Put a Virtual Prototype on Your Desktop

An Air Force Collaborative Research and Engineering Environment for Acquisition Reform

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Are you tired of reading statements of work, technical specifications, proposals, and monthly reports? Have you asked yourself, what does this proposal really mean? What is the contractor actually saying, or more importantly, what will the deliverable really be able to do? Or perhaps you've indulged in a little wishful thinking: If I could only reach out and touch the new system before it exists and do a

Virtual Reality Battleroom for the Joint Synthetic Battlespace — a "virtual photo" of a "virtual facility." An artist's concept of the immersion theatre to demonstrate future technology and weapons systems using simulation and visualization. The photo is actually a digital enhancement of two photos depicting the inside of the DoD Warbreaker Facility in Washington, D.C.; the faces represent people who actually work at Wright Laboratory.

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DoD Digital photos

ENGINEERS AND ANALYSTS WILL USE THEIR DESKTOP PCS AS ACQUISITION PORTALS INTO THE JOINT SYNTHETIC BATTLESPACE. DURING REQUIREMENTS DEFINITION PHASE, THEY WILL BE IMMERSED INTO A SYNTHETIC ENVIRONMENT — A TWO- OR THREE-DIMENSIONAL WARGAME WHERE THE MILITARY WORTH OF THE PROPOSED CONCEPT CAN BE EVALUATED WITH REALISTIC SCENARIOS AND LOCALES.

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"virtual test drive" now, before I invest extensive resources in their concept. How do I put this in terms that all members of my acquisition team can understand? Under Acquisition Reform, as a program manager I only have *insight and not oversight* of my contractor. How do I get insight into the contractor's effort when I have less people and smaller budgets?

Help Is On the Way

Good news – help is on the way. Some innovative uses of simulation and information technologies will bring technical and program management data in a comprehensible format to a personal computer near you: desktop virtual prototyping and collaborative engineering. Changes in simulation and information technology now allow computer engineers to create computer models of conceptual hardware systems prior to building the actual hardware. The collaborative development of a digital computer model in parallel with the hardware is called Collaborative Virtual Prototyping (CVP). Any definition of CVP must encompass all of the following characteristics:

> *CVP is the application of advanced information systems technology in design, modeling, simulation, analysis, manufacturing, testing, and logistics to support life-cycle development of a system in a geographically distributed electronic environment.*

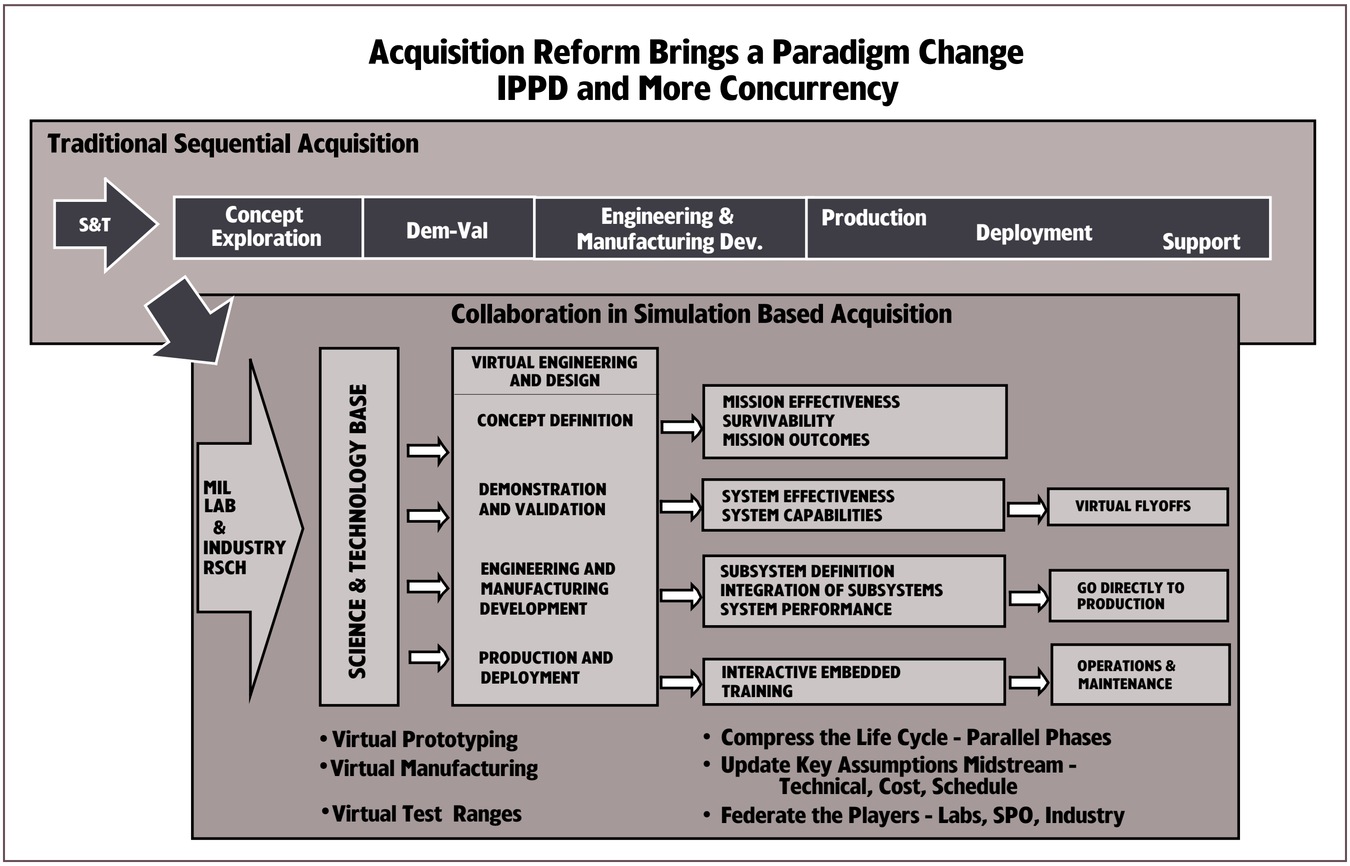
Its use throughout DoD is consistent with current acquisition trends in the Department as well as the commercial sector (Figure 1).

