Cyon Research™

The Value Proposition of High-End Mechanical CAD

A Cyon Research White Paper
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Executive Summary

In the high-end mechanical CAD software market, value is a function of both the product, and the company that is selling the product. High-end CAD software products are, as a rule, competent to handle even very difficult product design problems, and have quantifiable strengths over their mid-range competitors. The vendors of high-end CAD products have significant depth and breadth of expertise in implementing solutions combining their products with services and training. Mid-range CAD programs are most often sold in shrink-wrapped configurations, with dealer-provided training courses.

High-end CAD solutions are significantly more expensive than mid-range CAD products. While there are many classes of customers for which the value provided by a high-end CAD solution justifies the price difference, there are also significant classes of customers for which either high-end solutions or mid-range products might be acceptable choices.

The Value Proposition of High-End Mechanical CAD

It's very rare to find a company that makes discrete products that doesn't use mechanical Computer-Aided Design (CAD) as an integral part of their design processes. It is a basic competitive necessity for products simple as bottle-openers, or as complex as nuclear submarines. And while it might seem obvious that the same CAD program that would be appropriate for designing bottle openers might not be ideal for designing nuclear submarines, the reality is a bit more complicated.

The mechanical computer-aided design market may be unique in having software products that, on their surface, appear to have similar capabilities, but range in price from nearly free to well over $10,000 per seat. In this paper, we'll take a look at the value proposition provided by the products at the higher-end of the price scale.

Before getting too deep into the subject, it might be helpful to look at the strata into which most 3D mechanical CAD products seem to fit. As a matter of convenience, we group these into three categories, by price: low-end products; mid-range products; and high-end products.

At the low end of the market are CAD products, which—while appropriate for many simple tasks—are missing just enough capabilities that they most often find users among those for whom price is the limiting factor. Price points in this market segment tend to be under $2,000.

In the mid-range, CAD products offer more fully featured 3D solid modeling and 2D drawing generation capabilities, and may incorporate certain advanced features as well. In addition, these products may serve as the foundation for other complimentary CAD applications from other vendors. While broadly capable, mid-range products are better suited for some classes of design than for others, depending on the emphasis of their developers and customer base. Mid-range CAD vendors have tended to focus on adding more capabilities for their mainstream customers, rather than trying to go after the most demanding customers, where high-end CAD vendors are firmly entrenched.

As the mid-range products have matured, the distinctions among them have become more subtle. This market segment has blossomed over the last few years, with a handful of products (including SolidWorks, Solid Edge, Inventor, thinkdesign, CADKEY, and IronCAD) developing loyal followings. These products are offered in a small number of standard "shrink-wrapped" configurations, with prices ranging from $2,000 to $6,000 per seat. User training is commonly available through dealer-provided courses.

The high end of the market is the realm of the tier-one vendors, who not only offer CAD products with no-holds-barred functionality, but also offer a wide range of related applications, including CAM, CAE, and PDM. Prices of these systems begin at the top end of the mid-range products, and extend to beyond $10,000 for a typical seat,

depending on the functionality required. Included in the pantheon of tier-one vendors are IBM (CATIA), EDS (Unigraphics and I-DEAS), and PTC (Pro/Engineer).

These days, most of the confusion in the CAD market comes in situations where a customer's needs are such that either high-end or mid-range CAD might do the job. To provide some perspective, we'll examine the value proposition that high-end CAD provides, considering both product- and vendor-related issues.

High-End Software

While it's common to talk about CAD as if it were a single application, in practice CAD software is sold as a program with some core capabilities, supported by a variety of other programs with more specialized capabilities. Today, most full-function mechanical CAD products include feature-based parametric 3D solid modeling, supporting both parts and large assemblies, as well as fully-associative 2D drafting. Beyond this, offerings differ by vendor, though it's not unusual to see even moderately priced products include what used to be separate applications, such as sheet-metal design, mold-design tools, and class-A surface modeling.

Yet, the distinction of what is "in the box" versus what is not is less critical than it used to be, as all significant CAD developers (both high-end and mid-range) support a variety of third-party applications to fill out their capabilities. This leads to a situation, where there is substantial crossover in capabilities between mid-range and high-end CAD products.

