Accelerating innovation with simulation:

Increasing simulation driven decision-making requires strategic cloud enablement and deeper community engagement.

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Executive Summary

Simulation's highest calling is to offer fresh, earlier, more frequent, and accelerated solutions to product development. Hence, more simulation driven decisions can enable further strategic advantage for design-led businesses - to innovate and differentiate.

Finding a solution to optimize simulation's strategic impact is inherently complex. Affected by balancing system trade-offs (capacity vs capability vs flexibility vs cost vs impact). And the need to resolve gaps (experience, knowledge, and capability) existing in and outside the business.

Simulation (in the cloud) as part of the CAE toolchain is an increasing part of impact optimization. The question has become not only "if cloud" – but increasingly "how much", "who from" and "why". Determination and governance of such balances needs strong and tight collaboration between Strategy, Engineering, and IT teams. Each armed with the provider landscape, respective advantages / disadvantages, and the broadest possible outside-in perspective.

Simulation (in the cloud) has a solution value chain. Specialist Cloud Enablement solutions provide an essential middle / glue layer in this chain. Blackbox, Whitebox/Custom and ISV Embedded variants are available. Current solution choices may or may not be optimised for future performance, fit or flexibility needs. Strategic provider choice maximises the chances that knowledge, capability and experience gaps can be more quickly identified and resolved. A connected and overarching approach is also required to tame the complexity. There is also a clear need for greater CAE community development and participation - especially where a whole-business approach is taken rather than a purely technical one.

Call to action

Heads of Engineering, IT Infrastructure & Operations and Business Strategy in design-led businesses should.

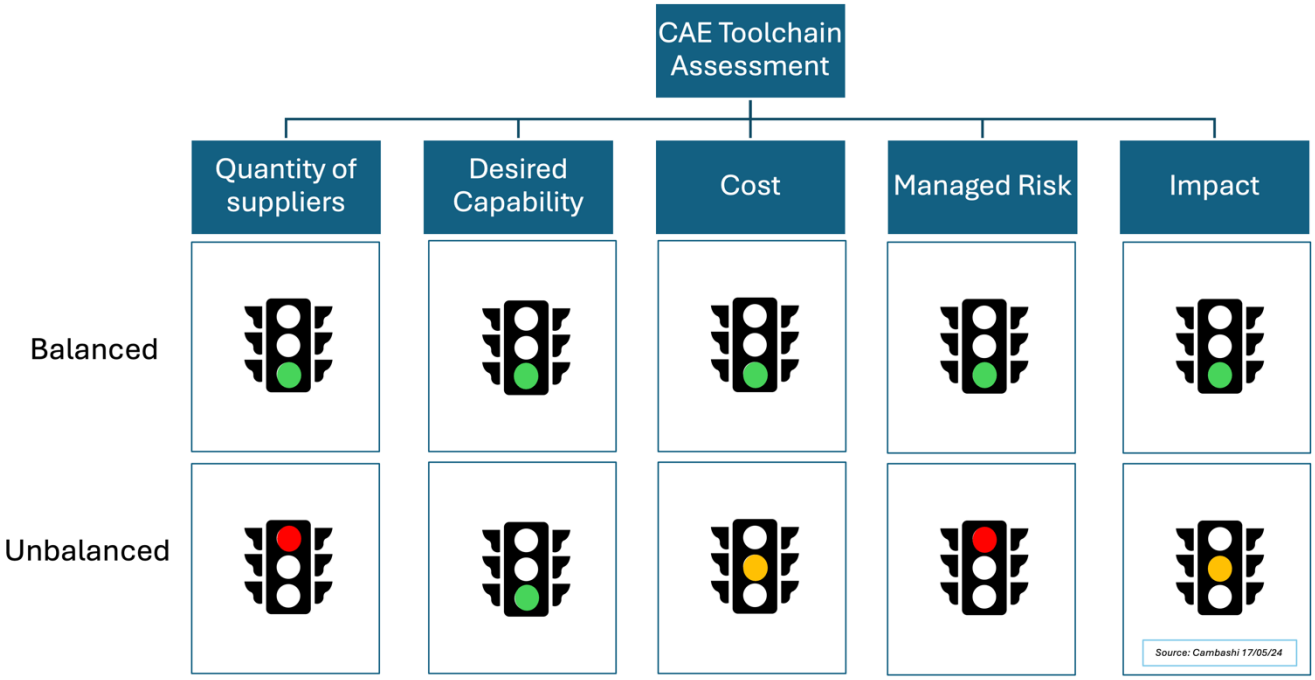
- Review and collectively reflect on the contents of this paper.
- Commit to regular simulation optimization interaction – starting with - what business decisions are / should be simulation driven and is the current solution chain sufficiently balanced for future needs.
- Ensure maximum outside in insight is brought to bear through membership and active participation in communities that join "the whole-business" dots together to drive simulation driven business impact.

