WHAT'S STOPPING WIDESPREAD DEPLOYMENT OF SIMULATION TOOLS ?

Joe Walsh

CEO – intrinSIM LLC

THEME

Broader deployment of simulation tools

KEYWORDS

Simulation-Based Design, Automation, Process, Business practices, CAE Market, Up-front simulation

SUMMARY

The use of simulation has seen a continual increase over the last thirty (30) years with a noticeable dramatic increase recently and we are now at an inflection point in potential growth due to increased recognition of the use of simulation producing real business benefits. The industry appears to be ready to want to adopt simulation in a big way but the implementation of widespread simulation raises some unaddressed issues. Software vendors have been addressing integration and process flow control but there's a hidden issue that also needs to be addressed before simulation can meet the increased usage necessary to achieve the intended business objectives. This presentation will discuss the nature of a key issue of the simulation expertise gap and what the software vendors and software user need to be considering for significantly broader deployment of simulation for real business benefits.

1: Business is the driver

The use of simulation has seen continual increase over the last thirty (30) years with type of analyses performed diversifying and growing (Aberdeen Group, 2006; Halpern, 2010; Holtz, 2010; Orr, 2010). This growth is coupled with an increasing awareness of business benefits from increasing usage of Simulation. There is a growing movement for using simulation early and often in the design process and a growing awareness that this type of use of simulation has the potential for significantly larger business benefits (Driesbach 2007; Evans 2007; Lang 2006).

The business view of simulation has been gradually changing as more and more documented success have been provided for up-front CAE and simulation driven design activities. The recurring success stories from the early adopters of Simulation Driven Design, such as Visteon, Whirlpool, John Deere, GM, Boeing, Airbus, Proctor & Gamble and others have made the potential business benefits of simulation clear and credible to the business community (Gielda, 2007; Lang, 2007; Rasche and Fricke and Hutton, 2007; Thomas and Panthaki, 2008; Webster, 2005) . This is coupled with market reports which have indicated that industry leaders typically make heavier use of simulation than industry laggards in a growing number of industries (Aberdeen Group, 2006).

The following illustrates a quick overview of the clear business benefits which result in a realizable means to achieve the "better, faster, cheaper" mantra of today's highly competitive worldwide marketplace.

- **virtual prototyping** resulting in reduced costs for physical prototypes
- **improved product quality** resulting in reduced warranty risk/cost and improved competitiveness
- **smarter early design decisions** resulting in lower committed cost, quicker, time to market and improved competitiveness
- **increased innovation** resulting in improved product performance and improved competitiveness

Coincident with the increasing awareness of business benefits the availability and affordability of computing capacity has grown significantly. The advent of Grid computing and the "cloud" have changed the computing landscape making it technically feasible to consider running simulation early and often in the design process (Fong, 2003; Verstraete, 2010).

Simultaneously, new technologies have been introduced for process capture and automation, Robust Engineering, Abstract Modeling, Stochastics accounting for complexity and variability along Systems Engineering based approaches and many others (Allen, 2007; Boudreaux, 2003; Leuridan, 2008; Panthaki, 2005; Webster, 2005).

The increased business awareness of clear business drivers, along with expanded computing capacity and technology advances we are now at an inflection point in potential growth due to recognition of the use of simulation producing real business benefits.

2: How far can we go?

The objective is clearly to use more complex simulations early and often in the design process in order to realize the potential business benefits. This means growth of both the types of physics simulated along with growth of simulation into areas that it has not previously been strong such as energy, biomedical and consumer products (Aberdeen Group, 2006; Arold and Kocem and Nillson, 2007, Blacker, 2006; Choudhry, 2010; McGinnis, 2006) . This multifaceted growth along with the advent of process oriented technologies can result in exponential increases in the use of simulation.

