Understanding
Product Lifecycle Management

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1. About this document

1.1 Purpose of this document

Since the term Product Data Management (PDM) became unfashionable there has been a flood of confusing terms and acronyms. Though there appears to be an emerging consensus on the use of Product Lifecycle Management (PLM) as the credible successor to PDM, there is still confusion as to what PLM actually mean. This document explains: the background the emergence of PLM, causes of the confusion relating what PLM means, and proposes a clear definition that helps developers, users and investors in this technology make informed decisions.

1.2 Who is this document for?

This document is aimed at:

- **Those who are looking for solutions for their business problems (users) -** Users want to have the confidence that what they buy will actually address their business needs. They also want to have yardsticks that help them in the evaluation and selection of the technology best suited for their immediate, as well as future needs.
- **Providers of PLM and related technology (vendors) -** Vendors want to provide products that address market needs and to be able to position these products accurately for more effective marketing and sales campaigns.
- **Analysts -** who want to provide trends and meaningful statistics for market size and growth rates.
- **Investors -** who want to have an accurate assessment of the technology they are proposing to invest in, the size of the market it is aimed at, and potential growth of that market.

1.3 Executive Summary

Many of the terms and acronyms that are in circulation today tend to include words that are either vague or imply time dependence. For a term to gain acceptance and wide usage, and over a long period of time, it must be unambiguous and stable. This document provides a definition of PLM that clearly defines the scope and role of PLM. A key aspect of this definition is the separation of the 'management' of product information from the 'processing' of that information. The document also proposes that since the scope and role of PLM impacts every aspect of an organisation's business, it should be viewed in a completely different light to past technologies which, in the main, had a 'point solution' focus. In addition, this document provides:

- A clear definition of what PLM is.
- A description of what constitutes PLM technology and where it fits in the overall IT picture.
- Classification of PLM related technologies into clearly definable groups that makes them easy to position, and to understand the benefits they deliver.
- An outline of the different approaches adopted by different PLM vendors and their key differentiating features.
- Prediction of how PLM technology is likely to develop over the coming years and what users of this technology can do to derive most benefit from it.

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2. Introduction

2.1 Key developments that led to the emergence of PLM

Though tens of new technologies have emerged in recent years, only two can be said to have had a fundamental impact on PDM. The first is web technology and the Internet - which made it possible for PDM users to access a system without the need for a “physical link”. The second is the realisation that geometry and other product information (Product Definition) can be reused by virtually all business processes downstream of the design process. This reuse provides an immense benefit through the elimination of non-value added activities (such as re-keying of data), enabling concurrent work as well as avoiding transcription and translation errors.

So fundamental has been the impact of these two developments that they have led to a profound change to the way PDM, CAD/CAM and other computer aided technologies are developed and used. The increasing use of the same product definition outside the design office, led not only to tight coupling of related technologies such as CAD, CAM and CAE, but also to the convergence of other technologies notably CAx and PDM. The Internet, on the other hand put an end to any site location and geographical constraints. Thus, together these two developments made it possible, for the first time, to solve the emerging needs of businesses operating in the highly competitive, heavily outsourced, global environment. Namely enabling organisations to:

- Cut costs and time to market - through more effective use and reuse of resources.
- Be nimble and quick to react to market changes - through the ability to focus on core business and increased collaboration with suppliers and partners.
- Increase innovation - through better visibility of product data to all personnel both within the enterprise and extended enterprise.

Today, with a ‘standard web browser’ as the user interface, and encryption technology to provide secure access across the Internet, it is possible for multi-disciplined teams to work concurrently on the same product data, from anywhere around the world. The only prerequisite is for users to be authorised to use the system - a task that the system administrator / project manager can do in the same way that he/she grants access to any other 'hard wired' user.

Another significant side-effect of the Internet, is the emergence of the web browser as the “standard” user interface. This has provided consistency in the presentation and interaction with product data, making it easier for team members to communicate. The result, is that project teams can include members from a wide range of disciplines, as well as include suppliers, partners, customers and other interested parties. What is more, such ‘virtual project teams’ can be set up and disbanded as the organisation business evolves.

2.2 Confusing terms and why they appear

Many of the terms and acronyms tend to refer to 'what is being done' (e.g. design, asset management); 'how it is done' (e.g. Collaborative ...); or a vague reference to the application area in which it is being done (e.g. 'Commerce', 'eCommerce' and 'eBusiness'). Also, some vendors present a piece of technology as a 'total solution', when in fact they are simply offering a tool or application that addresses a specific application domain. Furthermore, some of the definitions given to the various terms and acronyms

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include long lists of benefits, and how the benefits are delivered.

The confusion arises because processes and benefits vary from one company to another, and from one industry sector to another. They also vary from one time to the next, depending on the key business drivers of the day. That in itself may be bad enough, but when the word 'Lifecycle' is introduced, the term can mean virtually anything. For something to be defined accurately, it needs to have ***a finite and identifiable scope***. Furthermore, if the definition is to have any reasonable lifespan, it should not rely on the definition of anything that is time dependent, such as a process or benefit. With this in mind the next section will introduce a new definition for PLM that is valid today and stands a good chance of still being valid next year and in ten years time.

3. Definitions

3.1 Product Lifecycle Management (PLM)

"PLM is a strategic business approach for the effective management and use of corporate intellectual capital."

This definition uses the term 'intellectual capital' because this is what is being managed, and its use is what delivers the organisation's objectives. Therefore, this definition will apply to small, as well as large businesses; to profit making organisations, non-profit making organisations, as well as service providers. The term 'from cradle to grave' is not used in this definition as an organisation may have any number of products (and services) at any point in time.

3.2 Corporate Intellectual Capital

"Corporate Intellectual Capital is the sum of retained knowledge that an organisation accumulates in the course of delivering its objectives."

