Plant Information Management

A White Paper

Process, Power & Marine, a division of Intergraph

INTERGRAPH

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1. Objective

There are three simple reasons for strategically investing in Plant Information Management (PIM):

1. **Reduce time to market (TTM)** – Design and construct the plant asset within budget, while avoiding schedule slippage and operating at capacity to meet market window of opportunity.
2. **Maximize time in market (TIM)** – Mitigate unplanned outages and delayed startups, optimize planning for engineering turnarounds, and prevent safety, hazard, and regulatory risks, which would otherwise halt production.
3. **Optimize operating parameters (OOP)** – Make the most of that which you have least (time, resources, and schedule) to gain more of the things you want (throughput, safety, and profit).

2. Executive Summary

Each of the above-mentioned objectives will mean something different to you, depending on your role, your organization, and where in the plant life cycle you operate. You will certainly use different information types, sources, and systems. But one thing is certain – all of these differentiators are similarly affected by the highly interrelated and interdependent, volatile, and distributed information that is plant information. How you manage this information in totality or within your domain specifically is the single greatest business differentiator.

"Virtually everything in business today is an undifferentiated commodity except how a company manages its information. How you manage information determines whether you win or lose." − Bill Gates, Microsoft

Research findings from a number of independent studies have drawn similar conclusions as to the benefits of managing plant information:

- POSC/Caesar for Better BUSINESS, SUMMARY REPORT, Prepared by: Coopers & Lybrand Consulting ANS, Oslo 20.10.97.
- Guidelines for Specifying Integrated Computer-aided Engineering Applications for Electric Power Plants. Electric Power Research Institute (EPRI) report NP-5159M, Research Project 2514-3, May 1987.
- Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry, Prepared for National Institute of Standards and Technology (NIST), report GCR 04-867, August 2004.

The first report analyzed the benefits that accrued from managing information for offshore oil and gas installations through the plant life cycle. When viewed holistically, an operator could reduce the whole life cost of the asset by 10 percent. Within specific life-cycle phases, the following was achievable:

- Reduce 10-30 percent of concept development time
- Reduce 15-28 percent of engineering hours
- Increase 30 percent engineering productivity
- Reduce 10-30 percent cost of quality and change management time
- Reduce 15-20 percent commissioning engineering hours
- Reduce 60 percent handover and startup costs
- Reduce 10-20 percent IT costs
- Reduce 10-20 percent operational costs

The second report for the electric power plant industry compared the benefits of "integrated information" to that of "automation tools." This refers to the development and management of power plant assets where automation pertained to computerizing data and tasks for use within a single activity or department and integration pertained to computerizing data transfer among multiple activities, departments, or companies.

One of many examples cited was that of "Relative Annual Savings from Automation and Integration at an Average Nuclear Power Plant," which found:

Data Set Savings	Automation Savings	Integration Savings	Delta x Increase in Savings Between Automation and Integration
Equipment Tagout	$69,000	$124,000	1.79x
Valve Index	$21,600	$167,600	7.76x
Instrument Identification	$17,800	$135,100	7.59x
Motor Index	$15,200	$123,100	8.09x
Piping Index	$12,000	$84,400	7.03x
Action Request	$12,100	$44,200	3.65x
Commitment Tracking	$5,000	$14,900	2.98x
Circuit Breaker Index	$5,000	$37,700	7.54x

It can be concluded that the advantages of integration are significantly greater than those from improving the productivity of the individual tools by automation.

This paper goes on to describe the effect on reliability, availability, and maintainability (RAM) by reusing the data more than once in other activities. The numbers get progressively larger, particularly when taking into account potential loss of revenue from outage or external resources involved in incident investigations and industrial safety. For example, equipment valve specs and associated activities − including performance monitor, performance analysis, reliability assurance, reactor safety, incident investigation, industrial safety assurance and analysis, valve/valve operator maintenance, maintenance procedure development, equipment history analysis, operational procedure development, emergency operations, and operating experience evaluation − yielded an annual cost savings of $8,071,275 alone (in 1987)!

While it is true that the two reports concentrate predominantly on the owner operator (O/O) in one specific industry (oil and gas in the first report and power in the second), the third report broadly covers asset construction in the continental North America and includes engineering, construction, suppliers, and O/Os. The NIST estimates that $15.8 billion in profits is lost in U.S. capital facilities every year. Most of these losses, ($9.1 billion or 2.8 percent of total installed cost), are realized in the operations and maintenance phase of the asset life cycle, while $2.7 billion and $4.1 billion are realized in engineering, procurement, and construction (EPC) phases respectively.

It is clear from the report that again the O/Os bear the brunt of the costs ($10.6 billion or 3.3 percent total installed cost) associated with poor information management (in this case interoperability) due to supply chain dynamics and duration. With proper incentives for their information supply chains, O/Os have the most to gain.

- 45 percent of costs are associated with operations and maintenance information verification
- 15 percent of costs are associated with unnecessary operations and maintenance idle employee time
- 40 percent, the balance, is an assortment of work process inefficiencies
- Though NIST's study was limited to the U.S., these opportunities are applicable to the rest of the world

For the information supply chain, the cost of doing business is extraordinarily high. Losses include architecture/engineering ($1.2 billion), general contractors ($1.8 billion), and perhaps most surprisingly of all, suppliers ($2.2 billion) as the quotes below testify.

- $15.6 million in post-construction redundant information transfer costs were calculated between architects/engineers and O/Os.
- The consensus among general contractors is that seamless electronic information management and exchange would permit them to compress their schedules by an average of 7.5 percent (as with architects/engineers, more efficient resource utilization due to acceleration is not included in the cost estimates).
- According to specialty fabricators and suppliers, fully electronic, interoperable design and business support systems would compress their schedules by 5-10 percent.
- 85 percent of O/Os' interoperability costs are incurred during the operations and maintenance phase.

The conclusions one can draw from these reports include:

- There are significant gains to be made across the whole life cycle, but the breadth of application sources, range of information types, classes of organization, and types of user and business processes would challenge the traditional "point solution" approach (classes of system required to solve these life-cycle issues need to be extensible).
- Companies have automated individual task processes and are looking to integration in all its forms as the next level of business benefit. Integration will bring other challenges that are not wholly technology oriented since data flows across business function boundaries. Integrations will require you to understand the inputs and outputs, customers, and suppliers (both internal and external).
- There is no right or wrong time to start and no problem too big or too small to benefit, but keep the big picture in mind when starting to deploy a solution. If there is one thing that is certain, the business constraints you find yourself in today will not be the same tomorrow. Therefore, deploy within the bounds of what you know today and plan for where you want to be. Be pragmatic and evolutionary.

