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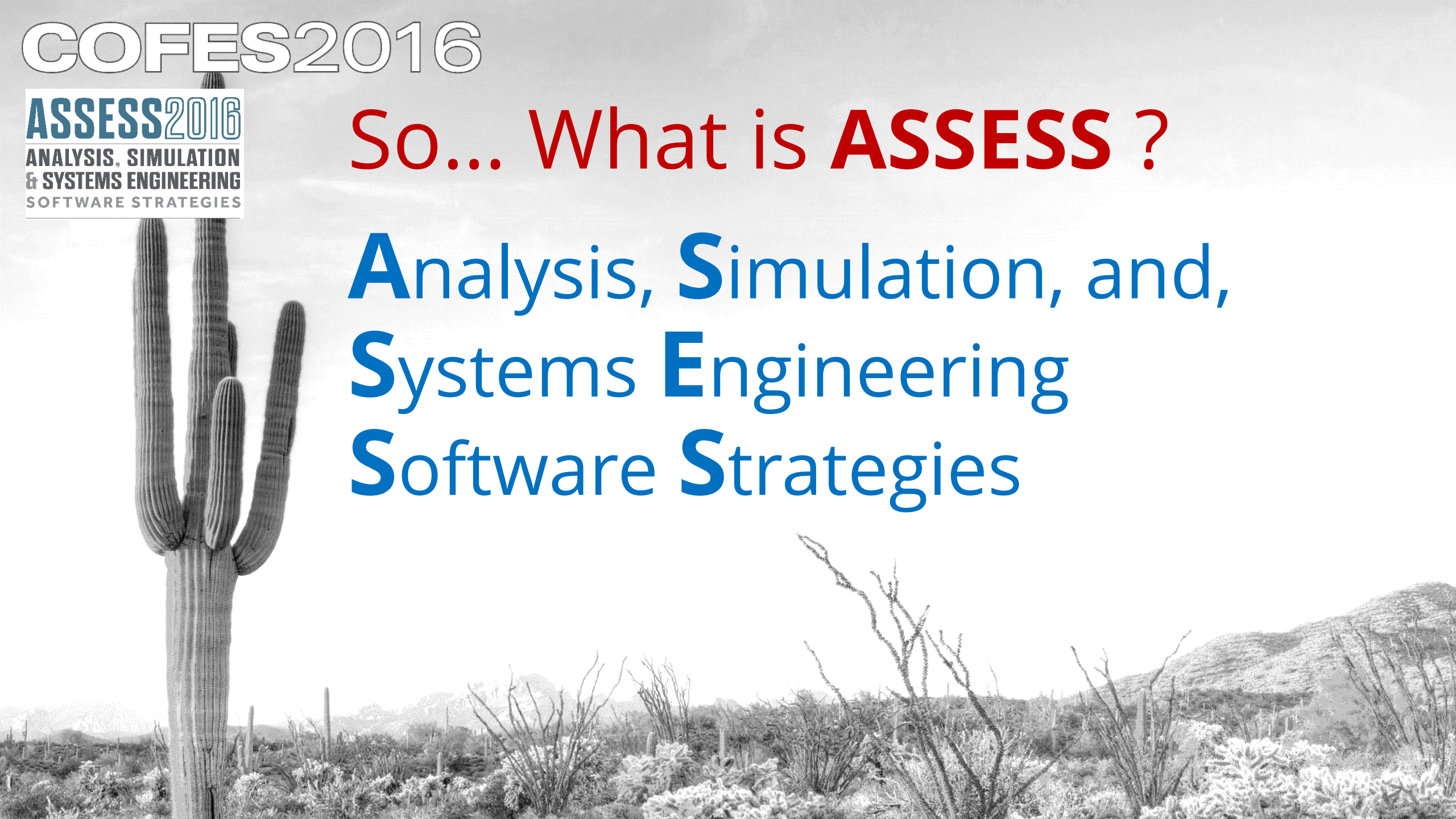
So… What is **ASSESS** ?

Analysis, **S**imulation, and,
Systems **E**ngineering
Software **S**trategies



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So… What is **ASSESS** ?

It's a broad reaching, multi-industry initiative …

…to expand the use and benefit of software tools for model-based analysis, simulation, and systems engineering **in the engineering applications domain**.

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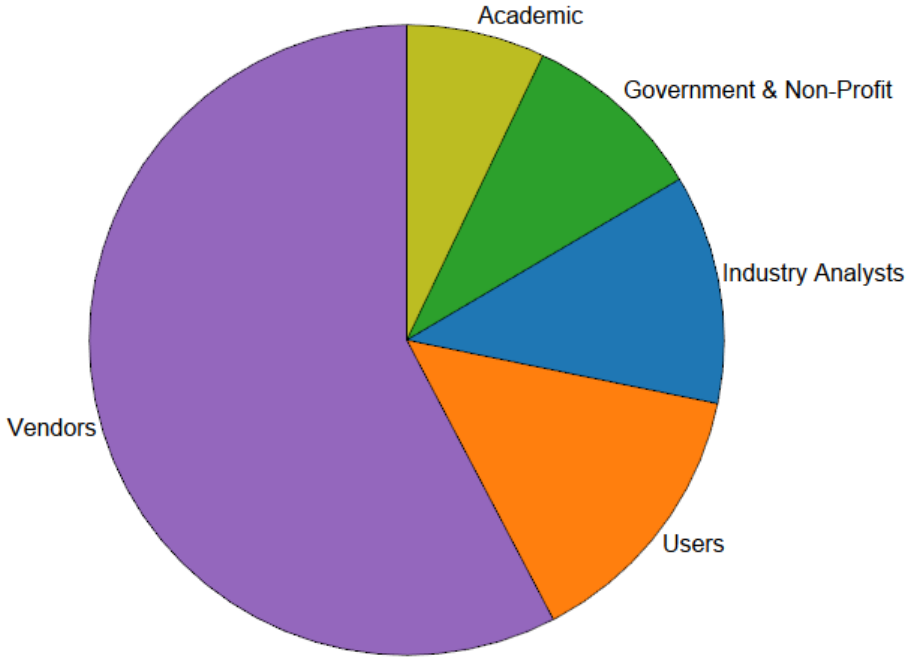
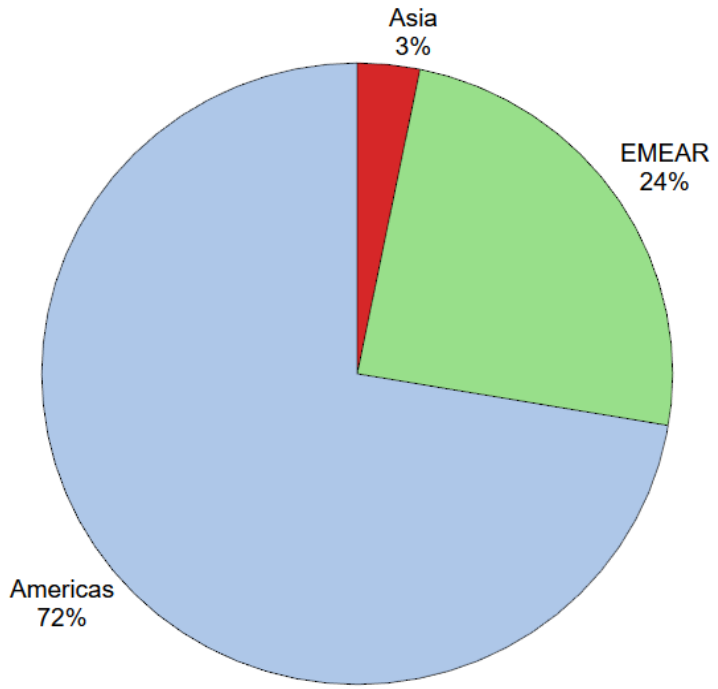
1st Annual Congress – January 2016

- Follow up to ASSESS Summit
  - held January 2015 in Sante Fe, NM
- 85 attendees despite the blizzard of the century





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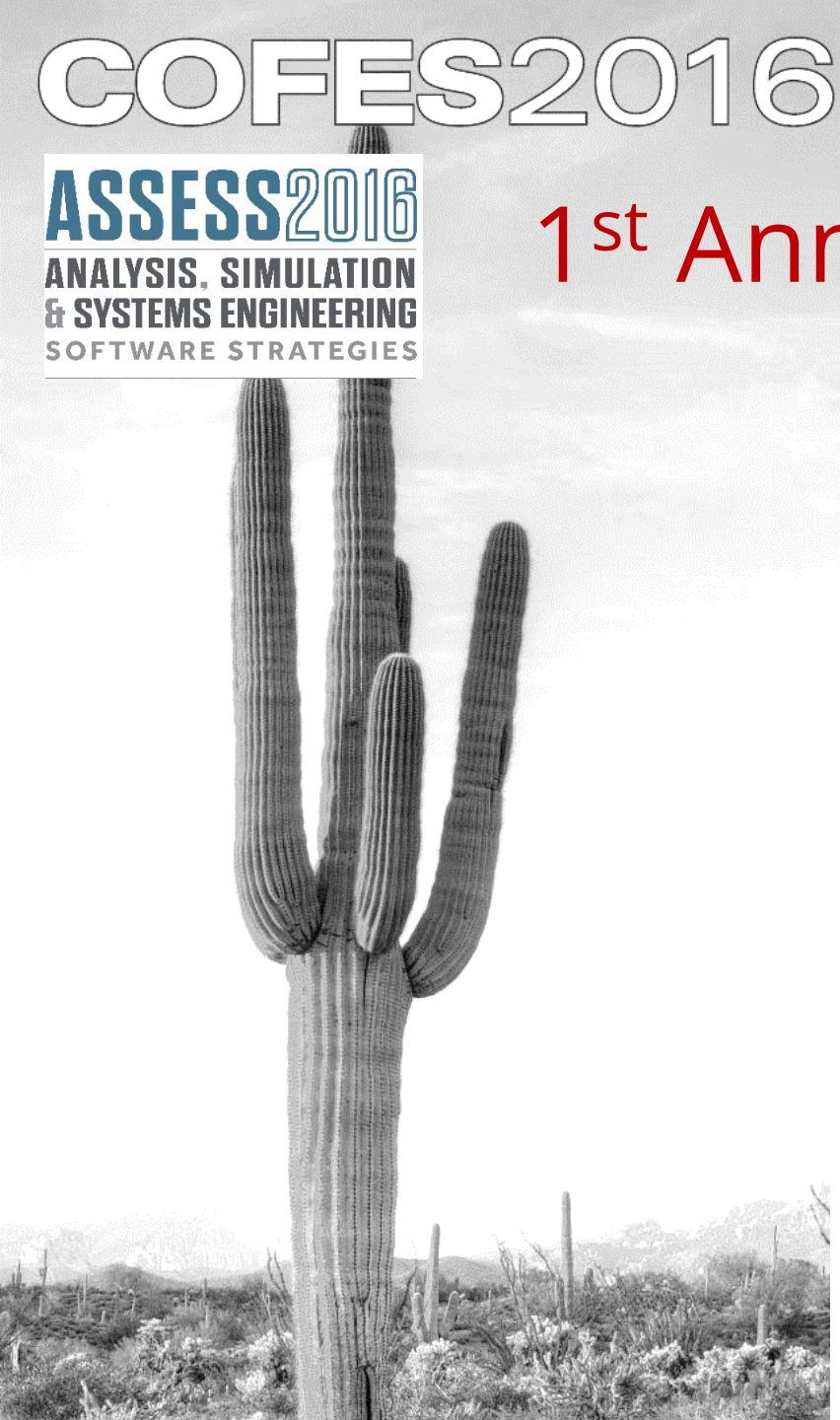

