that we can't even think of, the same way automobiles revolutionized the way we move today," Betts said. "Think of someone with a mining truck who needs to decide whether to send it for repair - you need engineering calculations in the field. By having this democratized CAE, you're going to be touching places that the enterprises of today don't even know - we cannot even think of how this is going to transform the way this industry is going to move."



Betts listed seven principles for these "intelligent, fit-for-purpose applications":

1. Leverage the company's existing intellectual property (know-how, methods, toolset, previous designs, etc.).
2. Work across a wide range of design changes and product families.
3. Speak the language of the intended user and prevent non-expert users from creating invalid designs.
4. Automate within or across workflows (i.e., CAD creation, analysis or other engineering tasks).
5. Are employable for different levels of model abstraction (i.e., from 1D functional-centric to 3D CAD and FEA/CFD computational analysis).
6. Are cloud-based/web-enabled and allow global collaboration.
7. Are built on an agnostic server-based platform allowing a variety of integrations that can start small and quickly realize returns.

The process for creating these applications is in three steps: workflow capture, app creation, and democratization. "Workflow capture is really about process capture," Betts said. "Then app creation is about being able to amplify that, being able to embed controls so that your non-experts are able to use this and democratize it across the enterprise. And we find this is an iterative process, because many times your experts don't know what they know. So we use an agile product development process, where it's iterative. And democratization is where you take this and then are able to go to the enterprise and deploy it in a controlled fashion."

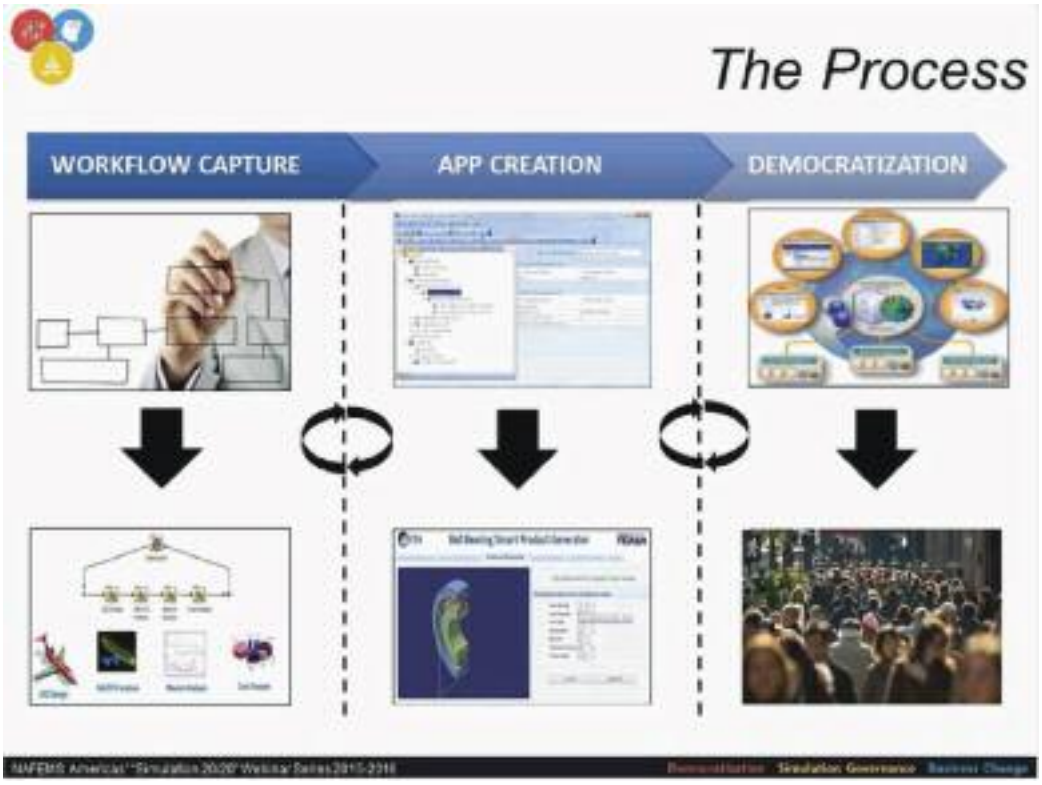
Engineering Calculators on the Web

Dr. Michael Tiller, president of Xogeny Inc., spoke about technical and business drivers for simulation apps as "Engineering Calculators on the Web." Xogeny develops products and services focused on ensuring that modeling has the greatest possible impact on the product development process.

What are the driving forces behind the democratization of simulation? One, said Tiller, is "getting rid of bottlenecks" in the process. "I worked at Ford Motor Company for ten years building models and being involved in modeling projects - engineering projects around powertrain," he explained. "And one of the things that you often see is that experts know a lot about these systems, but they end up in the process being bottlenecks. There's a lot of work to do, a lot of analysis to carry out, and not really through any fault of their own, all the work ends up having to be driven through them. And as a result, there's a limitation on their bandwidth affecting the overall flow of work getting done."

