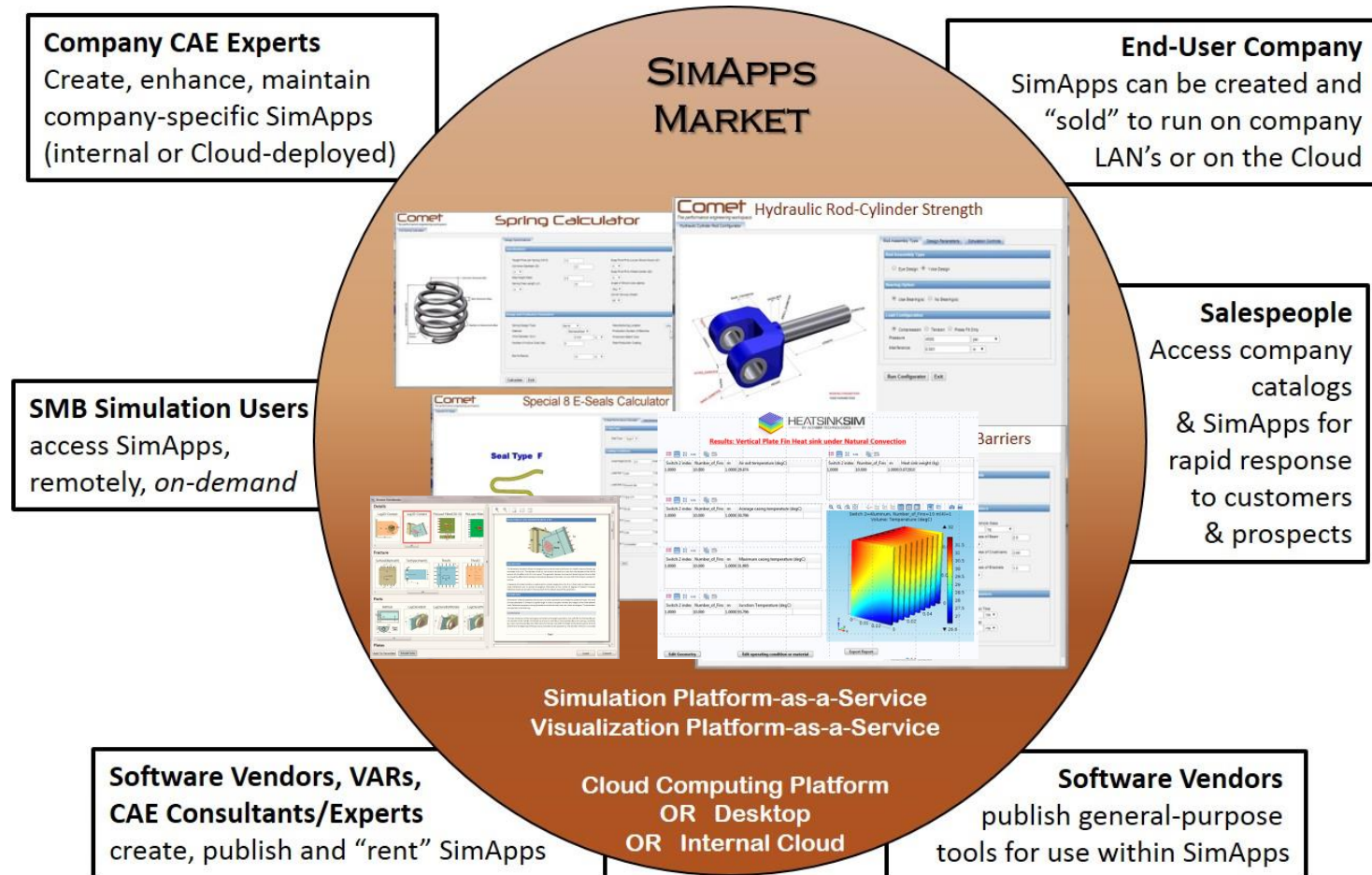


Democratization Using Simulation Apps

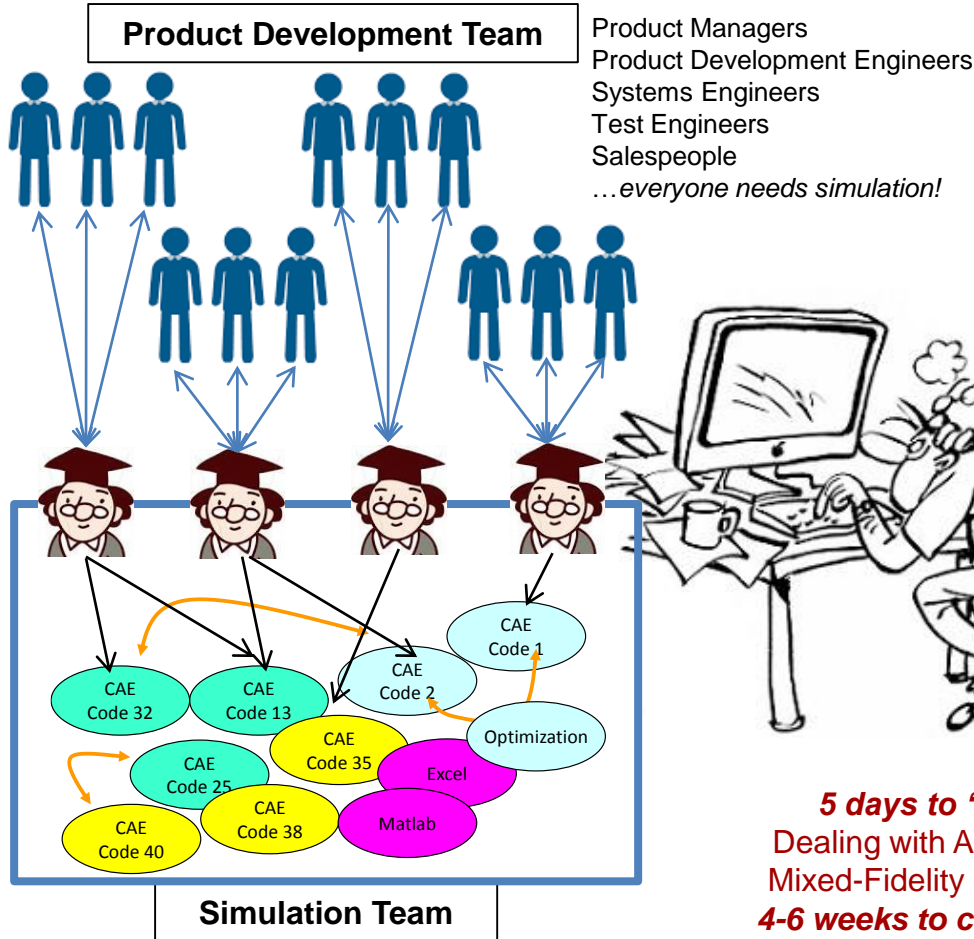
Wading Through the Hype! Where Do We Go From Here?

