Powerful Digital Manufacturing Tools for SMEs

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ABSTRACT

If a picture says 1000 words, then a 3D simulation represents the equivalent of a novel. Correctly built 3D simulation models can accurately depict the appearance and functionality of manufacturing equipment. This includes the equipment motion, parts moving through the production line, timing studies, and material routing. In combination individual machinery models when connected together can look, behave, and function like the actual factory, giving you the capabilities to view a complete line from different angles, while it is running (see Fig.1). This provides a much greater level of understanding than a static CAD model or a fixed view video. It enables you to actually see how a line is going to function before it has been installed .

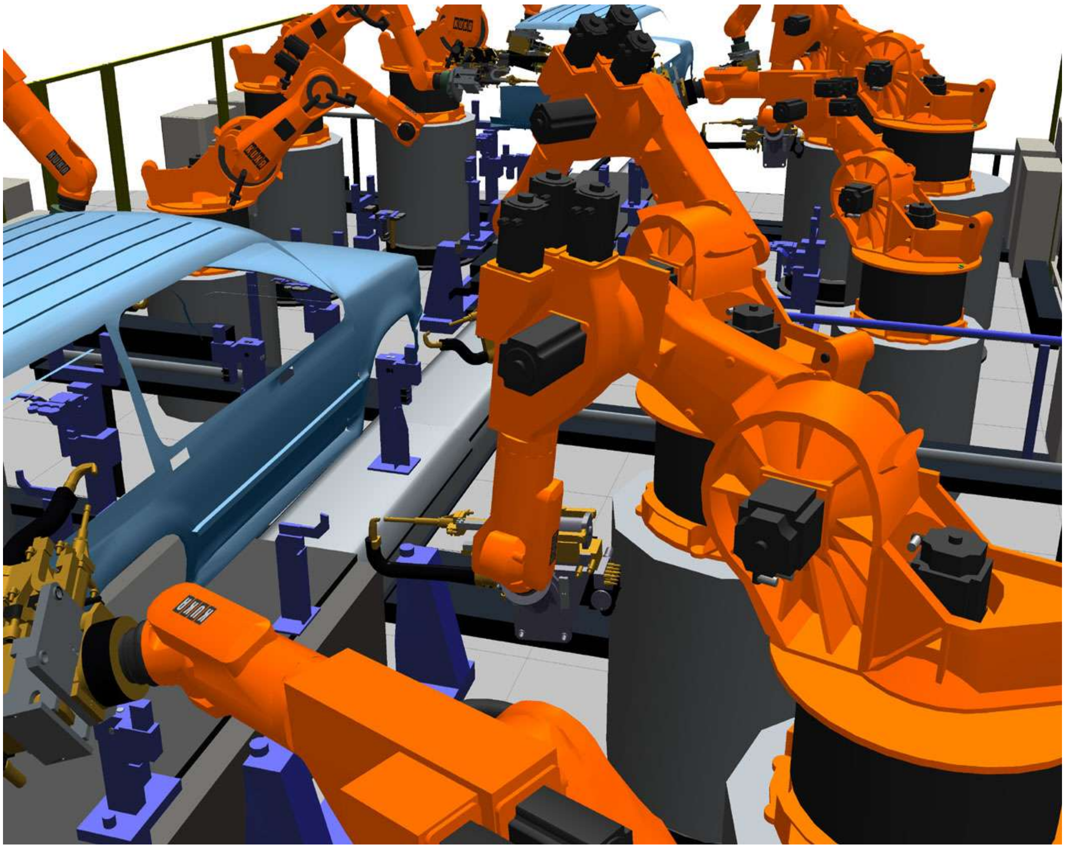

Figure 1: Automotive Production Line Simulation

Selling capital equipment is tough even in the best of times. Communicating concepts and illustrating ROI has been a challenge for any sales team whose product is too large to fit in a brief case. With manufacturing equipment, the challenge is intensified by recent trends toward flexible manufacturing, increasing levels of complexity, and the continuous quest for improved efficiencies. This makes the challenge of justifying new equipment purchases even more difficult without the proper tools.

Imagine being able to visualize your equipment operation on a notebook computer and being able to snap a line together and adjust parameters that configure the equipments physical size and behavior. Then, by pressing a button, see the effect of your changes and cearly demonstrate to others the results by simply e-mailing them the layouts. This capability can be realized by using the right 3D simulation tools.

