Product Lifecycle Management software tools in small-to-medium aerospace enterprises: Help or hindrance?

Extended Abstract
Aircraft Design and Development Stream

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1. Introduction

Small-to-medium enterprises (SME), or businesses employing between 1 and 499 people, are significant stakeholders in the Canadian economy. SMEs represent 99.7% of total Canadian employer businesses, 90.3% of the private Canadian labour force, and about 30% of the gross domestic product (GDP) [1].

Cost reduction and process efficiency are two of the many challenges faced by SMEs in the competitive globalized market. These challenges are amplified in sectors producing safety-critical systems, defined as "systems whose failure could result in loss of life, significant property damage, or damage to the environment" [2]. Such is the case in the aerospace industry, where, to regulate safety, civil aviation is regulated by law through Transport Canada Civil Aviation (TCCA) [3]. Aerospace companies must comply with a series of regulations through a process known as certification, where TCCA approves that an aerospace product conforms to its documentation and is safe for flight [4].

Aircraft modification challenge
A particularly complex aerospace SME can be found in the aircraft modification sector, often categorized under aircraft Maintenance, Repair, and Overhaul (MRO) [5]. Aircraft modification companies modify existing aircraft, often for either a major technological upgrade, or for repurposing of an aircraft to perform new missions. The certification of these major modifications poses a unique challenge to the SME, who must contend with high product variability in types of aircraft to be modified, high variability and low production of modification design and development, and requirements to ensure that the changes to the aircraft are as-safe or safer than the original design [6] [7]. The added constraints of traceability required for the certification process has resulted in many aerospace SMEs investing in methods and tools to remain cost and process efficient.

Product Lifecycle Management
Product Lifecycle Management (PLM) is a term commonly used to describe methodologies and software tools that help manage product development programs through business integration [8] [9]. The marketed purpose of these methods and tools is to increase process efficiency and reduce cost during product development. Originally developed to manage the data produced by computer aided design (CAD) [10], PLM has evolved to address the many challenges associated with larger and more complex product development programs [11], both through software suite automation and methodological approach to product

development. Examples of PLM methodologies include the Configuration Management [12] and Lean Methodology [13]. Software solutions can be modeled to reflect one or more of these methodologies, and typically support specific functional groups. Examples of software solution focus areas include Enterprise Resource Planning (ERP), Product Data Management (PDM), and Material Resource Planning (MRP) [14].

Problem statement

Each functional group within a company will view the same product from different perspectives [15], and while PLM software and methodologies attempt to unify product development, they are often designed to reflect the needs of a functional group for which they were designed to support.

The case study for this research was conducted in a typical Canadian aircraft modification SME [16]. The aircraft modification company was considering the purchase of a PLM software solution with the intended purpose of improving process efficiency and reducing product development costs.

An investigation was conducted to evaluate the current state process of the company's product development cycle through a process mapping technique, and make recommendations for improvements in process efficiency. This approach provided the company with potential areas for automation and digitalization, with the intention of selecting a software solution that would have the most impact on efficiency.

2. Research Methodology

A process mapping methodology was used to understand the flow of information across the different functional groups within the company during a complex aircraft modification program. An interview approach and 3-tiered process mapping technique was used to capture the current-state process and identify opportunities for process improvement. Rummler and Brache [17] identify 3 key stakeholder categories of company personnel: Executive, Manager, and Analyst, each requiring different levels of process detail. 82 interviews were conducted across all three stakeholder categories, and the 3 process mapping tiers were designed to reflect these levels respectively.

The Tier 1 Phase map, the highest level of detail, illustrates the product lifecycle broken down into phases. The information on this map is used to meet the needs of the Executive stakeholders, in providing an overview and major gates in a product's lifecycle. A generic example of a Tier 1 Phase map is shown in Figure 1.

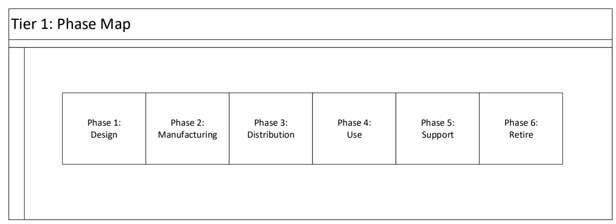

Figure 1: Tier 1 Phase process map, illustrating product lifecycle phases needed by the Executive stakeholders

The second highest level of detail is the Tier 2 Deliverable process map. This map illustrates the major deliverables, milestones, and decision gates that occur in each Tier 1 phase. In addition to schedule, resource, and cost planning, these instances can be used by the Manager stakeholders to track project status. An example of a Tier 2 Deliverable process map is shown in Figure 2, as generic milestones that would be expected in the Tier 1 Design phase.

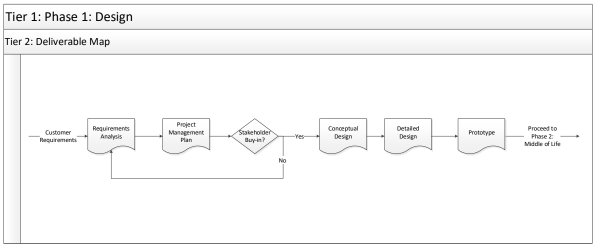

Figure 2: Tier 2 Deliverable process map, illustrating major deliverables, milestones, and decisions

The final level of detail is presented in a Tier 3 Activity map. This map illustrates the activities and activity sequence for a given deliverable, milestone, or decision in Tier 2. The Activity map is also separated by functional group swimlane, and activities placed per the functional group responsible for the activity. This level of process map is designed to meet the needs of the Analyst stakeholders, for a visual representation of the activities and order of precedence for the completion of a milestone. A depiction of a Tier 3 Activity map is shown in Figure 3.