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NAFEMS

DPS Digital Product Simulation

IEEE SMC Systems, Man, and Cybernetics Society

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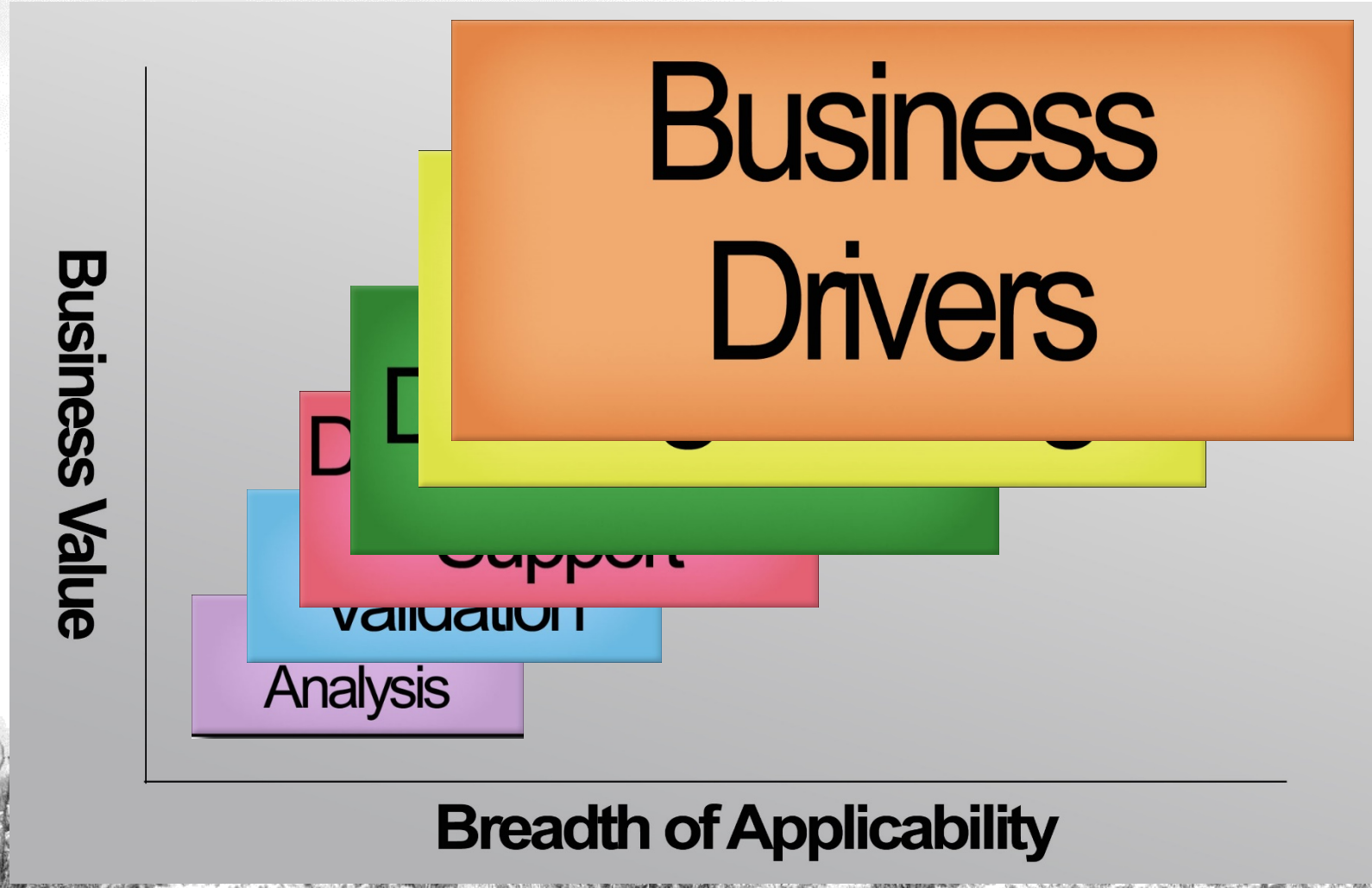
The Changing Role of Simulation



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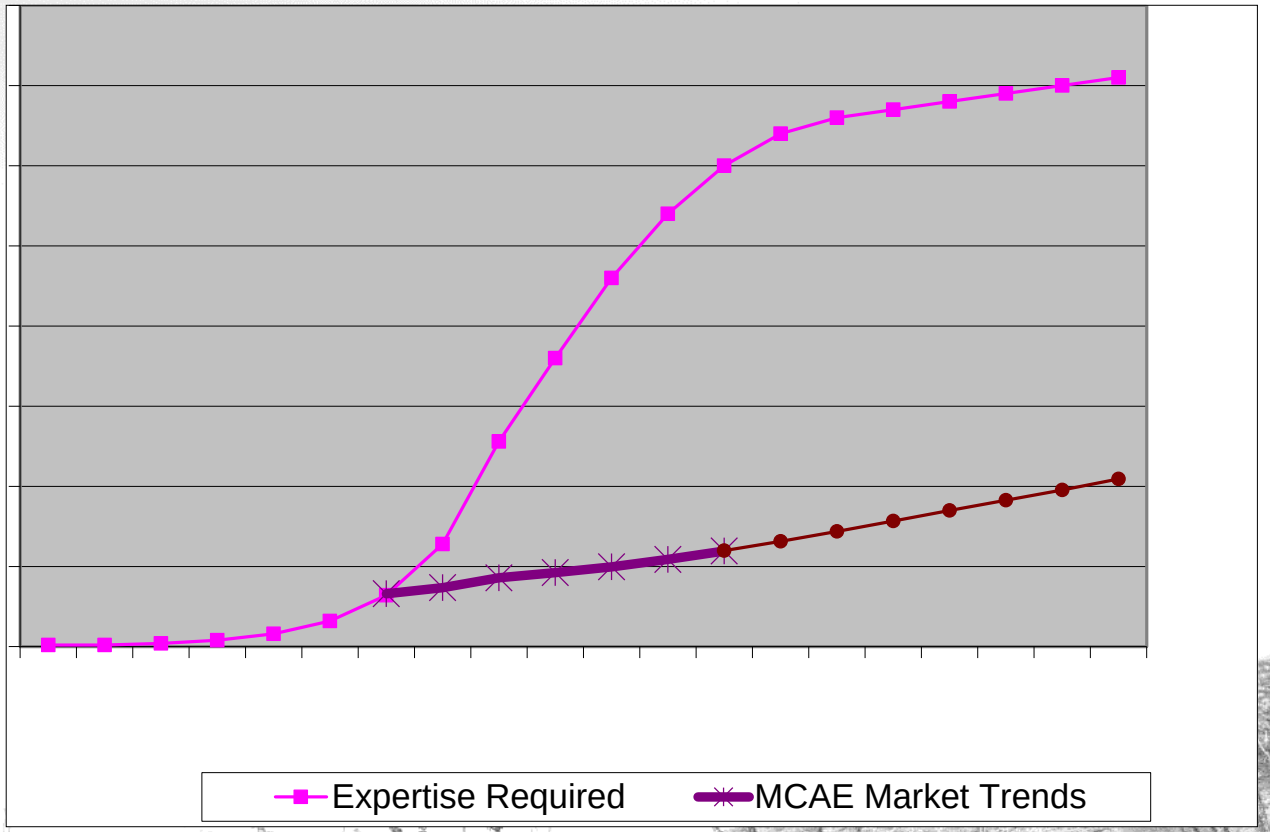
Business value drives broader demand

- Simulation is still done primarily by specialized Analysts
- Growth is tempered by lack of expertise available



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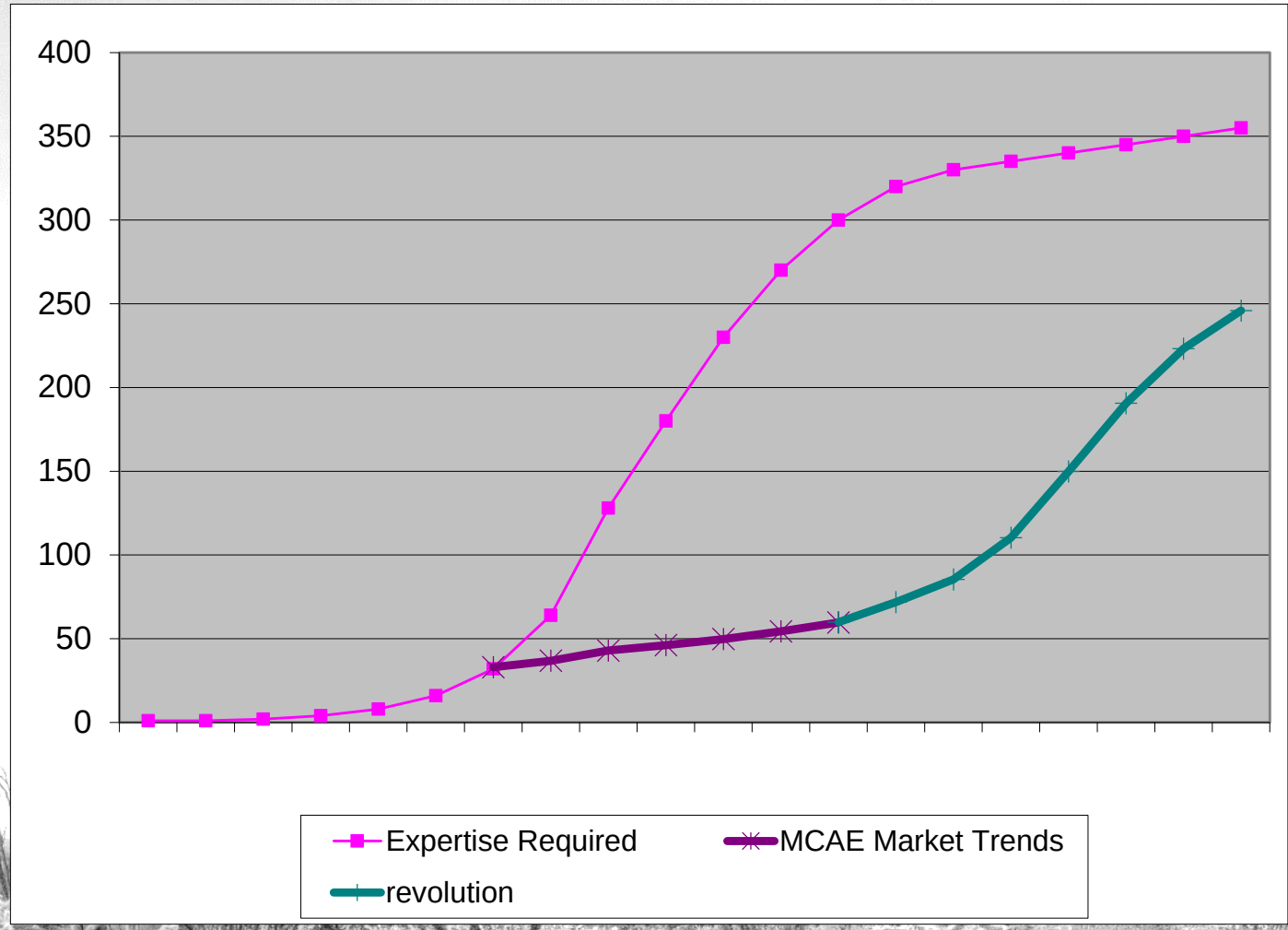
The demand is not going away