A SALES TOOL

Using simulation as a sales tool is nothing new. A few forward thinking companies embraced the promise 3D simulation offered as a sales tool in the early 90's. 3D simulation enabled these companies to demonstrate their current facility to the customer, how it could be improved with the next round of equipment purchase and, most importantly, the lasting vision of what their manufacturing facility could be capable of in the future. This enabled the equipment manufacturer to gain much more than a sale. They obtained a commitment to future expansion, which resulted in a steady flow of equipment sales.

Although there were a few success stories, these early adopters faced many challenges with 3D simulation including:

- High initial purchase costs
- Learning curves that can easily extend over 2 years for new operators
- Dependency on high priced consultants
- High level of complexity
- Difficulties in distributing the 3D simulation to a wide audience; this forced the use of static images or video as the main mechanism to share a simulation.

Due to these challenges, the use of 3D simulation as a sales tool was usually limited to companies selling very expensive equipment with the high margins necessary to fund the work required to develop, deploy, and maintain 3D simulation models of the company's equipment.

Recent advances in simulation technologies have drastically reduced, and in many cases, eliminated the challenges faced by the early adopters. Thus, allowing 3D simulation to be deployed on a much larger scale by equipment manufactures. These advancements include:

1. Applying component modelling techniques to simulation models so that a plug-and-play works for connecting equipment together and drastically simplifies the task of line layouts.
2. Encapsulating the complexity within a component to facilitate re-use and streamline maintainability.
3. Simulation products that are layered for different user levels throughout the organization. The most basic of which can be easily used by anyone with basic computer skills.
4. The reduction in purchase price of the products.
5. Advancements in computer and software performance enabling interactive performance on laptop PC's.

The origins of factory simulation began in the 70's, with the products that were mainly statistical in nature. These products took numbers from timing studies, as input and output reports, enabling the industrial engineer to run experiments in order to determine which methods could improve the manufacturing process. Very quickly, these products evolved to include 2D charts and graphs. This technology was called "discrete event simulation" because of the way that manufacturing processes were approximated into single time taking events. This approximation made it possible for entire factories to be simulated on computers that were very slow by today's standards.

The 80's brought a new generation of simulation which is sometimes referred to as "physics based" to distinguish it from discrete event. These products were initially targeted at the Robotics market. They offered the ability to accurately simulate the motion of robots, check for collisions, and simulate the effects of inertia based on payload. The key advancement of these products is that they were completely 3D based. There were a number of success stories using these products for sales presentations and proposals due to the realistic nature of the 3D display.

Advancements of the 90's included a trend to provide 3D graphics capabilities in discrete event simulation products. Unfortunately, the simulation engine used by these products did not contain the accurate motion that was common in the physics based robotic simulation counterparts. While this technology proved effective in identifying bottlenecks and optimizing throughput, it did little to give the customer a clear picture of what they were purchasing and why.

The most recent advancements include the combination of physics based simulation and discrete event technology within the same product. This provides the ideal platform for the sales proposal market, since many of the key decision-makers in large-scale factory installations are non-technical in nature. These products provides a conduit for effective communication including:

1. Communicating new ideas and concepts to a customer thereby obtaining commitment earlier
2. Describing the competitive advantages of your equipment
3. Justifying value
4. Understanding what is being purchased and why

The use of 3D simulation does not stop once the order is received. It provides benefits that extend from the supplier, to the line integrator, and to the end user. By leveraging the model throughout the business process, a large cost savings can be realized, much more than if just the engineering department use simulation to complete layout and process design analysis.

COMPLETE PRODUCTION LIFECYCLE SUPPORT

3D manufacturing simulation can support the complete production lifecycle from the early product designs to the re-configuration of production. 3D simulation can be used in all these steps as a communication tool to convey the idea of how a production works and how it performs to avoid costly mistakes as early as possible. Easier communication speeds up the decision making process creating better results faster.

In the early product development phase 3D simulation can be integrated into the design process in order to see the working product with performance data. This easier virtual prototyping supports the testing of a greater range of alternatives instead of settling into the first found solution found.

The simulation data created in the engineering processes can be reused in the sales and marketing phase when a customer is introduced to the new production capabilities with the modular reconfigurable simulation models (see Fig.2). This is the place where new component-based simulation really shows its advantages. Earlier it has been impossible to re-use the engineering data for other purposes, but now production lines and systems can be configured to meet customer requirements in front of the customer showing realistic simulated processes with animated 3D graphics. The same models can be used to create high quality animations and pictures for all marketing and sales needs. Using visual simulation with performance data will give both the customer and the seller a clear understanding of what the customer will receive.

