ALM - PLM INTEGRATION: BREAKING STEREOTYPES, BUILDING THE FUTURE

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Abstract— Engineering products and solutions used by the Railways, Airways and Roadways are complex and multi-faceted. They are driven by real-time embedded software. The design and development of these products require real time global collaboration. This can be achieved by seamless flow of data across all the stakeholders from conceptualization till retirement. Traditionally the management of these complex engineering products through their lifecycle was enabled by PLM (Product Lifecycle Management) and ALM (Application Lifecycle Management) independently. However, this compromised the product quality and delivery. To address today’s product development demands ALM-PLM must work in unison. The PLM manages the variations and mechanical configurations of the parts as dictated by a BOM or engineering bill of materials and ALM controls the variations of the software and systems delivery process throughout the course of product development. This paper brings to the forefront strategies and methods to integrate the product development process with the software and system development processes.

Keywords— ALM, Collaboration, Embedded Software, Integration, PLM

I. INTRODUCTION

Today, almost products of each and every industry are software-driven. There is significant growth in every new engineering product wherein every hardware component or a system is associated with an embedded software in it. On the other hand, customer expectation of new products are growing exponentially. To keep up with the pace of the market, organizations need continuous innovation, improved design, product management, traceability and faster time to market [1]. The systems are becoming more and more complex and are dependent on software and embedded real time controllers [2]. These engineered product value is getting enhanced by addition of more and more software [3]. This has generated the need for finding a mechanism to get the act of ALM - Application Lifecycle Management & PLM – Product Lifecycle Management together. Since these two domains of PLM & ALM are complete different culturally, this should be seen as a well-planned strategy to capture and re-use engineering knowledge, share best practices of both domains, strengthen innovation, and intellectual property.

"Ultimately, as products continue to grow in complexity, manufacturers' ability to collaborate across disciplines and to support multi-disciplinary decision making in product development — using tools and strategies such as PLM, ALM, and a systems-driven approach — will become increasingly important, not only to improve time to market and to achieve competitive advantage but to manage and mitigate risk." — Amy Rowell, research manager, Product Lifecycle Strategies, IDC Manufacturing Insights.

The objective of this paper is to explore unique capabilities of ALM-PLM integration, create a common platform for all stakeholders irrespective of their domain, purely software or purely hardware or combination of hardware and software, to work in collaboration with access to real-time data.

A. Related work: It is observed that much work has been done in the area of ALM-PLM integration. Siemens’ PLM Software has addressed the challenge of ALM-PLM Integration on multiple ALM-PLM use cases that span requirements interoperability, closed-loop embedded software development, integrated change orchestration and continuous integration of software deliveries. Today practically almost all engineering products are software-driven, thus enforcing the integration of ALM with PLM [1].

II. ALM-PLM Integration

A. Necessity

The engineering activities of an aircraft life cycle have transformed from the vertically integrated organizations into highly distributed and collaborative mode [4]. The modern
engineering projects especially of military versions are with a multitude of design integration and adaptability problems. This involves subcontracting of various product and process design packages into Tier 1, Tier 2 and tier 3 entities all over the world [4]. Also most of the subsystem / components of the modern engineering products during R &D stages need the real time data access from both PLM and ALM. Thus ALM has become an integral part of PLM [5]. Always there are changes in end user requirements (e.g. single /double pilot, short take off and landing, improved design requirements like weight savings [6]. This needs continuous innovation to meet the requirements of end customers and meet the peer competitors, of both whose outcome is not certain. These challenges can be met with the seamless flow of real time from ALM+PLM. Hence there is an urgent need to get ALM and PLM integration. To give an example of author’s practical experience in aircraft project in India, where the author got an opportunity to work in the area of design and development of avionics and weapon systems and also in implementation of PLM solution for various variants of the aircraft. The Indian scenario is spoiled by poor traceability of engineering data during production and maintenance of the aircraft. ‘Successive’ processes for design and manufacturing have taken a much longer than scheduled time making it imperative to use an ALM-PLM integration [7]. In India most of the PSUs and R&D labs are not aware of the importance of using ALM system. An ALM system will relate and link information related to code [8]. A PLM system will relate and link information to items such as formulas and tolerances. The integration of ALM-PLM reduces the risk arising from the embedded software [9]. Fig. 1 shows the ALM and PLM in the engineered products. Fig. 2 shows the maturity of ALM in the PLM world. Due to lack of awareness about ALM the entire process of product development fails to reap the following benefits.