(When using the word *capable*, we're referring to the ability of a program to complete 100% of a task. We're not making any judgment about the elegance or ease with which it does so. If it takes an expert user on one CAD program a half-hour to do a task, and it takes an expert user on another CAD system four hours to do the same thing, one system may be more productive than the other for that particular task, but they're both *capable* of doing it.)

Experience has shown that gross differences in capabilities between CAD products are transitory. Over time, all strong products get better, and are capable of handling more and more difficult tasks. Not long ago, it was only high-end programs that could handle assemblies with tens of thousands of parts. Now there are several mid-range CAD products that easily handle assemblies of this size. Today, only high-end CAD products can do complete digital mockups of aircraft, or even aircraft carriers.

Fundamentally, there is a difference between the capabilities a CAD vendor might be able to add to their product, and the capabilities they choose to add to their product. It's a matter of difficulty, cost, competition and market demand. High-end and mid-range CAD vendors, because they have different sales channels, customers, histories, and development budgets, make different choices in this area.

Consider the broad spectrum of capabilities in CAD products. There are similarities and overlaps between mid-range and high-end products. But there are also some capabilities that, as a practical matter, are differentiators for high-end CAD.

No-holds-barred functionality. One common theme among high-end CAD products is that they are mature, and are able to handle most any type of problem. For the vast majority of users, high-end CAD products provide a complete capability. There is very little risk of investing in the product, then discovering significant functional limitations down the line.

Breadth and depth of applications. High-end CAD products include core functionality, buttressed by a large suite of integrated applications. A seat of a high-end CAD product can be configured for the needs of its user—from basic part and assembly design, to analysis, simulation, manufacturing, and specialty processes. The result of this is that users can get the specific tools they need for their job, and add capabilities if their needs change.

Integration with enterprise applications. High-end CAD products have extensive frameworks for integrating with other software products, including both engineering and enterprise applications. There is probably no such thing as a canned integration among CAD, PDM, ERP, SCM, and CRM—but the CAD products from high-end vendors have the hooks and middleware necessary to successfully integrate with these enterprise applications.

Knowledge-based engineering. While it's often a straightforward task to create a CAD model, it's substantially more difficult to capture and account for the knowledge that goes into designing that model. Knowledge-Based Engineering (KBE) allows users and organizations to encapsulate their process-specific expertise in software—propagating time savings throughout design, manufacturing planning, and manufacturing. Although it is possible to implement KBE in any CAD system that supports an applications program interface, doing so is not a trivial task. Because KBE has historically been of the most interest to larger firms, and because it has, to date, been a capability that's often required some consulting help, KBE has gotten more attention from high-end CAD vendors than from mid-range vendors. Still, KBE is not just for large firms—it is of particular interest to any company that has a mature view of their product development process, and would benefit from knowledge reuse.

Related to the theme of KBE is *product abstraction*. Historically, CAD systems have represented product models in a geometric form. But geometry is only one facet of a product. Consider something as simple as a bolt. While bolts may be represented geometrically in a CAD system, they are almost always specified functionally—based on their strength, cost, weight, and finish. There is a trend, most evident among high-end CAD products, to represent products at a higher level of abstraction, letting the geometric representation flow from the functional requirements. (D. H. Brown Associates, the well regarded consulting firm, has

identified twelve distinct ways in which product data may be represented in an enterprise.)

Advanced surface design. While the sculpted surfaces on consumer goods, automobiles, ships, and airplanes may have a lot in common visually, they are very different functionally—and impose different requirements on CAD software. Several mid-range CAD products (and associated third-party applications) offer surface modeling tools that can handle tough problems—but high-end CAD vendors spend substantially more than mid-range vendors do on research and development to provide surface-modeling tools specifically tuned to the needs of their large customers. In the realm of aerospace and automotive surface design, high-end vendors have a justifiably commanding presence.

Specialty design tools. In many industries, there are common processes that are best served by specialty tools. Some of these processes, such as basic sheet metal design or injection mold base design, can be handled by either mid-range or high-end CAD. Other processes, such as progressive die design, are currently handled much better by high-end CAD, but may be eventually receive attention from mid-range CAD developers. But there are some processes which, as a practical matter, will probably remain the domain of high-end CAD products.