The desire to achieve business benefits through simulation will result in an increasing the level of expertise required. For clarity we are not referring to engineering capabilities when we refer to expertise in this document, but instead the ability to map an engineering problem into a form that the simulation software can use to generate appropriate results for design decisions. If we define expertise as "the average level of expertise" times "the number of people" we can graph a trend for expertise required.

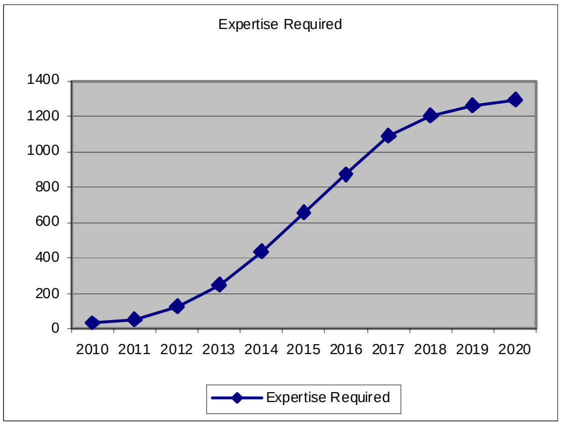

Figure 1: Expertise Required Trend Graph

This raises the question as to whether or not the expertise available today and in the near future can meet the growing requirement. Looking at the expertise available for performing simulation we can quickly uncover a few key issues. In the case of the new users the expertise is clearly currently not available and needs to be found. In the case of the established simulation users there is a well known issue of vanishing expertise due to voluntary and forced retirements.

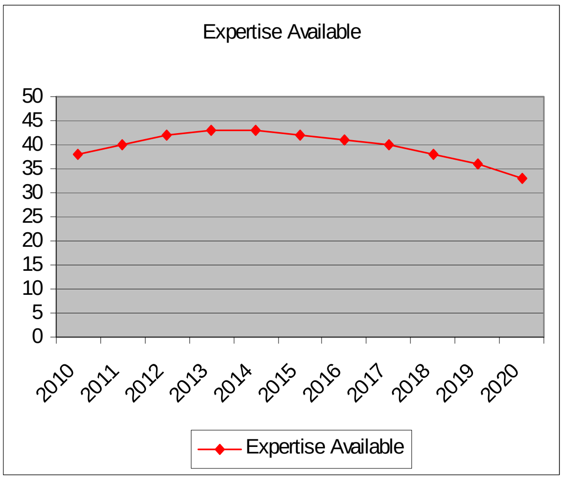

Figure 2: Expertise Available Trend Graph

Figure 3 below illustrates the graph of expertise available overlaid in the same scale with expertise required illustrating clearly that the future growth of simulation usage will be limited primarily by the available resources with the required level of expertise.

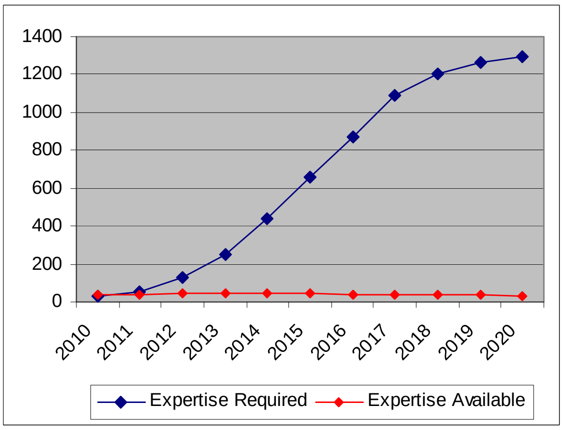

Figure 3: Expertise Required Trend Graph

To achieve the level of potential deployment of simulation driven by business we need overcome the expertise gap by radically reducing the expertise required to run simulations. Throughout the years several attempts have been made by software vendors and end users to make the analysis tools easier to use and achieve broader deployment. Simulation software vendors have been trying to achieve broader deployment for over 20 years and typically have done this by reducing capabilities and making the software "easier to use" and is generally accepted as being ineffective (Keene, 2008). The only viable approach forward is to make the software "smarter" to reduce significantly the expertise required. This is not just an "ease of use" issue.

