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Visualization of the Advanced Digital Enterprise

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Abstract

The developments in the deepwater triangle of the Gulf of Gulf of Mexico, Brazil and West Africa are setting new standards for the design of all aspects of the "oil field of the future". Such new projects could provide "green-field" opportunities to implement integrated design/build/support process-improvements from the aerospace industry. Boeing terms their new manufacturing paradigm an "advanced digital enterprise", of which visualization is a key component. Implementation of advanced tools and processes used by Boeing for the design and construction of offshore facilities might lead to revolutionary cost and cycle-time savings for the energy industry.

Introduction

The purpose of this paper is to look at how visualization is used in modern aerospace manufacturing, and at the prospect of enough commonality for it to be exportable to the energy business. Based on what we have seen of visualization technology in the energy industry, it is clear that the issue is not one of technology. The energy industry is clearly on the leading edge of visualization technology. For example, there have been significant advances in discovery and delineation of new oil and gas reservoirs through the use of 3D visualization to characterize subsurface geometries. This paper will look at the next step, or how visualization technology can be integrated into the total life cycle of upstream processes to increase the performance of the overall enterprise.

Energy and Aerospace

At first glance, the similarities between energy and aerospace seem few and far between. However, looking at the big picture, there are a several similar attributes:

- Both deal with large complex capital projects
- Both end products have long life spans and operate in hostile environments
- Failure at anytime can be catastrophic, both economically and in loss of life
- Economic success is dependent on keeping to cost and time schedules

Given this commonality, we hope that interaction of people and technologies between these different worlds can produce common benefit through the use of advanced tools and processes.

The Advanced Digital Enterprise

For many years there has been promise of the paperless manufacturing environment and the many productivity benefits such will bring. We have seen evolutionary benefit in many industries over the past ten years, but seldom do we see a truly revolutionary benefit, as has been discovered in aerospace. This is primarily because of the large scale and scope of the impact on the overall organization required to "going completely digital."

To this end, Boeing implemented a program called the "Lean Engineering Thrust" specifically targeting the design, build and support of its large, complex military and commercial aircraft systems. The idea was not to take our paper world and digitize it, but to re-look at all our processes and determine what they would look like, and if they were even needed in a digital environment. Then, if they were, how could they be improved within the overall digital process? Out of this exercise came a proprietary product called the Digital Manufacturing and Production System (DMAPS).

DMAPS is the result of significant investment into looking at lessons learned on previous projects, and analyzing best practices over several major design projects. Boeing started in the 1970's and moved first to the completely digital design of the 777 aircraft in the early 1990's, and then on through four successive generations to the Joint Strike Fighter of today (which made its maiden flight in 2000 and completed flight testing in early 2001).

The goal of DMAPS is two fold: first is to design better aircraft and second is to lower the cost of both the production of the aircraft AND its operation for the life of the aircraft. The Lean Engineering Thrust set out to make major improvements in the process rather than just incremental improvements in technique. As shown below, Boeing targeted and then achieved 50% or greater improvement in cost- and

manufacturing time-reduction with 90% improvement in quality.

DMAPS Overview

DMAPS is a totally integrated design/build/support tool for managing the information required to move the facility from concept through operations **(Fig. 1).** DMAPS should be applicable to aircraft, offshore platforms, LNG plants, as well as other surface or subsurface factories. The core of the system is the common geometry. We employ high fidelity Virtual Reality facilities, similar to the HIVES and CAVES in the oil exploration world, where design reviews are held. However, Boeing has found that the key to maximizing the benefit of visualization is to make it available to the entire team all the way through the process and down to the desktop. In addition, all the physical attributes of every part in the system are included as part of the common geometry. So this allows visualization of the whole facility for simulating maintenance exercises or performing stress tests on a discrete part. From the common geometry the engineer or procurement specialist can identify all the critical engineering data associated with a part or subsystem as well as pull up the vendor's delivery schedule of the part or where it is in the design process. **Figure 1** illustrates this integration as a continuous process, rather that the typical linear progression common to most manufacturing today. Many processes are happening simultaneously which reduces both cost and cycle time.

Through continuous improvement over the past several years, Boeing has been able to continually bring down the cost of the non-recurring as well as the production of our aircraft through the use of a highly integrated visualization system that delivers the information to every team member. This includes suppliers and partners located in all parts of the world. **Figure 2** illustrates the relative reduction in non-recurring costs versus production time to first-produced-vehicle; a relevant metric to the energy business since one-off production is the norm. The four plots in the graph represent the improvements over four successive generations of aircraft projects as the DMAPS system was enhanced and fully implemented.