3. Business Strategies and Tactics

These are troubling times for executives determining strategies and tactics for their organizations. Gone are the safe, traditionally competitive, resourceful, and technological advantages of the recent past. Being "lean and mean" doesn't cut it any more (most organizations are skinny and hard already). Competition is global. The days of the vertical, self-sufficient organization are becoming numbered as specialist organizations appear on the Internet as if from nowhere to bid for plant assets being deployed in ever-more remote and cost-efficient locations. Where "saving money" is almost a slow way to go out of business, making money is the only way to survive (obvious, but true). So, what issues, strategies, and tactics are prevalent today, and how does a PIM strategy play a part?

3.1 Engineering, Procurement, and Construction (EPC)

Most of the focus on PIM technologies to date has been aimed at the O/Os since they have the most to gain financially. Technologies, such as data warehousing, integration with enterprise resource planning, and operations systems, would seem to offer little to the EPC − having a project and the data only for a relatively short duration. However, for the EPC, PIM is being linked to strategic business expansion, and in some cases, survival, in an increasingly competitive and complex marketplace.

The days of the centrally organized, vertically integrated EPC are becoming numbered. Dealing with globalization is probably the number one issue, but even this comes in a number of flavors as indicated below.

3.1.1 Low Cost – High Value/Distributed Engineering

A PIM strategy is seen as a way to distribute the engineering between remote, low-cost centers where control of the project and data are seamlessly distributed and do not rely on the traditional file transfer methodologies of the past. Therefore, the PIM should overarch the departmental and discipline tools, integrating data between disparate tools, providing remote access and improving decision making. This "distributed engineering" strategy combats the "commodity Internet engineering boutique," developing in remote locations, allowing the EPC competitive pricing.

3.1.2 Acquisitions and Right-sizing

Growth by acquisition or rightsizing is an opportunity and also a challenge. Clearly, EPCs are seeking opportunities in remote locations to extend their reach and capability. However, replacement of tools, technologies, and processes at the acquisition may destroy what was their competitive advantage. In this scenario, a PIM strategy by the acquiring EPC is viewed as a systems and process wrapper to the acquired company, leaving intact as much as possible the best of the company, while assimilating it into the greater organization to allow for overall control and management.

3.1.3 Collaborative Partnering and Complex Execution

Very few major projects these days are sole source. The value chains are becoming long and complex. A PIM strategy is seen by EPCs as a way of neutralizing and controlling data that passes over the boundary between the partners. In this way, common systems and processes do not necessarily need to be deployed by the project partners, and control is still maintained.

3.1.4 Communication

Time, cost, control, quality, integrity, and decisions are all major factors in global execution projects. A PIM strategy that incorporates messaging, workflow, and tight application integration is seen as an effective way of communicating between disciplines, departments, and project partners.

3.1.5 Knowledge Acquisition, Retention, and Intellectual Property Rights

Attracting and retaining new talent to the EPC business is difficult when the industry is not seen as a leader in deploying innovative, cutting-edge technologies. And as EPCs leave − as an aging and contract-based, mobile workforce – so too does the inherent knowledge. A PIM strategy is seen as a mechanism to capture, retain, and reuse valuable knowledge not only for future use, but also to remain competitive.

3.1.6 Business Process Integration

The age of automation is done. The age of integration and interoperability is underway. EPCs have deployed automation tools, and an extra mouse-click savings here or there is not going to significantly affect the bottom line. The integration and workflow capabilities of a PIM strategy is seen as a way to improve the speed of decision flow through the business, reduce potential for errors, and as such, mitigate risks in execution.

3.1.7 Homogenous, Heterogeneous, and In-house Tools

Some EPCs have selected their primary design tools from one single software vendor. Some have selected best-of-breed tools from multiple vendors, and some have developed their own in-house specialist tools to encapsulate their competitive advantage. In any case, integration and interoperability − not automation − are seen as the next competitive differentiators. PIM is a critical component as EPCs right size their in-house development and support activities focusing on standardized, repeatable projects and integrated information deliverables (to the operator).

3.1.8 Value-added Service Extension Opportunities

Some EPCs are looking to partner or take over traditional business functions from operators as a way of extending their own businesses. Therefore, the integrity and quality of information is thrown into even sharper focus. A PIM strategy, in conjunction with the operator's own

information management practice, is seen as a way to mitigate risks and losses from such a potential long-term engagement. Indeed, some EPCs are even considering the potential for partnering with specialist application service provider or data center providers to offer the operator managed engineering information provision and update services.

3.1.9 Competitiveness

Of course, every EPC is looking to competitiveness. However, the ability to win more projects and execute with the same amount of resources is distributed. Whether these projects are fixed price, time/materials, risk-reward, or any combination, a PIM strategy is seen as a way to manage and control risk, improve productivity and efficiency, and reduce cost − not only the cost of the customer's asset, but also internal operating expenditure) – "to do more with less."

3.2 Suppliers

Somewhat surprisingly in the NIST report, suppliers were subject to significant lost opportunity and resources through poor integration and interoperability. However, this does not manifest itself in the same way as the above EPCs' integration and interoperability issues. Primarily, this is through integration and interoperability with the value chain or sharing/exchanging information with EPCs and O/Os. In many occasions, the exchanges between specifier, purchaser, and operator are long and torturous, with many re-keying activities exposing the opportunity for confusion, mistakes, and risk. There is also little opportunity for identifying economies of scale and rationalization without a holistic information strategy integrated with the EPC and the O/O's own information management strategies.

For example, typical plant equipment from the same supplier/vendor may be purchased by a number of different parties. Unless the supplier is integrated into the exchange of data, many redundant copies of the same information is exchanged and stored. Additionally, there is little opportunity to rationalize spare and other consumable inventory. In discussions with many suppliers, they indicate that the cost of purchasing could be reduced by as much as 10 percent if they were part of the process and not an adjunct to it. Many suppliers are looking to PIM strategies as a way of increasing the efficiency and integrity of information exchanges between themselves, EPCs, and O/Os as a way of reducing their costs and improving their competitiveness.

3.3 Owners

Many owners are mistakenly referred to as O/Os when in many cases they may or may not have a separate operations organization. At one time, many owners were vertically integrated, providing the full scope of business services. Many completely outsourced their engineering and operations functions, but increasingly they are resuming these activities, realizing they fundamentally affect the total cost of the final product, and therefore, cannot be outside their sphere of control.

