# System Modeling and Simulation at Dana Holding

Frank Popielas

Dana Holding Corporation, Lisle, IL, USA

*Abstract: System Modeling and Simulation (SMS) is the next logical step within Dana's engineering community to achieve a fully integrated, front-end driven, optimized engineering ecosystem. We believe this evolution will enable Dana to maintain continued leadership in the industry for delivering product innovation, quality and customer responsiveness. In order to achieve this vision in an efficient and coordinated way, we at Dana identified the basic steps we have to take, determine which engineering areas are critical participants, and, decide on which technology pillars we have to focus our attention. At the very beginning of this journey we understood that this means a step change for a new way of thinking as well as a cultural change within our engineering community, company and extended enterprise.*

*In this paper we explain what SMS means to Dana, how we approach this topic, and what technologies we are investigating in order to achieve this new level of engineering. Since the process is very complex, we decided to start with a business value assessment (BVA). This engineering assessment was undertaken to understand the current status of our engineering organizations and existing technology, and then identify the gaps to where we want to be with our business. This helped to formulate a foundational strategy and long-term roadmap. With an existing strong focus on the CAE environment this also meant we needed, as previously mentioned, enhance the mindset and our global culture to make the next step in our systems evolution. This only can be achieved through a dedicated effort to educate and engage the people throughout the process Therefore, as a very important topic we will also discuss the meaning of simulation, CAE in general, system engineering (SE), model-based system engineering (MBSE) in the context of SMS for this new environment.*

## *Introduction*

Innovation and the development of new technologies are no longer ethereal marketing promises, but have evolved into critical requirements to effectively compete in the automotive industry. Of-course, it's not just something special to this industry but across all the different areas in general. But, the competitive pressure in the automotive industry in particular pushed engineering into new thinking, applying new techniques and approaches. While all industries are feeling the competitive pressure, the automotive market is driven heavily by individual consumers in mass to produce an environment where a technical shortcoming can result in massive changes in market share for original equipment manufacturers (OEM's). The highly competitive nature of the market has forced the individual suppliers and OEM's to invest heavily in new thinking, new techniques, and new approaches to try to achieve and sustain a market lead. Presented recently ([1], [4]) that in order to be considered a key supplier one need not just to be a full service supplier but a development partner. *(*Figure 1*).*

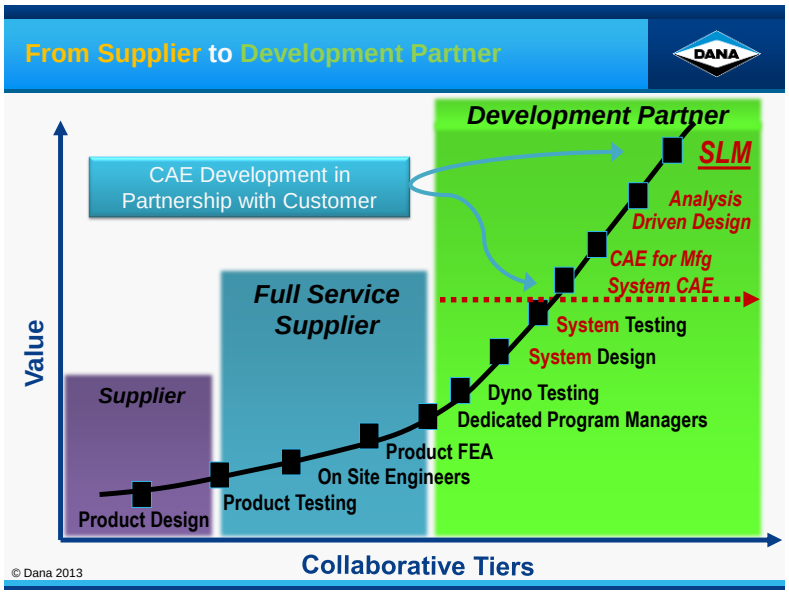


*Figure 1: From Supplier to Development Partner*

Initially, we approached this concept from a computer aided engineering (CAE) point of view. We found that companies that did not incorporate CAE could not stay competitive in the long run. CAE, however, is not the complete story because this point of view focuses almost entirely on the structural design and performance of individual components. In order to go beyond structural simulation we had to expand our focus across additional engineering disciplines, such as computational fluid dynamics (CFD). As our use of CFD matured we began to relate this discipline back to structural mechanics through the use of fluid structural interaction and multiphysics in general to execute cosimulation. Cosimulation was the essential basis to be able to contribute as a development partner and add value to the final OEM. (Figure 2*;* [2] [4]*)*