Malcolm Panthaki, *Founder & CTO, Comet Solutions, Inc.*



Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Simulation status quo: *Silos Everywhere!*



Simulation Data: in silos, inconsistent, non-integrated

Simulation Processes: manual, error-prone, highly inefficient

Simulation Experts: often the bottlenecks

5 days to "clean up" CAD and create a "perfect" mesh??
Dealing with Assemblies & Connections is tricky and highly manual.
Mixed-Fidelity Modeling is a manual nightmare and needs expertise.
4-6 weeks to complete the analysis of a single design iteration??

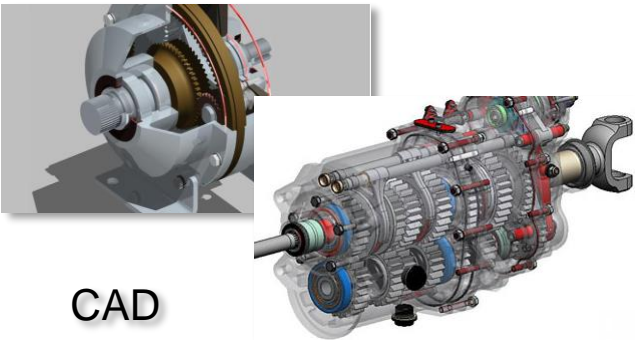
How can simulation be a driving force in design?

Simulation processes are manual & highly inefficient

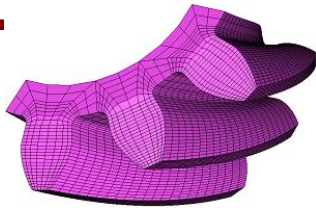
How can we capture simulation processes for automated Design Space Exploration?

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

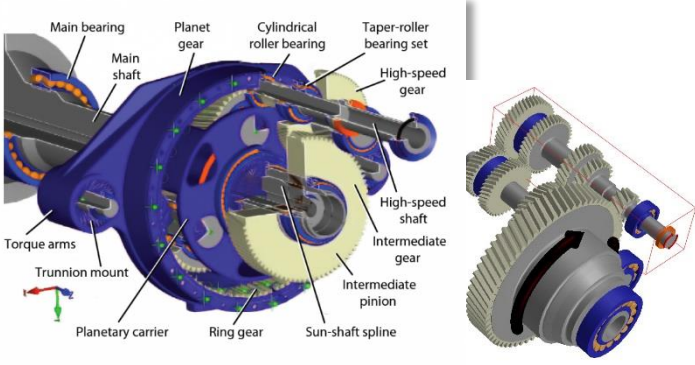
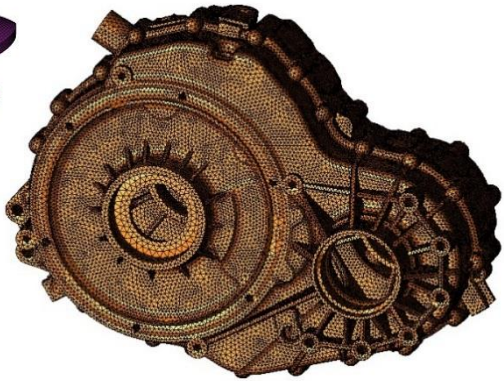
Gearbox Product Design: Common Silos & Tools



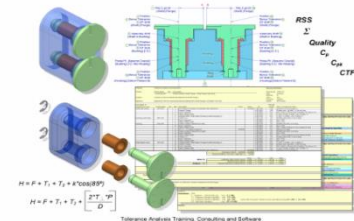
CAD



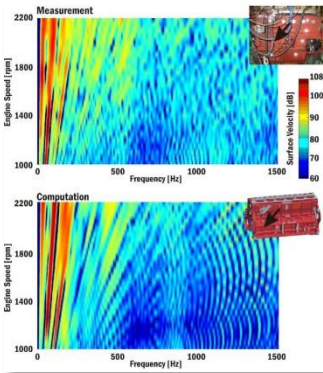
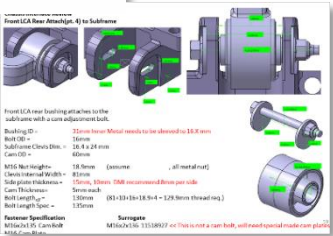
FE Meshing