Not “if cloud” – but “how much”, “who from” and “why”

Globally an estimated 1.6m engineers worldwide currently utilize simulation software (from entry level to advanced solutions). Critically each engineer will typically work for an organization endeavoring to optimize simulation outcomes. This optimization challenge is inherently complex. Undertaken in the context of attaining organizational goals, IT and CAE spend. A developing team sport where rules and roles are not always fully defined or worked out. From deciding/provisioning the right and balanced portfolio of CAE solutions to engineers (see fig 1) to testing next generation solutions perhaps running in parallel. Complexity can be compounded. Benefits and impact easily obscured.

The highest (and most noble) calling for simulation is that it offers fresh, earlier, more frequent, and accelerated solutions to product development. The opportunity and capability to differentiate and innovate becoming transformed. To thrive and survive design-led businesses will increasingly need to maximize simulation driven decisions and harness their resultant business impact. A broad optimization opportunity is present and worth pursuing - now. But how? And where are such optimization ideas and strategies currently taking root?

Figure 1 Deciding/Provisioning the right CAE Toolchain – balanced vs unbalanced.



Movement of engineering simulation to the cloud was and is a significant optimization focus. It is being driven by assessing requirements (capacity vs capability vs flexibility) alongside cloud vs non-cloud opportunity costs. Our research (and that of others) shows innovation as *the* key strategic driver – but other business drivers (cost, change management, risk appetite) must balance an otherwise elegant strategic clarity. Innovation – but, at what cost? Flexibility – but, at what cost? Data jurisdiction – but, at what risk?

Two contrasting starting points / trends for simulation in the cloud adoption are apparent.

- **Independent Software Provider (ISV) led adoption** – where software solution providers (cloud and on-premises) seek to add value and continue relevancy with existing clients or attracting new clients.
- **Buyer led adoption** – where organizations through various triggers establish simulation in the cloud capability (such as estate modernization, contingent expansion (as projects are won) or maintaining innovation bench strength. Some will have developed and now manage their own inhouse tools.

Provider led adoption has dominated thus far. Typical of many technology paradigm shifts.

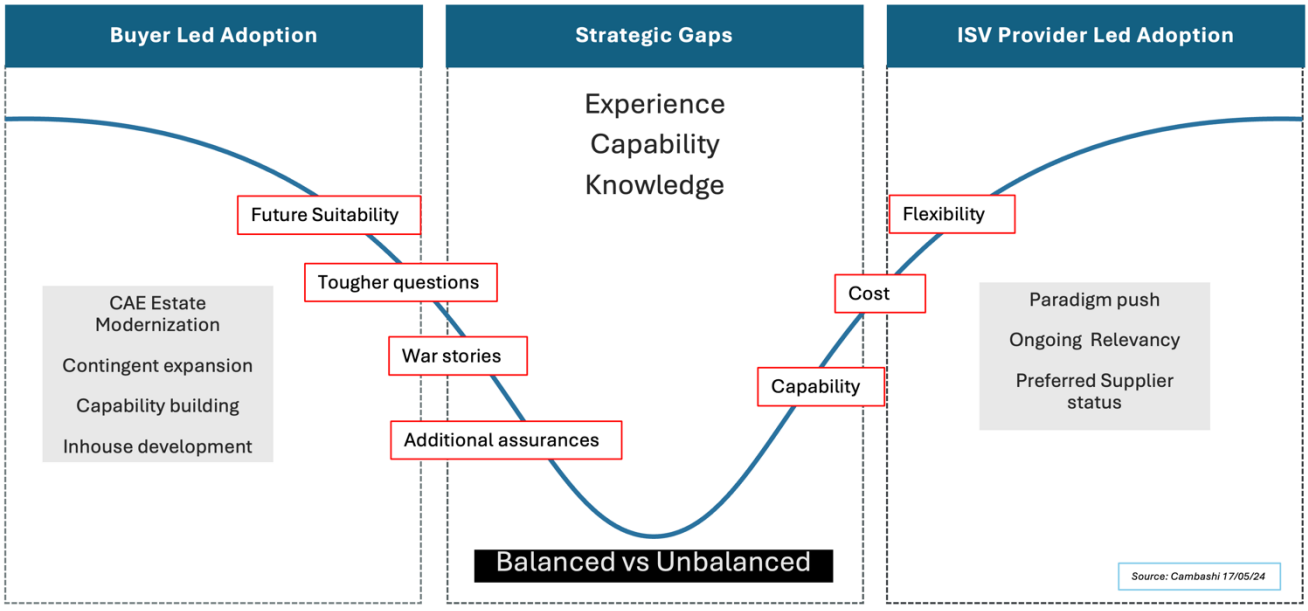
Inhouse (or DIY) development being deployed by end user organizations where specialized, exotic, and esoteric engineering simulation capability was/is required. No suitable commercial off the shelf solutions appearing to exist at the time of procurement.