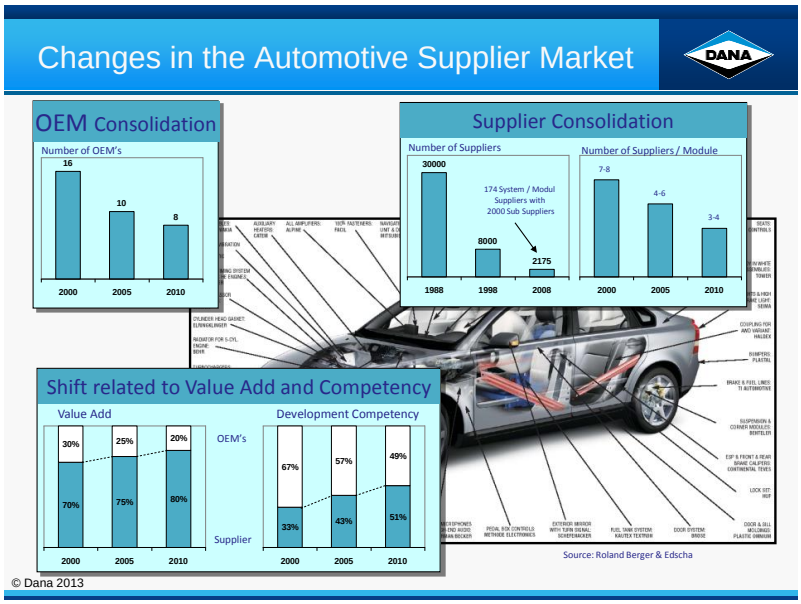


*Figure 2: Changes in the Automotive Supplier Market (Source: Roland Berger and Edscha)*

*Current Market*

The competitiveness of the market, the push by the developed countries in particular into greener product technologies, and the end-consumer requirements with ever more sharpened focus on comfort, created the need to introduce electronics on a broad scale. (Figure 3, [2])

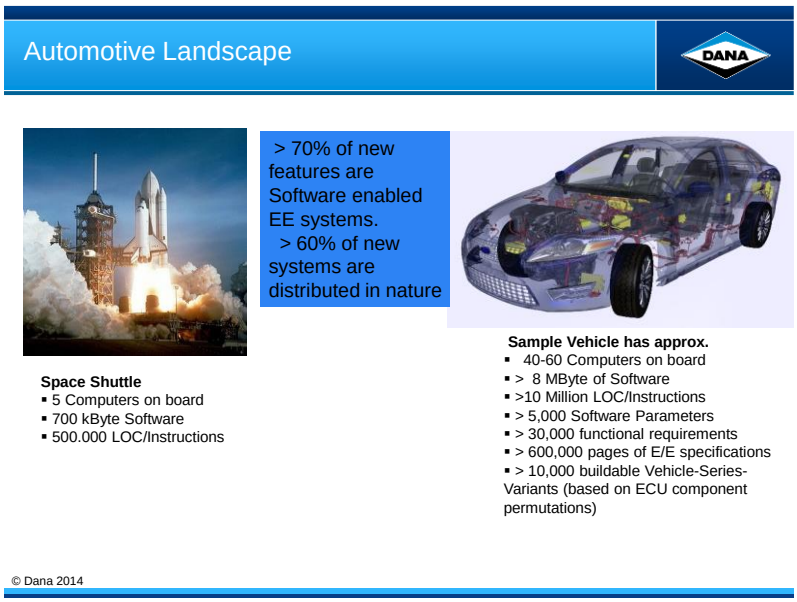


*Figure 3: Automotive Landscape [2]*

The starting point where we had to apply principles of system engineering (SE) was developed in the aerospace industry and automotive industries. Simple application of existing SE as we knew it was not sufficient. A more modern approach was needed, which went beyond just the application of the SE principles. The automotive industry is a much faster evolving industry where new models and technologies need to be introduced into the market every two to three years in order to stay competitive. The need for agility to adapt to a rapidly changing market was the principle driver for the implementation of CAE – simulation, or even simpler – virtual engineering. The international council for system engineering, INCOSE, formulated the Model-based System Engineering (MBSE) initiative to address this and it became a major pillar within the INCOSE vision 2025 ([3]).