Large aerospace and automotive manufacturers are examples of companies which need the specialty design tools available with high-end CAD. Airframe, turbine engine, and auto body design all benefit significantly from specialty design tools that are simply not available except from the tier-one CAD companies. And while the best-in-class mid-range CAD programs may be geometrically capable of handling these types of designs, they lack the fine-tuned process-related capabilities to be truly productive in doing so.

Consider, for example the design of an automotive hood. It has an outside styling surface, and an inside structural surface. Any good CAD program with strong surfacing tools can design a hood (though getting both the surface quality on the outside and the structure on the inside right can take some work.) But automobile manufacturers don't design individual hoods – they design a lot of hoods—often iterating one design over and over when moving from concept to production. These manufacturers also take proven designs, and adapt them to new projects. The best in class high-end CAD products have the capability to take a hood from one model of car, and morph it to fit another model (with both styling and structure intact) in the matter of minutes. Or less.

On large projects, it's often said that there are no "small" design changes. That's because each change requires the interaction of multiple requirements and multiple constituents. With the design process being, by nature, iterative, a CAD program which allows for fast iterations, while preserving design intent, can change the economics of a project.

Though it's pretty obvious that the Boeings and Daimler-Chryslers of the world couldn't effectively compete without the specialty design tools available in high-end CAD products (and, in fact, the tools were designed for them), what's not so obvious is that much smaller companies can get a big payoff with these tools as well. If John Z Delorean started his eponymous car company today, with access to the CAD tools that the big-3 automakers currently have, he'd have a real shot at success. Or at least at building a high-quality car.

Large/complex-project management tools. Today's mid-range CAD products can deal with impressively complex projects. But they are rarely called upon to handle something as complex as an airliner, a complete automobile, or a full-size cruise ship. High-end CAD systems are specifically optimized for managing these types of massively complex projects in environments with large project teams. Of particular note are integrated digital product mockup tools which allow engineers to work on the smallest of details while retaining a complete-project view. (And, though not strictly a CAD product-centric issue, high-end CAD vendors have substantial experience in working with customers that do large projects, and have large teams. But this gets into PLM solutions, which are covered later in this paper.)

Continuous innovation. High-end CAD vendors continuously invest a large portion of their income in research and development—typically well over $100 million per year, and in some cases far more than this. This is reflected in a product portfolio that is both broad and deep—and that continues to grow. Because of the mission-critical nature of the relationship between high-end CAD vendors and their larger customers, this level of investment is unlikely to significantly drop in the foreseeable future.

Ultimately, when a high-end CAD vendor spends as much on R&D as the total income of a mid-range vendor, the gap in capabilities is not likely to close. Yet, the comparison of R&D spending is not entirely fair (nor is it entirely unfair), because it doesn't account for the R&D spending of third-party vendors.

Both high-end and mid-range CAD vendors consciously balance in-house development versus working with third-party developers. High-end CAD vendors will spend the money to build capabilities where those capabilities either don't exist in the market, or where they can do better than the best-in-class. But they gladly work with third-parties when those vendors have products that would be hard to beat. Mid-range CAD vendors focus more on their core products, adding capabilities (for example, sheet metal, or mold base design) that many customers need, and working with third-parties on most everything else.

It's a philosophical difference—high-end CAD vendors provide a very complete suite of solutions for even the most special of needs, while mid-range CAD vendors provide an excellent product for mainstream needs, and rely on third-party vendors to handle the exotica.

Despite the significant range of areas where high-end CAD products have the lead, there is an area in which mid-range CAD products have historically been better—and that is in ease-of-learning and ease-of-use. Historically, high-end CAD systems have been focused on capabilities and enterprise productivity, with ease-of-learning and ease-of-use taking a back seat. Happily, that trend has recently changed. By the end of 2002, all the high-end CAD vendors will be shipping software with radical improvements in this area. Subjectively, we feel that the mid-range products still have a better "out-of-the-box" experience, but the improvements in high-end CAD systems may make these differences transitory.

Despite improvements across the board in ease-of-learning and ease-of-use, there is still a lot of work to do. As CAD has moved from "glass-walled rooms" to Unix workstations to Windows-based computers, the typical users have changed as well. Customers are demanding that CAD programs be used not only by trained full-time engineers and designers, but by casual users as well. And though it may be difficult to make a large and complex CAD program intrinsically easy for neophytes to learn and use, it is not impossible.

