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Evolution from 2D to 3D

A Product Development Manager's Perspective

Date: January 2006

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Cambashi researches the use of Information and Communication Technology (ICT). Our goal is to understand

- the business reasons that drive ICT investment decisions,
- the technology that addresses these issues,
- the market mechanisms that bring users and vendors together, and
- the impact of deployment of applications and infrastructure.

Our work in the Manufacturing Industry sector has grown from a focus on design engineering to include industrial automation and business systems. The ideas and opinions expressed in this white paper are Cambashi’s own, based on our continuous programme of independent research and monitoring of the Manufacturing Industry sector. We wish to thank UGS for sponsorship of production of this document, enabling us to communicate our analysis in this format.

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1 Introduction

Since we first looked at the issue of migrating from 2D to 3D design, we have found that many companies are using 3D as a stepping stone to a full Product Lifecycle Management (PLM) implementation, even in smaller or mid-sized companies. Improvements in software capabilities together with better packaging and easier deployment have eliminated many of the obstacles to PLM investment by mid-sized companies.

PLM enhances the value of engineering data by integrating design, analysis, workflow and data management, enabling wider and controlled reuse of available information. PLM used to be seen as a technology available only to large companies. A PLM project needed significant IT resources. For all but the largest companies, the technology was previously out of reach.

Now, there is a new situation. Preconfigured applications and affordable pricing put PLM within the reach of all companies. But to achieve the full benefits of PLM, it is essential to be working with 3D CAD data. Cambashi estimates that just over half the mechanical and electro-mechanical engineering designers in the world are now using 3D CAD technology, including solid modelling, while the other half are still designing using 2D systems. Recognising that 3D technology is now very well developed, and that the benefits of using it are universally accepted among a broad range of engineering firms, we found this result surprising.

Use of 3D is a key step towards effective PLM. 3D CAD systems help designers in their own work, and also in collaboration across extended teams. With 3D data, PLM makes engineering information useful to non-specialists, who are not able to interpret engineering drawings, but benefit from product visualisations linked to other product and operational information.

These capabilities are important not only inside a company, but also in interactions with suppliers and customers. Increasingly, PLM is required for a company to be fully integrated into the collaborative procedures of a modern supply chain.

So why are so many of the world’s designers and engineers still using 2D tools? What are the factors causing engineering companies to hesitate in adopting

Terminology

In this paper, we use the broad terms “2D” and “3D” to cover both design and manufacturing applications.

We recognise the typical deployment roadmap as above, in which initial investment in 2D is extended with 3D, PDM and, in many cases, simulation and analysis.

We distinguish PDM from PLM as follows. We use “PDM” to describe the more inward looking, engineering centric approach to access control, version management and maintenance of datasets across one or more applications. We use “PLM” to extend this to include a more outward looking, business centric approach which enhances integration of engineering applications, and extends this integration to other business IT systems, supporting technical collaboration between companies.

We also use “PLM” in line with industry practice as an umbrella term, describing the whole product data IT environment.



technology that is widely recognised as critical to engineering company profitability? Is making the change considered too difficult, too costly or too risky at the present time? And, if so, are those perceptions based on inadequate knowledge of current 3D and PLM technology?

This white paper presents our conclusions from the perspective of a product development manager responsible for maximising returns from CAD systems investment through greater engineering efficiency, enhanced support for product innovation and collaborative engineering, faster product development and shorter time to market.

Two companion white papers address the viewpoints of:

- the senior company management;
- the engineering designer/CAD system user.

2 Product development imperatives and challenges

Managing product complexity, regulatory compliance, and multiple product variants for global markets are all essential product development competencies. Sourcing components and materials from around the world can be the key that enables rapid response to changing markets while controlling costs.

It is wrong to pick out just one issue that determines the success or failure of an engineering company but the quality of the product, the extent to which it is superior to the competition's, and the speed with which it is brought to market are paramount. Successful companies must deliver continually improved products at a speed and cost outside their control – these parameters are determined largely by the market. In many environments, creation of timely quotations competes for attention with committed product development projects. Yet speed is the natural enemy of quality and cutting down on costs, resources and elapsed time can be taken only so far before everything else is adversely affected. Somehow, an optimum engineering solution to incompatible objectives has to be found.