3.3.1 Reduced Time to Market (TTM)

Integration and interoperability (not automation) are seen as key to reducing time and cost to market. For an owner, being able to readily participate in the design and construction process, collaborating without the need for specialist tools at the desktop, or intruding on the EPC's business (hence, containing cost and potential delay) is seen as a primary use of PIM technologies.

3.3.2 Holistic Assets

More business managers are identifying that CAPEX and OPEX cannot be separated. Simply bringing a plant on stream at the most reduced cost can be highly successful for the short-term CAPEX project manager, but can inadvertently load the cost of operations and add to the cost of the final product. Many owners are assessing PIM for whole-life strategies, not only simply to get the asset operating within schedule and on budget, but also to reduce its whole life operating cost by as much as 10 percent.

3.3.3 Outsourced vs. Insourced Engineering

The final cost of the product to market is largely dependent upon the efficiency of the process being used to produce it. Many owners have developed proprietary processes and techniques for efficient and high-quality production. But without necessary in-house engineering expertise, they lack the resources to effectively scale up and deploy. In outsourcing, they run the risk of losing control of intellectual property rights and competitive advantage. Many are looking to PIM strategies as a way of regaining control and privacy of intellectual assets through a distributed, outsourced, but secure value chain.

3.3.4 Partnering and Acquisitions

Assets are bought and sold, but how many know the true operating conditions before the acquisition is complete? Often an expensive "plant walk-down" is the only way to get the true picture. Additionally, many owners do not wish to impose corporate systems and processes to burden an operator with technology swap out and retraining. In these instances, a PIM strategy is seen as providing a technology wrapper or interface between the operator and the owners' corporate systems.

3.4 Operators

3.4.1 Extend Time to Market (TIM)

Often brought in too late to affect the base operating cost parameters of an asset, operators seek to maximize production opportunity; reduce bottlenecks to enhance throughput (are unable to wholesale replace equipment and need to); make it as reliable as possible; and optimize maintenance and engineering to reduce turnaround time. PIM is viewed strategically as a mechanism to continuously load operations systems with quality data and/or provide access to

cross-functional information not normally held online in operations systems, which improves decision making.

3.4.2 Regulatory Compliance and Remediation

In industries that document everything, locating, cross-referencing, and managing the change of content is burdensome with traditional document management techniques. Many operators are concluding that the content and configuration management capabilities of a PIM strategy are more effective than 'container' management strategies. Indeed, as regulators seek to become ever-deeply engaged with operators, effective collaboration and security cannot be accomplished with a traditional document exchange strategy. A PIM strategy is also seen as crucial to maintaining the configuration between design basis, license basis, and operating basis.

3.4.3 Abnormal Situations Management

No one likes to pay for insurance, but planning and dealing with the unexpected can be the difference between profit and loss for an operation. To do so requires operators to have access to the full spectrum of plant information − not just the normal day-to-day transactions − in a controlled and easily navigable paradigm. A PIM strategy assists operators in preventing the cost and risk of shutdown, unplanned outage, and potential hazardous situations by providing users cross-related information for decision support and impact analysis.

3.4.4 Reduced Handover and Startup Time

Initial project/asset handover and any turnaround or unplanned startup demands access to accurate information to avoid costly delays for mechanical completion, commissioning, and operations systems qualification. Increasingly, a PIM strategy is being seen as a way to harvest and neutralize data from multiple source systems, consolidate it for new applications, and convey to operational systems.

3.4.5 Safety, HAZOP, Environmental, and Security

Failure in any one of the areas of safety, HAZOP, environmental, or security has serious repercussions. Rapid access to the latest, approved information, controlled warnings of potential changes, and the ability to "look beyond the bounds of the discipline" are often critical to enabling a balanced and authoritative decision. This cross-functional, interrelated data is a primary component of a PIM strategy.

3.4.6 Cross-plant Optimization

Many operators have multiple facilities, trains, or even plants producing similar products. Often, optimizing strategies that have yielded significant benefit are unable to be shared across the enterprise because there is not a common PIM strategy for identifying and exposing this knowledge (or it is hidden within documents).

4. Plant Information Strategies and Tactics

So where does one start with a PIM strategy? First, look at the big picture – all the potential possibilities. Then, become very granular. Look for one application or problem area in the business that can immediately benefit from applying information management techniques. Next, look to adjoining opportunities where extensions to what you already have is easier to justify and deploy than reviewing a myriad of point solutions and trying to integrate them.

To accomplish this, let us first start by introducing you to Intergraph's vision for PIM followed by some examples of applying these technologies to solve typical information management problems. This is by no means an exhaustive list of possible scenarios, but it will give you an idea of the possibilities to help you define your own strategy.

4.1 SmartPlant® Foundation – The eEngineering Integration Hub

SmartPlant Foundation (SPF) is Intergraph's eEngineering Integration Hub. Why do we say eEngineering Integration Hub? First, SPF was not designed specifically to be "the" corporate information portal or corporate "generic" document management system, nor was it designed in any way to compete with the existing capabilities of enterprise resource planning and other line-of-business systems.

SPF was primarily developed:

- For the consolidation, aggregation, configuration, distribution, and change management of engineering information (data, drawings, documents, models, etc.) across multiple sources
- To establish and manage an ever-changing, holistic, highly interrelated, high-quality/integrity, and object-oriented digital representation of a plant to ensure consistency, validity, and accuracy
- To provide a "single source of truth" for engineering activities and a "source point of access to the truth" for non-engineering activities (e.g., access to non-engineering data for engineers and access to engineering data for non-engineers)
- To support engineering over the plant's entire life cycle irrespective of the multiple tools that will come and go during this extended period

In doing so, we require integration in all its forms, including data integration, application integration, business process integration. Through this, we replace the mass of point-to-point systems integrations with a hub, distributing and feeding high-quality engineering information − not only between engineering systems, but also to and from operational, maintenance, and planning systems that require to be fed with engineering data.