Earlier it was mentioned that CAE was applied by leading companies as a systems approach, but the traditional CAE is focused on detailed physical models. The market demand for a two to three year model cycle provides for just enough time to optimize systems with all their variations based on highly complicated models, though. NAFEMS, the international association for engineering modeling and simulation understood this new requirement early on and started to reach into new upfront simulation techniques. The logical result was that NAFEMS and INCOSE got together formulating a new strategy by combining forces in creating the joint System Modeling and Simulation Working Group (SMSWG). (Figure 4)

*To develop a **vendor-neutral**, **end-user driven consortium** that not only promotes the advancement of the technology and practices associated with integration of engineering analysis and systems engineering, but also acts as the advisory body to **drive strategic direction** for **technology development and standards** in the space of complex engineering.*

*This group will support activities that **bridge engineering analysis and systems engineering** to provide digital solutions to represent real life experiences; and optimize the integration of systems engineering and simulation solutions for both OEM and supplier.*

*This includes education, communication, promotion of standards, and development of requirements that will have general benefits to the simulation and analysis community with the identification of benchmarks and major strategic issues (grand challenges).*

*Figure 4: Mission Statement of the joint NAFEMS / INCOSE System Modeling and Simulation Working Group*

Market drivers capture this very clearly [4]:

- "First time right"
- Reducing time-to-market
- Front-end optimization
- Reduced development time – reduced development costs
- Improved product robustness
- Quality guarantee
- Flexibility
- Globally one voice to customer
- Global regional availability and support
- Partnership across companies

This results in a change the way we approach engineering development. The previous upfront spending needed to be turned around and, at the same time total spending needed to be reduced (Figure 5; [5]).

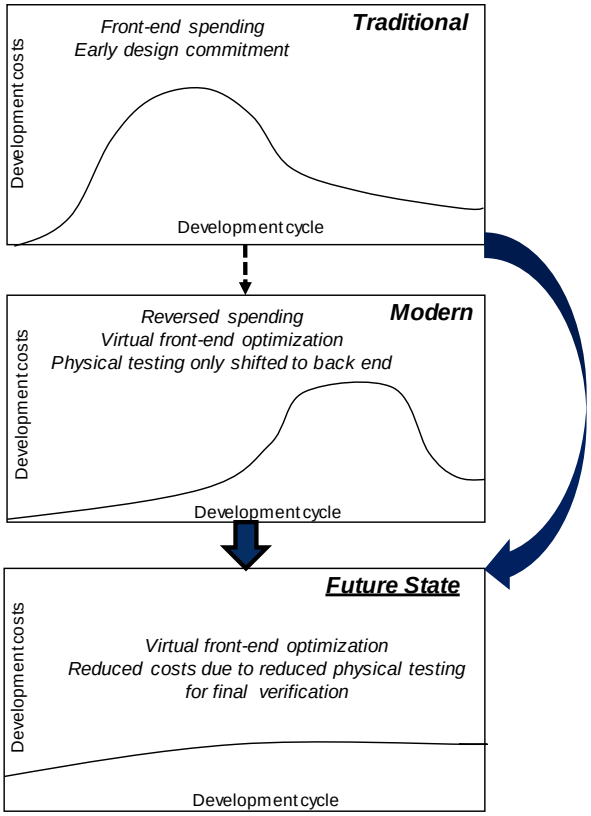


*Figure 5: Development Costs over the Develoment Cycle*

*System Modeling and Simulation at Dana*

It became clear that a completely new thinking was needed. In Dana we started to call this i*CAE™ (*[4]*).* This idea was further developed within Dana over the last few years and resulted from an organization perspective in merging SE and CAE. Coordinating isolated activities wasn't sufficient anymore. This made Dana a very active contributor to the SMSWG activities, as well as NAFEMS and INCOSE.

At the same time, we looked beyond the initial understanding of SMS focusing on the product related system. For Dana we define it the following way [5]:

- System Modeling: represent / link all engineering domains as a system (might it be from a product or ecosystem perspective) within Dana and across companies (customer and suppliers)
- Simulation: being able to predict behavior, efficiency and performance upfront and in real time using only virtual methods

This provides an immediate and different dimension to the term "system". It isn't just simply one definition. System has a different meaning for each of us based on the environment, industry and product

line. In order to bring this together in a relatively simple way we identified the main areas and disciplines throughout the engineering life cycle (Figure 6; [5]).