Product design and development is a process of trial and error to reach an optimum balance between product 'perfection' and time to market. Time, as always, is the enemy. Time pressures normally mean that design has to start before all the necessary information is to hand. Teamwork, bringing in production people and suppliers at an early stage, saves time and helps to ensure that initial design concepts are valid. Mechanical, electrical and electronic design must be carried out in parallel. Everything has to be made to fit and work together. Engineering analysis leads to design modifications that optimise weight, minimise material, avoid dynamic problems and simulates performance. Manufacturing considerations may change initial design ideas, and late changes to product or process specifications may be required to optimise supply chain integration. Customer requirements or market conditions may change during a development project. The product development manager has to control the whole of this dynamic process and still deliver on time.

Back in 1988 McKinsey & Partners showed how much company profit can be lost as the result of loss in market share due to late delivery of a new product, highlighting the



crucial importance of ‘time to market’. Changes that take place late in the design/production cycle can be disastrous, though changes made in the early stages of design might represent desirable design improvements and innovation.

To respond to these challenges, many product development groups have launched initiatives, and re-organised, to implement their own blend of approaches such as concurrent engineering, collaborative engineering, systems engineering, lean manufacturing and six-sigma. Multi-disciplinary product teams have replaced functionally-organised groupings in many companies. More work is managed on a project basis, rather than a steady-state flow of activity. There is more collaboration with suppliers and customers. These changes have improved performance, but the resulting high volume, complex information flows between the stakeholders have demanded the better visibility and control of information provided by IT tools.

	Loss of Profit
6 months late to market	33%
9% material cost overrun	22%
50% development cost overrun	3.5%

Source: McKinsey 1988

3 3D CAD, PDM, PLM and the product development process

Nowadays the product development manager must look way beyond questions of drawing productivity when deciding on the right CAD tools to specify.

- 2D CAD technology has delivered all the drawing productivity improvements we are likely to get and those benefits have long ago been absorbed.
- 3D CAD is a completely different technology, capable of delivering far more wide-ranging benefits across the whole of the engineering and collaborative engineering process.
- PLM, including, but not limited to, the implementation of product data management (PDM) creates a managed environment of consistent datasets, maximising the speed and efficiency of access, communication, sharing and re-use of product information.

These different characteristics mean that the different technologies can be deployed in different ways. 2D CAD was often introduced as a simple substitute for manual methods - nothing else changed. Shorter timescales were achieved through individual productivity and better re-use through shared libraries. Changes in the established development process could be introduced a little at a time, as people became familiar with the new technology.

3D CAD goes much further, directly supporting the whole product development cycle, speeding up every activity and increasing the quality of design by removing many sources of inaccuracy and error. The model holds all the information required to procure, analyse and make it, in a form immediately usable by all engineering



processes. The accurate 3D solid geometric model, together with all the non-geometric engineering information attached to it, becomes a complete 'digital product model' for purposes of design review, and thus can eliminate prototype cycles. When integrated with analysis applications, the availability of 3D data can make analysis and simulation a routine step of every design iteration, resulting in quicker convergence to viable, optimum designs

To maximise the benefits of these capabilities, most product development managers find they need to spend time with their senior people, agreeing new working practices. The fact that the new 3D data could be useful to non-engineering people is recognised, but exploiting the 3D data in this way is rarely a priority. However, when allied to PLM and the Internet, 3D CAD provides an entire foundation for product information flow between multiple groups at multiple sites both inside the company and in partner organisations. This is a collaborative engineering network, and it depends on accurate and complete communication of information.

In all environments, a 2D drawing is an indirect and incomplete representation of an engineering product or system. The drawing is subject to interpretation and error. For example, taking off correct data in the correct format for downstream analysis, simulation and manufacturing processes requires additional effort and is subject to mistakes. Sending drawings electronically to partners, customers and suppliers is fine, but the potential for errors and misinterpretation remain. In a collaborative engineering network, a 2D drawing is a risk.

By contrast, 3D solid modelling produces a complete and accurate geometric model of the product, analogous to a physical model.

Any required geometric and physical information can be derived from it for purposes of engineering analysis, simulation and manufacture, using linked specialist applications that have become an integral part of the concurrent engineering process. Given this high degree of integration it becomes feasible to iterate through several cycles of design, analysis and manufacturing simulation at an early stage in design in order to encourage innovation while achieving the best possible product within the time available. Integrated non-geometric data will help ensure that the engineering product is fully and accurately documented by the time the design is complete.

Digital assembly

A supplier of machinery to the canning industry found that the use of 3D solid modelling allowed them to design a new machine in half the time it would have taken using 2-D CAD. The ability to 'digitally assemble' the machine, which automatically bags can lids and places them on a pallet, ensured that all 4,000 components interacted perfectly when the first prototype was built. Being spared the lengthy process of finding and fixing problems in a physical prototype accounted for most of the 12-month timesaving on the project.