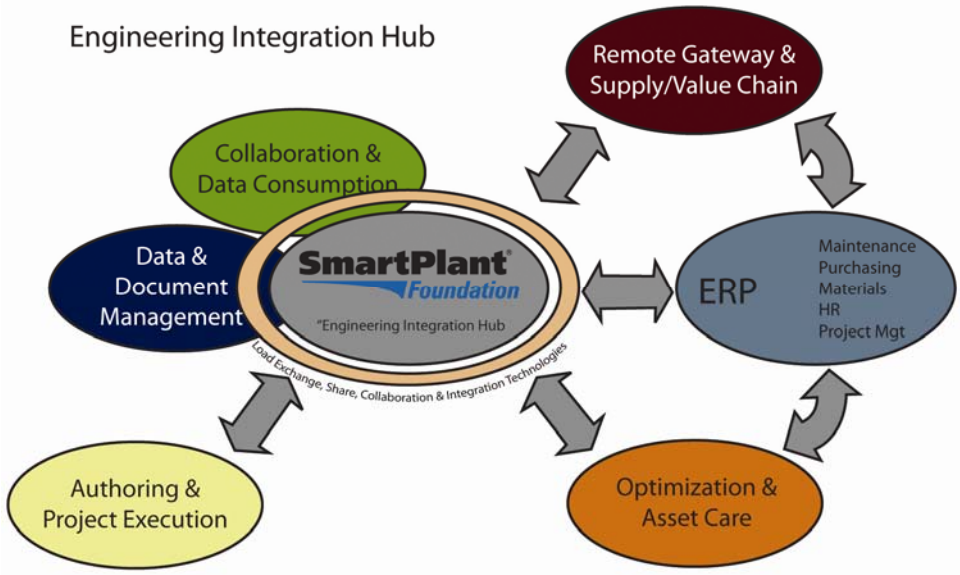

Figure 1: *eEngineering Integration Hub*

As you would imagine, this is not an easy domain for SPF to occupy, and many organizations have already tried to assemble their own capability. Arguably, it has not been possible until now to fulfill simply because the right mix of components either did not exist or were too costly to assemble.

For instance, a number of these examples include:

- Maturing and acceptance of relevant engineering data warehouses and information exchange
- Interoperability standards, such as ISO15926 and ISO10303
- Technologies needed to normalize, neutralize, map, and transform data for export and import accordingly
- XML for federated data schema design and data transport
- Enterprise application integration technologies, not only traditional API and ODBC connections, but also Web Services and service-oriented architectures supporting application interoperability
- Web technologies, such as portals for access and browsing independent of the source application
- High-performance viewing of complex drawings and models across both high and narrow band networks
- Security and encryption technologies to protect the intellectual asset

5. Tactical Applications of SmartPlant Foundation (SPF)

Using the above capabilities, SPF has established the largest and continuously growing customer base within the power, process, and marine industries. Our customers have duly considered the "big picture" – where they want their businesses to be − and are now deploying SPF at a variety of starting points or tactical applications. Some of which are indicated below.

- Be an engineering data warehouse, a clearing house for the capture, cleansing, and consolidation of data, drawings, documents, and all manners of interrelated engineering information for handover purposes, either download or upload.
- Be an information bus or framework between engineering applications that requires complex negotiable transactions between software products from multiple vendors to drive out engineering inconsistencies. Some might call this product data management, engineering data management, engineering document management, knowledge management, product life-cycle management, workflow, etc. There is an element of each.
- Be a portal for collaborative applications that consumes, shares, and utilizes this aggregated pool of high integrity and related engineering data. Applications, such as construction status visualization and commissioning and completions, replace formerly standalone applications that were initially inexpensive to acquire but costly to populate with engineering data.
- Be an engineering companion to plant enterprise resource planning and plant operation and optimization applications, such as maintenance management, reliability-centered maintenance, and digital control systems, providing clean engineering data as it is approved. Provide decision support to operations staff for engineering-related queries. Manage and maintain the different information associated with the original design basis, the operating or as-built basis, and the licensing and safety basis to ensure all parties obtain the engineering information they need − whether engineers, maintainers, operators, or inspectors.
- Be a supplier gateway not for financial but for technical information, posting technical requirements, and receiving design and engineering characteristics as well as documentation. In other words, be the engineering data broker between the supply chain and the engineering-authoring applications. And when approved, upload the consolidated equipment masters and bill-of-materials for purchasing, spares, and inventory management and provide the link back to the source requirements and delivered documents for future reference. Also, reduce traditional volumes of duplicate information distributed from suppliers to one single copy pointed to from multiple locations.
- Be a hub for plant-centric and engineering-related applications, such as live safety case and lockouts, competency assessment and permits to work, abnormal condition engineering, plant configuration and BOM/inventory control, cross-plant performance analysis, quality and environmental auditability, scheme feasibility and cost evaluation, process isolations, and so forth.
- Be a collaboration hub or document control hub for joint venture partners working on the same project and needing to collaborate and share information while preferring to deploy their in-house optimized and potentially dissimilar applications. In addition, be a hub for joint venture partners needing to isolate their operational systems not only to control change, but also for security and intellectual property reasons.

- Be a client or even a regulatory authority (such as FDA) review portal, consolidating and linking released information from multiple sources and providing remote access for easy navigation, discovery, viewing, review, decision support, analysis, and approval via the Internet without the need for any of the source applications at the reviewer's desktop.
- Be an overarching "change impact analysis" and "management of change" system. Each of the island applications may have workflows attuned for change within their own application domain, but the most costly changes to control and manage are those that overarch these applications, disciplines, and departments, particularly where many are running concurrently, affect the same plant objects, and as such, are in different states simultaneously. Traditionally these program management activities have been costly to perform, provide little visibility of the current status and projected risks, and leave alone any associated contractual commitments and changes, which invariably are difficult to resolve at conclusion.
- Be a hub for program management, intersecting the work breakdown structure (what we need to complete) with the project plan (when we need to complete it) and the status from deliverable completions in SPF (the state of what we have completed), enabling project controllers to get a rapid and accurate view of project status (also known as program management).
- Be an engineering document management and document control system. While it is possible to integrate and utilize existing document management systems, since there is such a high degree of relationships between the documents/drawings and data, it seems natural to utilize the same engine for data management as well as document management. In doing so, utilize it for a new breed of document control applications, such as release management, progress (program management), transmittals, and receipts − the core functions of which are the same as those found in some of the previously mentioned applications.

Aside from the application examples above, there are also many other opportunities that could potentially be realized from an integrated PIM strategy. For example:

- Think of all those cross-functional questions you cannot ask today because the information is in silos.
- Consider the value of audit/traceability to be able to find out who, what, and when − if something unplanned occurs.
- Ever experienced trouble tracking down a problematic piece of equipment?
- Ever had the same problematic piece of equipment appear on the next plant because site problems were never passed back into design engineering?
- Have you always wanted to "set the clock back" to a point to in time before the incident occurred to view all of the information people had on hand at the time?

In other words, a whole breed of new applications that can mine and act on a consolidated, high-quality data source can be realized from an integrated PIM strategy.