- Full system governance through a unified requirements and change management platform.
- End to End traceability of hardware and software product requirements from the original product concept through design up to testing and validation.
- An integrated bill of materials combining hardware and software components.
- Scalable tracking and management of defects and changes at each process stage.
- Wide collaboration through the hardware and software development teams.

**B. Characteristics of ALM-PLM**

The intelligent infrastructure for any engineering product is Digital Engineering Processes (DEP) on the Digital Mock-Up of the product. An effective real-time ALM-PLM system with better collaboration connecting globally distributed engineering processes in real -time to build the virtual pro-type is the need of today.
the latest protocols and best practices of the engineering product on a common platform. The architecture should be capable of delivering a simplified ALM-PLM platform that can support end-to-end product innovation on a future-oriented basis, while also providing the overall enterprise IT infrastructure needed to facilitate harmonized co-existence.

- **Usability:** A ‘one user interface fits all’ approach does not work when it comes to meeting the usability needs of ALM-PLM constituencies. User communities with different experiences and business roles will be using ALM-PLM common platform. The environment for a successful solution must provide a unified foundation with the following capabilities to address four user experiences.
  - Access through integrated authoring tools, application software, Microsoft Office, MCAD and ECAD design tools
  - A web browser that users already know and understand.
  - Task and role-based portals that organize information in the context of the user community’s business and assignment needs.
  - A rich client interface to create and manage product and process data across various lifecycle states.

- **Scalability and performance:** Large enterprises need to scale their ALM-PLM environment to support changing user workloads and optimize system performance accordingly. Successful solutions need to support three levels of scalability:
  - **Horizontal scalability,** which connects multiple servers and ALM-PLM data instances.
  - **Vertical scalability,** which optimizes performance as the ALM-PLM solution is scaled for larger user workloads.
  - **Global scalability,** which enables the chosen ALM-PLM solution to handle large files through a sophisticated caching mechanism; global scalability also optimizes the ALM-PLM environment for global performance while enabling it to efficiently utilize a complex network topology comprised of wide area network (WAN) connections.

- **Secure and controlled access:** The ALM-PLM solution should provide the entire enterprise with a single source of product and process knowledge whose access can be secured and controlled on the basis of:
  - **User metadata,** which controls who is able to access the ALM-PLM common platform.
  - **Object metadata,** which controls what product and process knowledge can be accessed.
  - **Control lists,** which determine who is able to access what kind of data.
  - **Rules-based engine,** which controls who can grant access to what data and when.

The ALM-PLM solutions must enable approved value chain partners to participate in product development processes while protecting intellectual properties of all participants. A rules-based engine is especially valuable since it can be leveraged to establish multiple levels of access controls to assigned and owned data.

- **Milestone-based ALM-PLM Platform:** The ALM-PLM platform should be milestone-based. At the end of each milestone achievement, a summary report needs to be submitted to give information regarding key issues that may have come up along with ALM-PLM solutions to them. The report should also identify potential risks that might hamper the implementation, so that a mitigation plan can be prepared. This will give the steering committee enough time to find ways to mitigate the risk. At the end of each milestone, the feedback of all the resources related to that milestone needs to be obtained, and analysis has to be performed about the expected results and the degree to which they are satisfactory. If some milestone has not yielded the results it was supposed to deliver, it should be not "closed" until steps are taken to ensure that the output of each milestone implementation is satisfactory. The Table 1 below shows eight basic features that an organization must look for in ALM-PLM Platform. The platform must provide consistent solution.

<table>
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<tr>
<th>Sl.No.</th>
<th>Feature</th>
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<tbody>
<tr>
<td>1</td>
<td>Weblogin</td>
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<tr>
<td>2</td>
<td>Task delivery to user's inbox</td>
</tr>
<tr>
<td>3</td>
<td>Auto-escalation regarding critical tasks</td>
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<tr>
<td>4</td>
<td>Bi-directional sync with authoring tools, application software and project management tools</td>
</tr>
<tr>
<td>5</td>
<td>Product Configurations, User-based configuration (user can create configuration only for his view) and Global configuration (to be shared across organization) with cost calculation</td>
</tr>
<tr>
<td>6</td>
<td>Creation of multi-level and complex BOM easily. Imports BOM from Excel, csv, and text files along with calculation of total BOM cost at each level</td>
</tr>
<tr>
<td>7</td>
<td>Collaboration with vendors and suppliers: limited data access to assemblies concerned with joint ventures and suppliers.</td>
</tr>
<tr>
<td>8</td>
<td>Easy report generation in Excel, PDF, and other formats</td>
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**C. Different Orientations of ALM-PLM Data**