- Business Drivers are going to force a "**revolution**" and Simulation will be forced to find a way



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1st Annual Congress – Day 1

- Started with 3 Keynote Presentations
  - Jesse Citizen -- DMSCO
    - The Defense M&S Enterprise
  - Roger Burkhart – John Deere
    - Challenges of Collaboration through Shared Models
  - Zack Eckblad -- Intel
    - Democratization of Structural Analysis Using Meta-Code and Webapps

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1st Annual Congress – Day 1

- Then 2 rounds of technical briefings
  - First round was intended to inform
    - 12 briefings
  - Second round was intended to discuss "state-of-the-art"
    - 14 briefings

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1st Annual Congress – Day 1

- Review of Key drivers
  1. how to be more competitive
  2. exponentially growing complexity
  3. available computing power rapidly removing the computing bottlenecks
  4. new world of 3D printed objects
  5. Entirely new applications are creating a rapidly growing demand to enable breakthroughs
  6. used almost exclusively by a limited number of expert analysts
  7. efforts have three key but disjointed vectors

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1st Annual Congress – Day 1

- ASSESS 2016 Working Groups
  1. Democratizing STASSE -- Monica Schnitger / Karlheinz Peters
  2. STASSE Confidence -- Keith Meintjes
  3. Business Challenges – Marc Halpern
  4. The Intersection of Systems Modeling and Classical Simulation – Don Tolle
  5. Aligning Commercial, Government & Research Interests and Efforts – Dennis Nagy
  6. Potential Game Changers – Andreas Vlahinos
  7. Looking Forward – Jack Ring/Bruce Jenkins

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1st Annual Congress – Day 2

- Started with 1 Keynote Presentations
  - Rod Dreisbach – formerly with Boeing
    - Evolution, Revolution, & the Next New Generation of Engineering Simulation
      - Strong call to action for a **Unified Vision** to convert **STASES** to **ASSETS**

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1st Annual Congress – Day 2

- Working Group Presentations
  - Vision
  - Goals / Objectives
  - Issues
  - Priorities
  - Recommended Next Steps

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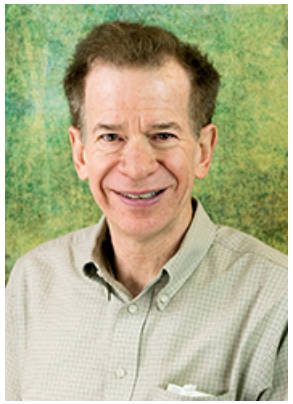

ASSESS Workgroups

Democratizing Software Tools for Analysis, Systems Engineering, and Simulation (STASES)

John Chawner, Pointwise

STASES Confidence

Keith Meintjes, CIMdata

Business Challenges

Marc Halpern, Gartner

The Intersection of Systems Modeling and Classical Simulation

Steve Coy, TimeLike Systems

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ASSESS Workgroups

Aligning Commercial, Government and Research Joe Walsh, IntrinSIM

Joe Walsh, intrinSIM

Potential Game Changers

Andreas Vlahinos, Advanced Engineering Solutions

Looking Forward

Chris Wilkes, Sigmetrix

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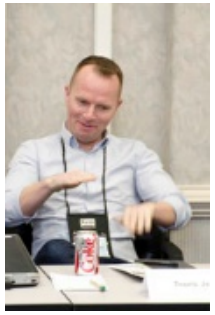
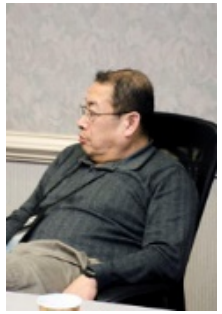
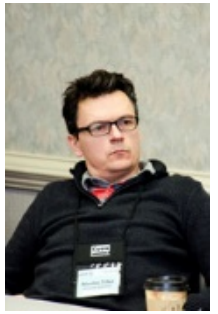
Democratizing Software Tools for Analysis, Systems Engineering, and Simulation (STASES)



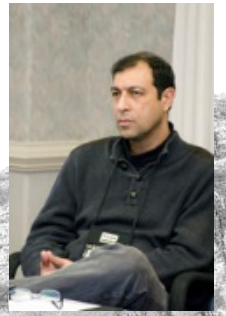
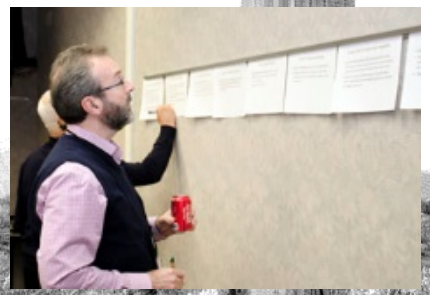






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Mission

- Make it possible for people who could benefit from using STASES to be able to use STASES.
- Get STASES into the hands of current non-users.
  - New (more users w/in existing organizations)
  - New New (non traditional users)
- Address STASES' ease of use issues.

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Scope

- The discussion about democratization at ASSESS 2016 in January overlapped three other breakout topics.
  - Confidence: Simulation governance as it pertains to non-expert use of STASES, validating ROI
  - Business Challenges: Licensing models (i.e. cost), value proposition (i.e. engaging current non-users)
  - Heterogeneous Models: data exchange including standards

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Vision

- Customers will benefit from optimized products for which STASES was an integral part of their design.
- Design organizations will benefit from a well-defined value proposition for the application of STASES to the development of new products.
- Users within a design organization willing to use STASES will be able to use it reliably.

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Goal

- Grow STASES use by 10x in 5 years
  - inside & outside of engineering
  - mostly from SMBs but the Fortune 1000 will benefit too

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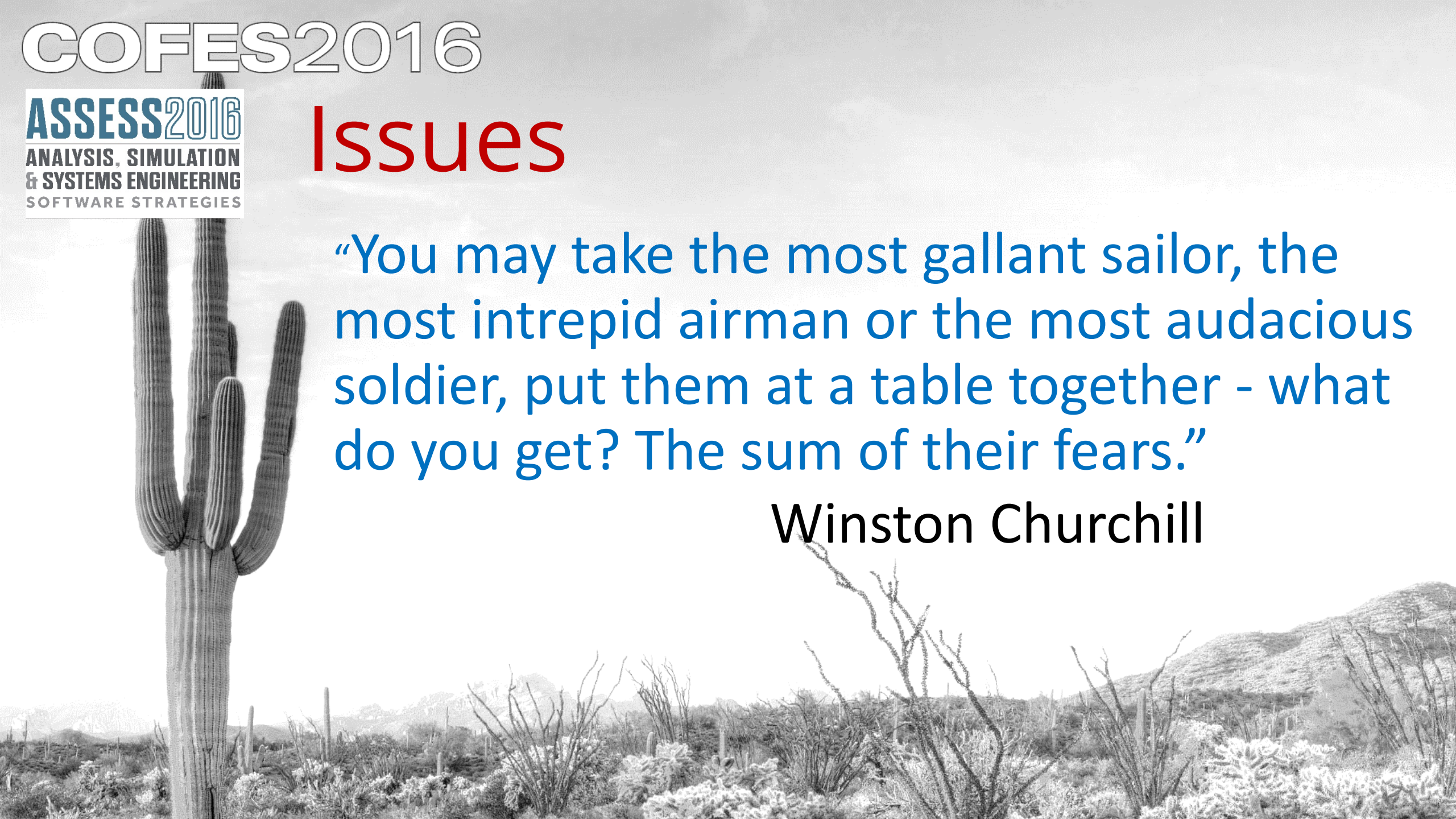
Issues

"You may take the most gallant sailor, the most intrepid airman or the most audacious soldier, put them at a table together - what do you get? The sum of their fears."

Winston Churchill



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The devil you know…

- Current non-users of STASES say…
  - "What we do now is working."
  - "But we do physical tests!"
  - "Why not Excel (or MATLAB)?"
  - "We'll just make the part thicker."
- Because they don't know…
  - what STASES can do for their product.
  - what STASES can do for them.

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It costs too much.

- Cost is a significant barrier to entry for SMBs.
  - A $30,000 software license is a significant barrier to entry for SMBs.
  - Then there's the computer to run it on.
  - And an expert to use it.
- Because today's norm is…
  - Annual/leased software licensing
  - On-premise computing
  - Expert usage

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It's too hard to use.