High-End Vendors

If we were to focus solely on software capabilities, we might be able to draw some distinct line, and say that high-end CAD was only for customers who needed capabilities they couldn't get in mid-range CAD—rather like saying that, if you have a 9/16" bolt, a 1/2" wrench won't do. But separate from differences in the intrinsic capability of high-end and mid-range CAD systems is the issue of the vendor.

CAD products, at least the ones we're talking about, are not sold in a box at the local computer store. They're sold by professional sales and service organizations – most of which are interested in selling not just software, but some form of solution.

Unfortunately, the word *solution* has in the last few years taken on an almost Dilbert-like meaninglessness in the business world. Here we use the word advisedly—referring to that which is required to address a problem. Solutions, at least in this context, are process-related, and almost always incorporate combinations of software, hardware, training, services, and consulting.

While all the vendors in the CAD market have as their goal to sell software and services, the high-end vendors, in concert with their business partners, are distinguished by having a deep pool of talent to pull from in order to deliver all the elements of a solution. They are also distinguished by having a large number of industry heavyweights—people who understand the "big-picture, " and who have depth of real-world experience.

A term for the big-picture orientation that has found resonance among both vendors and users is PLM: Product Lifecycle Management. One reasonable description of PLM is that it is an IT strategy for creating and managing a company's product-related intellectual property, from initial concept to retirement.

Of course, being a strategy and not a product leaves the exact scope of PLM open to interpretation. Though there is some disagreement among industry pundits about what is in the PLM circle, and what is just connected to it, there is general agreement that a PLM *solution* includes CAD, CAM, CAE, PDM, and manufacturing software, is interfaced with ERP, SCM, and CRM, and can't be implemented without careful planning, hard work, and buy-in across the enterprise. The expertise of a partner who has substantial experience in implementing PLM solutions is not a bad thing to have either.

Most enterprise-level software vendors paint a picture of PLM that is centered around their applications. At Cyon Research we ask: where is the intellectual property created? We believe that the answer to that question (which may vary depending on the nature of the enterprise) also answers the question of where to start, and with whom to work, on designing and implementing a PLM solution.

For discrete manufacturers, intellectual property is most often created in the engineering department, through the product development process. So, in developing a PLM strategy, we believe these companies are best served by starting with vendors who understand and focus on product development, rather than starting with vendors who focus on controlling resources and budgets (ERP.) It's simply a matter of priorities: Without high-value innovative products, the only purpose of ERP software would be to manage a company's slide into bankruptcy.

(There are cases where we would grant that ERP is a good starting point for a PLM strategy. Examples can be found among process manufacturing and non-manufacturing companies.)

The High-Value Offerings

High-end CAD vendors have the capability of supplying an almost endless variety of services. And, if they can't supply it directly, they'll have a partner that can. But certain service offerings are particularly valuable, and distinguish high-end vendors from their competitors. Among these are:

> **Needs assessment.** In our experience, one of the most valuable things a company can do prior to making an investment in CAD software is have one or more vendors make an assessment of their needs. While the results of such analyses may be skewed towards each particular vendor's products and services, that doesn't reduce their value. Given the depth of experience (both good and bad) that high-end CAD vendors have developed working with a broad range of customers, they often bring potential problems to light, and offer pragmatic suggestions. Any assessment of significant value will take more than a day or two to perform, will involve people other than a salesperson, and will actually cost some money.
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> **Data migration.** Though the capabilities of high-end CAD vendors in data migration vary, in general they are able to provide significant guidance in transitioning product data between disparate systems. This is an area of

significant growth and change over the last few years, with some major improvements being made in maintaining or improving the editability of legacy data.

Customization. Determining that a CAD program can be customized for a particular application or integrated with enterprise applications is only a first step. The next step is to find someone who can actually do the customization. This is a core service provided by high-end CAD vendors – and one where the advantage of having a substantial pool of experts can make all the difference.

Best-practices consulting. There is still no substitute for experience. High-end CAD vendors have found ways of doing things that work—often by first finding ways that didn't work. By employing consultants with deep backgrounds in the best practices of a number of industries, high-end vendors are often able to help their customers avoid common, and uncommon, pitfalls. Over time, high-end vendors also integrate their best-practices experience into their software, adding knowledge-based industry-specific design tools that all their customers can benefit from.