5.1 SmartPlant Foundation (SPF) Technology Strategy

Traditional technical databases, engineering databases, and data modeling (employing data models expressed in tables [with rows and columns], foreign keys, joins and views, and an application hardwired to updating the data model) do not lend themselves to *lifetime PIM*. In

these traditional types of environments, it typically demands that you define extensive data modeling, integration points, and interfaces before data is generated, thus having a placeholder for the data before it is created.

However, at the commencement of a project, little time, resources, and funds are available for such an activity. Typically, as a result, high-quality data models are never deployed in time. The data model becomes fixed too early and is inflexible to change, or the integrity of data deposited is called into question. Furthermore, integrations either do not happen or do not happen at the required level of granularity, and correlations and consolidations of data from multiple applications do not occur, resulting in inconsistent data. When proprietary data is received from a partner late in the project, there is little opportunity to include it within the data set. And this does not take into account the vast quantity of data (sometimes of questionable integrity and often with multiple duplicates) received from vendors and suppliers.

What is required for such a lifetime technical database is that it is:

- **Generic and flexible** – Applicable to unlimited types and formats of data, irrespective and independent of application and usage
- **Extensible and soft-coded** – The data model is data driven, self-describing, and grows with the addition of new data
- **Interoperable** – Capable of managing highly interrelated and highly interdependent, ever-expanding data types and sets

This allows the PIM technology to be deployed as early as possible by the plant designer. It eliminates the need for lengthy pre-project data model development. It allows ongoing addition and adjustment, data integration, and turnover of a consistent, stable data set to the plant operator. Such are the goals of Intergraph's SPF PIM system. The system:

- Uses non-specialized, commercially available hardware for servers and clients
- Communicates via industry-standard and secure Ethernet protocols and Web messaging
- Features a commercially available relational database and Web server technology
- Encompasses an extensible, generic, and data-driven data model
- Organizes interrelated, structured data and documents within an integrated plant data model
- Renders file formats for long-term storage or as neutral forms for remote viewing such that the source application is not required at the remote location
- Supports state, status, version, revision, and configuration management with temporal attribution
- Exposes the data and documents used throughout the design process for other tasks, such as construction sequencing and status visualization, mechanical completions and commissioning, and maintenance and operations

Commercial turnover of the information from the plant designer to the plant owner should also not be viewed as a one-off activity. The PIM system should be an evolving entity with value to the plant owner from day one of deployment. Its content and latent knowledge capacity should be made securely available to engineering, construction, operations, maintenance, and regulatory parties alike − either locally or remotely − without the need for the source technical application on the desktop.

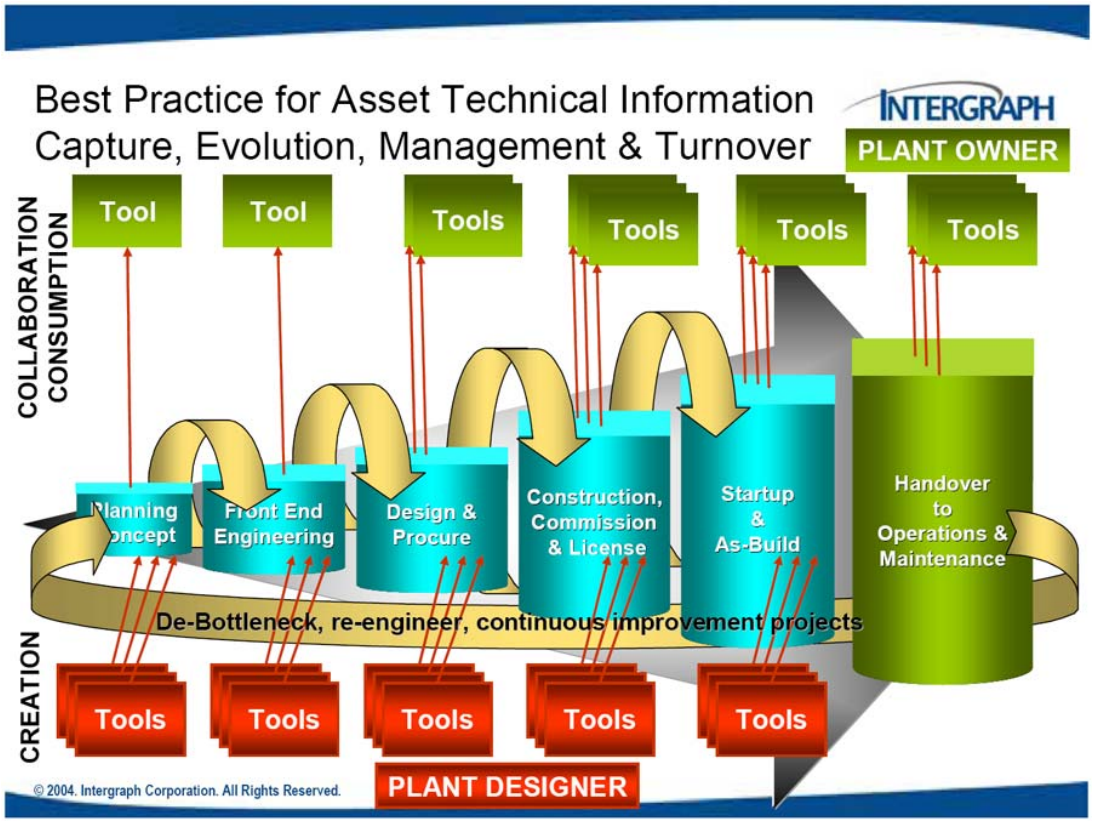

Figure 2: *Best Practice for Asset Technical Information Capture, Evolution, Management, and Turnover*

The above evolutionary and continuous information turnover is a capability of SPF. This capability is delivered by a number of discrete functions, including:

- Dynamic, extensible, data-driven and flexible data model, which allows it to evolve over the life of the plant
- Neutralized and normalized data (converted from proprietary formats) stored for remote access (i.e., streamed media) or delivered to populate plant owners'/regulators' tools
- Secure, Web-accessible, and requiring non-specialized, mainstream computer equipment designed for longevity

6. Plant Information Management (PIM) in Practice

Many of the world's leading process, power, and offshore companies are beginning to realize the true value of their plant engineering information. This section provides descriptions of current and ongoing information management projects that some of our customers have undertaken and also describes the current and future benefits of the projects.