To maximise the value of the 3D data, a PLM solution will support additional and appropriate access and communication. Product development can share data with non-specialists without worrying that the data will be corrupted in some way. Workflow definitions can flag changes, and other groups can collect new versions of information if required.



For those people not yet using 3D CAD it is important to review the available technology regularly. Examples across a range of industry sectors show that a modern Windows-based 3D solid modelling system with hybrid 2D/3D technology is capable of delivering results such as:

- product development time reduced by up to a factor of five;
- engineering change orders reduced by 50% to 90%;
- a doubling of design productivity, including drawing productivity;
- elimination or major reduction in physical models or prototypes;
- increase in product innovation and quality through greater potential for engineering analysis;
- virtual elimination of design related tooling and manufacturing errors.

In our view, 3D solid modelling technology has now come of age and should be seriously investigated by any product development manager who faces the kind of challenges we have described. Not everyone will achieve top of the range results in every area, but there is now ample evidence that '3D' can typically cut product development times in half. With 3D data in place, a product development manager can go on to introduce PLM, and be confident that the new approach to information control and communication will help other groups keep in step with, and benefit from, engineering information.

4 Implementing 3D CAD

We recognise that there are still some concerns about the possible difficulty and cost of implementing 3D CAD. We have analysed comments we hear from companies that are considering a move from 2D to 3D. We wanted to understand how real these concerns are, and whether they are based on insufficient understanding of the technology.

It seems that the potential major advantages of 3D technology are generally understood but these tend to be perceived as "theoretical" advantages not "guaranteed" advantages until the person concerned has had a chance to see a 3D system in practice, or hear the experiences of a company similar to their own. In this respect, 3D is no different from any other technology - all new technology inevitably carries some risk.

Concerns appear to be of three main kinds.

"It will cost too much"

It is important to check out the situation regularly. We would suggest, however, that system cost is not the primary issue. In all the companies we speak to, the investment has been made in order to protect their business, sometimes as a matter of immediate survival, more often as a planned strategy to increase product competitiveness and get their products to market faster.

3D CAD is seen in these companies as impacting both sales and costs: sales as a result of better product engineering; and costs as a result of shorter product development cycles and less waste of time and material. It has been said to us many times, "The real issue is the cost of not doing it".



“My engineers don't think in 3D”

Surely this is not true! The authors have direct experience of many engineers who say almost the opposite, namely that the boundary between 2D and 3D doesn't really exist in their minds – if a cross-section or projection is enough to provide visibility of the engineering issue they are thinking about, then they use a sketch; but they are thinking about the real, 3D object. We all live in a 3D world and would not survive without an innate ability to navigate in it. People had to work with 2D drawings before CAD was invented and that created a certain mindset.

The first CAD systems were for 2D drawing, with crude 3D wire-line facilities, included because designers needed at least to create perspective drawings for visualisation purposes. Much time was wasted on physical modelling and prototype building activities that are wholly or mainly eliminated by the use of 3D CAD. In our experience designers and engineers generally feel a huge sense of empowerment when presented with a 3D CAD modelling system, because it is the natural way to think and work.

Easy to learn

One of the world's leading manufacturers of printers and copiers moved to 3D solid modelling several years ago, choosing a system that would enable them to make the transition efficiently. across a large engineering organisation. So far they have successfully trained hundreds of engineers to work with the system.

A related concern is that people will find 'driving' a 3D modelling system difficult. In our opinion, neither of these concerns is real, given a modern 3D CAD system with a well designed user interface and a structure that feels logical to a design engineer. With several hundred thousand design engineers out there successfully using 3D CAD solid modelling, it hardly seems feasible that all those who are not doing so are incapable.

Anyone considering 3D investment for the first time, however, should always say “show me”. It is important, at the earliest opportunity, to see 3D in action and if possible to get some hands-on experience in order to prove the point. This should dispel doubts about most people's ability to drive these systems and will certainly show the speed with which a full three dimensional solid digital model of the product is generated.

“I won't be able to get my present job done”

This thought reveals a basic misconception, namely that adopting 3D means dropping 2D. Modern mainstream 3D CAD modelling systems are in fact hybrid 2D/3D systems, integrating 2D drawing and 3D modelling within the one system, so enabling the user to work in drawing mode or solid modelling mode interchangeably. In practice, 2D drawing continues to be essential for various reasons:

- drawing on planes or surfaces is a standard way of creating 3D solid models;
- legacy 2D drawings are likely to form the basis of at least parts of new products and need either to be reused or imported into the 3D system to help create solid models;
- complex assembly layouts are often best worked out initially in drawing mode;
- in a collaborative engineering environment it may still be necessary or desirable to send 2D drawings to design partners, suppliers and contractors.