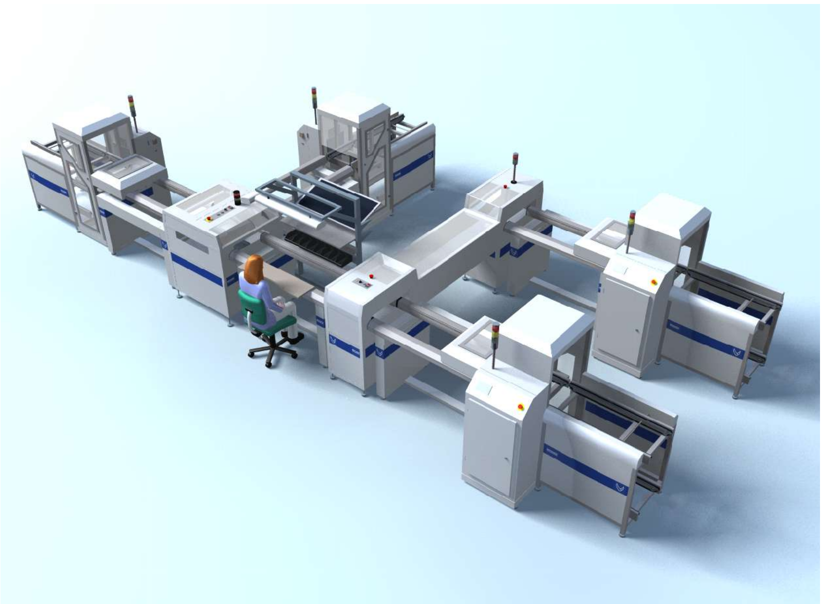

Figure 2: Reconfigurable Simulation Sales Model

Once a production system goes into the implementation phase, previously created simulation models can be used for verifying the line control logic to speed up the ramp up phase. This creates other possibilities to use the same simulation model for training purposes before the actual system is up and running. All this is achieved by using the simulation model as a virtual test bench that is connected to real control systems via a COM interface.

During production, the simulation model can be used for every day planning to validate and optimize production orders in advance. The simulation model may also serve as a 3D interface to the real system for monitoring and remote diagnostic purposes.

At the end of the production lifecycle, the simulation model can be reconfigured to meet the new production requirements.

SAY GOOD-BYE TO EXPENSIVE, ONE-OFF SIMULATIONS

One-off simulation models built from scratch by a dedicated simulation engineer are expensive and used mostly for engineering purposes. The new component based simulation model approach re-uses simulation components allowing non-engineers to build simulation models quickly to meet many other needs within an organsiation see Fig 3).

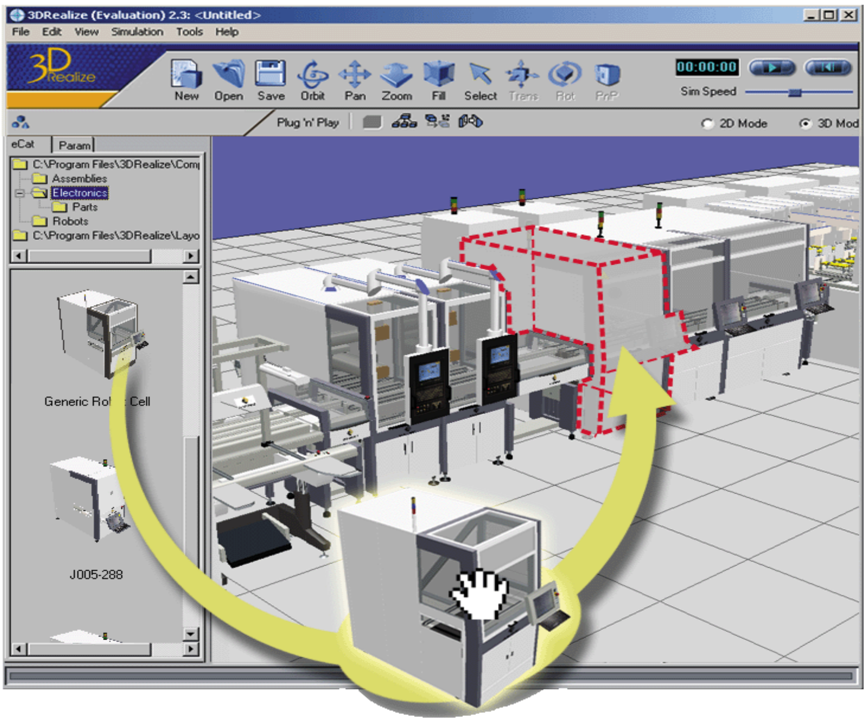

Figure 3: Easy Model Building with Plug&Play

Component based simulation is a similar phase shift, as movement to component-based software has been in the software industry. The same benefits which were discovered in the software industry can now be applied to simulation: components can be developed by a 3rd party, component complexity is encapsulated within the component, components can be added, deleted and
exchanged easily, the component lifetime is easier to manage and it is more future-proof. All this is available as long as the component interface remains same.

