BDrive®
Power for Intelligent Collaborative Infrastructures™

Design Driven and Infrastructure Aware

About

In this article, we lay down the foundations of incorporating the latest IT technologies in Engineering Design, an area dominated by legacy CAD/CAE/CAM systems, current trends in Process and Design Collaboration and our view on the next generation of PDM systems that will optimize Product Lifecycle by efficient management of Product Development.

"Every major PDM vendor now has a program to make browser technology part of their product suites," says Ed Miller, president of CIMdata Inc. (Ann Arbor, MI). "The big push for these browsers [in PDM] is heavily driven by the user community that sees Web browsers as incredibly inexpensive, simple to understand, and capable of supporting almost all users," Miller adds.

What does the addition of Web browser technology bring to a PDM system? It expands access to the system, allowing people to connect regardless of their computer, operating system, or location. "Our implementations of PDM span multiple sites, multiple applications, multiple uses, all the way from the salesperson through manufacturing," says Scott Vanselous, PDM product manager at EDS/Unigraphics (Maryland Heights, MO.) "With a Web browser as the front end to our PDM system, we will provide a common platform for information access. Users won`t have to slog through the corporate network or navigate systems they`re not familiar with."

Access to information is certainly something engineers get from the Internet, but that`s not all they need as they develop new products. Collaboration is equally important. Here, too, the Internet has people excited, but this is the area where some of the Internet`s promise is still evolving.

Virtual Prototyping

The reason virtual testing works is because software and hardware developers have greatly improved the correlation of physical and computer-generated systems so that simulated results are more believable. This concept, used for years in the nuclear and aerospace industries, has expanded to include component-level, assembly, and full-system testing in a number of other industries, including aviation, building design, heavy-equipment manufacturing, even entertainment animatronics, with automakers leading the way. Companies intent on speeding up their design process are investing in more virtual test software than ever before, a market trend tracked by analysts at Daratech (Cambridge, MA), the IT marketing research and technology Assessment Company. The firm's figures show a 10 percent growth in user spending on virtual prototyping products in 2001 (over 2000) in spite of the recession. The research firm expects a modest 8 percent growth for 2002, with an

average growth of 15 percent per year through 2007. Even at these rates, this growth outpaces that of other CAD/CAM and CAE applications, and virtual testing is a significant factor in this area.

@GM - From Road to Lab to Math

General Motors calls its program "moving from Road to Lab to Math," emphasizing virtual testing for everything from tracing the path a glass window follows as it opens and closes to determining the behavior of a vehicle in a simulated crash.

General Motors has made a corporate-wide commitment to virtual testing as part of its "Math-Based Synthesis-Driven Vehicle Development Process," a mouthful of a phrase that describes the company's fundamental quest for a virtual proving ground. Steve Rohde, technical director in the Engineering Process & Math Strategy Group, notes that GM has been in the business of mathematical modeling for a long time, even in the'40s and '50s. Given the title of his department, it's no surprise that GM actively uses math-based tools to make decisions on form, function, sales, and marketing, to reduce development time and cost, improve product quality, and even enhance innovation. In the past year, with virtual testing and increased compute power, GM has achieved a 300 percent increase in the total number of crash simulations completed, and reduced the wait times for results by factors of 6 to 60.

@Daimler-Chrysler - Hybrid Approach

Daimler-Chrysler has been employing virtual testing since 1999 in six different vehicle programs; fields of interest include suspension fatigue issues and fluid flow performance.

In the Hybrid approach employed by Daimler-Chrysler, one measures a minimum set of physical data, then uses these values as inputs to a computer model, in this case built with Adams software from Mechanical Dynamics Inc. (MDI), which calculates the remaining load points. All subsets of the mathematical model are then fed into finite element analysis calculations. The beauty of the hybrid approach is that it combines the best of both the physical and virtual load-generation techniques with fast turnaround times, simultaneous calculations of various components, and the ability to correlate values.