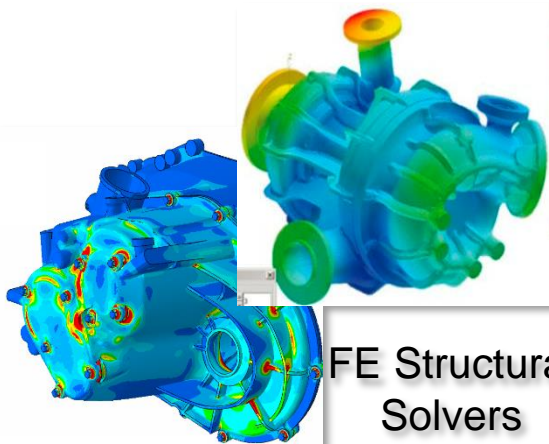
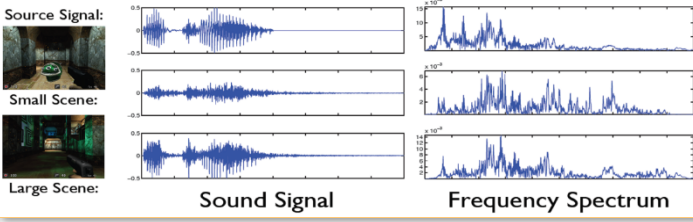
Gear/Bearing/Shaft System Simulation



GD&T
Tolerance
Stack-Up
Analysis



Acoustics Solvers



FE Structural
Solvers

Why is Democratization Urgently Needed?

The Answer is Obvious!

- Product Development *is* Design Space Exploration
Simulation is the best technique for exploring the design space
However, it is *way too manual and requires experts at every stage*
- There aren't enough engineers capable of using the general-purpose simulation tools to perform all the simulations that are needed
- Automated Design Space Exploration, in the hands of *everyone* in product development, will result in an explosion of innovation, as it promotes "Systems Thinking"
- ***Smaller companies designing innovative products cannot afford the high fixed costs of simulation – tools, experts, hardware***

Goal: *Democratization of Engineering Simulation*
ASSESS Task Force: 10X Increase in # Users in 5 Years

Why is Democratization Urgently Needed?

Hundreds of Engineers Needed to Perform the Simulations

Increasing Product Reliability is key.

Hence, a design must be tested over huge numbers of operating conditions.

Hundreds of engineers are needed for these calculations – WE DO NOT HAVE ENOUGH EXPERTS!

Demystify CAE!

Complex mixed-fidelity and multi-physics calculations are required.

These must be templated and automated by the experts so that non-experts can perform them *rapidly and safely*.

Roles are Changing

Experts focus more on creating and validating the Templates rapidly. They are responsible for ensuring that the Templates present data to the non-expert in a manner they can understand.

Engineers (non CAE experts) who use these templates need to be trained to interpret the results correctly.

We Are Now Doing This At AAM!

Ravi Desai

Director, CAD & CAE

American Axle & Manufacturing

Democratization – *Gaining Momentum*

- Many end-user companies have been expanding their simulation user footprint using automation and SimApps
 - ***User adoption is the most important, exponential driving force!***
- NAFEMS: *An organization “of the experts, by the experts, for the experts!”*
 - Democratization workshop at the 2015 global conference (1/2 day)
 - 20/20 Webinar Series on Democratization in 2015, after the conference
 - Us, here, again – *a mini-symposium at NAFEMS NA Regional 2016*
A single track over 2 days with many, real-world, end-user case studies
 - ***A special shout out to Matt Ladzinski...***
- Media articles/blogs/discussions over the last 2 years are growing in number – community of industry experts, expert analysts, and engineering management interested & engaged

The Need for Democratization is No Longer Debatable
The Questions Are: How? And What Are the Cautions?

Democratization – *Gaining Momentum*

Participation

1,217

Registrations

633

Unique Attendees

	Democratizing CAE	Expert Knowledge	Usability	Accessibility
Attended	234	154	145	100
Registered	424	292	284	217
Attendance %	55%	52%	51%	46%



What Are People Saying?

Alan Chalker

AWEsim Project
Ohio Supercomputer
Center

Alan Chalker

- **Educating Users**

Lack of awareness by SMBs that they have needs/bottlenecks in their existing workflows that we can address. The old adage of 'when all you have is a hammer, everything looks like a nail' is true in so many situations when I go talk to a potential client.

- **Software Licensing Models**

The complicated and costly licensing models from most of the leading ISVs. We need simple, adaptable '*micro-licensing*', and flexibility in contracting and relationship management, which currently doesn't exist with most of the large ISVs.

Matt Ladzinski

NAFEMS

Matt Ladzinski

- **We Need Democratization**

In order for the engineering simulation industry to move forward into the ***next era of influencing the product development process***, it requires many fronts to align. In the past year, there has been ***significant progress through a number of industry influencers and end-users, embracing "Democratization"***.

- **We're Making Progress!**

This mini-symposium is just one of many ways that the industry is coming together to discuss this important topic. ***The timeliness and relevance of this topic, as viewed by the end-users attending the conference, is impossible to ignore and a thrill to support.***

What Are People Saying?

Jeff Crompton

AltaSim Technologies

Jeff Crompton

- **Confidence (V&V)**
How can we show the non-expert user that the App provides valid results?
Apps must be thoroughly validated.
- **Usability**
Apps are the answer to getting simulation to non-experts.
They must be solution-focused (targeted) offering mass customization.
With the need for customization, a strong business case for App Developers may be difficult to achieve.