6.1 Chiyoda Corporation, Japan

Global Information Management and Project Engineering Solution

Company and Project Background
Chiyoda Corporation is one of Japan's premier EPC and facilities management service firms. Chiyoda and Intergraph signed a long-term contract for implementation and development of global information management and project engineering software. Under terms of the agreement, Intergraph and Chiyoda work to further refine EPC requirements within Intergraph SPF. Intergraph uses Chiyoda's internally developed i-PLANT21 system as a knowledge resource for these additional EPC requirements.

How SPF is Being Used

- Chiyoda employs SPF as its worldwide project-engineering document and data management system and uses it for the integration and workflow management between applications.

Volumes/Types of Information Managed

- Document management is applied to documents and drawings for design and construction in addition to vendor prints. These documents are delivered with transmittal and progress management.
- Data management is applied to almost all engineering information, which is exchanged and shared between various disciplines, subsidiaries, vendors, and plant owners. This information includes instrument index, line list, equipment list, process datasheet, specification sheet, and so forth.

Benefits

- SPF comprises a single, commercial off-the-shelf (COTS) solution to support Chiyoda's worldwide projects, while reducing cost and improving engineering.

The resultant system helps Chiyoda maintain its competitive edge and continue to successfully deliver complex projects through improved collaboration with all stakeholders, while better serving plant owner demands for delivery of integrated life-cycle information systems.

6.2 Hyundai Engineering Co., Ltd., South Korea

Engineering Data Management Solution

Company and Project Background

Hyundai Engineering Co. Ltd. is a leading EPC firm in South Korea. A long-time user of Intergraph applications such as Plant Design System (PDS®), SmartPlant P&ID, and SmartPlant Instrumentation, Hyundai had planned to develop in-house applications for line list management (LLM), vendor data management, nozzle management, equipment loading data management, hydraulic calculation data management, and pre-commissioning data management. However, after evaluating SPF's capabilities and best practices, they elected to use SPF for their data management applications.

How SPF is Being Used

- In 2003, HEC completed development of standardized list managements for line, equipment, instrument, and valve data management based on the SPF BO model, and currently, they are applying to the power plant project.
- In 2005, HEC started to develop SPF SO model-based LLM and is planning to apply them to real projects in 2006.
- In 2006, HEC is planning to apply The Engineering Framework (TEF) Adapters for the data integration between SmartPlant P&ID and SmartPlant Instrumentation.

Volumes/Types of Information Managed

The plan includes the management of:

- Piping, equipment, and instrument data
- Engineering information spreadsheets
- Project-related documents

Expected Benefits

- Improved capabilities in executing global projects
- Optimized and controlled engineering work processes
- Built-in best practices for key work processes and overall flexibility

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6.3 Murray & Roberts, South Africa

Engineering Database Solution

Company and Project Background

Murray & Roberts Engineering Solutions is a prominent South African engineering contractor that provides world-class multidisciplinary project implementation services to a wide variety of local and international clients. They had a requirement to replace an existing in-house database with an integrated, data-centric database that would serve as a central data hub.

The project entailed the creation of a SPF-based engineering database to form the central engineering data hub for forthcoming Murray & Roberts' projects. The SPF project consists of four phases.

How SPF is Being Used

- SPF serves as the engineering data warehouse. All engineering reports (equipment list, datasheets, etc.) are issued from the data warehouse. The workflow facility is used for

design review, approval, and sign-off. The document control module is used for all project document management.

Benefits

- Single point of data entry
- Reusable and standardized data
- Improved accuracy and quality
- Improved risk management

6.4 The Dow Chemical Company, USA

Integrated Engineering via SmartPlant Foundation's (SPF) Engineering Framework

User Company Background
The Dow Chemical Company serves customers in more than 170 countries as well as a wide range of markets. It engineers more than $1 billion (U.S.) in capital per year.

The Dow Chemical Company's Goals
The primary goal is to reduce costs and improve design quality on all its capital projects. Other specific goals include decreasing the time required to plant startup and operation, ensuring regulatory-compliant projects, and improving asset utilization through effective access to plant design information.

How Intergraph's Information Management Solutions will be Used
The Dow Chemical Company is working with Intergraph and Aspen Technology on its Global Project Methodology Automated Improvement Project (GAIP). This project, which started in 1999, is expecting to pilot the complete application toolset in 2004, and begin global implementation soon thereafter.

GAIP is focused on managing and integrating engineering information across the plant life cycle. SPF's engineering framework provides information management, information access and reuse, and defined workflows. Intelligent applications include AspenTech's Aspen Zyqad™ and Intergraph's SmartPlant Instrumentation, SmartPlant P&ID, and SmartPlant 3D. Using TEF technology, these applications exchange common information in a dynamic environment.

For example, using Aspen Zyqad, a process design engineer decides when process information is ready for issue. Information is published and stored in SPF. Based on a predefined workflow, SPF would advise the SmartPlant Instrumentation and SmartPlant P&ID users of the availability of, or changes to, shared information. Conversely, the SmartPlant Instrumentation and P&ID comments or actions would be referred back to the process engineer via the same workflows.

Projected Benefits
Projected benefits will be derived from the use of an integrated, data-centric environment built on industry standards, which enables the reuse and exchange of engineering information throughout the life cycle. Once in production, the following benefits are anticipated:

- Reduction of up to 3.5 percent of a plant's total installed cost through:

- Design optimization of material and labor
- Increased engineering productivity
- Reduced cycle time
- Duplicated success and reduced risks through reuse of proven designs
- Increased operating efficiency and shorter shutdowns via effective control of as-built and asset information

6.5 Western Mining Corporation, Ltd., Australia

SmartPlant Foundation (SPF) Solution Offers Distributed Engineering Design Environment

Company and Project Background
With more than 4,700 employees, Western Mining Corporation (WMC) Ltd. is one of the largest mining companies in the world. The company's Olympic Dam mining and processing site in remote Roxby Downs, South Australia, is the largest known multi-metal and uranium ore deposit. Olympic Dam demands a high level of engineering excellence.

WMC partnered with Intergraph to provide a resilient and flexible engineering IT infrastructure. Although WMC's capital engineering is headquartered in the southeastern city of Adelaide, access to engineering information is needed daily to support operations and maintenance at the Olympic Dam site in the Australian outback. WMC tackled the problem by adopting Intergraph's PIM solution, SPF, using the Internet as the delivery mechanism.

How SmartPlant Foundation (SPF) is Being Used

- On-site operations and maintenance personnel can easily access the simple user interface. SPF's CAD file management allows WMC users to manage both primary reference files as well as nested reference files. Once SPF's document management capabilities are implemented as well as the powerful system architecture that enables the application, users can incrementally improve the management of their other engineering data, such as tags and related installed assets, building links between the tags, documents, and assets, which are automatically updated as changes occur.