- Use of STASES is complex.
  - Requires both CAE & subject matter expertise.
  - Results are not presented in a form appropriate for non-experts.
- New users fear…
  - Non-expert use of STASES
  - Reliability of results
- But it needn't be complicated.
  - Causes: general purpose STASES tools, lack of V&V

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The Unknown Unknowns

- Organizations not using (or not widely using) STASES may not be aware of some challenges awaiting them.
  - Workflows will need to change to support use of STASES
  - Representation and management of STASES data (inputs and outputs) is a significant challenge.
  - Data exchange between STASES tools is a quagmire.

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Next Steps (1 of 3)

- Communicate STASES success stories.
  - Technical successes
    - Benefits to casual users
    - Benefits to expert users
  - Business successes
    - "Simulation is the key enabler to increased competitiveness."

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Next Steps (2 of 3)

- Promote the appification of STASES.
  - Successes of early adopters.
  - Expand their implementation and adoption.
  - Consider frameworks to aid their proliferation
- Consider any other idea to improve STASES ease of use.
  - For example, invisible mesh generation

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Next Steps (3 of 3)

- Cost – What are the main issues?
  - Up-front cost as barrier to entry?
  - On-going (TCO) cost?
  - Too expensive relative to what?
  - Is the barrier to adoption total installed cost or license?
  - What alternative business models can reduce the barrier(s)?

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Democratizing Software Tools for STASES

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STASES Confidence

The Team

Core

- Keith Meintjes - CIMdata
- Laura Michalske – The Procter & Gamble Co.
- Ricardo Actis - ESRD
- Rod Dreisbach – The Boeing Company (Retired) & Private Consultant
- Scott Hutchinson – Sandia National Laboratories
- Scott Leemans – AlphaBet [X]
- Oleg Skipa – Computer Simulation Technology

Defector

- Ken Welch - SIMSOLID

Saw The Light

- Ravi Shankar – Siemens PLM

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STASES Confidence

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STASES Confidence

- Scope Incudes:
  - Appropriate Model Fidelity
  - Verification & Validation
  - Uncertainty Quantification
  - Risk Management
  - Deployment & Governance
  - Unsexy Stuff

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STASES Confidence

Enablers to increase confidence:

- Policies
- Best Practices & Procedures
- Expectations
- Skills & Competencies
- Culture

What is this really?

STASSE Confidence = Simulation Governance

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Simulation Governance

- Simulation Management as a corporate strategic asset
- Command & control of all assets to achieve a goal
- Goal = Business Need = Simulation Governance ROI
  - Reduce Cost (ROI)
  - Reduce Time
  - Increase Quality
  - Increase Business Growth
  - Reduce Risk
  - Increase Innovation

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STASES Confidence – Next Steps

1. Compose Industrial CxO Message – ASSESS Working Group
2. Messengers
   - Brad Holtz & Joe Walsh
   - Analysts
   - Consultants
   - Software Suppliers
3. ASSESS & NAFEMS Collaboration
   - Matt Ladzinski & Rod Dreisbach
4. Examples

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STASES Confidence

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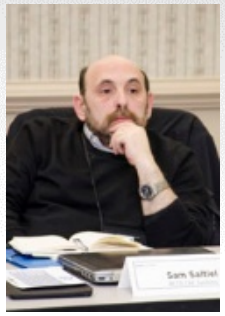
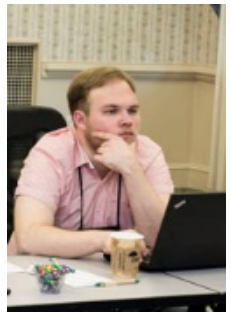
Business Challenges





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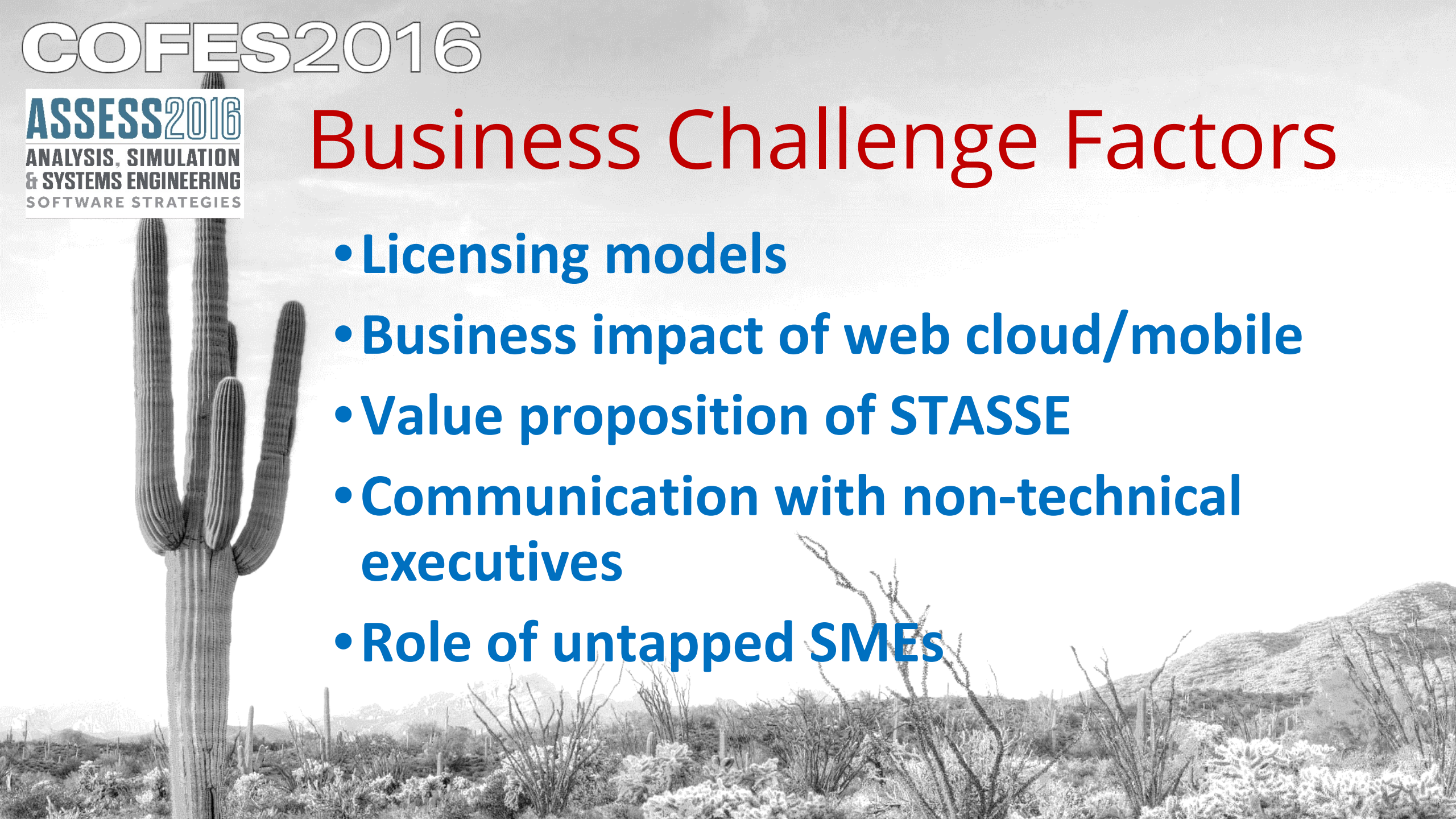
Business Challenge Factors

- Licensing models
- Business impact of web cloud/mobile
- Value proposition of STASSE
- Communication with non-technical executives
- Role of untapped SMEs



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Licensing models

- **Challenges:** Expensive and restrictive
- **Impact:** Limits experimentation and use of CAE/systems engineering tools
- **Proposal:** Pay as you go licensing models
- **Anticipated effect:** Willingness to provide education and experience to new users
- **Inhibitors:** Major vendor business practices
- **Recommendation:** Promote “pay as you go” and adopt services/vendors that provide “pay as you go” CAE/simulation access

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Business Impact of Web Cloud/Mobile

- **Challenges:** Development, validation, and building trust/experience
- **Impact:** Limits accessibility of SW and availability of compute power
- **Proposal:** Pilot offerings and provide feedback
- **Anticipated effect:** More agile and scalable use of CAE and simulation tools, faster adoption
- **Inhibitors:** Corporate IT practices and beliefs
- **Recommendation:** Educate the IT organization and be patient as SW markets will change

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Value Proposition of STASES

- **Challenges:** Hard to attract wide attention, poor reward and recognition climate for achievers
- **Impact:** Limits growth of educated and skilled user community as current CAE veterans age
- **Proposal:** Publicize success stories, promote and publicize competitions, public school intros
- **Anticipated effect:** Increased awareness and inspiration
- **Inhibitors:** Current culture and priorities
- **Recommendation:** More aggressive promotion through professional societies, Others???

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Communication with Non-technical Executives

- **Challenges:** Other priorities, lack of education and understanding
- **Impact:** Inadequate funding and sponsorship of CAE/Simulation initiatives
- **Proposal:** Communicate with focus on business metrics, use simple metaphores
- **Anticipated effect:** Increase executive sponsorship
- **Inhibitors:** Getting executive attention
- **Recommendation:** Expose CAE/simulation value through media that executives prioritize

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Role of Untapped SMEs

- **Challenges:** Intermittent CAE use discourages investment in education and tools
- **Impact:** Limited SME use of CAE/Simulation
- **Proposal:**
  - Expand “certified” CAE consultant community (e.g. COMSOL initiative)
  - Enable low cost contextually rich specialty “apps”
- **Anticipated effect:** Expanded CAE/simulation use among SMEs
- **Inhibitors:** lack of interchange standards, availability of low cost tools
- **Recommendation:**
  - Further development and support of standards for data sharing (e.g. FMI)
  - Cultivate best practices and use of “certified” consultants with expanded communication clarity and bandwidth
  - Guidelines and best practices for contextually rich apps

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Business Challenges

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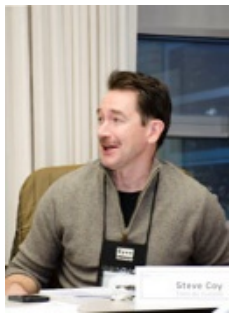
Combining Heterogeneous Models