Acquisition Reform and the Joint Synthetic Battlespace — Made Personal

DoD has implemented significant changes in how it buys weapon systems. The new emphasis is on concurrent engineering with Integrated Product and Process Development (IPPD) and collaboration with Integrated Product Teams (IPT). The new DoD vision includes Simulation Based Acquisition, a process supported by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs.

To be competitive in their fields, throughout the commercial sector world-class companies in the automotive, electronics, aircraft, and heavy equipment manufacturing areas use CVP and collaborative engineering for requirements, analysis, and design. You, as a program manager, will be working with companies that use these technologies to design their products. As partners in developing DoD products, these companies will be applying the best industry

FIGURE 1. **Simulation Based Acquisition**



practices to your work, and you will need to collaborate with them.

Today, a commercial-sector program manager can turn on a personal computer (PC) on the desktop, check E-mail, and then look at the status of the program, – a completely paperless, electronic review. That same program manager can distribute solicitations electronically, and receive return proposals by the same mode. Along with the standard full text descriptions of the technical task in their return proposals, contractors can also submit a digital model of the concept or design.

The program manager's technical evaluation team can look at an electronic representation of the proposal in the form of a computer model. The model then becomes part of an electronic design and a simulatable specification for the system. Further, the technical team can also "what if" – hypothesize uses of the system and run excursions on competing versions of the same concept or design.

In the commercial sector, a virtual prototype of a car or a plane allows design teams to walk through the virtual prototype to see how the components are changing. The virtual prototype serves as a common frame of reference for the designers, engineers, and managers. It allows you as the program manager, to establish a level playing field for consistent comparisons among alternative concepts and designs. Ideally, CVP provides the insight you need into what your contractor is doing.

Even earlier in the acquisition process, the program or technical manager can work with the user to define requirements using a virtual prototype. Historically, program requirements are difficult to quantify and verbalize. Users are able to state what they don't want much easier than describing what they do want. A simulation model developed in parallel with the hardware or technology development allows scientists, engineers, or end users to refine system requirements early in the engineering process. The users then become an integral part of the design process. Ultimately, when program managers follow IPPD procedures and bring users into the design process, commercial-sector applications show a significant decrease in development time. As we extend this approach to military acquisition, the Air Force Battlelabs will allow the operational commands to do a "virtual test drive" of new weapon concepts and provide feedback to the acquisition community.

Within the Air Force, we envision an integrated, common modeling and simulation (M&S) environment that will be accessed by analysts, warfighters, developers, and testers supporting the range of Air Force tasks, from determining requirements through conducting operations. The key concept in the Air Force M&S vision is the Joint Synthetic Battlespace – an integrated M&S environment where simulations extend from high-level aggregate models to detailed engineering models, from pilots in live aircraft and simulators to hardware components and laboratory test beds.