Volume/Types of Information Managed
WMC manages the engineering information for the Olympic Dam facility, which encompasses more than 200 kilometers of underground tunnels, including a five-kilometer automated underground rail haulage system. The Dam's ventilation system displaces 260,000 metric tons of air daily. More than 660,000 drawing records were incorporated from WMC's existing system into the SPF solution.

Expected Benefits
The SPF solution is expected to:

- Manage associated engineering information and cross-reference it to related documents, thereby helping to achieve plant integrity
- Provide the infrastructure for both current and future facility requirements
- Reduce labor-hours and cost as native viewer applications are not required with the SPF solution

- Ensure accountability with date-stamping and dial-back components
- Enable greater productivity via enterprisewide benefits and faster, easier configuration using SPF's building blocks yields a much lower cost of ownership
- Reduce cost of meeting regulatory compliance with SPF's audit history capability

6.6 Repsol-YPF, Spain

Corporate Document and Asset Management for Multiple Petroleum Refineries

Company and Project Background
Repsol-YPF, an oil, gas, and chemicals company headquartered in Spain, undertakes exploration, refining, distribution, and marketing of chemicals, natural gas, oil, and electricity. Intergraph's information management solution is currently used within the company's Petroleum Division − including five refineries and an engineering center − to manage documents.

How Intergraph Information Management Solutions are Being Used
- The system is managing the procedures and documents necessary to maintain the integrity of the technical baseline of the operational refineries.
- The electronic library has been designed around one unified plant/data model for all of the refineries. This business model manages plant equipment tags and documents and the interrelationships between them.
- The system also manages control of all document revisions (i.e., as-built in a project).

Volume/Types of Information Managed
The system manages 60,000 documents per site across six sites for an estimated total of 360,000 documents.

Expected Benefits
- Cost reduction from streamlined procedures through removal of non-productive steps and optimization of documentation management
- Unification of processes across departments and between refineries
- Improvements in efficiency and decision making resulting from better information availability, quality, and security
- Support of ISO 9002 document management for quality documents, removing the need to distribute paper documents manually
- Support of concurrent work on common information

6.7 Statoil, Norway

Advanced Plant Information Management (PIM) Solution

Project Background
Building on Statoil's success in plant information handover on the Åsgard offshore project to Åsgard operations, the Statoil Kristin project represents a major step in Statoil's long-term PIM

strategy. Kristin − designed to eliminate the costs and resources demanded by traditional, paper-intensive work processes through implementation of radically new, optimal electronic work processes − is based on three concepts, including life-cycle information, collaborative project execution, and collaborative operations execution.

How Intergraph's Information Management Solutions are Being Used
The Kristin project experience is summarized to date within four main areas of lessons learned and ongoing challenges. These areas include contractors/suppliers; streamlining of work processes; information technology and security issues; and new PIM requirements. Statoil plans to use the Kristin template as well as lessons learned from the project in application of future projects with increasing sophistication.

Expected Benefits
Statoil expects numerous business benefits in operations, including:

- Reducing information handover costs to virtually zero through e-Collaboration, thus achieving significant reduction in document handling costs
- Improved handling of site queries, deviations, and changes
- Reduction of life-cycle information costs and reduced effort in managing package equipment life-cycle information
- Improved staffing allocation
- Overall streamlined work processes

6.8 Customer List

Since its release in 2002, SPF's customer list has grown rapidly. As indicated above, customers are deploying it to solve a wide variety of PIM problems. As of June 2005, the customer list extends to those below. Increasingly, customers are also extending the range and capability of solutions that each deployment is satisfying.

AEBA (Afval Energie Bedrijf Amsterdam)	Lyondell Chemical Company
Air Products	MHI (MCEC)
Alstomecs	Mitsui Babcock Energy
Australian Magnesium Operations	MLNG
BASF	Mochovce Nuclear Power Plant Project
Bayer Tech	Murray & Roberts
BP, Gulf of Mexico	Neste Jacobs Oy
BP Petronas Acetyls	New Zealand Steel
DPS Ltd	NOVA
Burns & Roe	Noving Novaky Spol
The Buzzard Project	Parsons Infrastructure & Technology
Chemoprojekt	Praxair
Chiyoda	Procter & Gamble
Clough	Profertil

ConocoPhillips	Rayong Olefins Co.
Conosistent SW	Rosenergoatom
CTCI	Royal KPN
Daelim Industrial Co.Ltd.	Sabic Engineering
Degussa	Sarlux S.r.l.
The Dow Chemical Company	Saudi Aramco
ECI	Selas Fluid
ExxonMobil	Sevmorneftegaz
Florida Power & Light	Siemens Power Generation
Fluor AMEC JV	Singapore Refinery Company
Foster Wheeler	Starstroy
Glow (Thailand)	Slovenske Elektrarny
Haldor Topsoe	Snaprogetti SPA
Heineken Technical Services	Societe Fives Cail
Hyundai Engineering Co., Ltd.	Statoil Corporation
IDO HUTNY	Stone & Webster
INCO Australia	Stork GLT
Instituto Mexicano del Petroleo	Swecomex
Intergraph Corporation	Syncrude/Fluor UE1 Project
Intergraph PP&M	Toyo
International Starch Institute	United/Jubail United Petrochemical Co.
Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI)	Vetco Aibel
Jacobs Engineering	Washington Group International
JGC	Western Mining Corporation
LG Engineering & Construction	
Linde	

7. Industry-specific Requirements

7.1 Pharmaceutical Industry

The pharmaceutical industry faces many challenges, including time to market, patent window (time in market), modular design to allow flexible production, compliance to stringent regulations (e.g. FDA requirements), ongoing facility audits in operation, avoidance of heavy fines, and shutdown penalties. Document management, document control, and configuration management are critical components supporting validation and ongoing operations.