Dennis Nagy

Beyond CAE

Dennis Nagy

- ***Not a Fad!***
However, the speed of adoption is still debatable.
- **Obstacles to Democratization of Simulation**
Cost of simulation software and non-flexible licensing.
Solution in progress.
Hardware costs.
Solution in progress with Cloud computing.
Only experts can use today's general-purpose simulation codes.
Simulation Apps are the solution and are a challenge.

What Are People Saying?

Greg Fallon

Autodesk

Greg Fallon

- **Why do non-experts need simulation?**
Today's product demands and rapid time-to-market require everyone in the product team to have access to simulation.
- **Rapid Automated Workflow Development**
Experts need tools to help them *rapidly* deliver simplified workflows to the non-experts.
- **Successful Simulation App**
Ease-of-Use and Ease-of-Learning

Bruce Jenkins

Ora Research

Bruce Jenkins

- ***We're Making Progress!***
Moving from CAD-Embedded simulation tools for designers to multidisciplinary Design Space Exploration tools for product engineers, *providing a strategic innovation impact.*
- **Key Enabler**
Explosion in affordable computing, esp. in the Cloud
- **Key Obstacles**
Cultural, attitudinal & organizational issues.
Work-Process changes may require breaking down silos.
Software licensing/pricing challenges.

What Are People Saying?

Ricardo Actis
ESRD

Ricardo Actis

- **Simulation Governance**

Simulation Apps must incorporate solution verification.
To achieve this, model definition and numerical approximation must be separated.

Hence, this rules out the use of traditional Finite Element Modeling for Simulation Apps.

Kenneth Wong
Desktop Engineering

Kenneth Wong

- **Why Change the *Status Quo*?**

The way simulation software is delivered and sold today has a limited reach and not much room for growth.

Making general-purpose simulation tools easier to use has limits.

Without an easier, affordable way to use simulation, many who can benefit will continue to remain on the sidelines.

- **Simulation Apps**

Initiatives to deliver template-driven Apps are gaining momentum.

This is a good solution for particular market domains that traditionally haven't invested in simulation experts in-house.

These Apps are most successful when they are targeted.

- **Current Licensing Models are an Obstacle**

Simulation vendors need to support on-demand, usage-based licensing models to penetrate new markets and bring in new users.

What Are People Saying?

Ken Welch
SIMSOLID

Ken Welch

- **Solve the Geometry/CAD Problem**
SIMSOLID works directly with full-featured, unmodified CAD assemblies and doesn't require any meshing.
- **Make it Fast**
Solve complex assemblies in seconds/minutes not hours.
- **Make it Accessible**
19 MB Windows App
On the Cloud with OnShape
Pay-as-you-go licensing starting at \$200/month

Wolfgang Gentzsch
The UberCloud

Wolfgang Gentzsch

- **It's All Finally Coming Together!**
To broadly deploy simulation, you need three major ingredients: **expertise** in engineering simulations, the right simulation **software** tools, and an easy-to-access **HPC system**. After decades of struggling and development on all fronts, we finally have all the ingredients to make simulation available to the wider engineering community. Major drivers of this breakthrough are simulation apps, software containers, and cloud computing, leading inevitably to the ***Democratization of Simulation***.

What Are People Saying?

Sebastian Dewhurst

EASA Software

Seb Dewhurst

- **Why Now?**

Over the last 10 – 20 years, management within big corporations have repeatedly heard about the successes associated with simulation and analysis, and have (eventually) come to realize that simulation must be a good thing. A question which naturally arises is, “Can’t we get even more value if more people can do it?”

I think the focus on PLM over the last decade or so MAY have been a reason why democratization of simulation did not take off sooner.

- **What is being Democratized?**

We see a definite preponderance towards democratization of the functional models e.g. Excel, Matlab, and in-house codes. However, it may be that quite simply the tools to make 3-D more automated (and therefore permit the next step to democratization with tools like EASA) simply did not exist until enabling technologies such as Comet arrived.

- **Obstacles**

I actually am beginning to believe that one of the larger obstacles was self-made: we (collectively) have spent some 10 years telling companies that democratization of simulation is great, you just need to do it, the benefits will come – honest!

The fact of the matter is that only a small percentage of models should ever be democratized. I think that a significant obstacle is overcoming the perception that when we talk about model democratization we are talking about all models, which of course we are not.

The Early Adopters

These are the Early Adopters,
on the *bleeding* edge of the Revolution!

Zack Eckblad

Senior Mechanical Engineer
Intel Corp.

Zack Eckblad

Democratization of Simulation is Essential:

- **What We Have Achieved**

Democratized complex analysis processes using rule-based templates and deployed using SimApps. Accelerated our high-end FEA analysis and risk level decision process to new levels.

These SimApps work across new geometry and operating conditions – essential for a useful App.

The turnaround time for Motherboard simulations went from months of experts time to days of non-experts time.

- **Improving Usability of the Web-Deployed SimApps**

The graphical usability of Web GUIs should be made more like today's desktop applications. It is important that we can create these Web GUI's rapidly.

- **Rapid Creation of Templates**

The authoring environment for creating templates and capturing rules needs to be graphical, requiring little or no programming or scripting.

The Early Adopters

These are the Early Adopters,
on the *bleeding* edge of the Revolution!

Salvatore “Tory” Scola

Senior Thermal Engineer

NASA Langley Research Center

Tory Scola

- ***Let Engineers do Engineering!***

Model building is highly inefficient. With automation templates, we significantly increase the efficiency. Build/validate a process once, then focus on concepts and engineering rather than building models.

- **We Need Many More Simulations**

The ability to analyze a large number of design options in a given time frame is critical to exploring the design space more extensively, to help find better designs.

- **Easy-To-Use Template Authoring Environments**

It is important that these environments allow experts to more efficiently develop & maintain templates. These tools can have a large learning curve, which can dissuade users from working with them.