3: "Intelligent Simulation Automation"

This is a new expertise focused approach to simulation automation targeted at allowing users to achieve the desired accuracy for their problem to enable design decisions and performance understanding with minimal effort to convert the engineering problem to a simulation problem definition. This new form of automation is called "Intelligent Simulation Automation" and can be defined as the integration of all of the following:

- better integration and use of existing tools
- transparent Simulation Data Management
- desired accuracy driven methodologies
- application based (rather than physics based) tools
- support for a broader range of design variability
- smarter results management

Simulation software vendors are currently putting a lot of effort into process capture and automation; however, the focus is on capture of existing processes and expertise and not on reducing the expertise required (Chinn, 2008; Choudhry, 2008; Evans, 2008). A significant portion of the technology needed to support "Intelligent Simulation Automation" exists today but not in a form focused on reducing the expertise required for simulation.

The first step to "Intelligent Simulation Automation" is to leverage the current automation capabilities provided. One of the challenges that the simulation community faces is that most of the current simulation process were designed for manual interaction and automating the current processes produces limited benefits. New processes need to be developed and implemented that are designed to with automation in mind from the start.

The best place to start is to revisit current simulation processes with intent to intelligently automate what we can today to reduce expertise required wherever possible. Some examples of where this can be done is automation of "Standard Work" and straightforward analysis of simple parts and assemblies. The range of problems that can be intelligently automated will increase as "Intelligent Simulation Automation" tools become available.

Simulation Data Management has received a lot of attention in the last few years and is a young and growing technology and market (Bartholomew, 2010; Blacker, 2010; Meintjes 2007, 2010). The requirement for managing simulation data and processes is growing in importance but is generally considered as a "nice to have" capability in the current simulation methods and processes. In order to support "Intelligent Simulation Automation" the use of Simulation Data Management becomes a fundamental cornerstone and a "must have" technology. There will be an increased need to be able to understand and audit simulations; this requires automatic creation of metadata, relationships between files, result report generation and versioning without any user input. One fundamental requirement for expanding the broad use of simulation to organizations that are not currently strong simulation users is that Simulation Data Management just happens without any need for user input other than running the analysis processes of interest.

The desire to reduce expertise required brings with it a requirement to automatically produce results at an appropriate level of accuracy to support the design decision. This appropriate level of accuracy should change as a function of the where the user is in the design process. This automated accuracy has to address errors from two different sources as follows: 1. problem definition and idealization and, 2. discretization error.

Problem definition and idealization refers to how the geometry is idealized (i.e. beams, shells, solids) and the definition of the simulation problem attributes (materials, boundary conditions, loads, etc.). Automation of idealization and problem definition is an ongoing research topic (Shephard 2005, 2006). Until further automation tools are available in this area a practical approach would be to minimize the idealizations used. The reduction in idealization allows the problem to be defined in a user understandable 3D context. For those who have automated idealization techniques in place for specific problems they should continue to leverage those.

During the period from the late 1970's to the early 1990's a great deal of effort was put into trying to determine the definition of a "good mesh" based on a-priori mesh quality metrics (Lowry, 1991). Discretization error is based on the inability of the local discretization to capture the local physics and the only impact that a-priori shape metrics have on this error is stability of the local discretization solution and distortion effects influencing local accuracy (Walsh, 1993) . The current state of simulation software is that except for certain specialty physics that still have a sensitivity to distortion that a-priori mesh quality metrics currently have little to no correlation with discretization error.

Adaptivity has been made commercially available for quite some time by simulation software vendors, but as advanced option requiring additional expertise. Mesh adaptivity needs to be provided as a means of reducing expertise required and should be in all simulations where it is applicable as a means to provide a simulation solution at a desired accuracy in an automated manner. Figure 4 illustrates the impact on a local detail during an electro-magnetic simulation.

