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Evolution from 2D to 3D

A Senior Manager's Perspective

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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.

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.

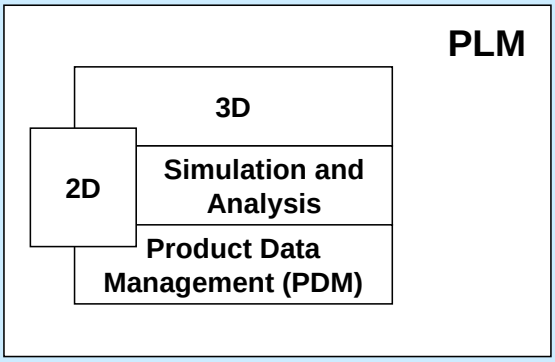
Now, there is a new situation. Preconfigured applications and affordable pricing put PLM within the reach of all companies. But to achieve the full benefits of PLM, it is essential to be working with 3D CAD data. Cambashi estimates that just over half the mechanical and electro-mechanical engineering 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 senior manager responsible for maximising returns from engineering systems investment – specifically, increased company profitability through greater engineering efficiency, increased product value, faster product development and shorter time to market.

Two companion white papers address the viewpoints of:

- the product development project/programme manager
- the engineering designer/CAD system user.

2 CAD, PLM and engineering performance

The sole purpose of investing in CAD technology is to increase company profitability within a business environment characterised by pressures from markets, competitors and economic conditions. The present environment for many companies is defined by limited economic growth, shrinking or static local markets, increased competition and tightened margins. Successful companies respond by raising engineering performance to deliver enhanced product innovation, higher product quality, more product customisation options, better product value in remote growth markets, greater value for money and reduced time to market. That's what 3D CAD investment is about, and 3D CAD opens the door to effective use of PLM.

It is important to distinguish 'engineering performance' from 'productivity', which is too often taken to mean personal productivity. 2D CAD systems were sold as automated draughting tools, aimed essentially at drawing productivity, and by now that benefit has been fully absorbed. **PLM with 3D CAD aims much higher – at the performance and efficiency of the whole collaborative engineering enterprise. Thus the payback from a PLM investment, properly executed, is much greater than the historic payback from 2D CAD.**

For example, creation of 3D data makes it possible to use 3D analysis and simulation packages. This helps identify design problems early in the cycle, when it is quick and easy to make changes. Simulations may make it possible to reduce the number of physical prototyping cycles needed, again saving time and money.

The workflow and data management of PLM solutions can open up new sources of business advantage through wider reuse and reduced re-invention of data, including 2D, 3D, and non-geometric information. In collaborative design environments, PLM technology makes the sharing and communication of designs, analysis results, manufacturing plans, reference data, service information and so on manageable, even when the engineering teams involved are in different locations.

3 Technology investment

Whenever a new technology appears the senior manager has to decide whether and when to adopt it, balancing the business benefits against the inevitable costs of change, and the time to produce the benefits. All three are difficult to analyse and the manager ultimately depends on advice from many quarters, the most useful being evidence from companies in related industries who have already made the change. The manager is unlikely to have personal hands-on experience of the technology, especially where technological development has moved fast, and the link between technology investment and ultimate profit becomes more difficult to assess as the technology becomes more all embracing.

A smooth step forward

An originally small engineering company supplying custom designed automation equipment, now with 60 engineering staff and 600 employees, prides itself on its ability to adapt to changing markets quickly when necessary. Some years ago they invested in 3D CAD in order to stay competitive - as soon as the technology, in their judgement, had become sufficiently productive and easy to use. Following training and two small projects, the next step was to complete a large mechanical design project (estimated at two man-years of work using old methods) exclusively using the 3D CAD system. The automated machine had multiple complex mechanisms, including three conveyor systems, a 6-axis robot, a 3-axis custom-designed positioning system, a feed system, two cam-driven indexing units, a vision system, and literally dozens of pneumatically activated motions. The three lead designers assigned to the project had taken part in the initial training six months earlier, but had no actual experience using the system subsequently. The 'bottom line' was that they came in ahead of schedule, under budget and with engineering change orders reduced to only 10 percent of what they would previously have considered normal.