The Intersection of Systems Modeling and Classical Simulation







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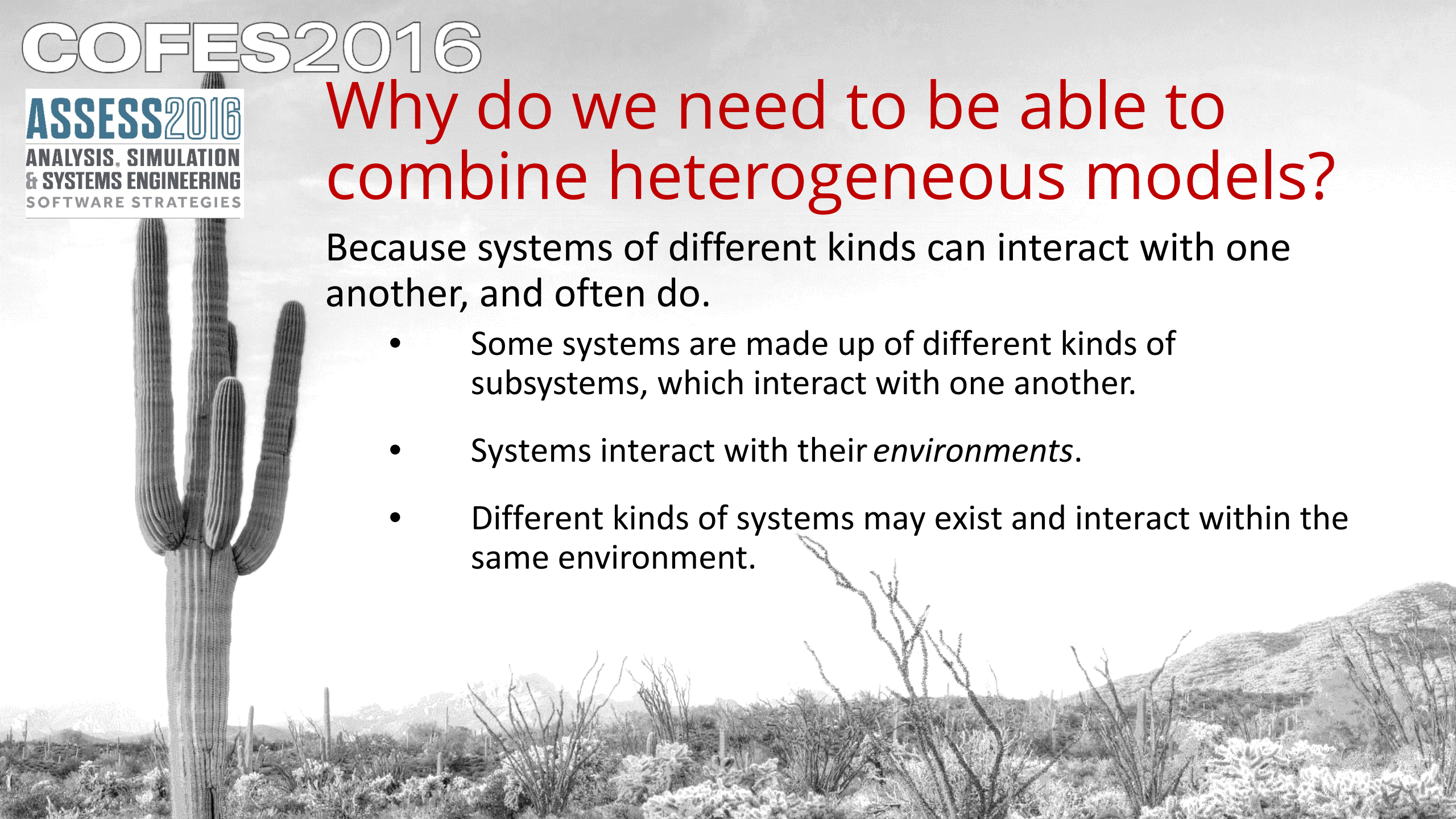
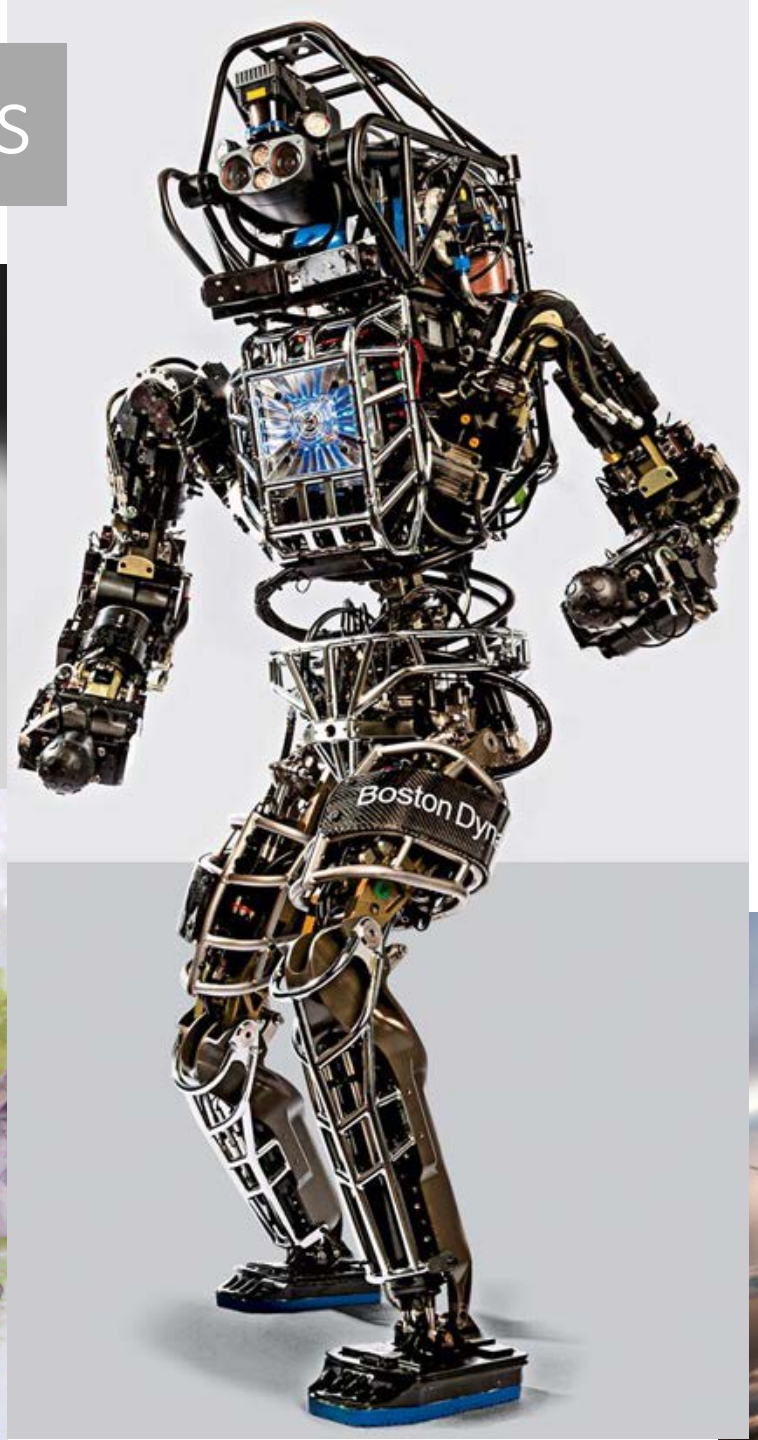
Why do we need to be able to combine heterogeneous models?

Because systems of different kinds can interact with one another, and often do.

- Some systems are made up of different kinds of subsystems, which interact with one another.
- Systems interact with their *environments*.
- Different kinds of systems may exist and interact within the same environment.



Engineered systems



Evolved systems

Systems plus their environments

Our world as a whole

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Mission Statement

Ideally, we aspire to find a single, well-integrated approach, that would enable us to model any kind of system, at whatever level of fidelity may be required to investigate whatever questions are of interest.

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Goals/Objectives

- Examples of the kinds of systems we need to be able to model:
  - Cyber-physical /mechatronic
  - Software, computers, computer networks
  - Biological systems, medical devices
  - Very large scale systems – climate, economy, population dynamics, etc.
  - "Black swan" events, e.g. tidal waves, earthquakes
  - Systems of systems, which may involve any or all of the above

Other goals and objectives:

- Ease of use
- Good and widely accepted standards
- VV&A, UQ (component-based)
- Libraries of accredited components

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Major Issues

- Need to break down (or bridge) “silos”.
- Need to find a common understanding (top level abstraction layer) that makes it possible to understand different silos (or at least their interfaces and interactions) from a common point of view.
- Need for standards for communicating required information between/among silo-specific tools and formalisms.
- Lack of funding / momentum
- Existing standardization efforts (e.g. FMI) are good, but very far from complete.

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Recent progress

- Modelica and “acausal” simulation
- The Functional Mockup Interface (FMI) standard
- Multi-physics simulation tools
- Cloud-based simulation, web-based UIs
- Uncertainty quantification (UQ) and sensitivity analysis
- Auto-generated/auto-refined *surrogate models*, and *surrogate-based optimization*
- More flexible / general simulation frameworks

What more is needed?

- Further evolution of FMI
  - More general coupling, e.g. DAEs, PDEs, not just ODEs
- More powerful, more robust solvers
  - Delay- / Partial- / DAEs of arbitrary orders, plus handling of initial conditions
- Micro-parallelization
  - Use causal relationships to identify parallelizable events
  - Take into account propagation delays, e.g. finite speed of light.
- More complete (while still flexible & general) simulation frameworks

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Priorities

- Cyper-physical / mechatronic systems / IoT
- Common understanding / sufficiently general top level abstraction layer
- Sharing information
- Enabling design and development of robust systems
- Providing robust, easy to use, well documented tools for model-based design and engineering that are sufficiently general and flexible to handle all the different kinds of systems we need to engineer.

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Recommendations

- Standards
  - Evolve existing (OSLC, FMI, Modelica, STEP, PLCS,SysML, etc.)
  - New standards for integrating 0D, 1D & 3D physics models, software-intensive systems, domain-specific tools and techniques.
  - Develop candidate reference implementations to test and refine possible standards.
- VV&A, UQ – best practices
- Develop libraries of accredited component models

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Combining Hetereogeneous Models