@Ford - Zero Prototype Build

Taking a somewhat different focus, Ford is pursuing a Virtual Manufacturing Strategy that increasingly relies on simulation for detailed planning in such areas as plant layout, ergonomics, assembly sequencing, mold-flow, formability, and welding.

Ford is focusing on a "Virtual Manufacturing Strategy." The plan emphasizes the need for a seamless process that takes virtual products from the design phase all the way through launch. Issues that traditionally need to be addressed in manufacturing, in order of increasing complexity, include geometric

compatibility, kinematics/sequencing ergonomics, equipment control, dynamic behavior, and product and process integrity. Possible virtual manufacturing tools to address these areas fall into four categories: process design, process verification, process validation, and operations.

We stand committed to the use of CAE simulations as part of our strategy to optimize design lifecycles. Using CAE software intelligently and proactively, we will be able to reduce costs on prototype builds and create designs that "fit" the requirements. A Systems Engineering approach to product development calls for tools that can be used for target setting and target cascading BEFORE most design geometry exists. Using a history of simulations (our Knowledge Warehouse), we will be able to assign the best software and practices to meet the deliverables and sign-off on requirements enabling the automotive manufacturers to reduce cost and timing in complicated design processes.

CAD/CAE/CAM in Motorsports

There are two major types of auto-racing today:

1. **NASCAR (National Association of Stock Car Auto Racing) events**
2. **the Formula One-style style CART (Championship Auto Racing Teams) races**

Although these two types of races are worlds apart in terms of automotive technology; both are now being driven by computer design, engineering, and manufacturing tools. Indeed, what race teams are discovering is that even the smallest engine or body enhancements made to virtual models translate into huge advantages on the track.

NASCAR's Winston Cup Series, the most popular form of auto racing in the US, features cars that look very much like those you see on the street, from familiar companies like Chevrolet, Dodge, and Ford. In fact, in its early years-NASCAR dates back to 1948-the cars were exactly the same production models that anyone could buy. Today's cars still resemble streetcars in the shape of their bodies, but they are hand-formed from sheet metal over a metal space frame and riveted together to meet NASCAR's strict aerodynamic shape specifications.

While creating stock car bodies is an art form in itself, the primary challenge in designing NASCAR vehicles is to coax as much horsepower out of the engines as possible. The "stock" V8 engines, although limited to 358 cubic inches in displacement, can be modified to produce up to 750 horsepower, enabling the cars to reach speeds of over 200 mph on the banked oval race tracks. NASCAR specifies that the cars must use four-barrel carburetors and four-speed transmissions. On some tracks, for safety purposes, NASCAR also requires the addition of a restrictor plate between the carburetor and intake manifold to reduce engine power to 420 horsepower and speeds to 200 mph. To meet these design challenges, NASCAR teams are starting to rely heavily on CAD/CAM/CAE technology.

Central to NASCAR’s marketing strategies is maintaining a level playing field among its three competing car brands, Ford, Chevrolet and Pontiac (Dodge will join NASCAR as a fourth brand in 2001.) In a series where the fastest car and slowest car can be differentiated by only tenths of a second, every detail of the car’s shape becomes critical in determining the

aerodynamics that can push a car to the back of the pack or onto Victory Lane. To control the use of those aerodynamic forces, NASCAR has created an intricate series of 22 templates that govern the bodywork of all cars. While the body styles of the production Taurus, Monte Carlo and Grand Prix are unique, these templates seek to legislate some consistency in the aero packages they create.

In 1998, when the Taurus replaced the Thunderbird as Ford's stock car for the Winston Cup, its primary advantage over its predecessor was aerodynamics. The Taurus had a strong debut in Daytona in 1998, winning the Bud Shootout and taking five of the top-10 finishing positions.