Through virtual manufacturing we are able to validate the product definition, optimize the manufacturing plan and costs, and simplify worker training and work instruction quality. Again, utilizing visualization and the 100 percent part definition of the common 3D geometry, we are able to solve most manufacturing problems prior to any metal being cut. **Figure 3** illustrates the virtual manufacturing tools used to simulate the manufacturing process.

By utilizing visualization in an integrated environment, we continue to drive down costs and improve quality and safety. As illustrated in the bullets below, we continue to meet or exceed our goals as we benchmark our progress. It is Boeing's intent to continue to set lofty goals in order to make the kind of revolutionary improvements required to survive in today's business environment.

TARGETS: (GOAL - CURRENT STATUS)

- Nonrecurring Development Cost: (50% - 48%)
- Nonrecurring Dev Cycle Time: (50% - 54%)
- First Unit Cost: (66% - 46%)
- Design Changes After Release: (90% - in-work)
- First Unit (T1) Quality Tags: (90% - in-work)
- Production Recurring Cost: (50% - 48%)
- Prod Recurring Cycle Time: (50% - in-work)
- Prod Recurring Quality Tags: (90% - 65%)
- Support (O&S) Costs: (50% - 25 to 40%)

Application to the Oil and Gas Industry

The "AS IS" situation in the "brown" oil and gas fields of the present will be difficult to improve quickly because most are "one-off's". There has never been an integrated design/build/support IT infrastructure in place to drive standardization and commonality, let alone real-time communications and coordination. However, the unbelievably expensive developments of new green fields of the deepwater triangle are setting new standards for the system-wide integration of all aspects of the "digital oil and gas field of the future."

Concerning the "TO BE" of future green facilities, the industry is already searching far and wide for more cost efficient processes. It is our prediction that the implementation of modern, integrated IT systems, tools, and processes such as those used by Boeing could have profound impact on the energy industry. Use of modern IT tools and processes for the design, construction, operation and support of energy facilities might lead to revolutionary cost and cycle-time savings. They certainly have in the aerospace business.

However, the energy industry will not be able to develop these IT tools and processes quickly. The Boeing improvements were developed over many years with annual research and development expenditures specific to integrated IT systems that are comparable in size to a typical exploration budget!

Conclusion

As the next generation of visualization tools becomes more integrated with other engineering processes (scheduling, finite element modeling, etc.), it is our experience that productivity will increase exponentially as transaction costs are reduced or eliminated. This type of approach in the develop of large offshore CAPEX projects in the energy industry might go a long ways toward reaching the industry's stated goal of 40+ percent improvement in cost to harvest deepwater reserves. This represents an opportunity for collaboration across apparently dissimilar industries to possibly produce "Game Changers" in the way we do business.