Corporate Intellectual Capital (CIC) consists of the following, Figure 1:

1. **Product Definition:** All the information relating to what the product (or service) is, its specification, how it is designed, manufactured, delivered and supported.
2. **Product History:** Any information relating to what the organisation has done in the past that is of relevance for the delivery of the organisation objectives, e.g. audit trails required for legal or regulatory purposes, or archives relating to past products
3. **Best Practice:** This encapsulates experience gathered by the organisation in the course of delivery of its objectives

Note that these definitions apply to any organisation regardless of what its products/services are, how it conduct its business, who it is collaborating/partnering with, and how it is delivering its products/services to its customers. Also the definitions do not incorporate any description of technology, system functionality, or processes which may make the definition time dependent.

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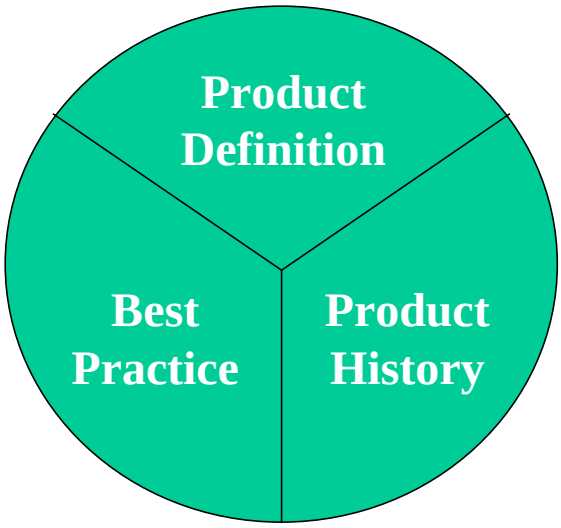

Figure 1: Constituents of Corporate Intellectual Capital

CIC consists of two type of data:

1. **Content:** Product definition and all related information.
2. **Meta Data:** Data that describe the content, e.g. creation and last modified dates, author/owner, version/status, how it can be used and by whom, etc.

3.3 Applications and Processes

Applications are computer programs that aid or automate specific processes. Applications often encapsulate Best Practice which define the accepted/recommended way to carry out specific processes based on past experience.

Applications may vary to address different business environments. For instance ECAD and MCAD are both CAD applications, but are tailored for the electronics and mechanical markets respectively. It is also worth remembering that processes are 'transient'. Process definition is only relevant in the context of current product and enabling technology. Processes are defined to make best use of existing technology, and refined with the help of the retained knowledge in 'Best Practice' and 'Product History'. For instance the purpose of a CAD system has always been to define product geometry. However, the way the geometry is defined, how it is visualised, interacted with and used has changed over the years as design practices and CAD technology have evolved.

For the purposes of this document, **Business Applications** include any software, tools and solutions that that process the CIC depending on how they are packaged/marketed, Business Applications may be grouped, according to the way they are packaged, under the following:

1. **Tools and Components:** Application software that is designed to carry out specific functions and is delivered as part of a larger software package, e.g. visualisation tools, conferencing tools and solid modelling kernels.
2. **Application Modules:** Self-contained software packages that are used to automate specific processes, e.g. Word Processing package, CAD, CAM, CAE, etc.
3. **Application Suites:** Sets of closely coupled Applications Modules, e.g. Office Suites, MCAD Suites, ERP system

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4. **Industry Solutions:** Comprehensive packages of Application Modules and Suites tailored for specific industry sectors, e.g. design solution for the aerospace, automotive or shipbuilding industries.

Applications can also be divided into two groups depending on what part of the CIC they process, namely:

1. **Authoring Applications:** These are the applications that create, edit, or delete 'content' of the CIC, e.g. Word Processing package, CAD, CAM, CAE, ERP, etc.
2. **Decision Support Applications:** These are the applications that control who has access to given content datasets, what they are permitted to do with them, for what purpose, and at what part of the process. Typically, these applications process the meta data and leave the content unaltered.

3.4 What constitutes a PLM system?

Having defined what PLM is, it is now possible to define what constitutes a PLM system. Clearly it is not a point solution in the way the last generation of systems used to be e.g. PDM, CAD, CAD, CAE, Office suite. Given the above definition of PLM, a PLM system has two implied functions:

1. **Effective management of Corporate Intellectual Capital:** Ensuring accuracy, currency, integrity and security of all corporate information.
2. **Effective use of Corporate Intellectual Capital:** Making corporate information readily available in the right place and format to the right users (both people and programs), for the right tasks.

Note that both of these functions are generic and do not state how the 'content' part of CIC is processed. The content processing function is provided by the authoring applications, e.g. CAD, CAE, Office automation, etc. The separation of the management functions from the authoring is important for defining the scope of PLM, and therefore, for understanding what it does. Later in this document it will be shown how this can also help in developing metrics or at least guidelines, that help in the evaluation and selection of different PLM technology and solutions.

4. PLM and its relationship with other systems

4.1 Role of PLM within an organisation's IT environment

Much of the confusion about what constitutes PLM (and in the past PDM) functionality arises when the 'processing' function is not differentiated from the 'management' function. For instance should CAD/CAM be part of PLM? If so why shouldn't ERP, SCM (Supplier Component Management) and CRM (Customer Relation Management) also be part of PLM? If these are included, the scope of PLM becomes so large that it becomes meaningless. It is important therefore to make the distinction between the management function of PLM provided by the core PLM functions described in the next section, and the processing function by the Business Applications. Figure 2 highlights this by showing PLM functionality as a ring around the Corporate Intellectual Capital with the Business Applications forming concentric rings around it. This representation accurately positions not only PLM, but also, all four types of the Business Applications that process the CIC.