A CART racecar bears more resemblance to a jet plane than to an automobile, which isn't surprising, considering that at race speeds of up to 245 mph, proper aerodynamic design is essential just to keep a car on the track. Constructed of honeycomb composite carbon fiber, the cars measure 199 inches long, 36 inches high, and 78.5 inches wide, with a 124-inch wheelbase. Each car weighs only 1550 pounds (compared to more than 3000 pounds for a typical passenger car), carries 35 gallons of methanol, gets 1.85 miles per gallon, and costs around $500,000 (not including the engine). The engines, 2.65-liter turbo-charged V-8s,rev to about 15,000 rpm and produce approximately 900 horsepower. Each of the 18 CART race teams purchase finished chassis from Lola or Reynard and lease engines from Ford-Cosworth, Honda, or Toyota. While the chassis as delivered is theoretically ready to race, it's really just a starting point.

Using the **Aerodynamic Expert System**, designed by BDrive, Ford designers can quickly predict the effect of changes in shape as related to aerodynamics (which in turn drives fuel economy). The Expert system is divided into three modalities:

1. the **Design Guidelines** where a series of hot-spotted images enable information to be quickly retrieved (these were typically available in tomes of text),
2. the **Prediction Tools** that simulate parametric wind tunnel tests using multi-variate regression analysis of existing data, and
3. **CDAero** a tool that allows the computation of the total drag coefficient of an automobile based on geometry feature inputs including dimensions, angles, radii of curvature and cross-sectional area information. The tool is based on the kernel algorithm which are the MIRA empirical equations and works on parametric geometries created in IDEAS for Car, SUV and Truck profiles

Our Perspective

Recent advances in IT have enabled the web to be the mechanism for collaboration. Hindered initially by bandwidth and technologies like VRML that allowed for limited manipulation of objects, we see today an opportunity to use the latest advances in dynamic display, design collaboration and process optimization (some of which we have pioneered) to provide end-to-end support for Product Design and Development, and enable super-efficient extraction of information from and to legacy systems to provide enterprises with an Integrated approach towards creating the next generation of products that "learn" from past mistakes, provide intelligent scenarios and tap into current trends in technology.

Our vision is to provide a secure, real-time view of product data across this extended design community, often in a portal-type interface that is structured to allow role-based viewing of the data. The data comes from back-office applications, such as product data management (PDM), materials requirements planning (MRP), CAD/CAE/CAM and enterprise resource planning (ERP), as well as tools such as supply chain management (SCM), component supplier management (CSM) and customer relationship management (CRM).

Applications Developed

For the past 7 years, we have been involved with providing IT infrastructure and support to different attributes at major automakers enabling the cataloging of CAE and Test data.

For CAE

1. **The CAE Task Manager** - The CAE Task Manager is a tool that not only allows tasks to be scheduled as per the vehicle milestone, but also automatically archives files and data associated with the analysis into the PDM system (Metaphase). Tasks are assigned by supervisors, status updates are maintained and action items can be issued.
2. **CAE Assemblies** - This was the precursor to the CAE Portal Application, where assemblies could be created by picking on Master Package definitions in VITAL, CAD geometry got via the IDEAS IMI bridge, Weld locations input and NASTRAN bulk data auto-generated via the DECOMP tool
3. **Analysis and Post Processing UH3D via the Web** - In this project, creation of UH3D files (including geometry and component information), its analysis (managing queues on the remote machine) and the post-processing was made available via the Web.

For Tests

1. **Scheduling Wind Tunnel Tests** - This web tool enabled Thermal/Aero engineers to schedule Wind Tunnel Testing at Lockheed Martin and Maryland Low Speed Wind Tunnel for Aerodynamic and Brake Cooling Tests of clay, prototype, production and race vehicles.
2. **TASE Benchmarking** - This tool enabled Aerodynamic, Heat Management and Cooling data to be uploaded into an Oracle database and reviewed via the web based on engineers specifications
3. **Powertrain Tear Down Studies Catalog** - This Catalog (based on Vehicle Parts structure) enabled the classification of Benchmarking data for Ford and Competitive vehicles by full vehicle, system, subsystem, component and part and its retrieval based on a shopping cart metaphor.
4. **NVH Test Data Analyzer** - Entire Noise and Vibration Tests conducted by FEV for Ford is cataloged and reviewed by Test centric, Vehicle centric or Noise and Vibration mode using a web front end for all activities.
5. **The Safety Test Data OLAP Tool** - Here metadata related to a Crash Test was uploaded to the SPRITE database so that it could be later on retrieved on demand and analyzed. This year we will be including regression and correlation analysis, and other datamining operations.