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The Valley of Death

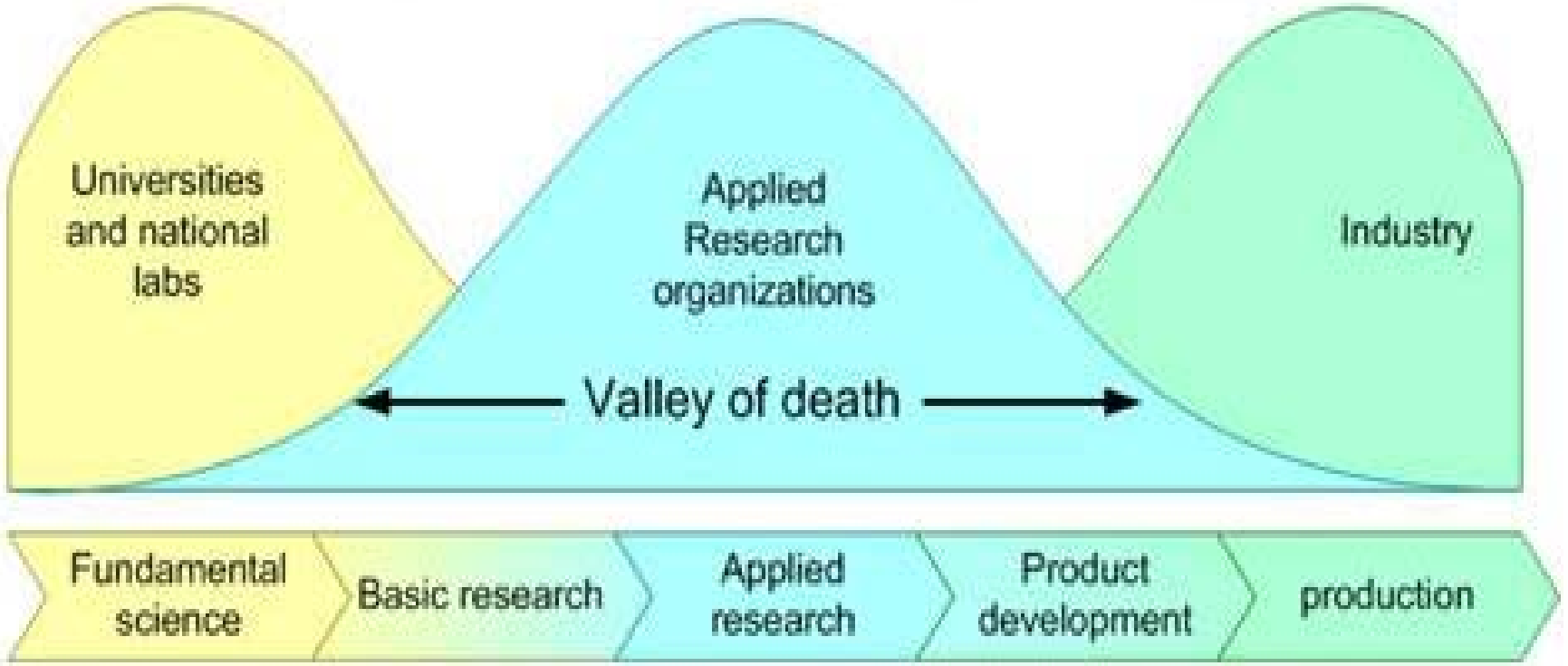

Figure from Walt Downing´s keynote at SoSE 2015: `Connecting through Research Partnerships`, showing the need to connect all types of research to achieve business.

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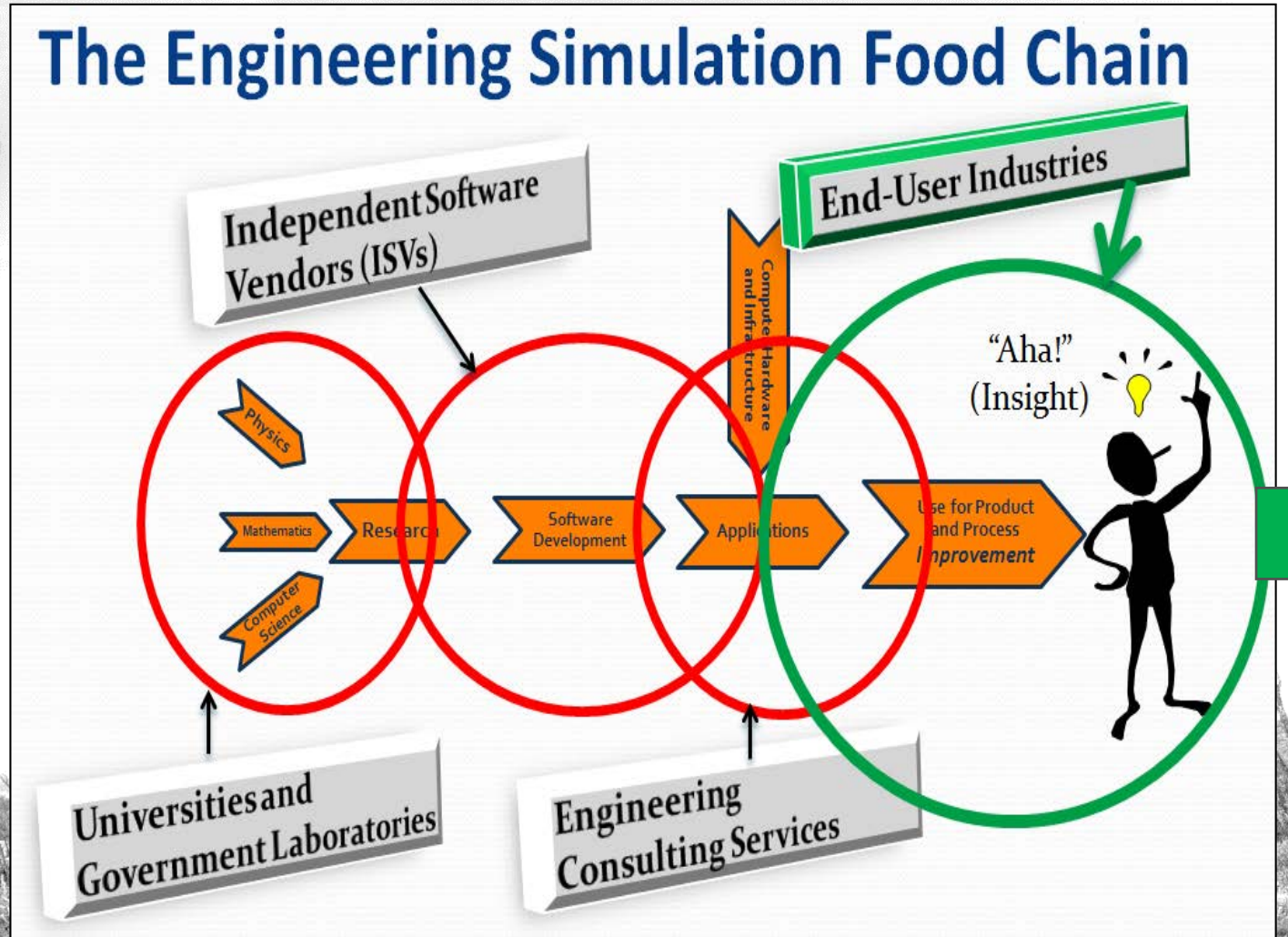
Vision



- **Influence how fast key developments flow along this food chain**

Perspective

- Early 80s, CAE vendors interacted well with university researchers
- Mid 80s – Late 90s, relationship broke down (almost adversarial)
- Camps are not aligned
  - Commercial
  - Research and Education
  - Government
    - Defense / Other

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Intellectual Property (IP)

- Do not start the discussion with IP issues in the abstract
  - First figure out what you want to do concretely
- Bayh-Dole Act (December 12, 1980)
  - **Before**: federal research funding contracts and grants obligated inventors to assign inventions to the federal government
  - **After**: permits to pursue ownership of an invention in preference to the government

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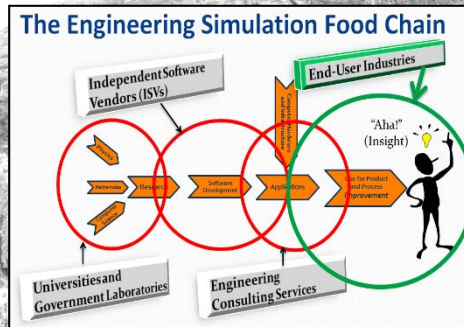
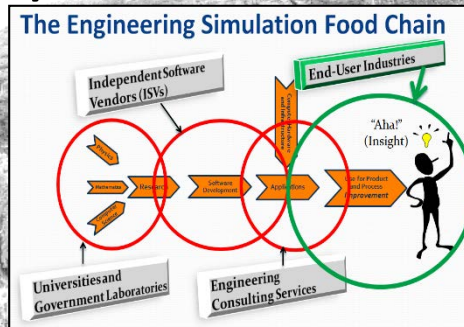
Issues: challenges along the chain

- The front of the chain has no incentive to carry deliverables further
  - The objective of Academia is to produce students and papers
- The middle of the chain does not have the resources or the inclination
  - ISVs expect content to be freely available and developed to commercial quality
- IP rights can block moving along the chain
  - BSD: anybody can take it and do what they want
  - GNU: if you do anything with it, you have to put back what you did with it



Examples of Current State

- NSF ERC: heavy administrative burden
- SBIR: must show a commercialization plan
- DOE: solicits proposals to commercialize DOE code
  - Not general enough or does not address customer needs (costly to commercialize)



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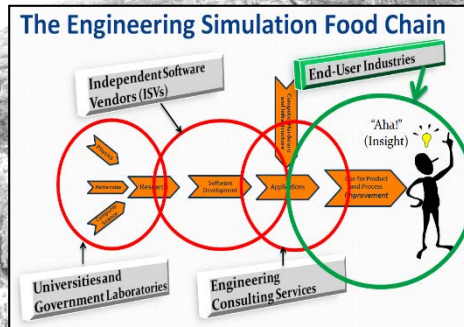
Motivate responsibilities

- Get people involved early along the chain
  - Stakeholders have ‘skin in the game’
- For example, pre competitive consortia
  - End user has early (first) access with product features adopted to needs
  - ISVs learn about (prospective) user needs
  - Government leverages funding multiplier to get research done



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Recommendations

- Form a working group for models to help move along the chain
  - Study barriers
  - Proposal to overcome the barriers
  - Smoothen the path
- Inventory current mechanism for cooperation to support the flow along the chain
- Study ongoing models
  - e.g., Fraunhofer, GOALI, DOE

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Some Key Take Aways

- ISVs are critical link in the chain and must be on board with the appropriate representative
  - Otherwise we cannot be cost effective in meeting end user needs
- Educate researchers about what are the good license models to enable the transfer of technology (not GNU)
- Trust in collaboration

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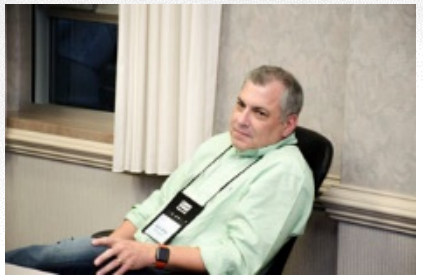
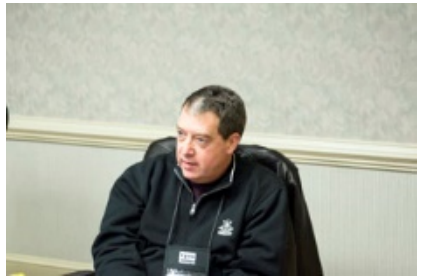
Potential Game Changers