The Early Adopters

These are the Early Adopters,
on the *bleeding* edge of the Revolution!

Jeremy Jarrett

VP, Kinetic Vision

Jeremy Jarrett

- ***Democratization of Simulation is Happening Now!***

Many large manufacturing companies are already deploying simulations to non-analysts using Simulation Apps.

User adoption is the number one Driver – ***a Simulation App with few users is a failed App.***

- **Obstacles**

Connecting Simulation Apps to computing hardware (esp. on the Cloud) is way harder than it should be. Many analysts still use “Command Line Shells” to launch simulations remotely in 2016!

Software licensing models are now a major bottleneck. Game development and 3D rendering license models on the Cloud are the direction we should be going.

The notion of job security by holding onto knowledge is flawed. The best job security is to create new breakthroughs and share them quickly and broadly. ***What will you create next?***

The Early Adopters

These are the Early Adopters,
on the *bleeding* edge of the Revolution!

Sree Anandavally
CAE Department Manager
Magna Cosma

Sree Anandavally

I believe in Democratization of Simulation:

- **Let Engineers do Engineering**

It is important to reduce or possibly **eliminate redundancy and monotonous processes** in the day-to-day activities in the CAE world to motivate and promote creativity, **thereby bringing innovation.**

- **Improve Efficiency**

CAE is the last line of defense in the virtual development cycle to ensure that the product meets the requirements, but ironically it is the group that receives the **least amount of time to perform their due diligence.**

- **Perform Many More Simulations**

Today, in the supplier world where everything needs to be "done yesterday", while at the same time capturing every possible detail, the CAE group lacks an **"EASY BUTTON" to confidently, accurately and repeatedly perform simulation.**

The Early Adopters

These are the Early Adopters,
on the *bleeding* edge of the Revolution!

Stefan Suwelack

University of Karlsruhe, Germany

Stefan Suwelack

- **Simulation Experts are now Even More Important**

We must avoid the narrative that the experts are being replaced by the automated Apps.
In fact, the creation of these tools requires their expertise to create and validate them.
This grows the use of simulation in the organization and increases the value of the experts.

- ***Beware the Hype Cycle!***

Democratization has shown great potential and is poised to advance further with new machine learning techniques.
However, raising expectations that cannot be met in the near future can be very dangerous.
We should try to avoid what happened to the Artificial Intelligence movement.

The Early Adopters

These are the Early Adopters,
on the *bleeding* edge of the Revolution!