For CAE and Tests

1. **The Welds Portal** - Here Weld locations by program and variant were cataloged as CAD, CAE or VO (Vehicle Operations), which could later on be overlaid for discrepancies using Design Collaboration tools.
2. **The Safety Quality Process** - In this application, CAE, Prediction and Test data were stored in an Oracle database and a correlation analysis enabled safety engineers to validate their CAE tools by comparing analysis versus test data using SPC (Statistical Process Control).
3. **The Confidence Assessment Pilot** - Here CAE, Lab and Test tools were rated for confidence by requirements per attribute so that they could be stored in FPDS/SETk as design guidelines.

For Process Optimization

1. **Attribute Expert Systems** - Here historical data related to CAE, Test and Vehicle Specifications are cataloged in an Oracle database to be available to prediction tools (aerodynamics, safety, nvh, powertrain, engine etc.) so that what-if scenarios can be quickly simulated for upfront understanding and approval/rejection of a design change.
2. **Verification Portal** - In this proof of concept project, engineering processes, business logic and web middleware technology were used to seamlessly integrate multiple databases to manage verification information. The user interface to VPIM, named myVerification Portal (mVP) was a Web-enabled Knowledge Management system that would enable Ford engineers to Manage, Review, Document and Sign-off on product verification deliverables based on requirements, historical data and warranty issues. State-of-the-art technologies in Middleware (WebLogic appserver, with application developed using EJB, Servlets and JSPs) were used to create the pilot making it robust, scalable and sustainable.

Common Services

1. **Plotting Service –** A Plot Server that can be accessed as a service to plot different types of graphs. Data, Attributes and Labels are supplied by the client application to the service in an XML stream via RMI or as a Web Service and the Plot Server manages its rendering and output to foreign formats like Excel.
2. **Analytics Service –** Statistical, Mathematical and Unit Conversions are available to client applications as a service so that users can perform correlation, regression and trend analysis, unit conversions and integration and differentiation. Additionally plots can be generated by directly referencing the plotting service.
3. **Discovery Patterns –** Data access functionalities like Explorer, Depictor, Discoveror, Metadata and FTP are available for client applications via XML descriptors so that these functionalities can be quickly provided to the client applications.

The Coopetition

Companies seeking continuous improvement of product development processes are increasingly using information technology to strategically aid and change these processes. Vendors in this space are primarily approaching it from the PDM realm. Companies that fit this description include Agile Software, Parametric Technology Corp. (PTC), MatrixOne, SDRC & Unigraphics (now part of EDS) and IBM/Enovia. ERP companies, such as SAP and Oracle, also have their eye on this space, as does i2, from the SCM perspective: Oracle with its Product Development Exchange, SAP with its PLM suite which has more of a transactional, PDM-focused offering, and i2 with its TradeMatrix Design. Finally, companies such as NexPrise, Engineering Animation Inc. (EAI), Alventive and eRoom offer less comprehensive point solutions, primarily geared toward Internet-enabled collaboration between disbursed design teams.

Companies intent on speeding up their design process are investing in more virtual test software than ever before, a market trend tracked by analysts at Daratech (Cambridge, MA), the IT marketing research and technology assessment company. The firm's figures show a 10 percent growth in user spending on virtual prototyping products in 2001 (over 2000) in spite of the recession. The research firm expects a modest 8 percent growth for 2002, with an average growth of 15 percent per year through 2007. Even at these rates, this growth outpaces that of other CAD/CAM and CAE applications, and virtual testing is a significant factor in this area. Several companies are putting extensive effort into providing the tools for users to conduct virtual testing and at the same time correlate results with complementary physical testing. Among these vendors are LMS International, Mechanical Dynamics, MTS Systems, nCODE, and PTC.