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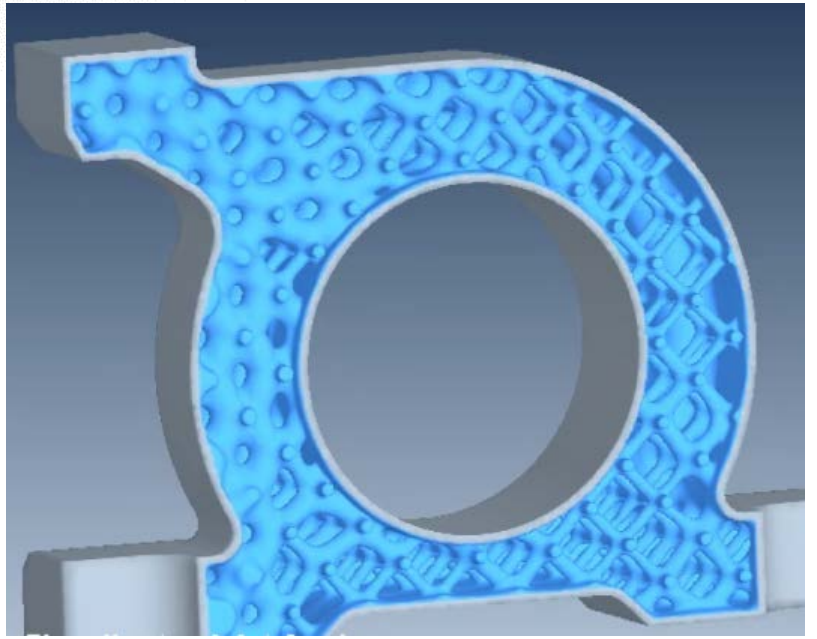
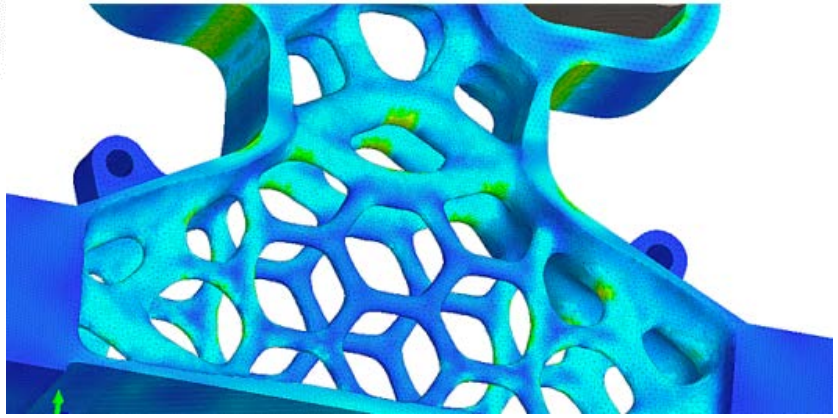
Potential Game Changers

- Integration of modern **Topology Optimization and ALM** has enormous potential of light weight designs
  - Conventional CAD inapt for ALM
  - Optimization tools can't handle complex freeform lattice structures
  - In the past we could design parts that couldn't build, now we can build parts that we couldn't design



Potential Game Changers

- **Eliminate CAD** from the Process
  - Topology Optimization designs shape (STL Model)
  - 3D printer manufactures STL model



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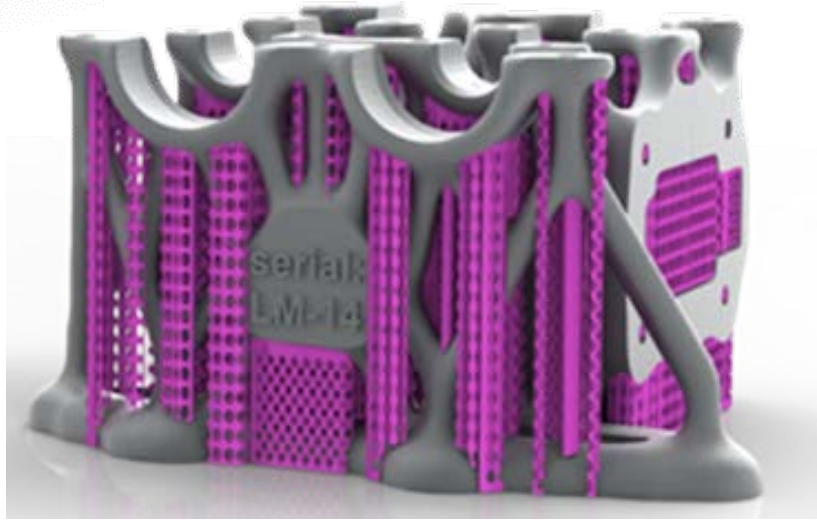
Potential Game Changers

- Design Process Automation that takes **the human out of the loop**
  - Enterprise transformation
  - Front End System Architecture
  - Make good designs fast
  - Uncertainty Quantification



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Potential Game Changers

- Simulation in the **Web / Cloud / Mobile**
  - Internal cloud simulations available for years
  - Public cloud simulations new and exciting
  - HPC Scale / Software updates / Installations / IT cost
  - SME can pay by the drink

Potential Game Changers

- Birth of **Digital Twins** with CAE and IoT
  - The customers of large systems demand delivery of not only a new product but also a **highly detailed digital model (digital twin)** *specific* to individual product
  - The Digital Twins would track the **products health** through its life and with real time CAE will provide feedback on the pragmatism of the **performance requirements** (load levels, fatigue cycles, temperature environments, etc.)
  - Augmented Reality

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Potential Game Changers

- Gaming Industry Model for Product Development Software
  - Collaboration – Crowdsourcing – Certification Levels

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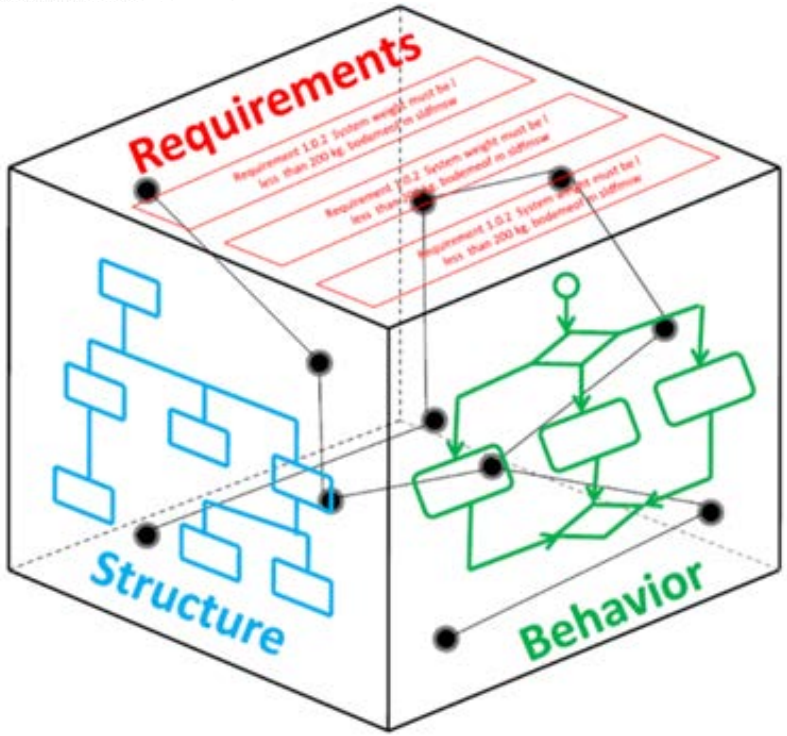
Potential Game Changers

- Model Base System Engineering
  - Data Structure for System Level Models
  - System Architecture Changes
  - Design Justifications
  - Agile Systems Engineering / Uncertainty in Requirements



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Potential Game Changers

- Knowledge Capture and Reuse
  - Reusable Design Processes
  - Abstract Modeling
  - AI in design tools / Knowledge-based engineering (KBE)
  - Knowledge must be managed globally

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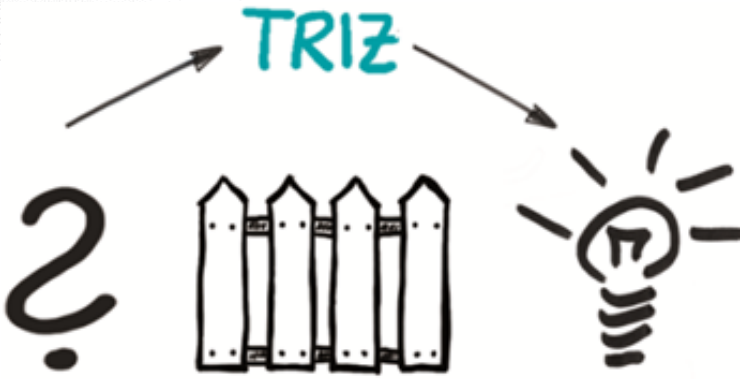
Potential Game Changers

- Computer Aided Innovation
  - Theory of Inventive Problem Solving (TRIZ)
  - Mechanism Synthesis
  - Material Selector
  - Shape finder



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Potential Game Changers

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Looking Forward





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Vision

- Evolve simulation tools to incorporate knowledge about themselves and their environment
- Improve the economic and educational support infrastructure

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Opportunities

- Improve education
- Improve economic model to fund R&D
- Incorporate human knowledge
- Enable systems to be higher-order
- Evolve systems within ethical boundaries
- Improve soundness and completeness of requirements
- Automatically discover when rules are needed for emergent systems

Education

- Next generation of engineers should understand systems engineering
- Correspondence between systems simulation and games:
  - Play with ideas / parameter space
  - Observe outcome (simulation)
- Exampes:
  - Sim City (City planning)
  - Kerbal Space Program (Aerospace engineering)
- Improvements?
  - Games for other engineering disciplines?
  - Incorporate into curriculum?
  - Teach engineering concepts earlier?

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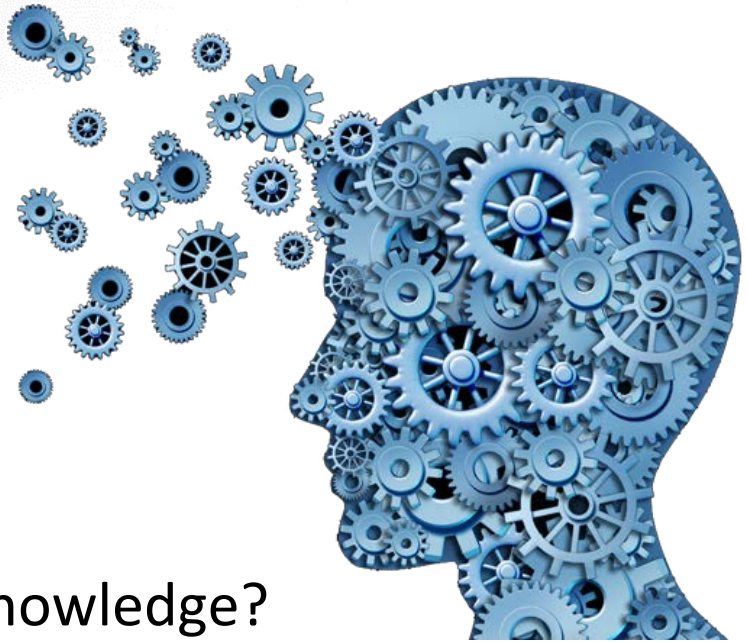
Economic Model

- Need to fund basic research in simulators and tools
- Common good often conflicts with Individual / Corporate Rewards

Improvements?

Human Knowledge



- Vast bodies of knowledge 'out there':
  - Referenced conference papers
  - Textbooks
  - Experts
  - Proprietary Data

Improvements?

- Can we automatically incorporate this knowledge?
- Can we mechanize how such knowledge is disseminated (e.g., 'call for models' or 'call for programs' instead of 'call for papers')?