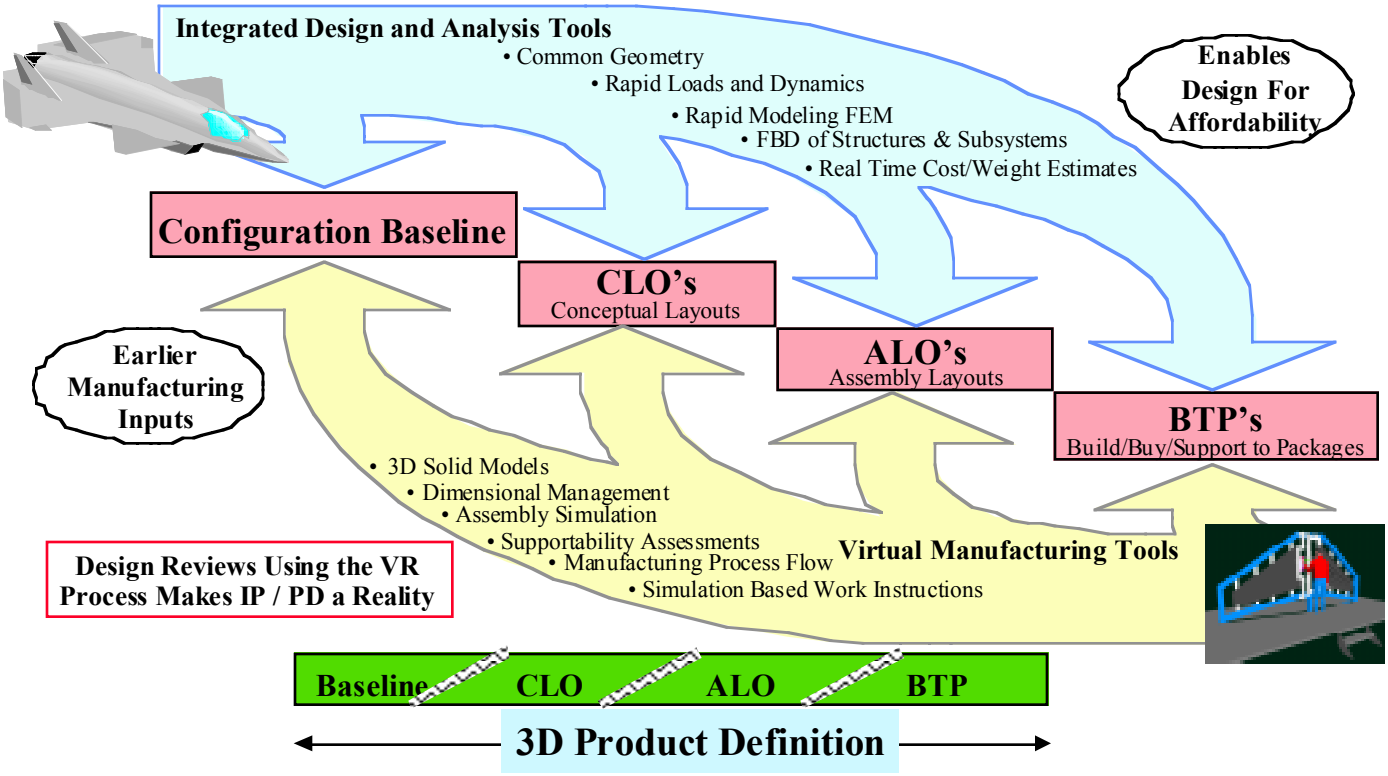

Figure 1. Lean engineering integrates product and process simulation tools for reduced cost and improved quality.