Glenn Valine

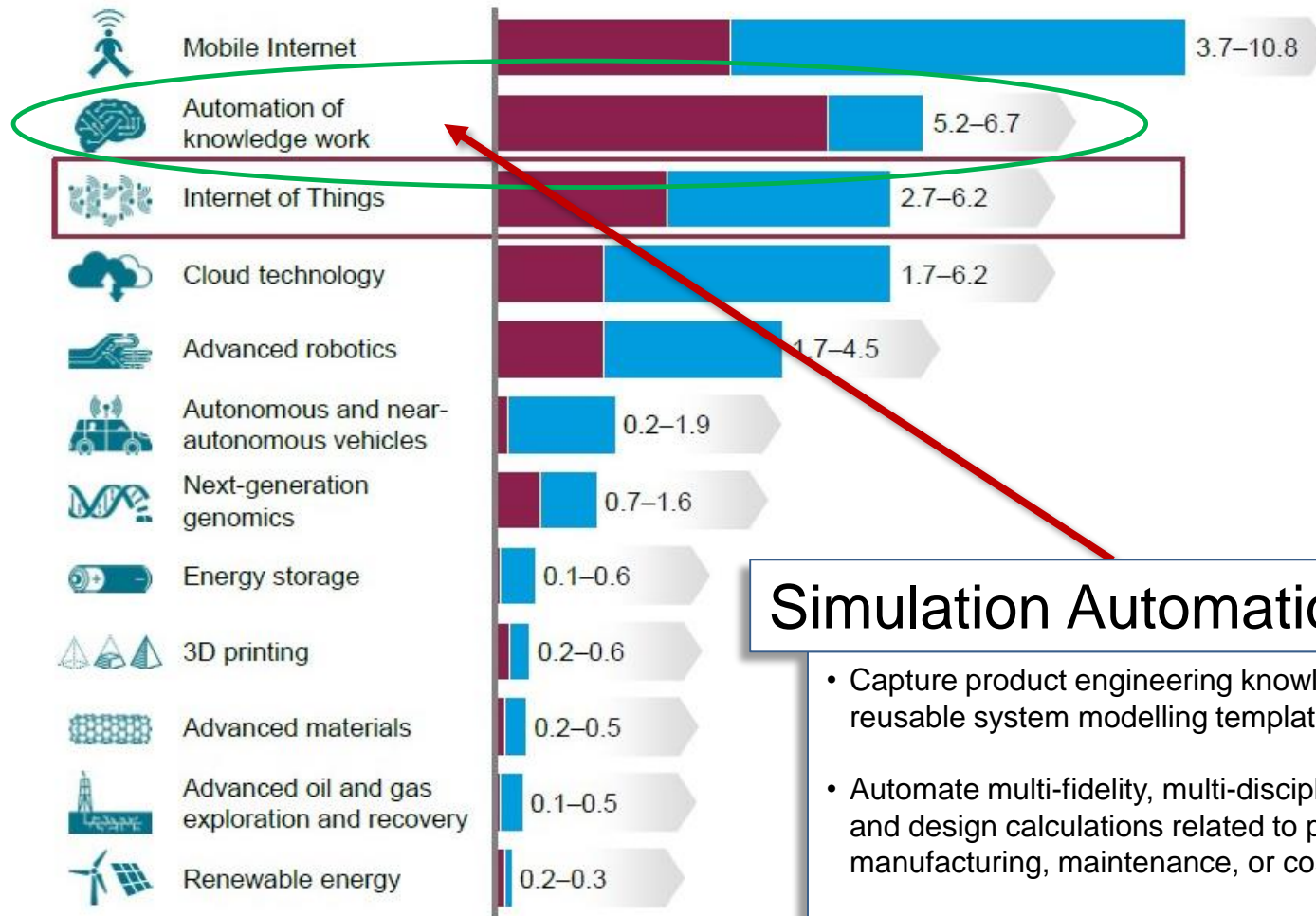
Director, American Axle

Ravi Desai

Director, American Axle

Disruptive Impact of Technology Waves

Potential economic impact of \$5.2T to \$6.7T per year in 2025



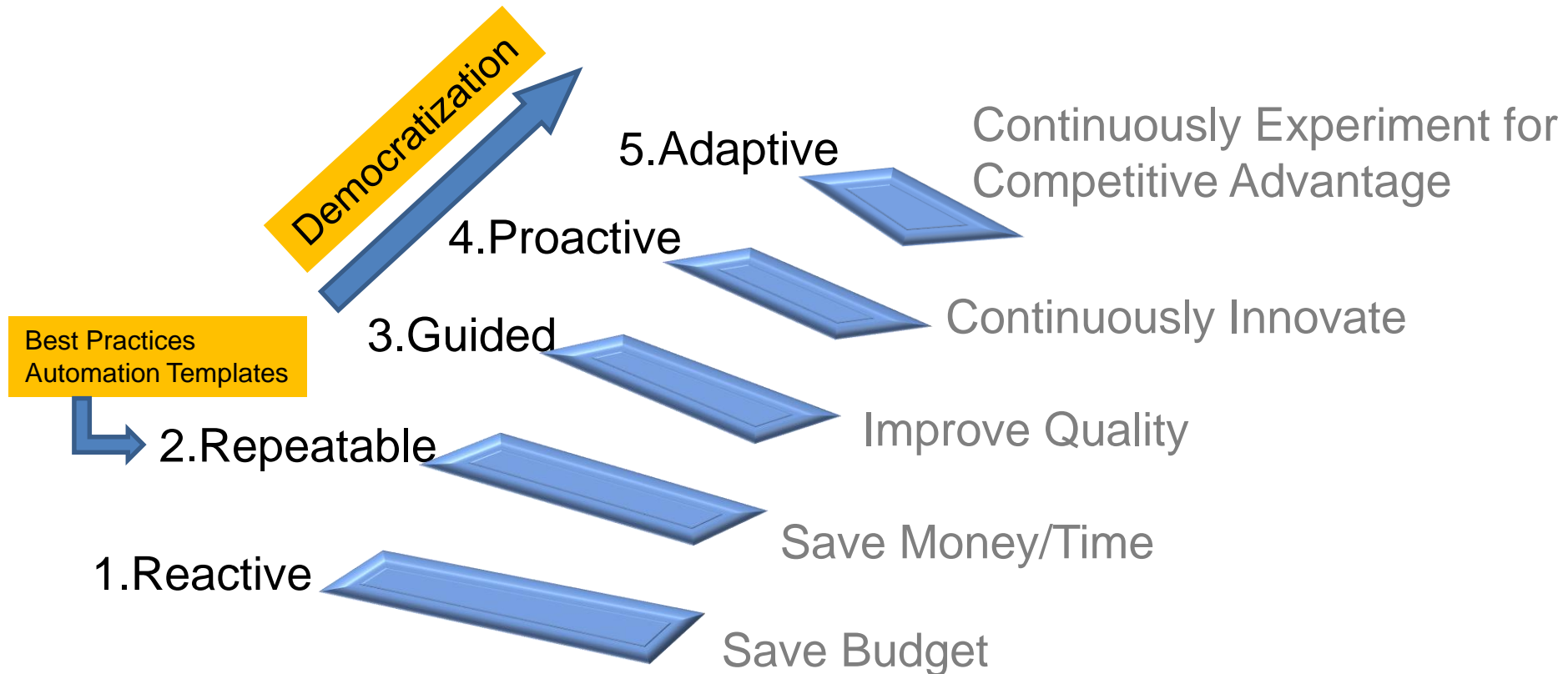
Simulation Automation & Apps

- Capture product engineering knowledge in reusable system modelling templates
- Automate multi-fidelity, multi-disciplinary product and design calculations related to performance, manufacturing, maintenance, or cost
- Deploy these automated calculations to be safely & easily, using simple-to-use Simulation Apps

Source: McKinsey Global Institute analysis

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Govern and Guide CAE and Simulation Through Five Maturity Levels



Courtesy: Marc Halpern, Gartner, Inc.

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Govern and Guide CAE and Simulation Through Five Maturity Levels

Marc Halpern

- **“Componentization” of CAE**
This is one of the most promising ways of achieving Democratization.
- **Fundamental Infrastructure – an Abstract Integrated Data Model**
Systems simulation requires a continuum of abstractions from the high level to the highly granular and detailed. The high level abstractions give us an understanding of allowable ranges of key parameters and how they interact. The detailed abstractions give us insight into fundamental behaviors of parts and materials, and how they could most likely fail.
Representations of data are different at each layer of abstraction. But, the data at each layer of abstraction must be semantically aligned to gain the deepest insights into system behaviors.

Courtesy: Marc Halpern, Gartner, Inc.