After the ALM-PLM platform has been established and used for a while, the accumulated data within the system becomes valuable. This data supports daily operations and has the potential to help the organization to understand the performance and predict the future of a release. Table 2 describes the four orientations of ALM-PLM. The below
Table 2 separates ALM-PLM data into four groups: product, project, process, and people. This is not a scientific way of categorizing ALM-PLM data since there may be overlaps, dependences, and consequences between one group and another. However, these four sets of data represent four different facets when we look at the entire collection of ALM-PLM data, and each of these facets explores an area of ALM-PLM analytics.

**TABLE II  FOUR ORIENTATIONS OF ALM-PLM**

<table>
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<th>Orientation</th>
<th>Description</th>
<th>Example</th>
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| Product     | This is the most prominent group of data within the ALM-PLM system. Product data (i.e., product definition information) is the backbone of the entire ALM-PLM data set. Other data exists and is organized around product data. | • Product Requirements  
• Software Requirements  
• Product structure data  
• Product document data  
• Product document metadata |
| Project     | Project-oriented data is used to define and help execute product development projects and processes. This group of data exists for the purposes of facilitating the creation of product definition information, but it is not categorized as product data. | • Work breakdown structure  
• Resource information  
• Work progression data  
• Project risk data |
| Process     | This group of data refers to ALM-PLM users' specific business processes. In general, there are overlaps between this group and the previous group (project data). Process data refers to the daily operational activities that are not managed as projects. | • Routing and approval activities  
• Problem-solving activities  
• Collaboration records  
• Transactional data associated with business processes |
| People      | User information (with regard to ALM-PLM systems) may be associated with all the previous categories. However, it is necessary to treat the user-oriented data as the fourth data set since the "people" element is an important part of a ALM-PLM platform. | • System user information  
• Roles and groups  
• User login data  
• User participation records |

**D. Future Work Challenges of Kovair Team**

**Engineering Process Management:**

- Manage all types of engineering data - MCAD, CAE, CAM, ECAD, documents, drawings, spread sheets, etc. in the context of engineering processes.
- Tightly integrate geographically dispersed multiple design teams, enabling design teams to synchronize design data frequently for global engineering.
- Advanced search and retrieval tools (use of filters in very highly complex, very big structures) to help quickly locate component, part, and product information that appears in both graphic and textual formats. Classify, locate, and re-use existing parts, products, process, and the engineering knowledge captured during the product development process.

- Enable designers to see every design change immediately in the context of their own design and digital validation capabilities to keep track of design changes continuously.
- Context management capabilities for users to simplify design collaboration allowing them to define, manage, and share their working contexts for product development.

- Workflow orchestration for change processes to view impact, initiate, administer, review/approve and execute product changes.

**Workflow management:**
Workflow management present in the application –

✓ A graphical design editor for configuring the workflow according to organizational processes.
✓ Versioning capabilities of workflows.
✓ Users are able to track every part/document which is being processed through a workflow and understand the state and the path of the document.
✓ Workflow is integrated with Organization’s e-mailing system for notifications and task assignments helping in eliminating manual handoff.
✓ Integration with MS Outlook to enable task synchronization, workflow approval.
✓ Access to managed, configured, design data such as 2D documents (drawings, images, PDFs), 3D models (IGES, STEP, VRML, STL, JT), and animated motion and their associated swept volumes in a complete product context.
✓ Consistent & intuitive user interface for even non-technical users to interpret design and manufacturing data directly within ALM-PLM (or in a standalone mode) using the same colors, orientation, and viewing angles as in CAD systems.
✓ Support for paperless engineering processes by leveraging Product Manufacturing Information (PMI) such as tolerances, weld symbols for both parts and assemblies.

III CONCLUSIONS

As can be seen from the information provided in this paper, ALM-PLM integration is an urgent requirement in India for rapid growth of the engineering industry, from the benefits accruable, to engineering industry such as:

• The life cycle engineering processes using IDE, DMU, MBD, ALM and PLM should be standardized by regulative authorities in their design/engineering procedure.

All R&D organizations, manufacturing engineering groups, should be networked by common ALM-PLM platform with access to real-time data.

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