This being where, and in pursuit of a new balance, it makes most strategic sense to consider (perhaps tolerate) a larger cohort of suppliers and to ensure simulation's impact at an acceptable cost, technical debt, and risk. Likewise, some organizations choose to work with an integrator or consultancy to assist with design, buy/build and operate of some or all elements of the value chain.

The two driving adoption patterns strive to "meet in the middle" influencing future adoption pace (see fig 2). In pursuit of a new balance early buyers are now reflecting on the future suitability of prior decisions – armed through experience with tougher questions. Mainstream buyers are needing additional assurances and war stories from early adopters to motivate their adoption. Strategic knowledge, capability and experience gaps require closure to allow for greater simulation in the cloud balance and impact.

The question has therefore become not only "if cloud" – but increasingly "how much", "who from" and "why". These are important balances to strike. The determination and governance of such balances needs stronger and tighter collaboration between Strategy, Engineering, and IT teams. Each armed with understanding the provider landscape and their respective advantages / disadvantages. And the broadest possible outside-in perspective. Reflection on future suitability, answers to tougher questions, additional assurances and war stories are unlikely to found within one business alone.

Figure 2 Achieving simulation in the cloud balance requires strategic gap closure

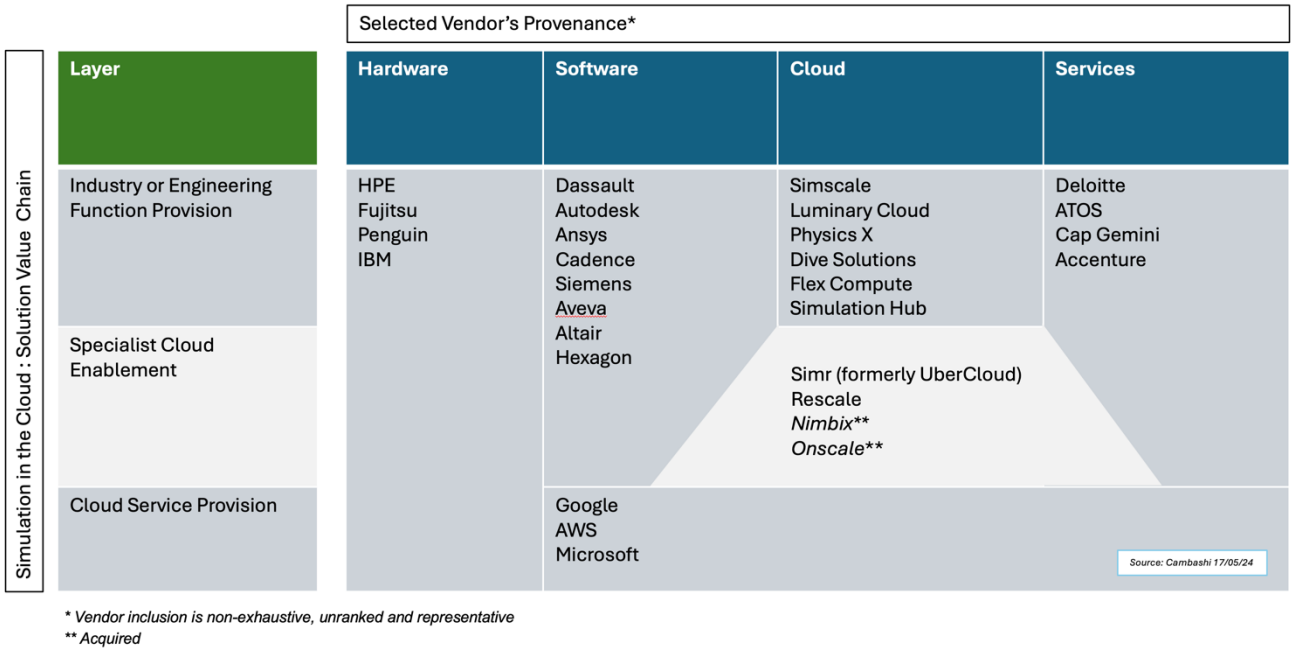


What is the emergent shape of current cloud simulation provider landscape?