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

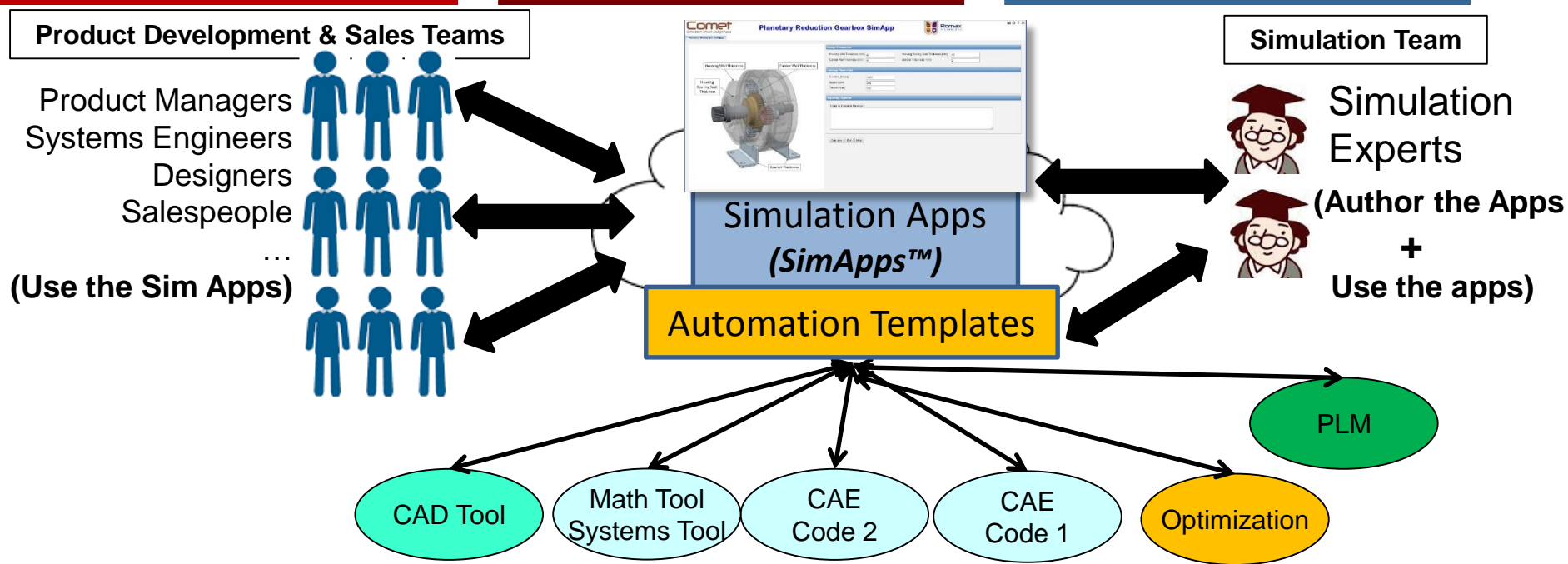
- Simple (*no manual or PhD needed*)
- Accurate (*98% of the time*)
- Reliable
- Cheap
- Accessible (*whenever, wherever*)

“Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or ***the age of calm technology, when technology recedes into the background of our lives.***” according to Xerox PARC’s **Mark Weiser in 1996.**

*Ravi Desai wants to Demystify CAE
With Democratization, we should “Make CAE Vanish”*

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Simulation Apps: *Simulation for Everyone*



Targeted Applications: answer particular questions, on a particular product family, at a particular level of fidelity

Expert Validated & Certified!
Safe and accurate for all users

Robust across a Product Family

Simple GUI's that drive Templates that capture/enforce expertise
Must work across significant design changes and across a Product Family

Must speak the language of the user, not "Simulation"

Web-deployed on Intranets & "The Cloud"
Provide all the computing required for rapid throughput

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Simulation Apps – *Key Ingredients*

What makes simulation apps safe, useful, accurate, and economically feasible?

- **Accurate & Reliable**

Expertise, expertise, expertise...and validate using test results
Capture and leverage best practices & expert rules across the global org.

- **Robust Across a Wide Range of the Design Space**

Rules based on Functional Architecture of a product family
Works across geometry, topology & configuration changes, and across a Family of Products

- **Inexpensive to Create & Maintain Web GUIs for the Apps**

Graphical Environment to rapidly create web GUIs for the simulation apps
GUI's speak the language of the user, not simulation
Easily connect to the underlying automation templates

- **Inexpensive to Create & Maintain Automation Templates**

Graphical Environment for template development to rapidly capture the functional model & the experts' rules – single integrated semantically consistent data model, minimize scripting & programming, *develop and customize existing templates in days not months!*

- **Use of Libraries of Parametric Components
("Componentization" or "Simulation Plug & Play")**

Overcome the tyranny of "CAD for Manufacturing", swap components easily
for rapid concept/architecture exploration, support efficient mixed-fidelity modeling

What Deserves Particular Attention?

- **“Think Automation”**

Find alternatives for anything that stands in the way

- Self-Driving Car Analogy – every function must be fully automated, robust and accurate, or it just doesn't work
- There's lots of room for improvement – *Automating Report Generation can save tons of valuable time!*

- Auto-assembly of mixed-fidelity models with connections
- CAD-to-mesh fully automatically, with CAD that is set up for analysis and design space exploration, not manufacturing
- Libraries of predefined, parametric components
- Reporting back to the non-expert user:
 - In the language of the user, with an emphasis on the user's goals
 - Performance characteristics *as well as analysis quality metrics*
 - Error reporting in a language the user will understand (“Here is the expert's cell #!”)