CAD is a classic example of this syndrome. The number of engineering managers hesitating to invest in 3D CAD is still quite significant. To accept the vision of PLM as the umbrella which manages and controls the applications and data for all aspects of product information authoring and use is an even bigger step. In this vision, 3D CAD is just one data creation and modification tool. Perhaps the individuals and management teams concerned are not persuaded about the business benefits; or they don't really understand how the technology delivers the benefits; or they feel that their organisation is not capable of implementing the technology without undue difficulty, cost or disruption of their operations. We will cover these issues in turn but first a brief recap of why PLM with 3D CAD is fundamentally different.

4 PLM with 3D CAD is a tool for the whole engineering business

Any company still using 2D CAD as its primary design tool is likely to recall the basis on which it was originally justified, namely as a means of increasing design drawing productivity. 2D CAD had relatively little impact on the far more costly and time consuming down stream processes of product development, engineering analysis, testing and production. Software for these processes became available in the same time frame as CAD, but 2D drawings provided a poor interface to such software, generally requiring interpretation and manual data transfer, with all the attendant

potential for mistakes. 2D systems have developed over the years and can of course handle the third dimension in various ways. But 2D drawing as a means of conveying design intent cannot shed its fundamental deficiencies: it is an indirect representation of reality, subject to interpretation and error, and not containing sufficient information to feed downstream computerised processes automatically. Its impact on the overall engineering business process is inherently limited.

3D CAD systems approach these issues from exactly the opposite direction. 3D allows the engineer to directly produce 3-dimensional 'solid' digital models of product's geometry in the form that down stream processes require, impacting much more of the overall engineering process. 2D CAD does not disappear – for example, 2D sketching is a key method of defining a solid object – but many drawings can be generated automatically as an output, not an input, from the 3D design process. This reduces the volume of manual drawing work and simultaneously increases speed, accuracy and consistency.

Data management

For several years a manufacturer of industrial equipment for the forestry, marine, mining, oil and gas industries wanted to make the move from an old 2D system to the much more productive environment of 3D solid modelling, but a requirement to include a design management system prevented the move. Identification of a 3D CAD system with integrated product data management allowed the company to move into 3D and bypass the need for a separate PDM system investment that would have cost $200,000 up front, and been more difficult to implement and maintain.

The company now manages 3D engineering data between 25 engineering department employees, with another 75 users on the manufacturing shop floor, the service department and in the technical publications department. Most of the legacy 2D drawings and data have been moved into the 3D system- managed workspace, which means that the company has been able to leverage the value of all their previous work.

By attaching non-geometric engineering information to the 3D digital model it becomes a complete digital definition of the product, holding all the data required to analyse, simulate, procure and make it. The results on the bottom line have now been more than adequately verified in thousands of companies, especially those developing complex electromechanical machinery and equipment. Typically they experience halving of development time through higher design productivity, better engineering decision making, reduced engineering change orders and improved reliability of communication with customers, suppliers and contractors.

Implementing 3D CAD as a step toward a PLM solution increases the re-use of data across all functions, from procurement to marketing. 3D data is useful to more people in the organisation, for example, to help illustrate or identify parts and assemblies. The workflow and data management capabilities of PLM solutions ensure that everyone can be confident they are working with consistent, up-to-date information.

Better handling of product information makes it possible to work with more suppliers, and improve both cost and service. PLM capabilities can be a pre-requisite for successful participation in customer "collaborative" initiatives, from design to inventory management. In many mid-market manufacturing companies, PLM is the only practical

way to manage the substantial amounts of data sharing and exchange expected by customers.

5 The present state of play

The 3D PLM vision has taken a long time to achieve and managers may be forgiven if they think they have 'heard it all before'. 3D technology development started around 40 years ago and in the last five or ten years it has progressed to become a viable proposition for companies of all sizes. The step from 3D CAD to PLM is becoming smaller, and is now a practical proposition - even essential - for any engineering company developing significant industrial or consumer products. Several strands of technological advance have helped convert these technologies into tools from which even smaller companies can benefit:

- greatly reduced costs of computing power, graphics processing and data storage;
- emergence of MS Windows as a standardised operating environment for 3D CAD, fully capable of supporting collaborative engineering in the extended enterprise;
- more utilisation of Microsoft standard data handling applications and utilities for lower costs and increased compatibility with other business processes;
- ability to model large assemblies in 3D and manage all the complex relationships between features, components and assemblies;
- integrated management capabilities, from local product data administration to multi-site, multi-workgroup PDM;
- improved connection to, or integration of, simulation and analysis packages to allow more to be done with the digital model, perhaps eliminating physical test cycles;
- tools that provide access to the product model and design data by external applications;
- easier to use systems resulting from improved logical structure and user interface style;
- establishment of industry best practices and workflows across a variety of applications;
- full integration of 2D drawing and 3D modelling within the same CAD product - known as 'hybrid 2D/3D' technology;
- mixed 2D/3D semi-automatic workflow aids for assembly layouts and modelling.

Some of these software characteristics are product dependent, and development continues to be rapid. We suggest that management should review the situation regularly and frequently, as discussed below.

6 So what are the problems?

Our own continuous monitoring of the technology persuades us that mainstream 3D PLM systems are at the stage where they will deliver the benefits claimed for them when implemented and applied properly. From some potential user companies we hear doubts expressed, not so much about the benefit arguments (which seem to be generally understood and accepted) but about their own ability to change their current methods without undue disruption or difficulty. Here are the principal issues raised, and some thoughts about them.

Can I implement PLM at a cost I can afford?

System cost may not be as high as anticipated - today's costs of a mainstream 3D CAD system are similar to the costs of a 2D system only a few years ago. There is a constant trend towards lower costs of technology, and competition between vendors over recent years has produced notable decreases in prices, so costs should be checked out regularly. Of course the cost of a modern 2D drawing system would be less than a 3D CAD system but that is not a relevant comparison: as we have seen, 3D technology delivers many more and quite different benefits across the whole of engineering.

Benefits

A world leader in personal protection systems for bomb disposal and mine clearance found that, "By creating accurate 3D parts, 2D drawings are only a few mouse clicks away. Using a 3D CAD system with hybrid 2D/3D technology we have reduced the time required to output a complete set of drawings by a factor of 8. That's an 87.5% time saving".

In any case, the real issue is cost benefit, not simply cost. 3D investment is almost invariably made as a way of increasing the company's competitive strength through increasing its engineering performance, delivering better products and getting them to market more quickly. Sometimes this is a planned strategy, at other times it can be a response to immediate market pressures or even specific customer demands. In such circumstances cost is naturally a factor but the real cost is seen to lie in a failure to respond. From our observations most successful 3D CAD investments tend to occur when times are tough, when there are budget pressures from loss of sales, or anticipated losses, and the company is highly motivated to deal with the situation.

By creating 3D data, companies create the platform to maximise benefits of PLM. PLM's managed environment for engineering information improves the use and thus ROI for that information. Business cases should examine savings and improvements not only in design and engineering but also in procurement, inventory management, marketing and customer service.

How to evaluate the benefits?

We have described the wide-ranging benefits that 3D CAD brings to the whole of the engineering process. It was relatively easy to assess the benefits of 2D CAD in terms simply of drafting productivity. With 3D CAD the situation is different. The CEO needs to evaluate the effect on the top line of 'better products delivered faster', and be able to

assess the value of greater productivity of the whole product development function, not just a bit of it. This "big picture" effect is even more pronounced when the workflow and supplier integration capabilities of PLM are being assessed. Justification for PLM investment includes both cost savings - through task efficiency and re-use of product information – and revenue growth – by improving innovation, supporting collaboration, and shortening time-to-market thus allowing for products to maximize their lifecycle and allow companies to deliver more product to market. As always, confidence in any investment justification will be greatly assisted by talking to companies who have already done it and are a year or two down the line.

3D will prove too difficult to learn.