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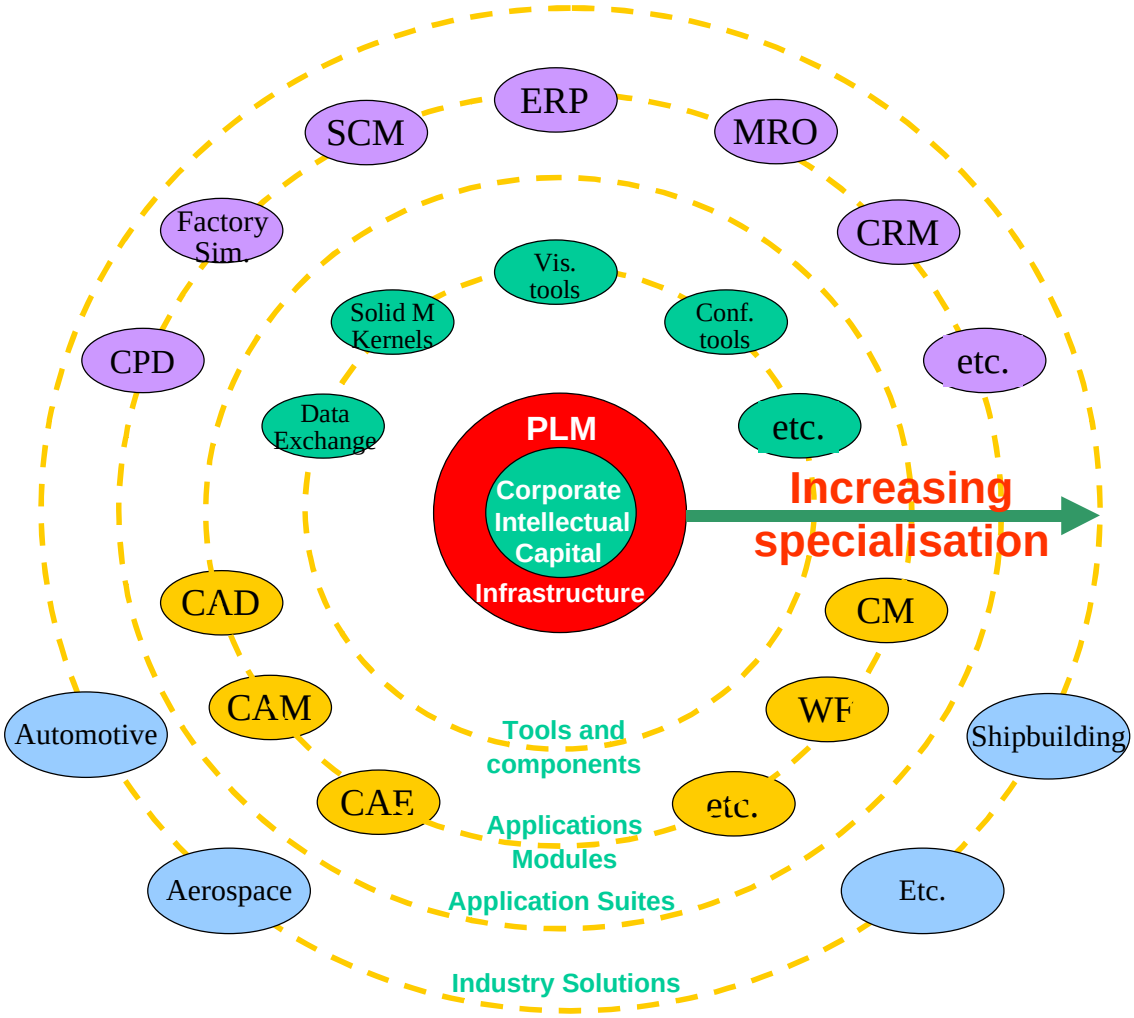

Figure 2: The PLM Universe

In the past there has been continuous debate as to whether CAD, PDM or ERP should be the 'centre of the universe'. At the heart of this debate is the overlap in functionality in these applications and the sharing of product data. This representation will help end this debate, particularly that all the major CAD/CAM, PDM, as well as the major ERP vendors are now adopting the term PLM.

4.2 PLM architecture

PLM functionality is delivered by three components as illustrated in Figure 3. THey are:

4.2.1 Infrastructure

The infrastructure is the foundation upon which Business Applications are built. It provides generic and core PLM functions as outlined in Section 5.1.

4.2.2 Integration and Application Development Environment

The Integration and Application Development Environment provide the means for building Business Applications that provide the initial functionality and enhance and extend the functionality of the PLM solution.

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4.2.3 Business Applications:

Business Applications provide the PLM functionality that process the CIC. These are divided into four groups according to the way they are packaged:

1. **Tools and components:** These are basic functions that can be used for building higher level functionality, e.g. geometric modelling engines, viewers and conferencing tools.
2. **Application Modules:** These are self-contained modules that focus on a specific process, e.g. CAD for the design process.
3. **Applications suites:** These are a set of complementary modules that focus on a number of related processes, e.g. an MCAD suite that includes tightly coupled CAD, CAM and CAE.
4. **Industry Solutions:** An industry solution is a set of applications or application suites designed for a specific industry sector. It encapsulates best practice that relates to that sector.