Advanced training. Training is not a competency exclusive to high-end CAD vendors, yet they, along with their partners, offer advanced or process-oriented training, geared towards the specific requirements of their customers.

Broad geographic coverage. Companies which operate internationally will find that high-end CAD vendors have direct or business partner sales and service forces throughout the world.

Reality Versus Theory

One of the important questions about high-end vendors is how the services and expertise they offer manifest in reality. Generally, these vendors like to point to success stories or sales wins—but we've discovered that, many times, these stories focus on the sale, rather than focusing on the elements of the solution that really provided the value the customer needed. This is often simply because the customers don't want to share their secrets with competitors.

Consider the story of a mid-size manufacturer of large products. This manufacturer, with about 150 employees, makes huge custom equipment—often the size of a five-story building.

In the past, the sales process for this company was typical for their industry. The manufacturer's sales reps would meet with potential customers off-site to discuss product requirements and criteria. The sales reps would take their notes back to the company, and get back to the potential client in seven to ten days with a proposal including cost and schedule estimates.

Today, the sales process is substantially different. After working with a high-end vendor to link KBE (knowledge-based engineering), CAD, PDM and ERP systems together, they can now deliver a proposal in real time—even on the floor of a trade show. The sales rep asks the customer a series of 15 to 20 questions, the answers to which are input into the ERP system via an Internet-connected notebook computer. The system gives immediate answers on cost and scheduling (not just estimates)—and provides 2D and 3D drawings of the proposed equipment for the customer to take back to their managers.

Another example involves a small company which makes products for the sporting goods industry. Using CAD, a Web-enabled CAD viewer, PDM, and CRM, the company is taking customer feedback, and using it to design revisions of its products in real time. Customers can look at new designs before they are even produced, and provide feedback, which is captured in the CRM system. The CRM system and PDM system are linked, so the company's design engineers are notified of and have access to all customer feedback. If they see that several customers are making similar comments, they can revise their designs before they even go into production.

These are real examples, though the manufacturers prefer to remain anonymous to protect their competitive advantage. In both cases, the solution depended upon CAD, yet the real competitive advantage came in connecting CAD to other enterprise applications, and building processes that automated things that would have been far to difficult to do otherwise—perfect examples of a PLM strategy. And in both cases, the manufacturers relied on the expertise and services of a high-end CAD vendor to make it work.

Our experience is that every CAD vendor can point to examples where their software has been used as a component in a PLM strategy—but it is most often the high-end vendors that can point out examples, such as those above, where they have provided not only the software, but the expertise and services required to implement that strategy.

A Single Point of Contact

If CAD were a single standalone product, there would never be any question about who to call when problems arise. But, of course, CAD isn't just a single standalone products. Any significant CAD installation will include many products that have to work together. And if that CAD installation is part of a larger PLM strategy, the number of products and interrelations can be staggering.

There are different philosophies for dealing with this complexity. One is for a customer to "roll their own," by doing an internal analysis of their needs, then acquiring the software which seems to best fit their needs. This approach can have a lot of merit when the customer's existing CAD capabilities are basic enough that significant gains are easy to come by—rather like giving a word processor to a person who previously only had a manual typewriter. It can also have merit when the customer understands the scope and nature of the problems they're trying to solve, has the resources to manage the integration of disparate applications, and isn't particularly daunted by having to call multiple vendors to get answers to questions.

Another philosophy is to build a long-term partnership with a solutions oriented vendor that can handle a large chunk of the problem. Often enough, even customers which already have a good idea of what they need will take a look at the technical and business-process issues surrounding the implementation of CAD (particularly in the context of a larger PLM strategy), and decide that they would benefit from working with a vendor that offers more than just software.

For any CAD vendor, large or small, there is a big difference between a customer saying "I want to buy your product" and a customer saying "I want you to help me optimize my product development process." The former requires only that the vendor ship the software and manuals. The latter requires the vendor to understand the customer's expectations, assess their needs, craft a solution (which might include many elements, including applications from other vendors), deliver on what they promise, and be willing to fix things when they go wrong—even if the problem isn't their fault.

In practice, most customers today have existing applications, systems, and processes that must be integrated with any proposed CAD solution. They may have more than one legacy CAD system. And they may have ERP, SCM, and CRM applications in an indeterminate state of implementation—but which still must work together.