Your desktop PC will be your acquisition portal into the Joint Synthetic Battlespace. During requirements definition phase, you will be immersed into a synthetic environment – a two- or three-dimensional wargame where the military worth of the proposed concept can be evaluated with realistic scenarios and locales. Such a system allows the user to selectively choose the level of detail needed for the task at hand, draw on distant resources, and easily "plug-and-play" computer simulations, manned simulators, and live hardware to create any needed simulation environment. Demonstrations of a future system's military worth will be conducted in the synthetic environment represented by the Joint Battlespace. More than just acquisition – analysts, researchers, decision makers, and warfighters must be able to "plug in" to a common battlespace from their desks, simulators, or crew stations in order to assess, develop, train, or conduct warfighting.

Your industry counterpart has long been driven by cost as the bottom line. Under Acquisition Reform, DoD will make buy decisions on life cycle-cost performance trade studies where cost is an independent variable. The future Air Force Collaborative Engineering Environment (CEE) will have constraint-based analysis tools to aid in early, high-level concept trade studies for cost of function and cost of performance for various alternative technologies.

> *"Your desktop PC will be your acquisition portal into the Joint Synthetic Battlespace."*

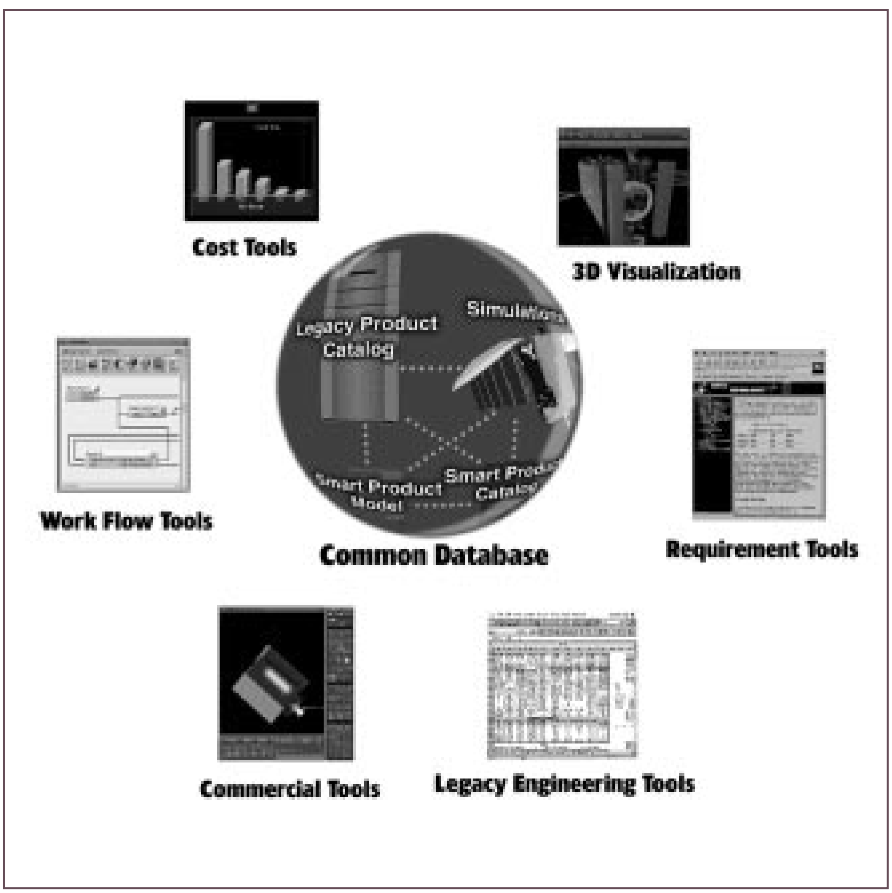
A virtual prototype allows the engineer to see the impact of design changes. Trade studies using the model can then be performed throughout development as an essential part of the systems engineering process.

A Collaborative Research and Engineering Environment Near You

Two of the most significant, technologically advanced programs are the Avionics CEE development project being conducted at the Avionics Directorate, Wright Laboratory (Figure 2); and the advanced research underway at the Defense Advanced Research Projects Agency (DARPA) Simulation Based Design (SBD) program. The Avionics Directorate has initiated a program to develop and exploit collaborative engineering technologies and implement a CEE to enhance productivity by advancing avionics collaborative virtual prototyping processes. It will build on the significant commercial technology base existing for electronic systems design, DARPA's SBD initiative, and other commercial/industry information and modeling standards and best practices.