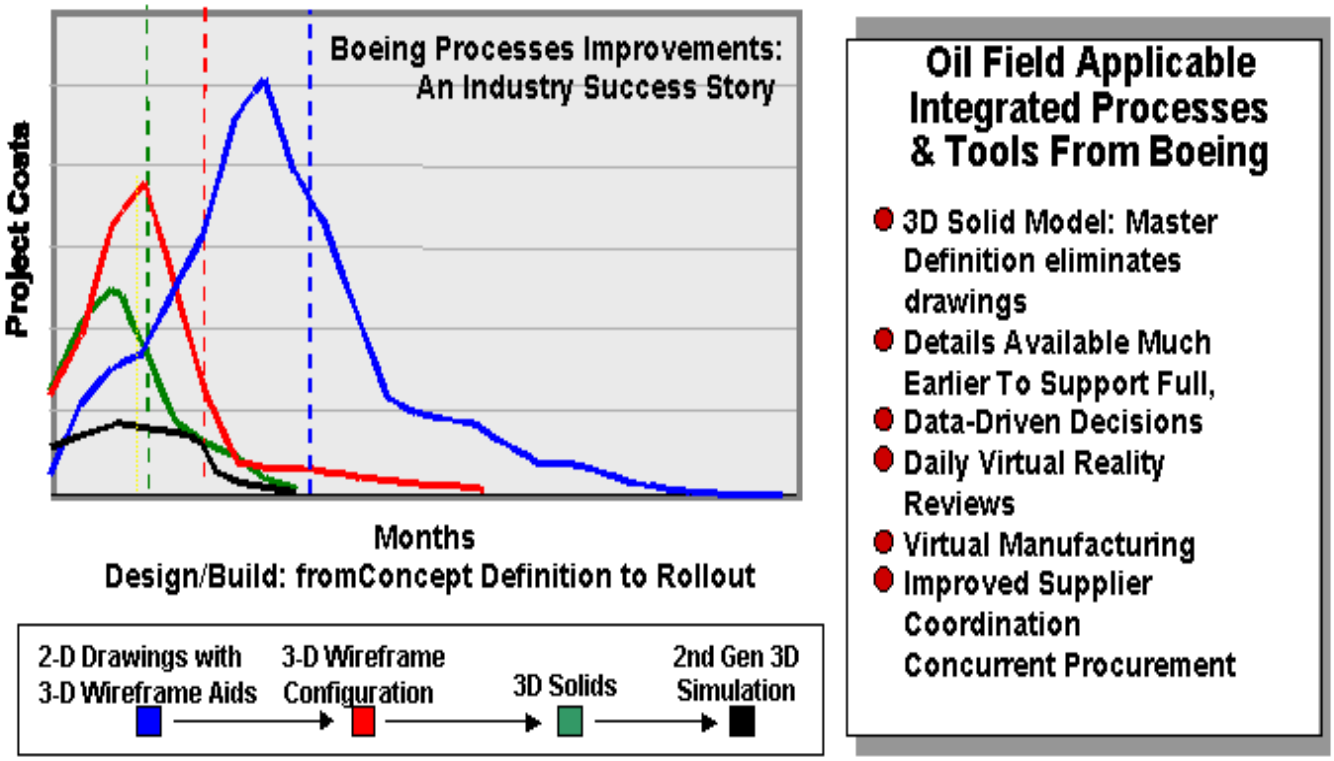

Figure 2. Boeing's proven integrated processes can reduce Cost and Cycle time in the oil industry.

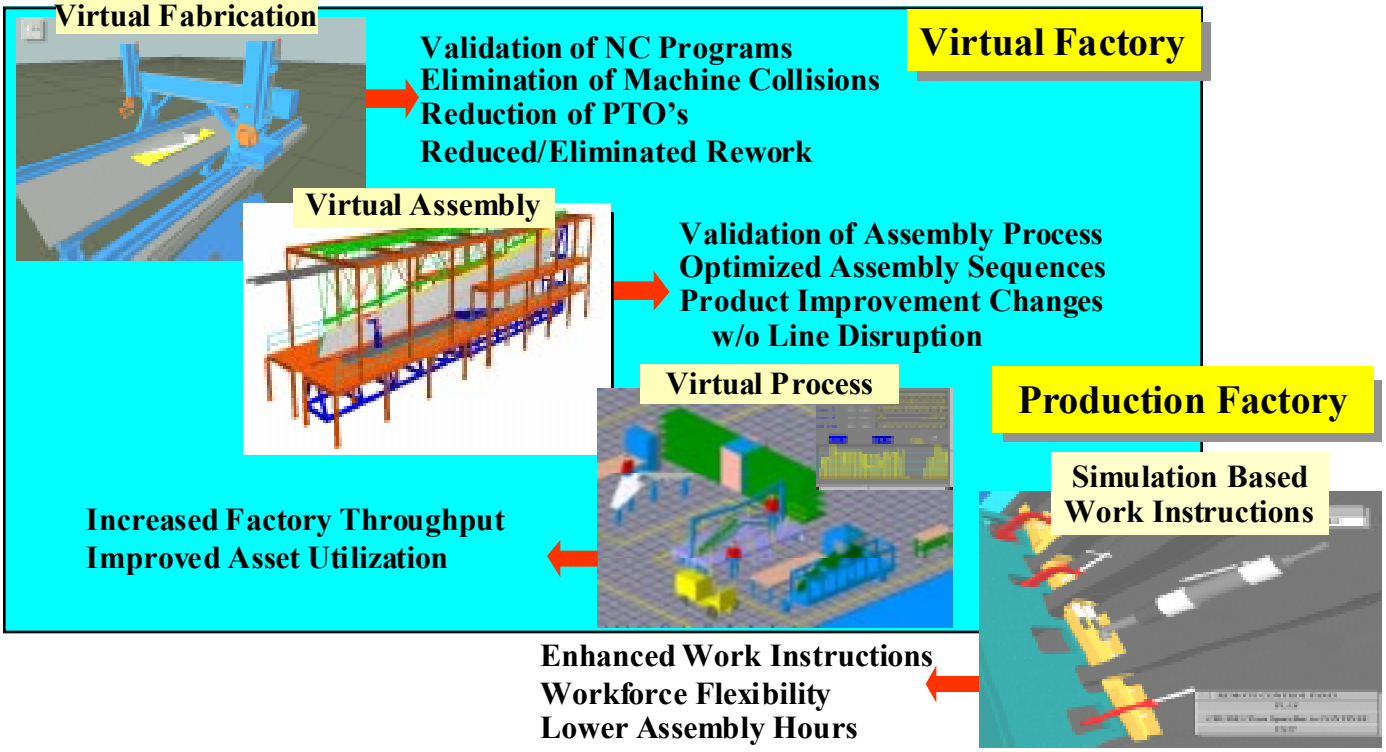

Figure 3. Virtual Manufacturing Tools support the Advanced Digital Enterprise.