This is one that we frankly do not believe, given the large number of companies and types of companies who have adopted 3D technology with relatively little difficulty. Some relevant points:

- most engineers think in 3D so the essence of the 3D modelling process is intuitive;
- after many years of user feedback, leading systems vendors have made modern systems easy to use, with a logical structure and user interfaces that are closely aligned to the Windows 'look and feel' which is now widely familiar;
- the structure of the 3D CAD design process and the data structure of the resulting digital product models is closely aligned with the physical structure of the product being designed (parts, components, sub-assemblies, assemblies), so the process feels natural;
- drawing functionality in hybrid 2D/3D systems is similar to existing 2D systems, so no significant learning curve is involved as far as 2D work is concerned;
- modern 3D CAD products include a large number of productivity aids that automate common processes and standardise work flows;
- the reduced effort needed to produce a full digital product definition, especially in a collaborative engineering environment, is a strong motivational factor;
- the 3D digital model enables each individual designer and engineer easier, better visualisations and access to the proposed design, and allows them to produce better results.

Migrating from 2D to 3D will disrupt operations.

Clearly disruption must be minimised. Most companies achieve this by targeting a defined small project to begin with and taking a step-by-step approach, introducing only certain features of the new system at a time. A large amount of training per individual is not recommended: CAD systems have so much operating guidance on-line that 'learn as you go' is often the best approach, especially when coupled with rapid development and sharing of local 'best practice'. Standard wisdom is to monitor progress, show management enthusiasm at all times and evaluate results at regular intervals.

With a modern 3D CAD system loss of productivity during the learning curve is likely to be minimal for many reasons:

- designing in 3D is inherently more efficient, offsetting any initial loss of impetus and leading to increased productivity within a short time;
- built in tutorials and 'intelligent help' guide the new user at every step;
- time spent producing drawings will start to diminish immediately;
- integrated 2D draughting and 2D/3D work flow aids help staff to adapt quickly;
- 3D 'wizards' help users quickly convert existing 2D geometry to 3D, so legacy 2D design data is not lost;
- hybrid 2D/3D technology means that the organisation can use the proper techniques at the proper time, for example, 2D initial layouts, then 3D models later, and can match the approach to the company's own circumstances, type of product and staff capabilities;
- Opening the door to simulation and analysis may trigger significant changes, such as exposing problems earlier in the lifecycle, and reducing the number of prototypes required. But most teams will warmly embrace these disruptive changes.

PLM is too complicated!

No! Access to information is certainly different in the regime created by a full PLM solution, and differences can sometimes be misinterpreted as complexity. In fact, PLM's capabilities to support and standardise workflows, and maintain consistent datasets, can significantly simplify operations, especially when multiple users are spread between a number of sites.

In contrast, a user trying to use file naming conventions and email to achieve the same result may appear to be doing simple things, but in fact will create complexity and uncertainty – which will quickly translate into delays and cost.

Modern PLM technology allows for implementations based on pre-defined workflows, eliminating customisation costs and follow-on maintenance. Familiar Microsoft infrastructure supports PLM, simplifying deployment. Individual vendors support a wide range of applications, eliminating finger-pointing.

7 Conclusions and Recommendations

- Having reviewed the latest 3D CAD technology and the experiences of many companies that have adopted it, we believe that any company in the business of product development, and their suppliers, would be well advised to re-examine the business potential and market opportunities offered by today's 3D systems and use them as a stepping stone to complete PLM implementations.
- Use of 3D data in design increases the value of product design information in areas outside of engineering, and PLM ensures people work with the right product data.

- The combination of 3D CAD with open PLM capabilities such as data management, workflow, and interfaces to analysis and other applications is an important step, since these capabilities will help many companies both in their own work, and also in their collaborations with suppliers and customers.
- The doubts expressed about the ability of companies to adopt 3D technology without undue cost or difficulty appear to us to be largely unfounded. The evidence, broadly, is the thousands of companies that have already done it. The technical reasons, however, lie in details of the advanced technology (such as hybrid 2D/3D) built into modern 3D CAD products. This technology has advanced rapidly in recent years, even months, and management should therefore ensure that the situation is reviewed regularly.
- Whereas 2D CAD simply increased drawing productivity, modern 3D CAD systems impact the whole of the design, engineering and product development management process. The typical result (confirmed by very many users) is improvement in design innovation and product quality; 50% or more reduction in engineering change orders; and greatly reduced product development time.
- PLM has the potential to impact top line revenue as well as deliver efficiencies that save cost. This makes PLM investment more than just a way of saving cost, it can be significant to a company's ability to compete to win new revenue streams.