To help pharmaceutical facility owners meet their industry-specific challenges, Intergraph has added capability to SPF over and above the core competencies described earlier, such as electronic signatures, specifically tailored to the needs of the pharmaceutical industry. This solution is based on SPF and the complementary SmartPlant suite of products. The pharmaceutical industry solution allows O/Os to:

- Maximize patent window and accelerate time to market by enabling global engineering via 24-hour access to a single source of all up-to-date engineering information
- Minimize project rework and costs through the use of intelligent design tools, reuse of design data, and modular design
- Reduce plant downtime during routine plant change and emergency repairs through the availability of engineering information and effective change management
- Expedite the reconfiguration of a plant for the production of different drugs through better plant configuration management
- Meet FDA requirements for 21 CFR Part 11 and current Good Manufacturing Practice requirements, and manage company best engineering practices
- Reduce risk of punitive liability to plant managers through improved work process audit trails that retain all historical information and configurations, enabling “rollback” of plant information

7.2 Nuclear Industry

Developing and operating a nuclear facility demands the most rigorous and exhaustive controls. Mistakes are not an option! Design must adhere to strict codes for which proof is required to obtain license to operate. Effectively, the design and engineering information forms a configuration – the design basis − that must be complete, controlled, and under strict change management. But this “network” of interrelated plant objects must also allow for the exploration and identification of potential risks. This design basis should be used to define the licensing basis and the operating basis – three distinct and interrelated views of the plant, including what we said would be there, what should be there, and what is there. Many nuclear facilities today suffer prolonged and expensive shutdowns for irregularities and errors within these configurations. Again, the hybrid data and document management capabilities of SPF, along with extensive configuration management, are having significant opportunity among nuclear designers and operators alike. The nuclear industry solution allows EPCs and O/Os to:

- Meet strict regulatory controls for conforming to codes and executing and recording the process, specifically where it pertains to data and documents
- Ensure a complete configuration of the plant. All its relations and dependencies are tracked and maintained with complete version/revision control and audit trail.
- Provide a mechanism for separating but maintaining the design, licensing, and operating basis of the facility, allowing controlled access by regulatory authorities
- Minimize project rework and costs through the use of intelligent design tools, reuse of design data, and modular design
- Reduce plant downtime during routine plant change and emergency repairs through the availability of engineering information and effective change management
- Reduce risk of punitive liability and potential closure through improved work process audit trails that retain all historical information and configurations, enabling "rollback" of plant information

8. Strategic Considerations

Given that the plant life cycle is long, is there a right time to act? Is it ever too late or too early to act? Does it require a greenfield opportunity to benefit from change, or is it too late for brownfield operations to benefit? Does it mean obsolescence and wholesale change of systems and procedures? Is this a big-bang deployment of new technology? The answer to all of these questions is a resounding NO. No matter who you are, what you have, or where you are going, there is never a wrong time to start deploying and benefiting from a structured PIM program. Assess and determine that now is good, yesterday would have been better, and tomorrow is not as good, but in any case, it is wise to be mindful of the following:

- PIM is not wholly a technology problem that can be analyzed, features and functions classified, and systems' vendors interrogated (e.g., document management in the insurance industry is totally different to document management for an active plant). As indicated above, every plant is different, every process is different, and each is in a different stage in its life cycle. Therefore, it is as much a business process management and configuration control issue as it is technology selection.
- Since all plants − greenfield and brownfield − will be in different states in their life cycle, so too will the tools and technologies deployed. Therefore, a PIM deployment must be harmonious to prevailing technologies – everything from data-centric to document-centric and from intelligent data to scanned images (and everything in between).
- Plan to manage engineering data as an asset as valuable as the plant itself. It feeds the operations/maintenance systems and is invaluable for decision support, but if not given constant care and attention, its integrity will degrade and so too will the quality of decisions based upon the data. Define a long-term, flexible, pragmatic, sustainable data maintenance and continuous improvement strategy that is harmonious for operations, maintenance, delta engineering projects, and regulatory affairs alike.
- Identify, locate, categorize, and rank engineering data in terms of importance, speed, and frequency of access and frequency of required update. Not all engineering data will require constant attention or intelligent tools to maintain it.
- It is unwise to let intelligent data become unintelligent or electronic data to become paper. Its quality and integrity will degrade, the speed and accuracy of decisions based upon it will suffer, the cost of quality will escalate, and its eventual recreation for the inevitable change of purpose will be significantly more expensive than its sustained care and attention.
- The best IT systems in the world cannot make up for bad or inconsistent data. The cost and resources required to uplift poor data will dwarf the IT and system costs. Plan for a process of continuous improvement and quality uplift at a pace that can be absorbed with current resources.
- Develop a PIM strategy for the WAN and not the LAN. In a world where customers, partners, suppliers, and plants are widely distributed common communication methodologies, taxonomies and the ubiquity of the Web will prevail.
- The PIM strategy should be robust enough to deal with high-end systems and lowest common denominator tools alike. Don't forget that the former systems are used by knowledgeable workers for whom the tool is the job. The latter are used by clerical, manual, and functional workers − often on temporary contract with their own information tools − where the system provides information that assists them in doing their job.
- A commonly used term is data handover – alluding to a one-off event, which is invariably a contractual commitment. Accordingly, any subsequent requests to obtain data early will be met

with threatened delays to the main project. Alternatives to this are a continuous exchange of data between the parties at best or at the very least, access through a "portalized" view. Therefore, a handover strategy that supports continuous collaboration and exchange should be viewed as a win-win for all concerned. It is about data quality, understanding and preparing for the next phase in the life cycle. It is not about policing and penalizing and should not challenge intellectual property rights, technology, or contracts.

- Manage the information inconsistencies rather than trying to enforce consistency. The latter is not possible in engineering projects not only because disciplines in engineering projects execute concurrently and not serially, but also because enforced consistency would stifle innovation. Progress and change are synonymous. Therefore, an overarching program of informing and managing change across and between the disciplines and "line-of-business" systems should be more important than change management at the application or department level.
- Integration comes in many forms, including data integration, application integration, business process integration, etc. Your PIM strategy should evolve to the highest form rather than starting there from day one. Start small, keeping the big picture in mind and grow organically, showing step-wise improvements. Even though technology can achieve the big picture in one step, very few organizations can!

9. Summary

PIM is not a technology as much as it is a philosophy − a methodology for systematically improving the operational efficiency of a plant. PIM includes a range of technology and business improvement options that can be deployed for continuous and sustained advancement of the design, enhanced uptime of the plant, safety and risk mitigation for the operatives and the environment, and a holistically reduced cost of the asset. Remember, there are three simple reasons for strategically investing in PIM:

- **Reduce time to market (TTM)** – Design and construct the plant asset within budget, while avoiding schedule slippage and operating at capacity to meet market window of opportunity.
- **Maximize time in market (TIM)** – Mitigate unplanned outages and delayed startups, optimize planning for engineering turnarounds, and prevent safety, hazard, and regulatory risks, which would otherwise halt production.
- **Optimize operating parameters (OOP)** – Make the most of that which you have least (time, resources, and schedule) to gain more of the things you want (throughput, safety, and profit).

10. References

***Insight* Articles**

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