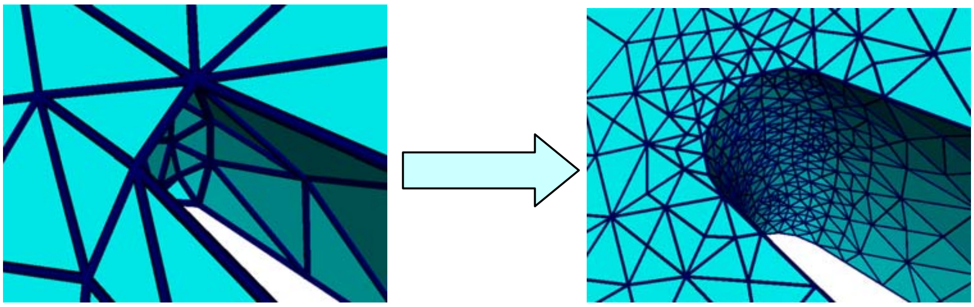

Figure 4: mesh adaptivity example

The combination of automatic mesh generation and mesh adaptivity can provide accuracy based solutions for a broad range of problems without the user having to even realize that a discretization exists. Additional work needs to be done by research and simulation software vendors to broaden the applicability of mesh adaptivity for physics where it is not currently appropriate or effective. The move to "Intelligent Simulation Automation" will require dropping the current emphasis on a-priori mesh quality measure and unfortunately also require a new set of simulation methods and validations.

The recent years have seen an advent of application based tools which embed simulation expertise and allow the user to work in the mental model of the application domain rather than the physics domain. Some examples of this are in rotating equipment and biomedical applications. New non-traditional simulation applications have little to no choice other to use application based tools since the simulation expertise is not available in their potential user communities. This approach will also allow traditional simulation applications the ability to capture and embed domain expertise and simulation knowledge for reuse by a broader audience. Most simulation software vendors are actively working on approaches to better support and provide application based tools (Lang 2007; McCoy 2010; Thomas 2006).

One of the outstanding issues is not broadly addressed is that implementation of the approaches noted above will result in a requirement to perform simulations over a significantly broader range of design variability than is currently done today. The advent of vertical application tools and Systems Engineering approaches will quickly make the current approaches of mesh-based scripts and CAD model based simulation attributes inadequate to handle the design variability and persistent simulation definition required. A persistent simulation model is required to support design variability and systems based approaches (Fortier, 2007; Meintjes, 2007; Panthaki, 2005). One such persistent representation that is available but not widely used is Abstract Modeling. This approach is, however, the cornerstone to many of the Simulation-Driven Design success stories (Fortier, 2007; Gielda, 2007; Rasche and Fricke and Hutton, 2007; Thomas; 2006, Thomas and Panthaki, 2008; Webster, 2005).