LMS International

LMS International's Virtual.Lab is the company's integrated test environment for functional performance engineering. It speeds up the design process by offering the ability to use validated models of existing components to make predictions about new ones. Fatigue-life predictions that used to take a couple of weeks can now be completed in a day. Virtual.Lab incorporates products and configurations that are initially targeted to the automotive domain in such areas as engine acoustic radiation and vehicle noise, vibration, and handling analysis. It can also be used for generalized noise and vibration analysis.

MTS Systems

MTS's VTL system is a set of files that models the actual test equipment (rather than the loads). Output data from a VTL system plays a large role in the predictive evaluation of fatigue, vehicle dynamics, handling, ride/comfort, and noise/vibration, by serving as input for MDI's Adams (now part of MSC Software) mechanical testing software. With the VTL-modeled test equipment, designers apply loads to simulated parts and assemblies, and set the latter in motion within Adams to "see" predicted behavior.

nCode International

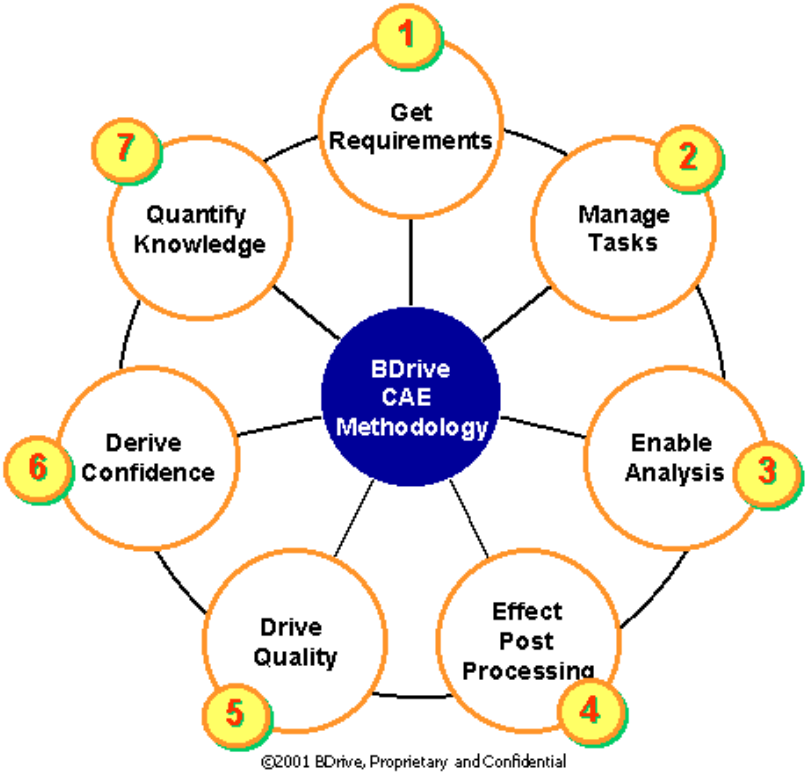
nCode delivers enterprise solutions to streamline and accelerate the durability process. These solutions address process-specific engineering workflow

challenges, and are developed and deployed by a team of specialist engineers with a wealth of experience in engineering processes, data management, workflow and web infrastructures. Innovative solutions utilizing state of the art technologies have already demonstrated dramatic productivity advantages over incumbent methods at a number of key ground vehicle OEMs and railway operators. These solutions are powered by nCode's emerging ICE-flow technology, which manages information across the enterprise and provides streamlined and innovative processes for collaborative engineering and test.