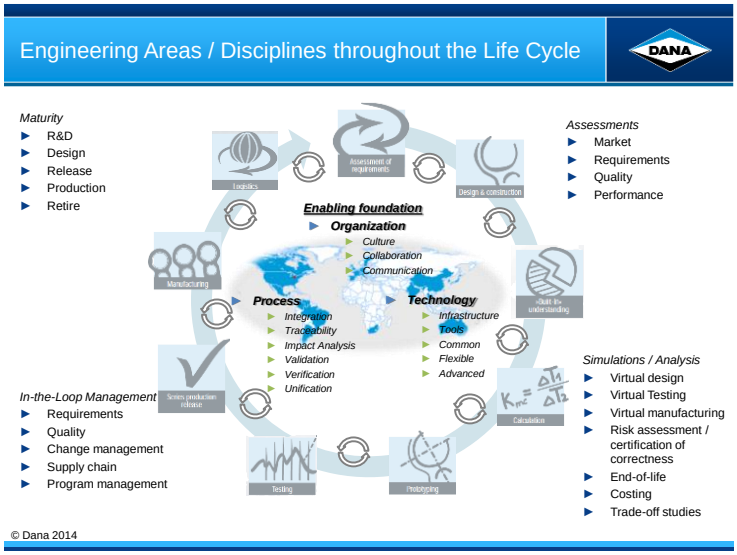


*Figure 6: Engineering Areas / Disciplines throughout the Life Cycle*

A few things need to be highlighted here:

- The life cycle spans over the different maturity stages of the product. Those can be easily captured with stage gate processes. The way we approach this means that we assigned over those different levels of maturity a general engineering approach, which can be captured by an overall engineering Vee. At the same time, within each of the stages there exist separate Vee's (approaches) which evolve from a flexible to a more stringent environment (or from an ad-hoc to a standard (best practice) -driven flow. This process is an iterative one. (Figure 7)
- The way one goes through the process was traditionally a sequential one. But, in order to make a truly front-end optimization driven development process it needs to be able to loop back at any time during the process for any of the engineering and supporting functions, i.e. in-the-loop processes.
- A very important feature becomes optimization with its statistical approach. The nature always comes with a certain uncertainty. The understanding of the risk associated with each level of uncertainty is a must in this new approach.
- The new principle of looking at the system from an ecosystem perspective (and not just linked to the product) means we need to incorporate manufacturing, costing, and other enabling and supporting functions.
- The middle of the circle represents the foundation of this approach. Way too often, the traditional focus was just on what is around it. But, without the enabling foundation this approach will fail. Each organization needs to identify for itself what this means for them.

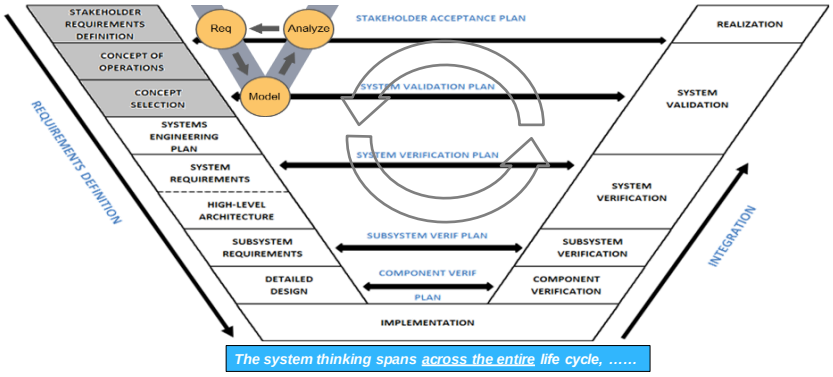


*Figure 7: System thinking across the entire Life Cycle*

This complexity as mentioned here on a high level clearly shows that business-as-usual doesn't work anymore. A step change is needed in order to achieve this. In order to do this properly Dana decided to assess first where we stand today and, where we need to be a few years from now in order to be competitive. The business value assessment performed covered all diversity within the company from a cultural, regional and product perspective. This was the basis for our System Modeling and Simulation roadmap, and helped to define the areas we need to focus on.

This requires a very flexible environment consisting of a wide basis of vendors and different linked technologies. It can be characterized in a simple way the following:

- The overall umbrella is intuitive, model-based with, where possible 3D to enable a visually intuitive system, and an open environment in order to be able to have a vendor-independent system. This is the foundation of a model-based enterprise;
- Product Lifecycle Management (PLM) and Simulation Lifecycle Management (SLM) systems complement each other and link to all other engineering systems seamlessly in order to achieve a "single source of truth" environment;
- An easy linking between the different tools is not just done by using SLM but also through the utilization of the Functional Mockup Interface (FMI) standard. This allows simultaneous time and cost-optimized deployment of the various tools, and very importantly, democratization of virtual tools within the entire engineering organization (Figure 8, [6]).