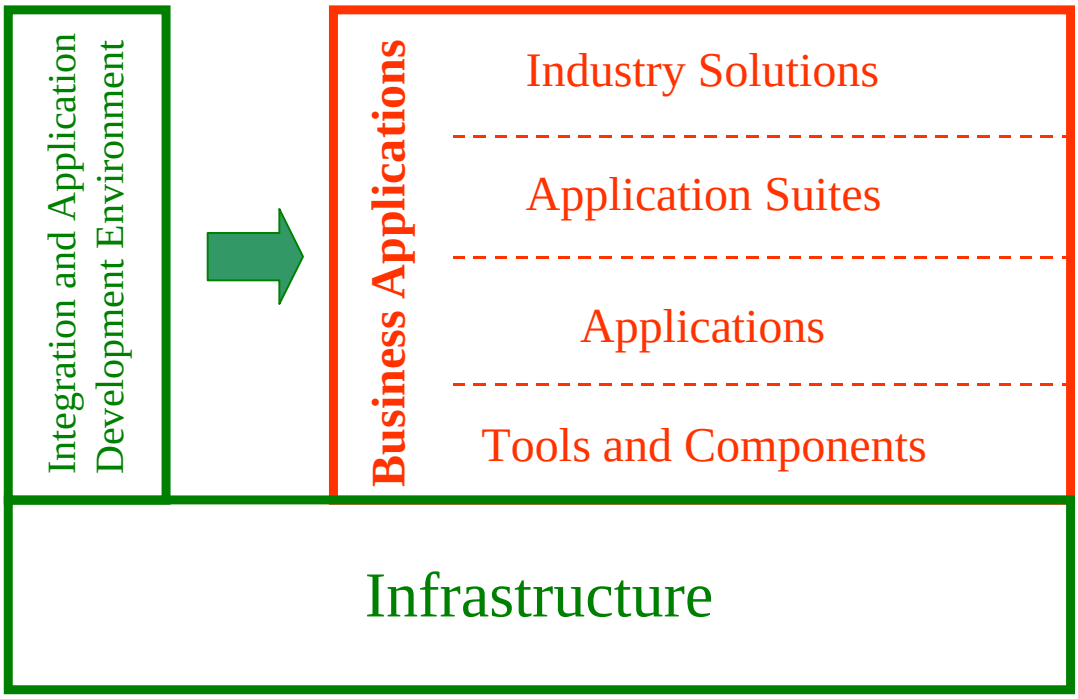

Figure 3: PLM architecture

4.3 Mapping popular acronyms to the PLM big picture

First the word 'Collaborative' has been banded extensively to give the impression that it is a prerequisite component of PLM. It is not. It is a valuable feature that enhances a PLM system, like say, an air conditioning system in a car. Specifically, the acronyms that include the word 'Collaborative' are mapped as follows:

1. **Collaborative Product Commerce (CPC):** This is a very vague term that can mean different things to different people. Essentially it refers to systems that enable aggregation of data held in multiple legacy systems to appear as if they are held in one database.

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2. **Collaborative Product Development (CPD):** This is far less vague than CPC, but a better term for this may be Product Development Management (PDM II). Essentially it refers to effective management of the product development process. A CPD system therefore requires a CAx application suite that is seamlessly integrated with PLM technology.
3. **collaborative Product Definition management (cPDm):** Though this was introduced to cover what is now called PLM, its literal meaning is very similar to CPD

The word 'Virtual' has also been used in a number of confusing acronyms. Since every computing activity on product data rely on a 'virtual product model', the word 'virtual' does not add anything extra. Below are mappings for some of these terms:

1. **Virtual Product Development -** similar to CAx
2. **Virtual Product Development Management -** similar to CPD
3. **Virtual Product Data Management -** essentially PDM with a new name

Other terms include:

1. **Asset Management or Asset Information Management:** A variant on PLM that focuses on the management of assets.
2. **Content Management:** Data management system that is tailored for handling masses of textual information, with powerful search capabilities, e.g. catalogues and on-line information systems
3. Less used and vague terms include Product Knowledge Management (PKM) and Intelligent Collaborative Commerce (ICC).

5. Outline of core functionality for a PLM system

The definition of PLM above implies that a PLM system serves everyone within an organisation, and manages all the organisation products through their respective lifecycles. It therefore must have a longer lifespan than most application software. As such it must not be seen as a one off point-solution. Instead it should be seen as an infrastructure that once deployed, its functionality can be extended through an evolutionary rather than revolutionary process. That is, adding and refining functions/components rather than wholesale replacement of the system. Such an evolutionary approach is now possible in most modern systems which are based on object technology and are designed to be modular. Adding new functionality can be effected through the addition of a new component(s), while refinement can be effected through enhancing the functionality of a component or replacement of a component with another.

To this end it is proposed that the key functionality for a PLM system should include:

5.1 Infrastructure

The infrastructure is at the heart of the PLM system providing a storage, and effective management of the Corporate Intellectual Capital. It includes:

5.1.1 Vault for storing Corporate Intellectual Capital

A PLM system should be capable of storing all type of data that is needed for product definition, best practice and product history. It should therefore need to support a flexible

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and extensible data model that cover product as well as process definitions and can evolve with the needs of the organisation.

5.1.2 Generic services and tools

General purpose functionality to support different users and applications. They include:

1. Access to system resources such as print, etc.
2. Notification services
3. Visualisation tools, e.g. view and mark-up
4. Collaboration tools, e.g. web enablement, portals, conferencing tools

5.1.3 Administration and configuration tools

These include general purpose tools that enable system administrator to carry out various administrative tasks such as assigning or modifying system resources to different users and/or applications. Typically, administration and configuration tasks are carried out with the aid of special menus, screens and wizards.

5.1.4 Core data management functions

The second key component of the PLM system is a set of data management functions that provide core functionality for the Decision Support Business Applications supported by the PLM solution. These include:

1. Product Structure and Configuration Management functions.
2. Classification and Retrieval functions.
3. Workflow functions.
4. Project / Programme Management functions.

5.2 Integration and Application Development Environment

The second key component of PLM is the Integration and Application Development Environment that provides the means to build functionality on top of the foundation provided by the infrastructure and the core data management functions. It includes:

5.2.1 Application Development tools

Tools that enable addition of new functionality or the modification of existing ones. This can be effected by various programming tools ranging from high level proprietary scripting languages to standard programming languages such as Java, C++, etc. Typically scripting tools are used for customisation work while programming languages are used by PLM technology developers and third party application/solution developers for major development work.

5.2.2 Integration and Interoperability tools

These are sometimes referred to as Enterprise Application Integration (EAI) Tools. Their function is to enable external applications to be integrated/interfaced to the PLM system. The communication they effect ranges from tight coupling and seamless sharing of the same data store, to effecting data transfer between independent Business Applications via exchange files. Data exchange, which can be in standard as well as proprietary formats, is a convenient way for bulk import and export of data, e.g. to populate the PLM vault with data from a legacy system.

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5.3 Business Applications

The Business Applications provide the 'visible' part of the PLM system functionality. They can be grouped into four groups according to the way they are packaged and into two groups according to which part of the CIC they process, see Section 3.3. Business Applications are depicted by the four concentric orbits of Figure 2 and provide increasing in specialisation as they move away from the centre. Each group builds on the core PLM functionality at the centre, and all groups enclosed within its orbit. Alternative representation shown in the architecture diagram of Figure 3. Here they are represented by four layers, each building on the layers below.

As mentioned in Section 3.3, Business Applications can be either Authoring Applications or Decision Support Applications. At the lowest level, Tools and components typically provide either authoring or decision support function. Applications and Application Suites have more overlap of these two types of functions, while in Industry Solutions, the authoring and decision support functions are seamlessly merged.