Smart Sim

Created in response to the automotive industry's demand for accelerated vehicle performance evaluation, The SmartSim Community has been established to research and develop effective methods for sharing and using engineering data through integrated physical and virtual prototyping. Dedicated to use of open standards and technical collaboration, the engineering solutions developed by The SmartSim Community will assist companies in reducing the time, cost, and risk of new vehicle development. Through this form of collaboration between the largest suppliers of physical and virtual simulation tools in the industry, the SmartSim Community will define the future of virtual and physical prototyping.

The Next Generation PDM Systems

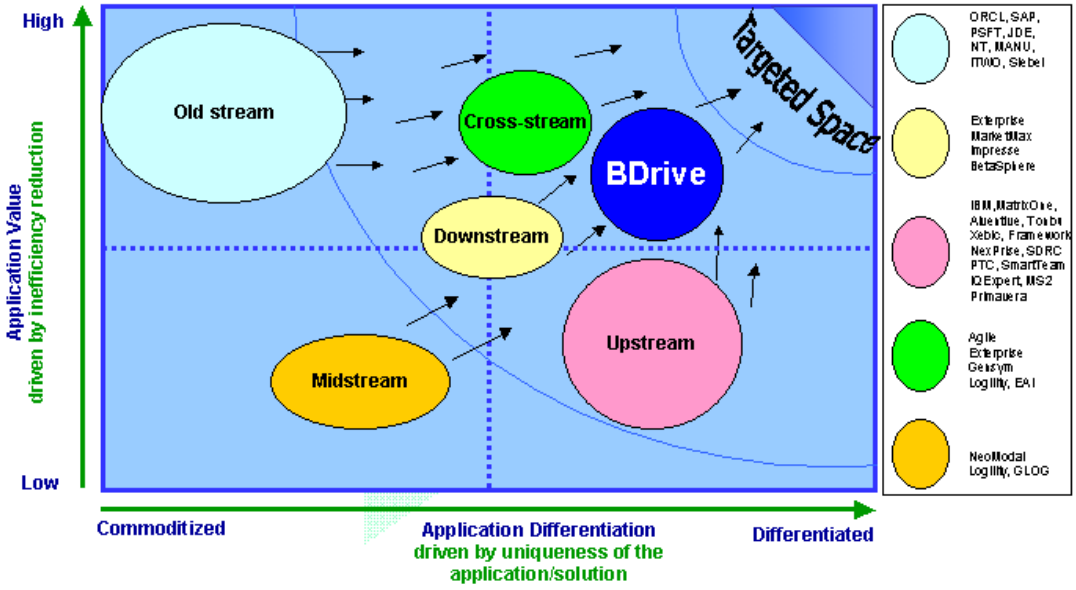


We envisage the next generation of PDM systems to seamlessly pull information from upstream sources and push information downstream of the process incorporating the theme of the "Semantic Web" to have data managed via intelligent agents with minimum human interaction. Thus Process Collaboration would be automated to provide all necessary information for the design engineer. Design Collaboration would be facilitated using the latest technologies in rendering objects so that teams in diverse geographic locations could do real time design, analysis and representation. To this end, we have created the concept of an **Intelligent CAE Portal** that will enable the maximum use of CAE techniques (parametric studies and the like) prior to the "expensive" build of prototypes to enable what Ford and Toyota call "Zero Prototyping".

Using the theme of Web Services, we will be interacting with proprietary PDM systems: Metaphase, Windchill, MatrixOne etc. to create parts map, catalog all types of information (CAD, CAE and CAM, plus Test data) and make them available on demand to the design engineers, process leaders, planners or upper level management so that appropriate information is available on demand irrespective of the source. We also see PDM systems evolving to more recent and stabler environments and will be providing translation facilities from archaic to new Electronic Data Management systems. Integrating it with other systems (HR, ERP, SCM and CRM) will provide it with the richness of other metadata, which is currently not available.

The following figure illustrates the emerging landscape of the different types of companies and where we plan to fit in.