Collaborative Engineering and Virtual Prototyping is the application of advanced distributed M&S and engineering tools in an integrated environment to support technology development, system design, performance, cost, and producibility trade-off analyses throughout the entire product and system engineering life cycle. As such, it enables all members of an IPPD to continuously interact through electronic modeling and data interchange; increases insight into life-cycle concerns; permits earlier testing and

FIGURE 2. **CEE Built on the DARPA SBD Framework**



experimentation through virtual test ranges; and accelerates physical production through process optimization using virtual factories.

Additionally, Collaborative Engineering simulations, with integral product and process models, will permit engineers to obtain detailed knowledge earlier in the conceptual and preliminary design phases where it can have the most influence on life-cycle cost. More emphasis will be placed on the collaborative development of virtual prototypes of key technology products to demonstrate their military effectiveness and worth in an *integrated systems/mission environment.*

As downsizing trends continue in both defense and industry, the military and commercial laboratories will increasingly depend on other organizations for key technologies to integrate into systems. Additionally, increasing demands will be placed on technology to facilitate more efficient, effective collaboration of widely dispersed personnel across many different application domains in order to solve complex problems and accomplish difficult tasks.

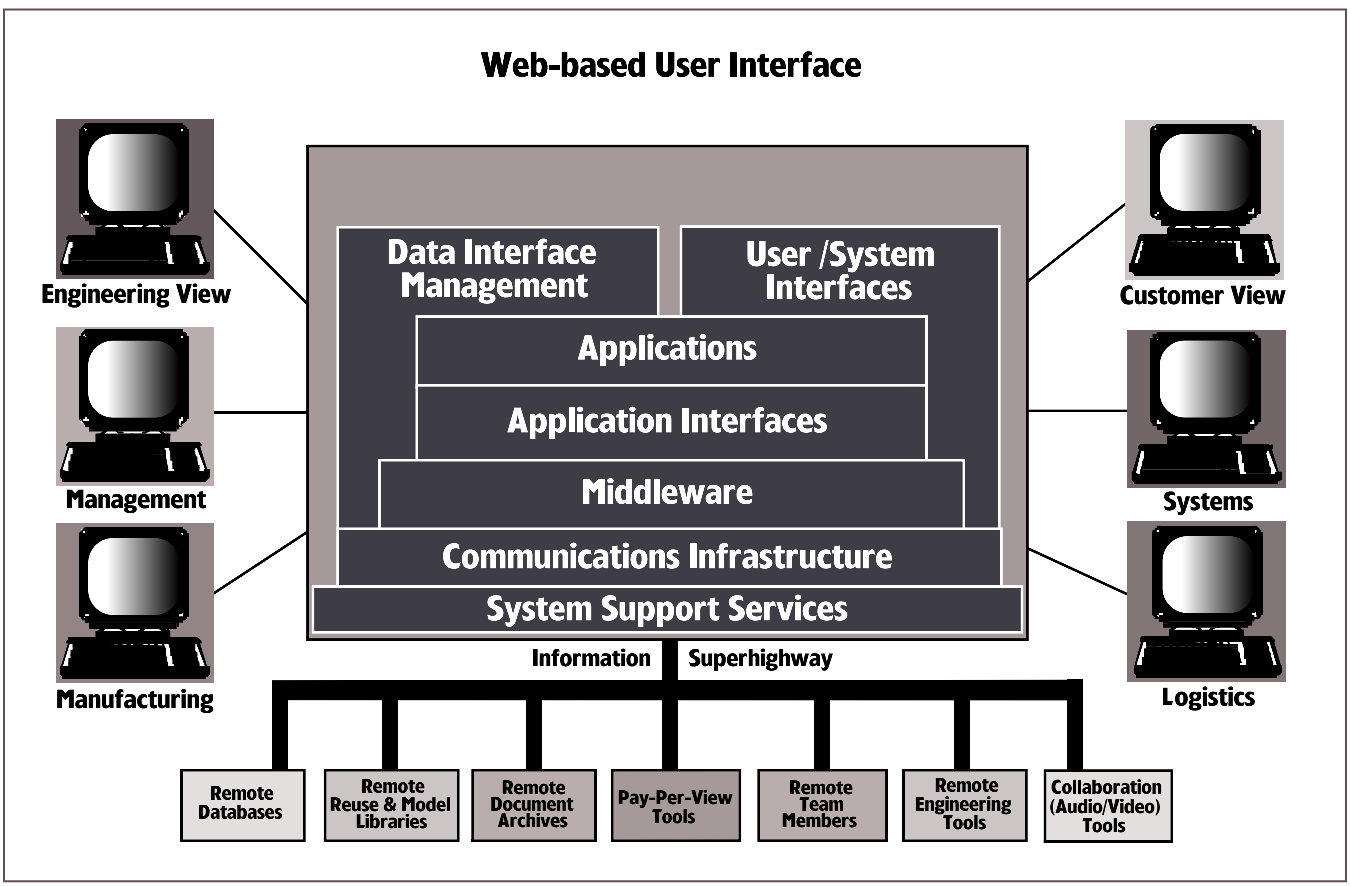
As an initial response, CVP meets the demand for technical assistance and provides the infrastructure to support these new acquisition requirements. It will also assist in the breakdown of technology stovepipes and become the construct for communication of technologies between domains.