The cloud simulation landscape (represented as a value chain) is split across 3 major layers (fig 3 Simulation in the Cloud Value Chain) and as follows.

- Industry/Engineering Function Cloud Providers
  - Industry cloud providers combine software, platform, and infrastructure as a service (IaaS) capability to provide specific solutions for different vertical industries – in the case CAE.
  - Engineering Function Cloud Providers provide cloud ready solutions to support engineering workflows and compute intensive tasks (i.e. Design, CAE, and Simulation).
- Specialist Cloud Enablement Providers (i.e. specialists for Engineering Simulation and CAE)
  - Provide "the glue"
  - offering a mix of software, middleware and services to support cloud deployment and operation.
  - serve to improve the economics, performance and usability of performance intensive solutions such as CAE (Simulation) when deployed through High Performance Computing within the Cloud.
- Hosted HPC Clouds, Cloud Service Providers (CSP) and Hyperscalers
  - providing cloud computing and data management services to organizations that require infrastructure for large-scale data processing and storage.

Figure 3 Simulation in the Cloud - a solution value chain



The current market position of the major players is heavily influenced by their origination or provenance. There is also a distinct "from to" movement e.g. some providers provide specialist cloud

enablement through either existing inhouse capability or acquisition. E.g. *ATOS with Nimbix and **Ansys with Onscale. The cloud enablement specialism essentially being “built-in” to their overall capability set.

As reflected earlier - current solution choices may not be optimised for future performance, fit or flexibility needs. Provider driven adoption of simulation in the cloud may represent a “first move”. Multi provider solutions may represent a potentially complicated legacy to unravel or an evolving perfect fit.

3 important architectural and solution governance questions should be addressed when considering if balance is in place.

- Does having multiple provider specific approaches to cloud enablement hinder simulation driven decision impact e.g. through excessive cost and /or complexity?
- Will the variety of approaches all suitably integrate with each other and in a performant way?
- What type of cloud enablement is required to ensure an appropriate new balance.

The ideal balance of value chain design will as such vary by company and vertical industry. Locking in future complications such as outcome realisation being slowed or diminished, vendor lock-in, duplication of solutions should be avoided. Enablement provider (and integrator) choice are critical decisions to help address these potential complications.

How to approach specialist cloud enablement provider choice

Cloud Enablement solutions (for Engineering Simulation and CAE) are an essential middle layer, and they can be categorized by approach/definition, namely:

- Blackbox
- Whitebox/Custom
- ISV Embedded

Each has inherent advantages and disadvantages – no one size fits all. Trade-offs are required to consider achieving solution value chain balance (see Table 1).

Blackbox and ISV embedded approaches are typically more suited to deliberately narrower and stable solution value chains (homogeneous). Deliberately narrower meaning that most if not all simulation workflows can be achieved largely through off the shelf functionality from a small number of ISVs. Care is ultimately needed with overall ISV numbers, understanding capability roadmaps and how composable their solutions can and will become through on demand workflows. Becoming too reliant on a smaller number of vendors can increase switching costs should needs fundamentally change.

Whitebox/custom are typically more suited to deliberately broader and more dynamic solution value chains (heterogeneous). This may suit situations where more scientific and engineering experimentation is required within the simulation workflow. Where inhouse solutions and their outcomes require integration with ISV embedded approaches.