6. Guidelines for System Evaluation and Selection

The business drivers for investment in any technology vary from one organisation to another. They may include reducing cost or time to market, increased productivity or innovation. In the past systems that delivered the highest proportion of these were more likely to have been chosen. This ‘tick in the box’ approach may have been adequate then when systems were relatively simple and addressed a specific problem - a point solution. PLM is different as it affects the whole organisation. Investment in PLM technology should therefore be seen not as an investment in a turnkey solution, but as a continuous investment programme. At the outset there is the investment in the infrastructure followed by incremental investment in new Business Applications as the business need change. A PLM system therefore is 'live entity' that is in continuous evolution. As such, a key element in the evaluation and selection process is to ensure that the system can grow with the needs of the organisation. To this end the following issues have added importance:

1. Deployment and support issues
   - Readiness for deployment
   - Services
2. Architectural issues
   - Scaleability
   - Extensibility
   - Robustness
   - Openness
3. Database management issues
   - Interfacing approach
   - Integration Platform approach
   - Hybrid approach

Though these are very hard to measure, the following guidelines will help in identifying what to look for in a system.

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6.1 Deployment and support issues

6.1.1 Readiness for deployment

'Out-of-the-box' is a much used term to indicate that the system is ready for deployment. In practice this is only applicable to small, relatively simple point solutions. PLM solutions are plainly none of these. Some level of effort, and investment, is often necessary to deliver functionality specific to individual customers.

Though the customised functionality is typically only a fraction of the overall functionality, it can represent a significant proportion of the overall cost and deployment time. What is more, the customisation may require an update every time a new version of the system is deployed, further adding to the total cost of ownership. This has been the reality in the traditionally designed systems as shown in Figure 4.

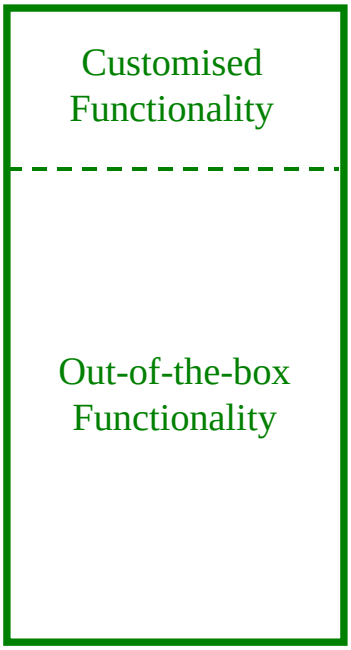

Figure 4: Traditional components of a system

With the benefits that object technology provide, today's systems are more modular and offer a number of ways of minimising the need for customer specific functionality. Figure 5 shows an example of modern architecture where the overall functionality can be delivered by at least three components/layers:

1. Foundation Modules: This is the part of the system that provides the core functions depicted as the 'Infrastructure' in Figure 3.
2. Business Application Modules: These provides specialised functionality from which the customer may choose to address key requirements, e.g. workflow, configuration management, conferencing and other modules.
3. Customer specific functionality: This is the functionality that typically is not provided out-of-the-box. It represents the company's own best practice that the company wants to add to the system.

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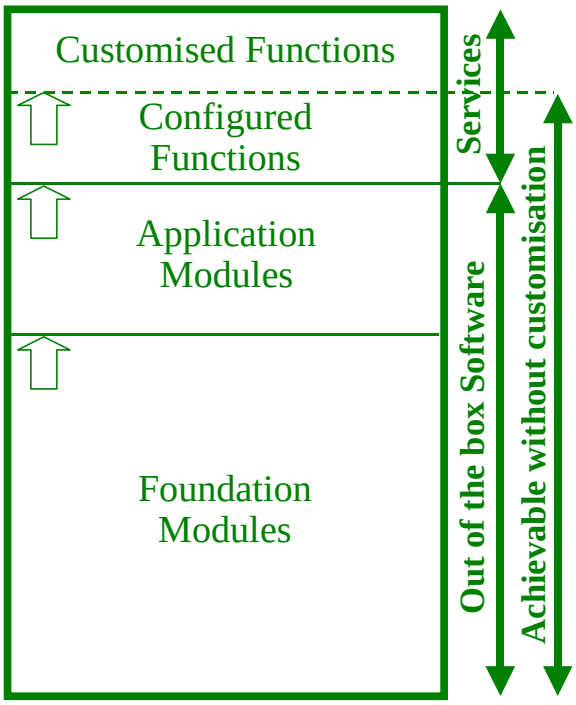

Figure 5: Modern modular system architecture

Ideally, the proportion of the combined functionality provided by the foundation and application modules should be as high as possible.

The customer specific part can further be reduced by providing 'Configuration Tools' that tailor the system through out-of-the-box utilities. Such utilities can be used to modify system parameters for the whole installation, specific departments and even individual users. Typically, parameters set in this way can be migrated to later versions of the system.

The remaining part of customer specific functionality can only be provided through custom programming which may, or may not be migratable to later versions of the systems. Here again there are ways to reduce the cost of developing and migrating customisations. Some vendors provide customisation tools such as scripting languages or wizard capabilities that provide access to high level system functions.

6.1.2 Services

Industry surveys show that, software cost is typically 40% of any investment in PLM technology. The remaining 60% is for customisation and other deployment related services. Furthermore, these figures do not include the cost of related data migration and work carried out by the organisation's own personnel. Therefore, since services account for a major proportion of the total cost of ownership of a PLM system, the quality and timely availability of such services is paramount. Services can be divided into the following categories:

1. **Deployment services** - include installation and configuration work. These are specialised services typically carried out by the system provider
2. **Customisation Service** - these can vary in scope and complexity. Minor customisations typically require knowledge of the system's Application Development Environment and may be carried out by the system provider, their partners and in some cases, the customer personnel. Larger customisations would almost certainly

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would involve some level of process analysis and therefore requires domain expertise. Such customisation projects therefore require user input as well as good domain expertise by the system provider. In other words, a system that offers good customisation capability is of little benefit without quality application domain expertise.