Simulation apps offer those experts "ways of being able to transform their models and their knowledge into applications that can be deployed to their coworkers so that we can alleviate some of these bottlenecks."

Another driver for simulation apps, in Tiller's view, is the "sharing economy (in the enterprise)." Like Airbnb and Uber in the consumer world, simulation apps "allow people within the enterprise who have something to offer to reach out to those people who need something. And the same principles that apply in the sharing economy apply here. We're trying to increase the efficiency of the overall system, making sure that resources are being utilized consistently and as much as possible."



However, he cautioned, "there also has to be trust involved, between the people who have these resources and the people who want to use them." To this end, "we need to make sure in this democratization process that the engineering knowledge is truly being captured so that people who use these tools, who may not have the expertise to have created them, still can have trust in them, and trust that the developers who created this content have captured the expertise in the application to make sure that users get good answers, or if they don't get a good answer, they know that there's something invalid about their input or the assumptions that they've made."

A third adoption driver is usability. Tiller noted that the technology can be mapped along two axes: capability (the primary focus in CAE to date) and usability. "One of the things I've noticed as an engineer," Tiller said, "is that we spend a lot of time and effort expanding capability, because we're trying to get more out of what we're doing. We want to be able to do larger meshes or more physics or greater interactions." But the other axis along which technology must develop is usability, he said, pointing out the evolution in usability from an Altair 8800 computer to an iPod. If the Altair 8800 were "a hundred or a thousand or even a million times faster, it still wouldn't be an iPod - it still wouldn't be as attractive to the end user. So you can add lots of capability, but that doesn't necessarily grow the market. Added usability really does that."

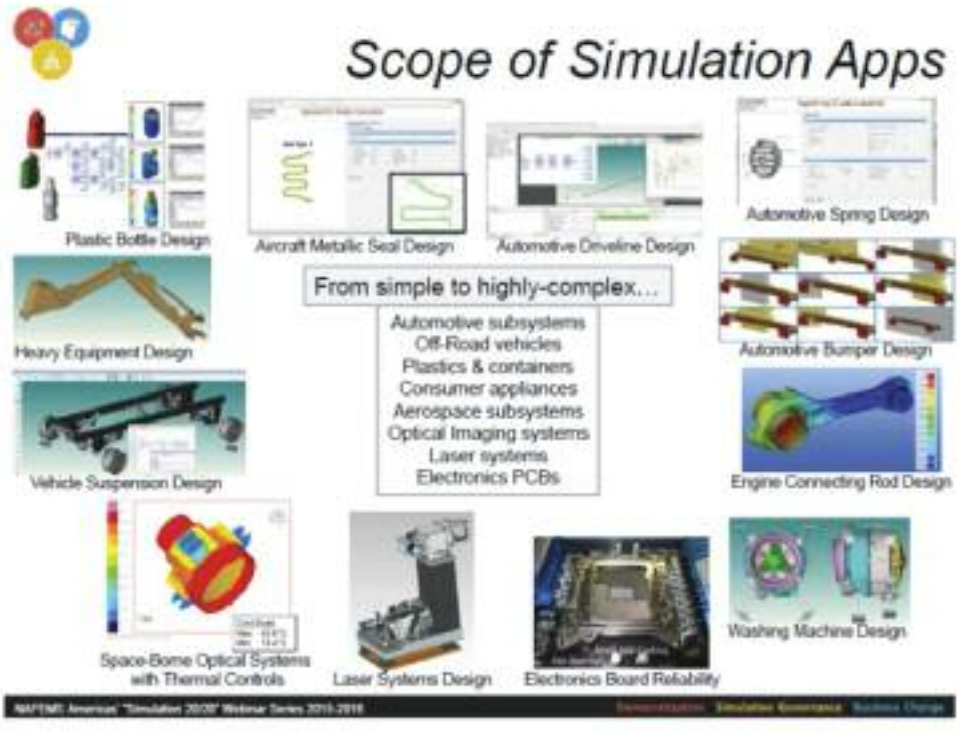
Example Simulation Apps and Conclusions
Malcolm Panthaki, founder and CTO of Comet Solutions, Inc., summed up the technical and business value of simulation apps. Comet Solutions develops simulation technology that establishes a single environment to build, analyze and optimize a single functional model for a product system that is "abstracted" from the details of FEA, multibody dynamics, CFD and other simulation and modeling tools.