The component approach encapsulates machine or cell complexity into a modular simulation component, which interacts with other simulation components through an interface (see Fig.4). In the component based approach interfaces have been abstracted to contain not only communication but also the material flow and connectivity.

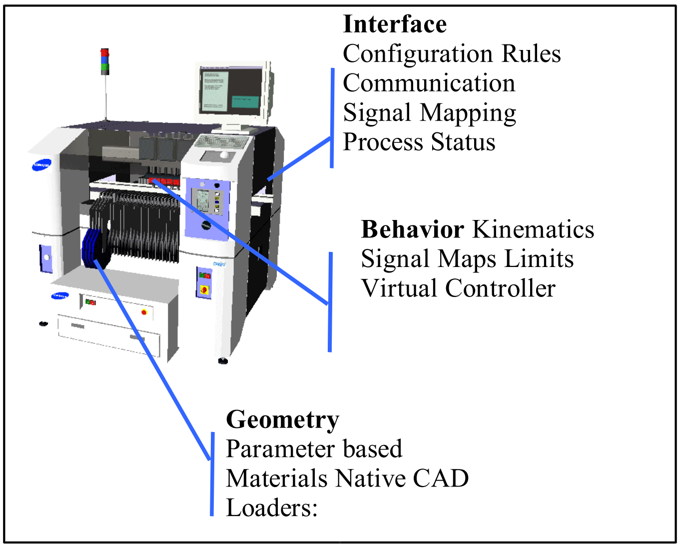

Figure 4: Component Based Simulation

Adding parametrics to a simulation component also enhances the reusability and mantainability of the simulation models. Equipment manufacturers can represent a product family with one component module, and this is ideal for modular based production equipment. Sales engineers can change a few module parameters that automatically adjust the physical appearance and performance of an equipment model and demonstrate the effect to the customer interactively.

ROBOTICS AND MATERIAL HANDLING ON THE ONE PLATFORM

The new behavior based component modeling approach now makes it possible to use the same simulation platform for robotics and material handling.

By combining different behaviours a component author can create a simulation module that has robotic mechanisms for assembly and material handling process for transferring parts to new processes (see Fig.5). In the electronics PC board assembly lines most machines are a combination of conveyors and robot gantry heads, even a manual workstation is a combination of a complex assembly operator and conveyor belt. With behavior modeling it is easy to build such a component by adding required behaviors and connecting them together. As a basic requirement the simulation platform needs to provide built-in behaviors to author primitive type components such as robots, conveyors, and grippers etc.

Figure 5: Robotic and Material Handling Simulation

PLC VALIDATION FOR FASTER PRODUCTION RAMP UP

Once simulation layouts are available they should support connection to the real operator interface or control system to validate the control logic. When a simulation model is connected to an industrial production controller most of the operator training and program debugging can be completed before the system is operational. This significantly reduces production ramp-up-time by removing most of the several weeklong debug periods traditionally required after the I/O field check. Real-time connectivity requires virtual time management to synchronize the communication with external systems. Using an Open Process Control (OPC) connection, the control engineers can continue to use their familiar code development environment for their robot controller or PLC while testing the results on a "virtual factory" test bed.

AUTOMATING THE PRE-STUDY NOT JUST PRODUCTION

Speeding up the pre-study phase for production with intelligent component based simulation tools allows engineers to keep up with the demands of reducing product cycles and increasing model variants running on the same lines.

As production lines become more automated and 'digital' in nature the opportunities now exist to 'plug and play' production line components such as conveyors, robots, tooling, and model variants together to evaluate a host of production alternatives very quickly. Using component based simulation makes it possible to check the layout, components, and their interoperability in one environment. Checking out the impact of a configuration or process change allows production management to quickly and directly trial and communicate 'what-if' scenarios/layouts without the need to translate the concept via a CAD operator or simulation expert. Earlier it could have taken days or weeks for a dedicated and experienced simulation engineer to create a simulation model for evaluation purposes. Now any engineer with a little training can generate the same models in hours.

ABOUT VISUAL COMPONENTS

Visual Components is a world leading 3D robotics and manufacturing simulation software provider offering machine builders, system integrators and companies using complex turnkey manufacturing solutions a simple, quick and highly cost effective way to build and simulate their total process solutions. Finnish based Visual Components has global OEM partners and an extensive reseller network. For more information please refer to www.visualcomponents.com