3. **Support services** - these are services needed to support the day-to-day operation of the system. Initially they can be provided by the system provider or their partners. But ideally, should be taken over by the customer at the earliest opportunity.
4. **Training services** - PLM systems require multi-level training designed for administrators, support personnel as well as users. Again, these are initially provided by the system provider or their partners and taken over by the customer at the earliest opportunity.

6.2 Architectural issues

6.2.1 Scaleability

As the name implies, scaleability is the ability of extending the use of the system beyond the scope of the initial installation to serve more users and/or processes. Key issues here are to ensure that there are no technical constraints on the number of users, sites, storage, and other system resources. In addition, it is important to ensure that system performance does not suffer serious degradation as the system is scaled up.

Scaleability of a PLM system tends to be related to good underlying architecture. If the system is well designed, it is more likely to be scaleable and therefore can grow with the growing needs of the organisation. Conversely, if scaleability features are not built into the system at the outset, their addition at a later stage is difficult, if not impossible, without a major re-design of the system. Also, good architecture means that the vendor has made a significant investment in the development of the system, and therefore plans to support it for a significant period of time.

6.2.2 Extensibility

Extensibility may mean different things to different people. But for the purposes of this document, extensibility is a measure of a measure of the ease with which the system functionality can be extended, as well as the scope for extension.

Driven by the desire to be seen as dynamic and innovative, or by the perception that their environment is unique, organisations tend to over-specify systems. The result is to inflate the cost of the initial system and the related customisation. Knowledge that the system they intend to deploy is extensible encourages pragmatism and spread the investment and deployment over a longer time period. This has the effect of reducing risk. First by minimising the initial investment. Second, by taking subsequent investment decisions in the light of experience gained during the initial deployment.

Like scaleability, extensibility of a PLM system also tends to be related to good underlying architecture. The following are good indicators of extensibility:

1. Support for a wide range of applications (both own and third party) - indicates an extensible data model and sound underlying infrastructure. It also indicates that the vendor has in-depth application domain expertise and therefore better able to provide quality support.

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2. Good customisation, integration and application development tools - indicates that the system is modular, extensible and can be integrated to third party systems. Such tools offer an alternative way to extend or add system functionality to those provided by the vendor.
3. Extensive and easy to use configuration tools - means a great deal of thought has gone into making tailoring the system easy.

6.2.3 Robustness

Robustness is a measure of the system's tolerance to errors or unexpected events in the normal operation of the system. Though it is difficult to measure, a few methodically carried out tests with illegal and/or inconsistent data can reveal a great deal about system robustness. In addition, there are a number of things that can give good indication of robustness. A systems with sound modular architecture is a good indicator, since modular systems are much easier to test than monolithic ones. Also unscheduled releases and patches are always an indicator of bad architecture and bad development practices.

6.2.4 Openness

Openness and “standard-based” terms are much abused terms. When asked about these, vendors often produce a long list of standards that they claim their system conforms to, giving the impression that “the more the merrier” is a good thing!

It is a fact of life that standards always lag behind what can be offered by proprietary technology. So the pragmatic approach is to select vendors who have a declared strategy for openness and who provide:

1. Effective interoperability and data exchange tools.
2. Published APIs
3. Third party development partnerships

6.3 Database management

The way database management is effected is critical as it dictates how the infrastructure interacts with the supported Business Applications. Currently, there are two fundamentally different approaches that make them suitable for some application domains but not others. One relies on 'Interfacing', the other on the 'Integration Platform' approach.

6.3.1 Interfacing approach

Interfacing approach, as depicted in Figure 6, enables the interfacing of multiple legacy systems but leaving each legacy system to manage its own database. At the centre, an interfacing application manages the dataflows between any number of 'federated' legacy systems. To add a new system to the federation, that system need only be interfaced to the central interfacing application. In this way, a user of any of the federated systems can access and navigate the data held in the other systems as if they were held in the same database

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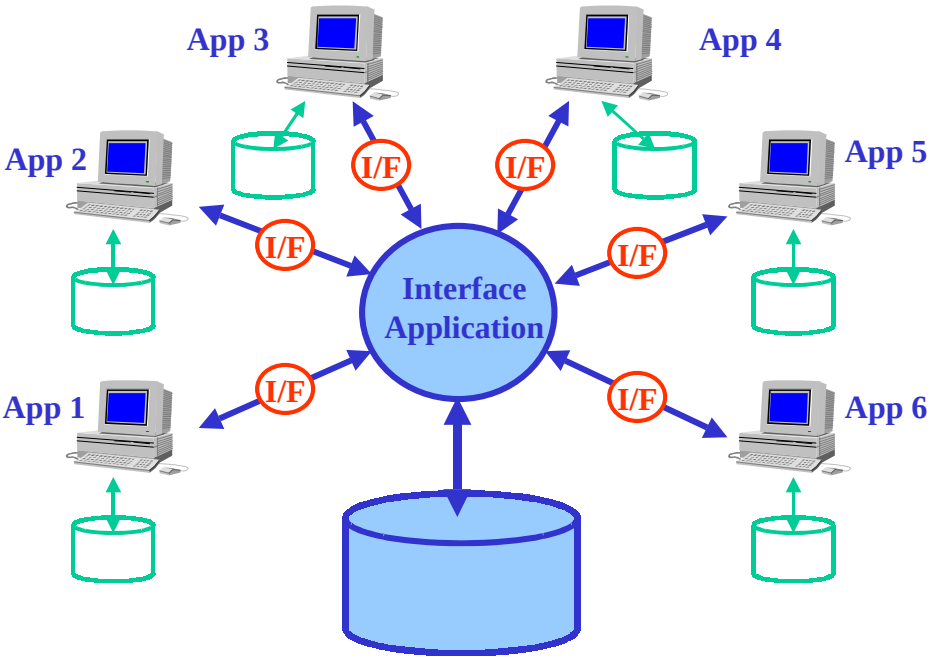

Figure 6: Interfacing approach

The interfacing approach has benefited from the emergence of the Internet and web technology which have removed the need for interfaced systems to be 'physically connected'. The different interfaced systems can now reside anywhere around the world, on virtually any platform. Furthermore, the 'federated' database can be accessed by users with a simple web browser, again from anywhere around the world - even from a PC and a mobile phone by people on the move. It is therefore ideally suited for quick visibility, quick implementation and with minimum disruption to existing processes. Examples of successful applications of this is in publishing and content management that aimed at 'consumers' of information.