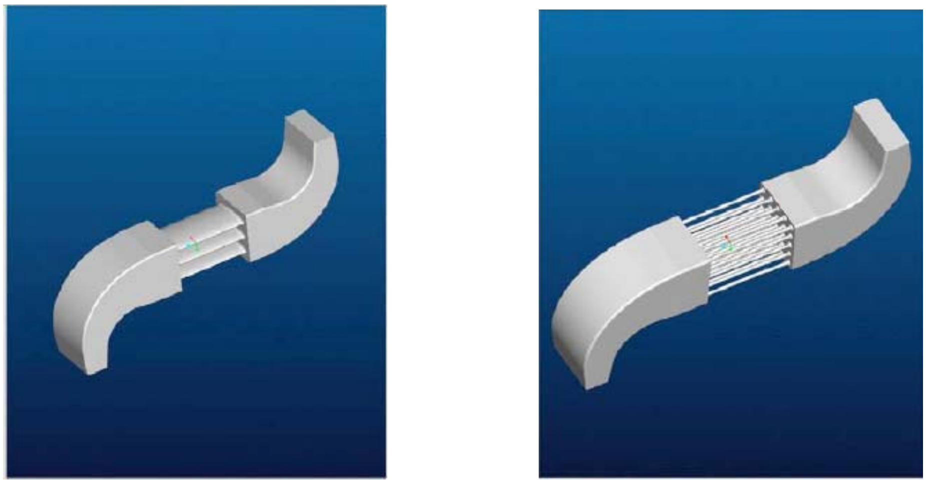

Figure 5: design variations handled by Abstract Modeling

Figure 5 illustrates to different design concepts for a simplified heat exchanger with each concept coming from different a different CAD system. Abstract Modelling was used to define the simulation problem and drive automated generation of execution ready data for a CFD analysis for both designs.

If we significantly increase the amount of simulation used by multiple orders of magnitude it quickly becomes apparent that the current methods of results review and management will be completely inadequate for several reasons. The first area of improved results management is a solution independent 3D visualization approach. Most organizations that perform analysis use a wide range of tools for various simulations and having a common representation and visualization tool across simulation disciplines and solvers can significantly reduce the expertise required to evaluate and manage results. Figure 6 illustrates a common visualization of the design CAD model, the FEA based vibration analysis and the CFD analysis allowing the users to focus on the results rather than the method of presentation.

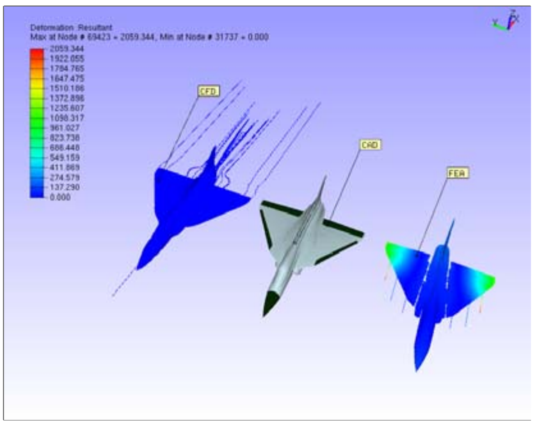

Figure 6: common visualization across domains

Another area for improving results management is that of automated standard result report generation. Several simulation software vendors are either developing or supplying tools in this area. Further work, however, is required for broader support of simulation tools and for support of interactive 3D representations of results data as part of the reports.

The third and possibly foremost area for improving results management is just the shear volume of data generated creating a requirement for data compression without loss in accuracy. Accurate compressed data representations coupled with a solution independent visualization approach can minimize the need to archive the large result data sets. Compression techniques which result in a loss in accuracy do not meet this requirement.

4: making "Intelligent Simulation Automation" a reality

Radically reducing expertise required for simulation requires a commitment by both simulation software vendors and simulation users to embrace the concept of "Intelligent Simulation Automation" and to start as quickly as possible to update current methods and processes toward this approach. The simulation users cannot rely solely on the simulation vendors to supply this as a technology. The simulation users will also need to make significant organizational and process changes. The following represent a sample of some of the simulation concept changes that will be required by simulation users:

- embrace and leverage Simulation Data and Process Management
- remove unnecessary effort related to idealization and simplification
- replace focus on a-priori mesh quality metrics with mesh adaptivity
- leverage current automation capabilities to capture expertise and move toward "Intelligent Simulation Automation"
- continue to push simulation vendors to support "Intelligent Simulation Automation"
- become the "Intelligent Simulation Automation" champions

5: Conclusions

The increased business awareness of clear business drivers, along with expanded computing capacity and technology advances we are now at an inflection point in potential growth due to recognition of the use of simulation producing real business benefits. This potential future growth of simulation usage will be limited primarily by the available resources with the required level of expertise. A new approach called "Intelligent Simulation Automation" was proposed as the means to make a radical reduction in required expertise. The aspects of this approach were discussed along with its innate emphasis on minimizing expertise and maximizing automation in the simulation process.

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