In the emerging landscape for collaborative applications BDrive would focus on providing high impact collaboration solutions



Intelligent Information Management

Information management refers to the process of extracting previously unknown, comprehensible, and actionable information from any source - including transactions, documents, e-mail, web pages, and other, and using it to make crucial business decisions.

The two most pervasive types of information are structured data and text, therefore information management includes data mining and text mining.

> Data Mining is an information extraction activity whose goal is to discover hidden facts contained in databases. Using a combination of machine learning, statistical analysis, modeling techniques and database technology, data mining finds patterns and subtle relationships in data and infers rules that allow the prediction of future results.

Text Mining is about looking for patterns in natural language text, and may be defined as the process of analyzing text to extract information from it for particular purposes. Text mining recognizes that complete understanding of natural language text, a long-standing goal of computer science, is not immediately attainable and focuses on extracting a small amount of information from text with high reliability. The information extracted might be the author, title and date of publication of an article, the acronyms defined in a text or the articles mentioned in the bibliography. Text mining uses recall and precision (borrowed from the information retrieval research community) to measure the effectiveness of different information extraction techniques, allowing quantitative comparisons to be made.

For being truly infrastructure aware, an application must be able to seamlessly present information from diverse sources. In the automotive industry, it is necessary to dig into warranty information and customer concerns so that analysis of malfunctioning parts can be carried out (what, where, when and why) and present the next generation of design with lessons learned, best/worst practices and reuse scenarios.

Following a Services Oriented Architecture (SOA) Model and using XML and the Web Services protocol, BDrive plans to enable PLM in Enterprises with scalable, layered architecture and robust implementation methodologies that would enable ubiquitous interconnectivity of entities and organizations dispersed throughout the world.

Summary

To get superior products to market ahead of the competition, product development companies must have control over every aspect of the product lifecycle. To accomplish this, product information must be easily captured, manipulated and accessed by everyone involved in the product development process.

A well-planned, flexible architecture extends the range of strategic options for a company. By preparing the infrastructure for emerging technologies and taking advantage of open source, modular code and industry standards, companies can rapidly meet market change with new alliances. They can extend onto next-generation platforms and integrate state-of-the-art technology into their information systems. With good planning, it will be possible for firms to move quickly to take full advantage of new opportunities while reducing outages and cost overruns. An infrastructure that is fully leveraged, able to respond to demand and is flexible offers the potential for cost savings, faster adoption of new technologies and rapid integration of new applications. In fact, such an infrastructure might go beyond being ready for new opportunities; it might create them by providing more latitude as new business possibilities become visible.

BDrive's innovative concepts in application development, knowledge management and process optimization will help enterprises achieve full collaboration and integration capabilities to pull/push information using state-of-the art technologies in RDBMS, XML, J2EE and Web Services. It will enable companies to be proactive rather than reactive to technology and market changes and better predict their future and make then amenable to changes. For PLM, where BDrive has focused its current effort, applications that span the end-to-end management of the lifecycle of designing, developing, manufacturing and

maintaining (servicing) products will enable organizations to grow organically based on the external environment with anticipation to changes.

Of course, the true value of a future-ready infrastructure can only be realized by an organization that has both the culture and the people who can take advantage of it. In addition to making investments in advance of expressed market needs; companies must move beyond traditional business case analysis - proactively building and prototyping technologies before they are completely proven. They transform their companies into learning organizations, encouraging employees to keep their skills current and to scan continually for new trends in technology and in the market. While not everyone in the organization needs to adopt this tactic, there should be a critical mass of appreciated employees who are intrigued by what's next on the horizon and are flexible and innovative.

References

The following documents were used as reference for this article.

1. **Engineering on the Internet**, Author: Caren D. Potter
2. **Virtual Testing**, Author: Pamela Waterman
3. **Design Driven**, Author: David Cohn
4. **Future-ready infrastructure: Getting a fast start**, Author: Peter Andrews