There are only a limited number of CAD vendors that have the capability to come into a customer account with complex problems, and be able to successfully manage a whole solution—giving the customer a single point of contact for any problems which might arise.[1]

The Value and the Price

Developers of CAD software don't blindly build products, hoping to find a place to sell them. They have a design intent, and a targeted customer base. For high-end CAD, the market has historically been larger enterprises that have complex products, processes, and problems. To serve these customers, high-end vendors employ large and expensive sales, consulting, and development staffs. Essentially, they focus on delivering high value and continuous innovation, making the argument that higher enterprise productivity justifies a higher price.

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[1] Over time, we at Cyon Research have seen many CAD implementations, some based on a "roll-your-own" philosophy, and some based on a partnership philosophy. We've seen good and bad in both types. Our experience is that problems due to inherent software flaws have become less common over time. Also less common today, but still vivid in our collective memories, are problems due to software that was just too hard to use. Of recent, the problems we've seen have been related to both customer issues (lack of training, unrealistic expectations, poor planning, or using out-of-date or inadequate software) and to vendor issues (failing to manage customer expectations, using junior people for jobs that need senior people.) None of these problems are insurmountable. For customers, the first step is budget for the training and consulting services that the vendor provides. The second step is to insist that the vendor bring in their senior people to provide these services.

For mid-range CAD, the market has historically been those companies which need a fairly standard CAD program. Though mid-range vendors spend significantly on R&D, their spending is focused on providing well polished mainstream capabilities. (An interesting twist is that several popular mid-range CAD products are owned by high-end CAD vendors. Even more interesting is that these vendors have generally taken a hands-off approach, giving the groups that manage these product lines substantial autonomy.)

While there are customers who are predictably oriented to high-end or mid-range CAD products, it is in crossover accounts—where either class of product could potentially meet the customer's needs—that things get interesting. In these situations, the customer ultimately has to make a decision between the extra value provided by a high-end solution, versus the lower price of the mid-range product.

And the Winner is...

Mid-range or high-end? There is no absolute winner. High-end CAD solutions have a number of areas where they are stronger than mid-range programs. We've looked at the following:

- Integration with other enterprise software,
- Knowledge-based engineering,
- Advanced surface design,
- Specialty design tools,
- Large/complex-project management tools,
- Continuous software innovation,
- Needs assessment,
- Data migration expertise,
- In-house customization services,
- Best-practices consulting,
- Advanced training,
- Global presence, and
- The capability to manage a complete solution.

These areas of strength, taken as a whole, are enough for some customers to justify a high-end CAD solution. Beyond this, there are certain categories of customers that commonly benefit from a high-end CAD solution, including:

- Major aerospace, automotive, and ship design firms, and their tier-one (and sometimes tier-two) suppliers.
- Companies that do repetitive design of products where major elements of the product definition can be encapsulated in knowledge-based engineering tools.
- Companies that design complex assemblies of complex parts (For example, turbine engines.)
- Companies that have high product turn rates, coupled with a complicated and iterative product development processes

- Companies that have run out of steam with their existing 3D CAD tools.
- Companies that have large geographically dispersed design teams.
- Companies that want to implement a product lifecycle management strategy
- Companies that save or earn disproportionately large amounts of money with small improvements in time to market.

Then there are crossover accounts, where either high-end CAD solutions or mid-range products could potentially be appropriate. With these customers, price is always an issue. Yet there are several ways in which a high-end solution might prevail:

- If the high-end CAD vendor's salesperson is able to effectively articulating the value proposition of their solution at a high-enough management level.
- If the customer is a supplier to an OEM that is also a user of the high-end CAD software.
- If the high-end CAD vendor is able to link the extra value provided by their solution to quantifiable near-term savings exceeding the price difference.

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About Cyon Research…

Cyon Research Corporation was formed by CAD industry consultants Brad Holtz, Joel Orr, and Evan Yares to foster clarity and provide vision to users and vendors of CAD and PLM tools. Current products include: CADwire.net, a leading provider of online news and analysis; COFES: The Congress on the Future of Engineering Software; Engineering Automation Report, A-E-C Automation Newsletter, Extranet News, and The CAD Rating Guide™. More information can be found at: www.cyonresearch.com, 301-365-9085.

Funding for this white paper was provided in part by high-end MCAD vendors. Watch for additional Cyon Research analysis of segment-specific value propositions.

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