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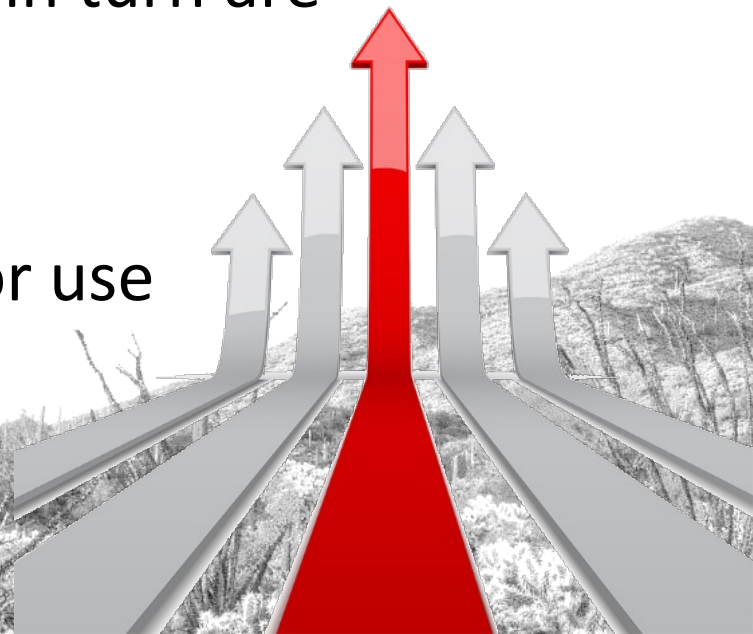
Higher Order Systems

- Simulators may need to simulate themselves
  - *Example:*
    Simulation of plane with autopilot may need to simulate autopilot decisions, which in turn are based on plane simulation

Improvements?

- Support for ‘meta-circular’ simulator use



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Evolving Systems within Ethical Boundaries

- Systems make increasingly autonomous decisions
  - Must deal with ethical dilemmas

Improvements?

- Improve system awareness/knowledge of human needs and expectations?
- Open dialogue (touches upon ethics/religion, full solution unlikely)?

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Requirements

- Today:
  - Customers have poor understanding of impact of requested features.
  - Engineers have poor understanding of customer needs.

Improvements?

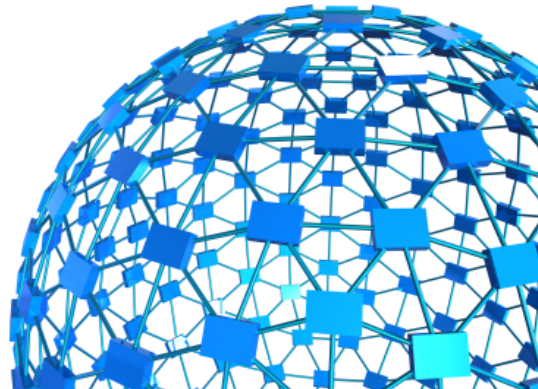
- Try to capture context?
- Model impact of requested requirements?

Rules and Emergent System Properties

- Complex systems exhibit emergent properties
- By definition, neither the properties nor their consequences are obvious

Improvements?

- Research challenge: can we detect when an emergent property violates explicit and implicit requirements?
- Improve system awareness/knowledge of human needs and expectations?



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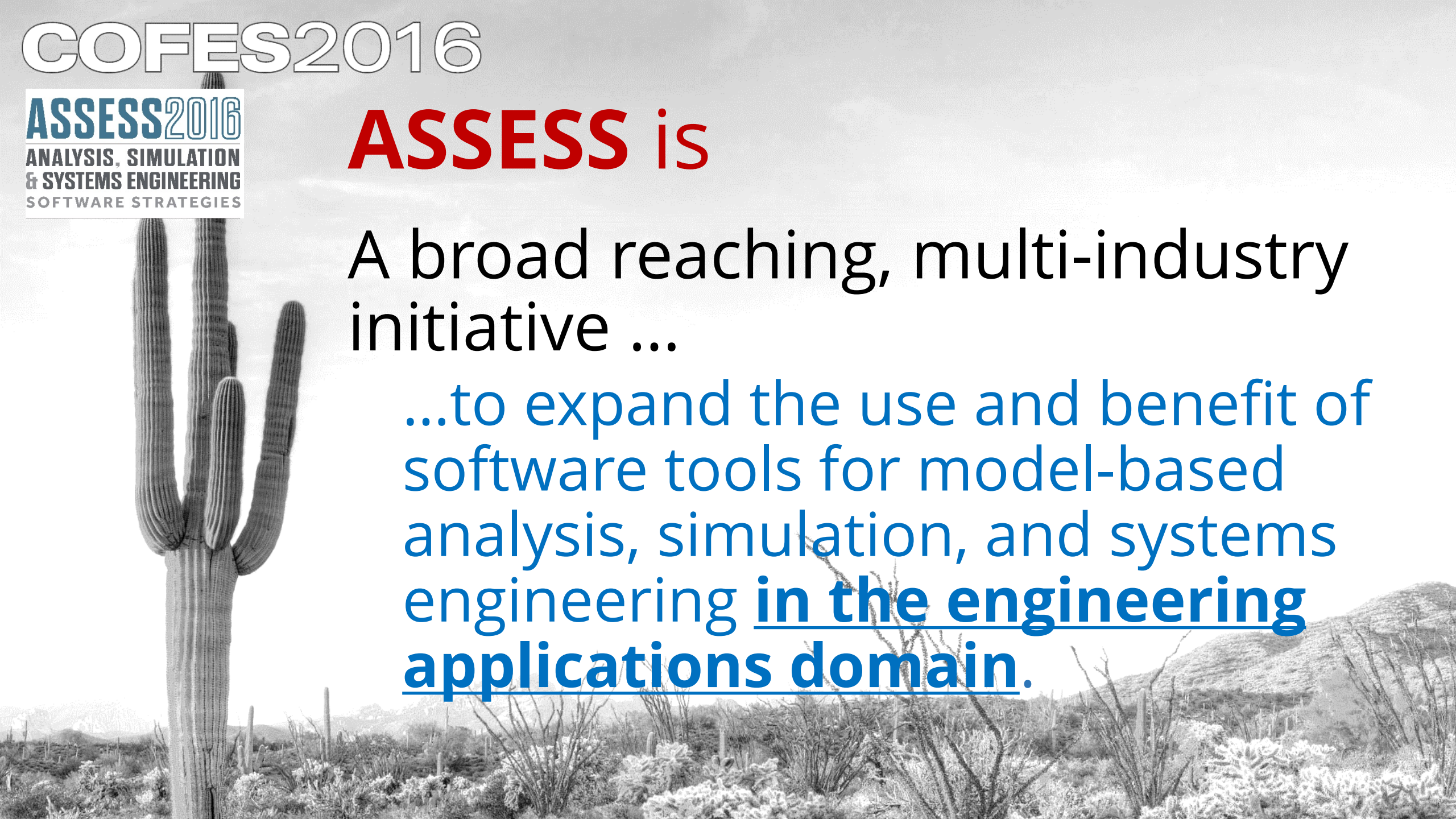
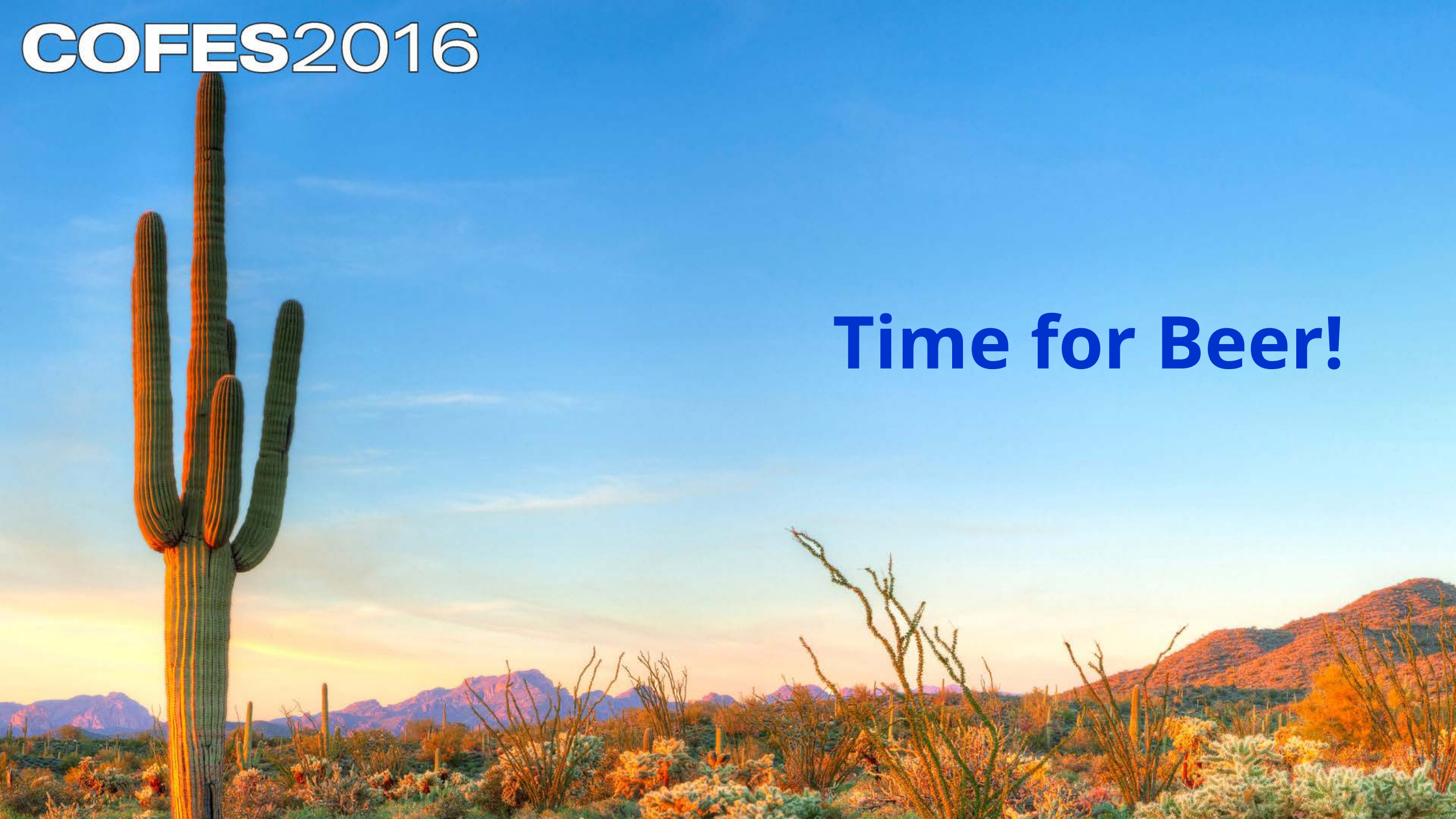
ASSESS is

A broad reaching, multi-industry initiative …

…to expand the use and benefit of software tools for model-based analysis, simulation, and systems engineering **in the engineering applications domain**.

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Time for Beer!