Barriers to Widespread Adoption

- *Use of ad-hoc scripting & programming to create automation templates (no framework and no underlying data model) and App Web GUIs*
- Over-Hyped potential that does not pan out rapidly in a short-term pilot at a customer's site
- Developing robust validation techniques across multiple physics and levels of fidelity – creating validated models that are automatable
- Getting users to “cross the chasm”
 - “Build & Break” (testing-centric) culture
 - “CAE Experts-Only” culture
 - “That’s not the way we’ve traditionally done things” culture
 - Changing roles in the product development organization
 - Dealing with organizational and budgetary Silos
- Ensuring that Simulation Apps are truly useful - *this is not easy!*
 - Cover a wide range of the geometric design space
 - Allow users to swap components & automatically create/connect assembly models
 - Work robustly across a product family
- High software costs – lack of consistent and practical cloud licensing models – ***make Design Space Exploration affordable on the Cloud***
- ***A small number of Success Stories, so far!***

The Next 12 Months...

- More pressure on companies to innovate faster and the recognition that simulation can be a key enabler
- *“Success Stories beget more Success Stories!”*
 - Keep building on current success stories and adding new ones
 - Find ways to publicize these success stories on the Web and at forums like this one
 - Build more executive sponsorship by documenting ROI
 - ***Achieve more success stories with SMBs – bringing the power of simulation to companies that do not have in-house simulation resources and expertise***
- Make the implementation and deployment of democratized simulation more and more affordable
 - Graphical Environments for rapid development of the customized templates and GUIs – *use of a semantically-rich data model*
 - More flexible cloud software licensing models
- Easier and more affordable access to humongous computing
- Find a more effective way to provide education, useful research, and resources to potential adopters...

RevolutionInSimulation.org – a Resource

A public, resource web portal, providing simulation users with **resources to help implement the next generation of simulation** – success stories, blogs, articles, videos, presentations, webinars, access to experts and other software/service providers, and a place to conduct discussions (hosted on LinkedIn).

Simulation & HPC



Democratization



Simulation Automation



Web-Deployed Apps

Success Stories

Join us – Be a Revolutionary!



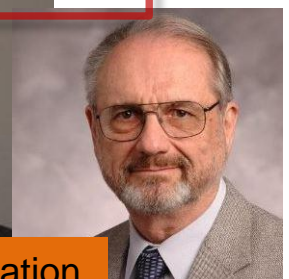
Business Challenges



Design Space Exploration



Simulation Confidence



Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Developing App Marketplaces

Company CAE Experts

Create, enhance, maintain company-specific SimApps (internal or Cloud-deployed)

End-User Company

SimApps can be created and “sold” to run on company LAN’s or on the Cloud

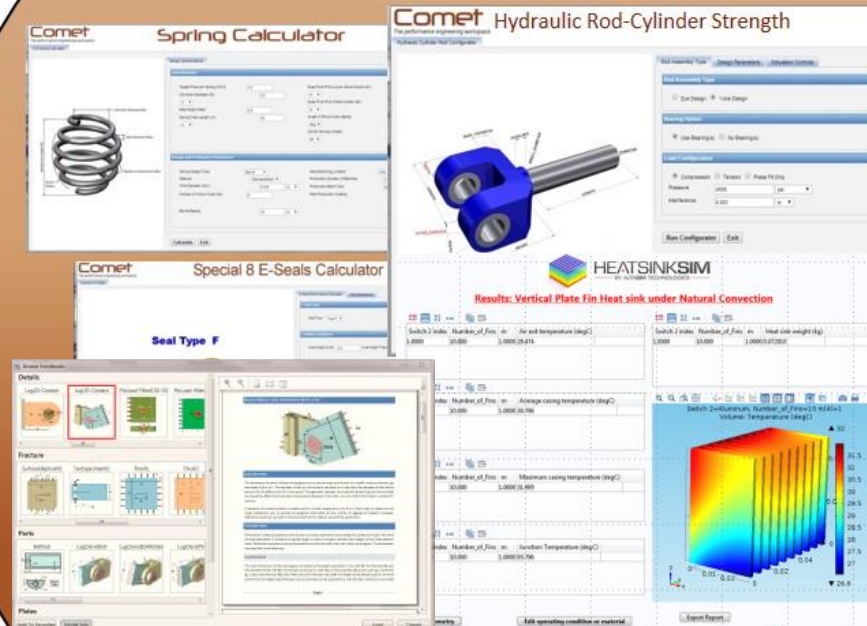
SMB Simulation Users

access SimApps, remotely, *on-demand*

Salespeople

Access company catalogs & SimApps for rapid response to customers & prospects

SIMAPPS MARKET



Simulation Platform-as-a-Service
Visualization Platform-as-a-Service

Software Vendors, VARs, CAE Consultants/Experts

create, publish and “rent” SimApps

Cloud Computing Platform
OR Desktop
OR Internal Cloud

Software Vendors

publish general-purpose tools for use within SimApps

Democratizing CAE Using Simulation Apps – Where Do We Go From Here?

Simulation Is Being Democratized!

- The original promise of simulation is here: Simulation-Driven Design for the *whole* product development team
- General-purpose simulation environments that are easier to use are not the solution for non-experts
- To make SimApps safe for non-experts, expertise must be embedded within them – enforces best practice
- These Apps must work across a Product Family
- Development Platforms to rapidly create Templates & SimApps are a requirement to make them economically feasible
- The advent of The Cloud makes it feasible and cost effective to access huge computing resources, as needed

**“Lights-Out Automation” facilitates
Automated Design Space Exploration
for Experts & Non-Experts**

Thank You!

Malcolm *“he must be nuts if he’s been working on this for over 20 years”* Panthaki
CTO & Founder
Comet Solutions, Inc.