Table 1 Advantages/Disadvantages of Specialist Cloud Enablement Approaches

	Advantages	Disadvantages
Blackbox e.g. Rescale	• Managed and predictable • Transparent to user • Pre-configured • Best placed for solver use cases • Basis for productized customization or solution editions	• Less user control • Less flexibility • Less portability options • Considerable switching costs when seeking more flexibility, user control and/or solution portability
Whitebox/Custom e.g. Simr (formerly UberCloud)	• Optimized for a client environment • Best placed for engineering workflow use cases • Tunable • Flexible • Source of scalable products / solution editions	• Unique to client and therefore not directly scalable • Maintenance and update costs always have client specific elements • Some clients will not value or may be confused by choices available
ISV Embedded eg Ansys or Simscale Source: Cambashi 17/05/24	• Tuned for specific ISVs • Lower learning curve • Transparent to user	• Potential multiple environments from different ISVs • Down-stream complexity and cost if simplification/ rationalization required • May ultimately require Whitebox support to optimize specific use cases • Risk of CSP or ISV lock-in

Ultimately strategic Specialist Cloud Enablement provider choice maximises the chances that knowledge, capability and experience gaps (see Fig 2) can be more quickly identified and resolved.

Equally all providers (Blackbox, Whitebox and ISV embedded) share an increased responsibility to convene a business led discussion about driving simulation outcomes. After all, technology is only one part of a cloud enablement strategy.

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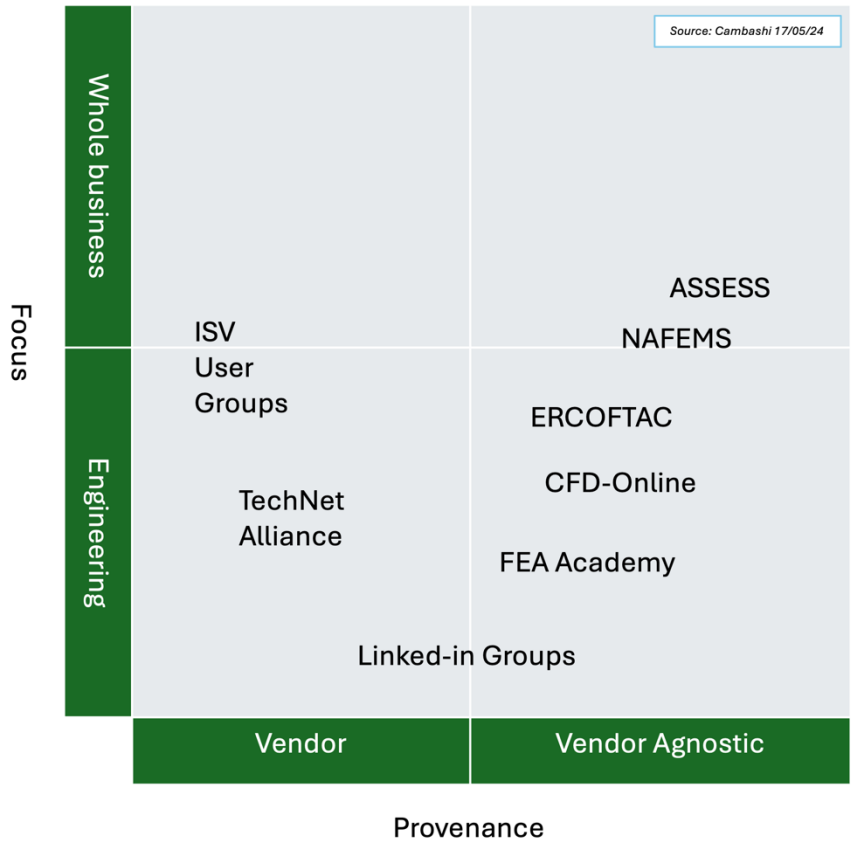
From its early days, different communities of simulation engineers have formed and evolved, sometimes by physics simulation discipline (e.g. CFD-Online), and sometimes by application or industry need (e.g. ERCOFTAC). The earliest, largest, and most comprehensive CAE community resource globally is that set up in 1983 in the UK called NAFEMS. It is an international association for the engineering modelling, analysis and simulation community that is a not-for-profit organisation. Today it has established branches across the Americas, Europe (by country and local language), India, Japan, and many ASEAN countries. It seeks to set CAE usage engineering standards, create Working Groups, provide educational resources and publications, establish certification pathways, and offer best practice governance for all fields of engineering simulation that is vendor neutral. Companies and individuals can become members of NAFEMS for an annual membership fee and all the main ISVs participate in NAFEMS globally as well as locally in a wide range of conferences, seminars and webinars, as do their software supply chain partners and customers.