On the debit side, interfacing has a number of limitations notably that there has to be a direct mapping (translation) for the shared data in each of the federated systems. This is not always possible particularly where data structures are complex or contain complex inter-relationships. For this reason typically only a subset of the data stored in each database is made 'visible' to users connected to the other systems. Furthermore, since each database is maintained independently by the system that 'owns' it, set rules have to be laid to establish which system owns the 'master' of each shared dataset. These rules are then used in the design of the interfaces. The result is that 'write' transaction can become unwieldy and complex.

In summary, while this approach is relatively easy and quick to implement and is effective for consumers of information, it is less easy and less effective for 'creators' of information, i.e. for authoring applications.

6.3.2 Integration Platform approach

This approach, as depicted in Figure 7, has a fundamentally different architecture to that of interfacing approach. It is also fundamentally difference from traditional PDM and document management systems where 'data' is managed to a 'document/file' level.

Here all Business Applications share a common database managed by an 'Integration Platform'. Because there is only one database, there is no need for interfaces and there are no translations related problems. Furthermore there are no write transaction related

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problems, as all the data is under the control of one system - the Integration Platform. In addition, not only can the Business Applications supported on this architecture interoperate seamlessly, but they also can share and reference data to low granularity.

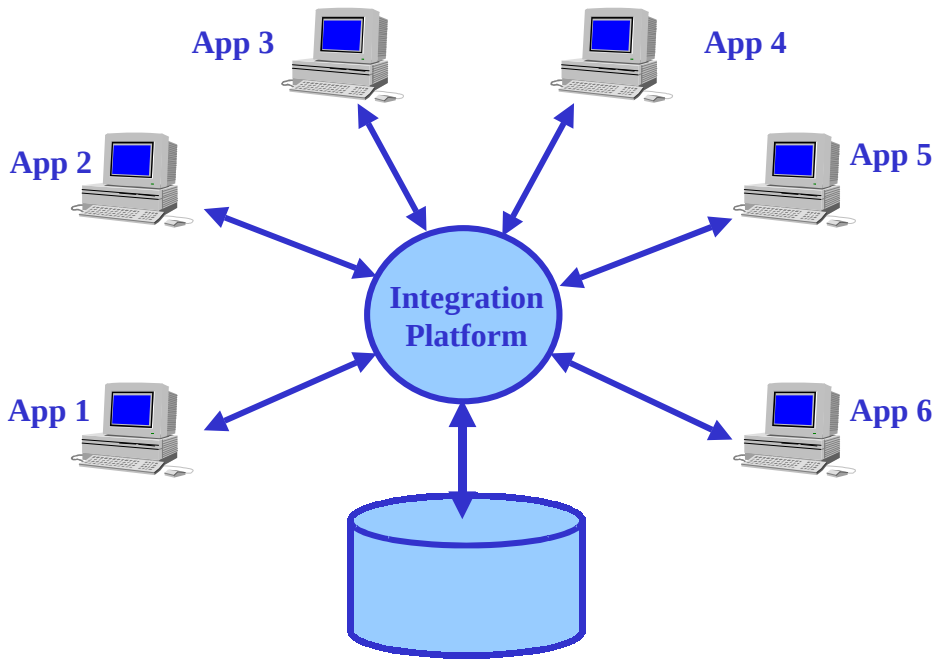

Figure 7: Integration Platform approach

The Integration Platform approach provides greater flexibility in establishing associativity and hence is more suited to handling complex data structures - an essential requirement for PLM. Indeed, this approach can handle, design, maintenance and other product data, process definition as well as meta data all in the one database. It can also handle complex audit trail and history information in a tidy and easily manageable way - also an important PLM requirement.

On the debit side, in order to gain the full benefit from this technology, as many Business Applications as possible have to be migrated to the new architecture. This implies the need for phasing out existing Business Applications and migrating their data. Though this is a one-off exercise, it can require extensive restructuring of existing processes. It also assumes that the technology provider supports/will support a wide portfolio of Business Applications on the Integration Platform.

6.4 Hybrid Approach

Clearly, as PLM technology matures, more and more Business Applications will be supported on the Integration Platform approach. However, while there is still a large number of legacy systems in operation, the Interfacing Approach will still deliver a valuable service. Therefore it is expected that an increasing number of vendors will offer both approaches for the foreseeable future.

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7. The future of PLM

7.1 User perspective

The days of point solutions are fast disappearing. PLM makes product information more visible as a coherent whole rather than bits and pieces spread over a plethora of incompatible systems. Thus, PLM can lead to better and more informed decision making, The potential for cost cutting, improved productivity and innovation is immense. So is the potential for pitfalls since decisions and actions will affect more people than before.

To get the best out of PLM, while avoiding the pitfalls, requires a fundamental change to new business practices. A change where strategy is developed centrally on a corporate level, while at the same time giving users flexibility and freedom at the local level. PLM technology, as described above combines these effectively with centralisation of the management of the CIC provided by the infrastructure, and local flexibility provided by the supported Business Applications.

7.2 Market consolidation

As PDM technology evolved from being departmental solution (typically for the design office), to one offering enterprise/extended enterprise solution, the size of PDM projects became bigger. This process resulted in market consolidation where some of the minor players were acquired by bigger players who were better positioned to handle bigger and more complex projects. The emergence of PLM technology, has led to the acceleration of this process, both in terms of project size and in the size of mergers and acquisitions.

As PLM technology matures, it is expected that of the 10s of remaining vendors who provided PDM systems in the past, only 3-4 will become suppliers of core PLM technology. The remainder, who remain independent will become providers of Business Applications. The most likely to make the 3-4 list of core PLM technology providers will be the current major players who also provide extensive CAx application suites.

7.3 More choice

Given the fundamental differences between the development of infrastructure software (which requires system development expertise), and Business Applications (which require application domain expertise), it is expected that vendors will eventually specialise in one type or the other. Furthermore, such development will open the way for a new breed of specialist developers of Business Applications that will use the core PLM technology of the majors as platforms for their software giving more choice from a wider range of application portfolios for the user community.