CVP can be implemented in many organizational structures. Traditional hierarchical workplaces, concurrent engineering environments, and work groups focused on rapid prototyping are a few examples. Implementation of a CVP system requires attention to the necessary enabling technologies and supporting infrastructure. A crucial part of a CVP system implementation is educating personnel on how CVP can meet customer, organizational, and individual goals as well as decrease time-to-market, lower life-cycle costs, and improve product quality.

Historically, 80 percent of the development costs and 70 percent of a product's life-cycle cost are determined during conceptual design. As the program moves from conceptual design into engineering and manufacturing development, the ability to substantially influence life-cycle costs diminishes. The freedom to make design changes decreases as the knowledge about the system design increases. In other words, a progression from soft to hard information occurs as the system moves from the conceptual phase to the detailed design phase.

CVP can move the knowledge curve to the left and increase the hard information available in the early stages of design. This improvement in the quality of information should benefit the acceleration of the technology maturation and ultimately facilitate

FIGURE 3. **Multiple Views in Collaboration**



technology transition. The end result should be designs completed in less time and at less cost.

The use of M&S in the design, development, and distribution of products is not a new concept or idea. The DoD and industry have been using virtual prototyping within many of their individual functional departments and organizations for many years. However, these individual *stovepipe* groups of functionality have not interacted with each other in an effective way and have oftentimes duplicated functionality.

A CVP system provides the capability to integrate *stovepipe resources* and increase the collaborative interactions of the people using the resources. Thus, the old mindset of having to move resources needed to do a particular job local to one location is no longer necessary or valid.

In the future, clusters of geographically separated resources will be integrated by advanced communications networks into a virtual system. Users will search repositories for the resources needed to solve their particular application, will assemble and configure the resources into a virtual system, and will execute or use the virtual system to solve their problem or accomplish their task. Additionally, products resulting from one task will seamlessly interact with the products of other tasks to accomplish unique functions.

The Collaborative Research and Engineering Environment will emphasize *product and process* models. Product and process model applications capture and provide information about a product technology development process.

Product Models. These models provide details about the specifications and requirements of a product, its structure and behavioral characteristics, its design and development constraint rules, and the different versions of the design and implementation. In this context, a product can be a prototype piece of hardware, a report, or an experiment/session. Product models also define any special test equipment or facilities required to support design and/or development. For CVP, the product models will have a virtual prototype as the central focus of all other information gathered and collected.

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Process Models. While product models focus on all aspects of the product design and development, process models provide detailed definitions of the engineering, development, and evaluation processes used to design and develop the product. Specifically, process models provide information and knowledge on how to use various tools and resources to perform the numerous scientific, engineering, development, and evaluation tasks associated with technology and product development.

Making Collaboration Work for Each Team Member

Each IPT is made of many participants with different backgrounds, experiences, and specialties. They literally do not speak the same language. The Collaborative Research and Engineering Environment must provide a domain-specific view in the native terminology of each of your team participants. There will be multiple user interfaces as shown in Figure 3. For example, the engineers on the IPT must be able to employ the applications that they customarily use. The engineering user interface must be intuitive for the engineering domain. Similarly, the manufacturing, financial, logistics, management, and end user must be able to access the information, databases, and virtual prototypes in a fashion natural to their way of doing business.

The overall architecture for the CEE is a layered, open-systems approach. The infrastructure consists of that hardware and software which provides functionality to the user, but resides in the background and does not directly interact with the user. The user sees a consistent interface that is based on Web technologies that provide portability to many different platforms, including the workhorse PC on your desktop.

CEE/CVP—Crucial Ingredients

Advances in software and computer technology are making desktop CVP possible and affordable for the engineering process in government and industry research. CVP will become a crucial means of sharing technology and systems integration for research and development and is a natural extension of the Air Force vision for an integrated, common M&S environment, accessed by analysts, researchers, warfighters, developers, and testers. Virtual prototyping and a CEE are crucial ingredients for Acquisition Reform – providing insight for the program manager.