Hybrid 2D/3D technology is a powerful development that removes the inherent problems of making a step change from 2D to 3D working, and provides the means for the user organisation to evolve in a controlled manner from 2D CAD to an optimum mix of 3D modelling and 2D drawing. The product development manager can largely avoid disruption by introducing 3D modelling methods progressively, step-by-step, according to the opportunities presented by the job in hand, the needs of collaborative engineering partners and the varying aptitude of system users.

Import 2D

When evaluating 3D CAD systems prior to purchase an international supplier of high-efficiency water heaters and boilers looked specifically at how well each system would ease the transition from an old 2D system into 3D. In order to maintain product development momentum they needed to import legacy 2D product data to the new system and avoid having to re-create existing parts and assemblies from the old system. This turned out to be one of the main factors determining their choice of system.

5 Implementing PDM

The control and consistency of an environment managed by Product Data Management may be highly desirable from a product development manager's point of view – for example, improvements in data quality, eliminating uncertainty about the status of data, managing access, and update control are all critical to successful product development. If a development team is split across multiple sites, then a PDM solution can be key to making the team function as a single unit. If partners are involved, then a PDM solution may be essential to avoid a nightmare of confusion about which version of what information is being used.

However, implementing PDM has a more global and strategic significance to the company concerned, reaching beyond engineering and product development. Assuming a basis of 3D data, then PDM creates the opportunity for widespread use of engineering data by non-specialists – all the people, from procurement, to marketing to service that could benefit from an image of the product, and may want to link related operational data.

For the product development manager, this may create new contact and interaction with functions of the business that previously have been remote. This is an opportunity to participate in and drive changes that will produce overall business process improvements. If this is not appropriate, then the product development manager may want a more low-key deployment of a PDM solution.

Fortunately, both approaches are possible. At one end of the spectrum, configuring PDM to drive workflows and manage access can force clear definitions of responsibilities and working practices. At the other end, things can be left much as they are using a PDM configuration which assumes ad-hoc access is the main approach.



6 Typical steps in a controlled transition

In our experience most companies find their engineers have little difficulty in adapting to 3D working. In any case, hybrid 2D/3D technology with fully integrated 2D drafting enables management to take a step-by-step approach to the transition. Typical steps would be:

- become familiar with the new user interface, while continuing to work in 2D mode;
- get some practice in producing 3D component models from existing 2D drawings;
- develop skills in assembly modelling, iterating between assembly sketches and solid models, exploring interference and motion simulation;
- progress to 'full 3D' design mode, utilising the full range of modelling and data management facilities within the product, taking advantage of hybrid 2D/3D design tools to optimize your process, but yielding a 3D virtual prototype;
- develop interfaces to 'downstream' engineering analysis, manufacturing, product data management and ERP systems, as appropriate as you move toward full PLM.

This approach will make transition easier for all concerned, and is likely to be completed quite quickly.

The product development manager will be fully involved in establishing requirements and guiding expectations for the transition to 3D and on towards full PLM. By establishing priorities for the new capabilities – for example, enabling collaborative design, and giving marketing early access to images of new products – the product development manager can help deliver a smooth transition and effective use of new systems.

7 Conclusions

Evidence from many engineering companies, and our own technology research, consistently provides confirmation that Windows-based 3D solid modelling CAD systems, with integrated product data management, are now more than capable of delivering greatly increased overall engineering effectiveness and major reductions in product development time scales – typically by half or more.

The time, cost and learning curve related to the introduction of this technology continue to become less significant. For example, we have noted how disruption of current product development work can be substantially avoided by exploiting hybrid 2D/3D technology to permit progressive evolution from 2D working to fully integrated 2D drawing and 3D solid modelling.

The growth of access to simulation and engineering analysis, and the capability of 3D systems to support design review, together create substantial potential to reduce the



number of prototyping and physical testing cycles required in a new product development project.

Integrated PDM capabilities offer the means to eliminate uncertainty, and improve confidence in versioning, access control, and data consistency. These improvements can make an organisation much more able to implement concurrent engineering practices, and participate in collaborative engineering networks.

The transition to PLM technology, once thought too onerous for mid-sized companies, is now available in price ranges and preconfigured product packages that are suitable for mid-sized companies. In order to remain competitive, 3D is just the first step toward what in the end has to be a transition to a full PLM solution.