Indeed the specialisation can develop in a similar fashion to is currently seen in the aerospace and automotive industries. Figure 8 depicts a possible future scenario where the system foundation (infrastructure and development environment) is acquired from the platform developers who will be the 'OEMs' of the PLM industry; the Industry Solution will acquired from the 'first tier' developers; while Application Suites and Modules acquired from second and third tier developers. What little customisation remain will be developed, with the aid of high level scripting languages, in-house or by a new type of bespoke developers specialising on the specific PLM platform.

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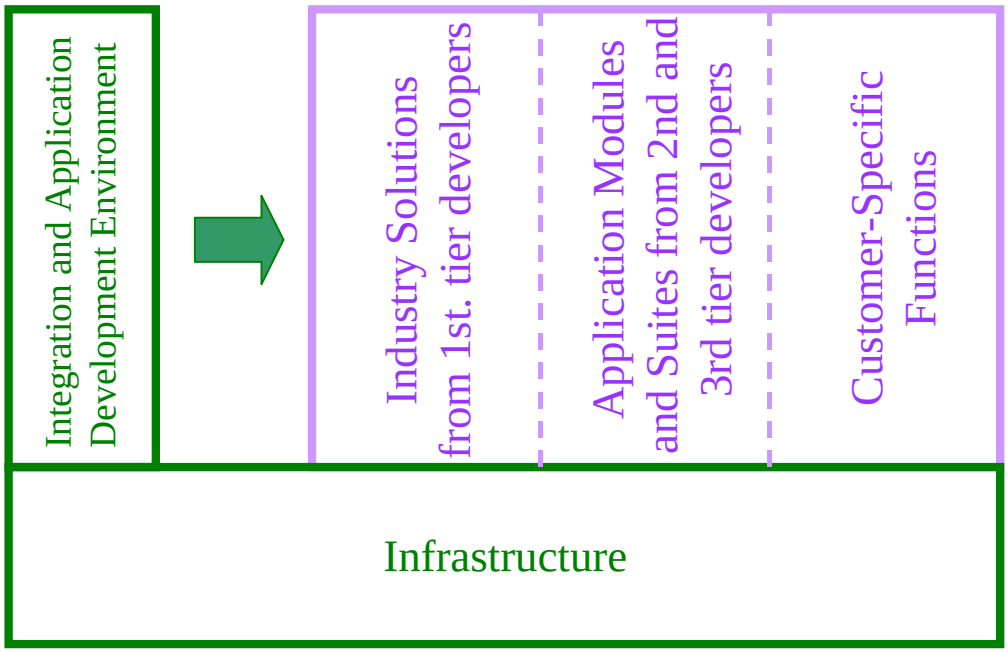

Figure 8: Plug and play application software

7.4 Wider scope for PLM

For historical reasons, PDM systems catered in the main for the engineering sector. This is still largely the case with PLM. However, because of the generic nature of what core PLM functionality can offer, PLM use is beginning to expand beyond engineering to other sectors such as the telecoms, utilities and pharmaceutical sectors. It is expected therefore that new PLM solutions will appear for new business sectors and subsets of these sectors, Figure 9.

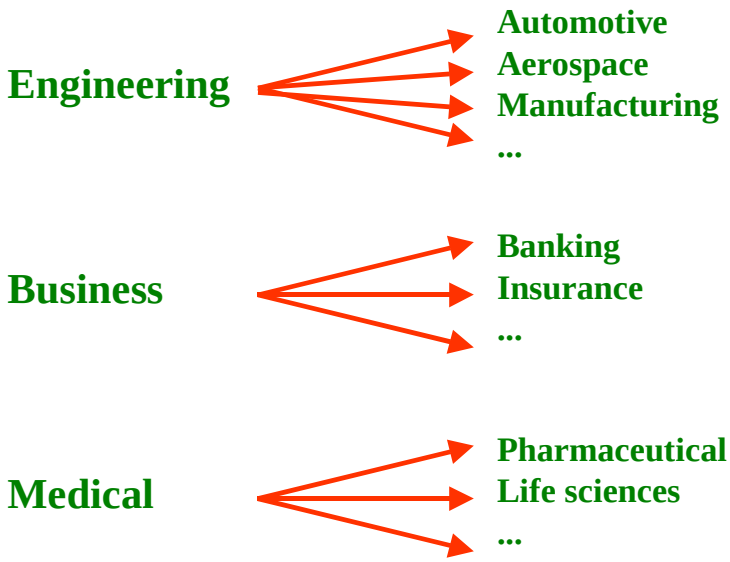

Figure 9: System specialisation for industry sectors and sub-sectors

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7.5 More innovation

Apart from the technological leap from PDM, PLM brings a new dimension to innovation. For the first time Corporate Intelectual Capital is managed as an integral whole, rather than bits and pieces locked in different non-interoperable systems. In addition to the new breed of specialist software developers mentioned earlier in this section, there will be new groups of innovators who specialise in capturing best practice and turning it into reusable templates for creating next generation products. This will enable the invention of much better wheels rather than re-inventing old one!

7.6 Estimating market size

With PLM and its role clearly defined, it would now be much easier to estimate market sizes. Unlike in the past however, there will not be one market size figure, but a number of figures. One for the core PLM and any number of figures for Business Applications that may be classified according to packaging, type or industry sector.

8. Abbreviations

The following is a list of abbreviations used in this document:

1. CAD Computer Aided Design
2. CAE Computer Aided Engineering
3. CAM Computer Aided Manufacture
4. CAx Computer Aided Technologies, covers CAD, CAM, CAE, etc.
5. CM Configuration Management
6. CPC Collaborative Product Commence
7. CPD Collaborative Product Development
8. CRM Customer Relation Management
9. MRO Maintenance, Repair and Overhaul
10. PDM Product Data Management
11. PDM II Product Development Management
12. PLM Product Lifecycle Management
13. PM Programme / Project Management
14. WF Workflow
15. SCM Supplier Component Management

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