In 2014 the ASSESS initiative was set up by senior members of the CAE community from OEM companies, academia, government, and the ISVs to facilitate deeper and wider engineering simulation enablement increasing its availability to maximise business benefits across the complete spectrum of industries, applications and users being addressed. One of its aims is to guide and influence software strategies for performing model-based analysis, simulation, and systems engineering. ASSESS was acquired by NAFEMS in 2022 and has come under its umbrella. NAFEMS puts on ASSESS Summits and World Congresses globally every two years. Aside from ISV community efforts in user groups in person and online, there are multiple CAE product line and physics discipline user communities on LinkedIn with varying levels of engagement observable.

Democratisation of CAE, that is, making it available and being used by a much wider community (x10 to x100 more) to get design and innovation work done faster and better has been a driver in the industry for the last ten years. Enabling technologies such as ever more powerful HPC, design space optimisation, machine learning & AI software, improved code usability and UX, CAD-embedded CAE software in PLM workflows, “appification” of CAE (especially with open-source codes), and latterly availability of cloud hardware and cloud deployments. In all these initiatives, experienced engineering simulation engineers have been a bottleneck for democratisation and increased usage of CAE in product design and innovation as they are in short supply and highly sought after.

Figure 4 CAE / Simulation focused communities by focus and provenance



There is clearly a need for greater CAE community development especially in the areas of cloud deployment, machine learning and AI where even more complexity of decision making is entering the CAE sector (see fig 4). Such increased community engagement needs to be vendor neutral but work with all ISVs, hardware suppliers, middleware companies, and establish further best practices, training & certifications, and improve workflow maturity models, automation methods, governance, and security protocols, in the light of the rise of big data, data mining and data security concerns.

Simulation engineers will become more prominent not just as CAE experts but also in handling complex workflows and toolchains especially as real-time physics simulations hove into view. There is a pressing need to accelerate their simulation driven design decision making in product development as manufacturing 'shifts left' to include ever more CAE simulation throughout a product's lifecycle. Dealing with manufacturing data management including integrating synthetic and real-world data (audio, video, lab measurements, field feedback, ML/AI), everything goes into next generation product innovation, and simulation operation automation. 'Human-in-the-loop' engineer simulation must be optimized on a cost basis for the cloud while IT departments maintain control of all proprietary data and complete simulation visibility. Ultimately, these issues will lead to faster speeds of simulation, greater product innovation, reduced time-to-market, cost efficiencies and better simulation engineer productivities doing what they do best; better product decision making.

The wider CAE Community needs to address big training related questions for engineering simulation users to enable a revolution of usage:

- 'What's the type of person we need?'
- 'What training to invest in?'
- 'What gaps in engineering expertise exist?'
- 'How to increase the number of product innovation decisions an engineer can make in a day?'

Companies and the CAE community in general need to address simulation engineer hiring, engineering simulation education, the governance around engineering simulations, HPC/cloud deployment simulation automation as well as larger business considerations such as:

- 'What is the best mix of ISV/Inhouse software and solutions for cloud deployment in order to best address our workflows?'
- 'How to get best business ROI for engineering simulation deployment of both cloud and AI/ML technologies?'
- 'What business actions are required to maximise the future strategic impact of simulation?'
- 'What other help is needed to support successful engineering simulation deployment?'

Conclusion

Optimising for simulation driven impact (e.g. for innovation excellence and time to market improvement) will require ever more strategic cloud enablement choices to be made. It will require increased and aligned whole-business thinking - from within the business and outside it.

The next stage of Simulation in the Cloud market development requires that the strategic structural gaps identified in the paper (experience, capabilities, and knowledge) become closed. This closure can only take place via organised and enhanced sharing. Complete whole-business or industry answers rarely reside in one function or company alone.

The enhancement needed will require that

- Existing vendor agnostic communities
    - accentuate a more whole-business focus and value proposition
    - increase membership / participation beyond the engineering function
- Existing vendor aligned communities
    - Extend whole-business coverage to include integration and enablement beyond a sponsoring vendor's walled garden and alliance network

The alternative market maturation scenario (for incumbents) will be that a new entrant will be better placed to take on and facilitate this enhanced sharing mantle.

Appendices

Definitions and Taxonomy

ISV=Independent Software Vendor

CAE=Computer Aided Engineering

Recommended Further Reading

Note: may require registration or establishing an account

1. Unveiling the next frontier of engineering simulation: Digital engineering in an AI world, McKinsey
2. Study on HPC and Cloud Computing for Engineering Simulation, Peerless Research Group
3. Engineering Simulation Workloads and the Rise of the Cloud, Ansys

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