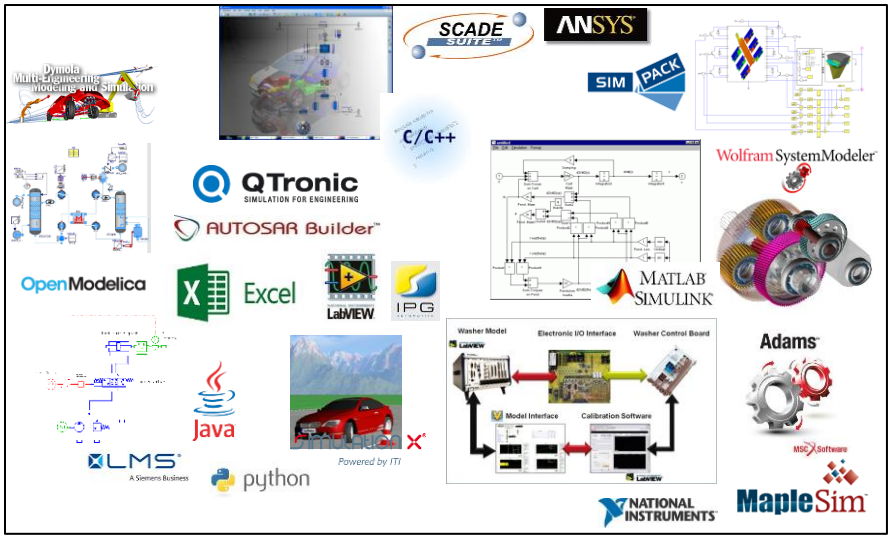


*Figure 8: Collaboration Model [6]*

Furthermore the following areas play a major role:

- Organization with its focus on deploying and teaching the idea of SMS and SE. This is a process which takes time and commitment on several levels of the organization. If organizational support is missing any attempt of deploying new tools and approaches will fail.
- Requirements need to be managed properly and interactively. We can never assume that:
    - The received or defined set of requirements is accurate or complete. A quality check is required.
    - Requirements are changing and accumulating constantly. The established system needs to be flexible and agile enough to adjust to this on-the-fly.
- The supporting infrastructure must be able to provide fast access to a large amount of data on a global scale. This means technologies, like:
    - Compute cloud
    - Virtual desktop infrastructure.

By discussing the above mentioned focus areas one can immediately see the link to two of the modern discussed topics:

- Big Data, and
- Internet-of-Things.

The major challenge from here on is not necessarily resources and funding, but speed of execution (deployment). In order to achieve here the optimum performance, a modern engagement approach is needed, which, at the same time requires a modern communication and collaboration infrastructure. Of-course, coordinating this is challenging due to the number of activities that must occur simultaneously. The right roadmap is achievable through a proper engagement and awareness so people start to "live" it.

*Summary*

System Modeling and Simulation is the next logical step for engineering-driven companies in competitive markets. It involves many modern technologies such as big-data, internet-of-things, model-based-enterprise, cloud computing, and much more. But most of all, in order to achieve this, the whole organization needs to be in agreement and alignment. This can only be achieved through engagement of the people. Every single person needs to be committed in order to be able to execute this. Dana has reached the momentum where the whole organization is becoming part of this and makes this a "living" environment.

*References*


[1] Frank Popielas: "Enabling Simulation as an Enterprise Engineering Practice"; Dassault 3DEXPERIENCE Conference 2013, Las Vegas, NV, USA
[2] Richard Riff, Technical Fellow; Ford Motor Company; September 2010
[3] INCOSE: System Engineering Vision 2025 - SE2025
[4] Frank Popielas: "Simulation and its new Role as the Development Engine in the virtual Engineering Environment"; NAFEMS World Conference 2013, Salzburg, Austria
[5] Frank Popielas: "System Modeling and Simulation at Dana"; Dassault 3DEXPERIENCE Conference 2014, Las Vegas, NV, USA
[6] Hubertus Tummescheit / John Batteh, *Modelon Inc. & INCOSE/NAFEMS SMSWG, INCOSE IW,* January 25th, 2015, Torrance / CA