"All of us believe that simulation has been in the hands of too few, the experts, for too long," Panthaki began, "yet large numbers of people in manufacturing companies could use simulation to answer questions and optimize their designs." Calling this a "huge, mostly untapped market," he emphasized the research cited by Betts showing that today's market of fewer than a million simulation expert users "could go one or two orders of magnitude higher." Adding that "simulation today is highly inefficient, inconsistent and error-prone - especially when experts from multiple groups are involved," he said, "the bottom line is, how do we get complex simulations safely and effectively to all of those who need it?"

There have been many attempts to solve these problems over the last few decades, Panthaki noted, "for example, the use of CAD-embedded simulation tools. These have often had limited simulation capabilities as they are used by designers. And they haven't really gone into widespread usage. The experts continue to use different tools. Software vendors have made their general-purpose simulation environments easier and easier to use - there has been great progress on this. However, these tools continue to be practical only for expert users, except for simple models."

"And finally, the concept of using solution-specific, narrowly defined vertical applications has been accepted for decades," he continued. "Unfortunately, these have been heavily scripted and programmed, expensive to create and maintain, and also limited in their scope and brittle - they break when your model changes too much, and most importantly, they don't work across an entire product family expect in simple cases."

So in essence, what are the simulation apps discussed in this webinar? "They're simple, targeted, web-deployed engineering calculators," Panthaki said. "They are targeted and narrowly focused; they answer specific



questions about the design of a particular product at particular levels of fidelity. They're dirt-simple to use, and available anywhere. They need to be useful and usable, robust across a wide range of design changes, and in fact across an entire product family. That's what makes them truly usable."

Very importantly, he continued, "they need to be expert-certified. The experts are the ones who embed their expertise in them and certify them. And in fact these apps must use the full power of the underlying expert tools, not tools that are in some way limited." Finally, they provide users with ubiquitous access to whatever amounts of computing power are needed, either on internal clusters or on the cloud.

"These apps can range from the very simple to the highly complex," he emphasized. "There isn't a limitation. You can go from simple (apparently simple) plastic bottle design, to aircraft and automobile parts and subsystem design, to complex optical systems that require multifidelity and multiphysics calculations such as laser systems, and even shock analysis of PC boards."

What are the key ingredients that go into making these apps safe, usable and, most importantly, economically feasible? "It first and foremost requires the expertise of the experts who need to build their rules and best practices into these apps," Panthaki said. "They need to be able to do this graphically - to be able to capture the functional model and the expert rules very rapidly, within a single integrated environment that minimizes scripting and programming, to create complex templates in days and not months."

Very importantly, these rules need to be based on the product's functional architecture. "What this does," he explained, "is to allow these automation templates to work across significant geometry, topology and configuration changes, and in fact across an entire family of products." By using reusable libraries of parametric analysis CAD - "CAD that's ready for analysis and system definitions" - users can swap components easily to create new representations of their designs for rapid concept exploration. "And finally, you need a web GUI development environment to rapidly create the GUI front ends for these applications."

Summing up, Panthaki said, "There's a huge unmet demand. Product engineers and others in manufacturing companies who are not CAE experts need - and are now using, safely and robustly - simulation capabilities that work across a wide scope. We truly believe that we can go from the under a million simulation experts we have today, to - as a first phase - the eight million engineers who could benefit immediately from these tools, and then ultimately to ten times that number of potential users - salesmen, designers and others who would want to use these simple engineering calculators in their daily work."

"Various technologies and approaches have now come together to makes this possible today," he said. "Simulation apps exist that are highly usable, they're useful, web-accessible and, I keep stressing, economically feasible. This isn't theoretical - it's happening today. We have worked with manufacturing organizations across a wide range of industries and applications, and the benefits are truly transformational. They're getting a lot more from their CAE investments than they did in the past, and in fact utilizing them more than they ever did."

And far from reducing the need for CAE experts, "the role of the experts is simply changing - they're becoming more valuable to the organization," Panthaki noted. "In fact, anyone who needs simulation in their global product developed in the organization can now access it safely and robustly, without the need to go to the experts each time. And in setting up each of these models for analysis, you can go from days, hours, weeks of an expert's time, literally to seconds or minutes of the non-expert - and it's done safely, robustly and correctly the first time if the templates are set up correctly."

"What this means is that design space exploration is now truly feasible across the entire range of model fidelity," Panthaki concluded. "And using these web-deployed sim apps, the entire global enterprise can leverage the expertise of your simulation experts or other consultants, including experts outside your organization, while removing them as a potential bottleneck. In fact, you can start now with a relatively small investment, get rapid ROI from the first use case, prove the value of simulation apps to your company - and once that happens, you'll find that you'll expand with apps that cover many other useful simulation processes."

Bruce Jenkins is president of Ora Research, a research and advisory services firm focused on technology business strategy for 21st-century engineering practice. **www.oraresearch.com**