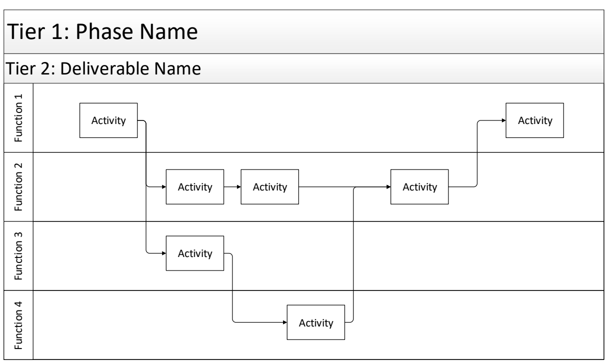

Figure 3: Tier 3 Activity process map, illustrating the flow of activities across different functional groups represented by swimlanes.

The interview and mapping research was conducted in an iterative manner. Following an interview, existing best practice documentation was consulted, and the information from both sources consolidated on a process map. Follow-up interviews were scheduled as needed to develop an acceptably mature map of the current-state process. The results of this process mapping case study found that there were opportunities for process improvement that needed to be addressed prior to selecting a PLM software solution.

3. Results

The process mapping methodology lead to three key findings. The first finding occurred in the Tier 1 Phase map, which revealed that multiple PLM methodologies were being used simultaneously to describe the same product development cycle, shown in Figure 4.

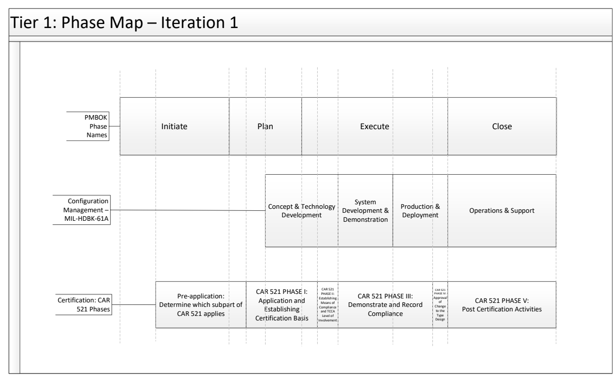

Figure 4: Tier 1 Phase process map results, identifying multiple PLM methodologies used simultaneously

The Project Management, Engineering, and Certification and Airworthiness functional groups were using the PMBoK®, Configuration Management, and CAR 521 Phases, respectively, to describe the product lifecycle. Each methodology used a different vocabulary to describe the same product lifecycle, and the resulting differences in language and phase definitions created a barrier to the alignment and communication of each functional group.

The simultaneous use of multiple PLM methodologies was also problematic at the Tier 2 Deliverable level, where deliverables, milestones, and decisions were difficult to place according to phase. The different vocabulary and phases used among each functional group made it difficult to understand how the activities of one functional group would align with another, resulting in gaps in process efficiency.

4. Conclusion

The barriers to communication between functional groups that were exposed as a result of the case study highlight the need to fully assess a company's current-state processes before selecting and implementing a PLM solution.

Bibliography

[1] Innovation, Science and Economic Development Canada Small Business Branch, "Key Small Business Statistics - June 2016," June 2016. [Online]. Available: https://www.ic.gc.ca/eic/site/061.nsf/eng/h_03018.html. [Accessed 01 2019].

[2] J. C. Knight, "Safety Critical Systems: Challenges and Directions," in *In Proceedings of the 24th international conference on software engineering, 2002.*, New York, 2002.

[3] Transport Canada, "Canadian Aviation Regulations: PART I General Provisions - Subpart 1 — Interpretation 101.01 (1)," 15 09 2017. [Online]. Available: http://laws-lois.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-101.01. [Accessed 29 01 2018].

[4] Government of Canada, "Canadian Aviation Regulations," 26 03 2018. [Online]. Available: http://laws-lois.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-500.01. [Accessed 17 04 2018].

[5] J. M. Garcia-Fornieles, I. S. Fan, A. Perez, C. Wainwright and K. Sehdev, "A Work Breakdown Structure that Integrates Different Views in Aircraft Modification Projects," *Concurrent Engineering: Research and Applications,* vol. 11, no. 1, pp. 47-54, March 2003.

[6] Transport Canada, "Advisory Circular (AC) No. 521-004: Changes to the Type Design of an Aeronautical Product," 16 03 2012. [Online]. Available: https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-500-521-004-1495.htm. [Accessed 26 02 2018].

[7] Transport Canada Civil Aviation, "Advisory Circular (AC) No. 500-016 Issue 1: Establishing The Certification Basis Of Changed Aeronautical Products," 01 12 2004. [Online]. Available: https://www.tc.gc.ca/eng/civilaviation/certification/guidance-500-500-016-903.htm. [Accessed 08 2018].

[8] A. Bernard and L. Rivest, "Product Lifecycle Management for Society," in *10th IFIP WG 5.1 International Conference, PLM 2013 Nantes, France, July 2013 Proceedings,* Nantes, France, 2013.

[9] CIMdata, "Product Lifecycle Management (PLM) Definition," Michigan Web Design, 2018. [Online]. Available: https://www.cimdata.com/en/resources/about-plm. [Accessed 25 02 2018].

[10] A. Karniel and Y. Reich, Managing the Dynamics of New Product Development Processes, London: Springer, 2011.

[11] S. Terzi, A. Bouras , D. Dutta, M. Garetti and D. Kiritsis, "Product lifecycle management–from its history to its new role," *International Journal of Product Lifecycle Management,* vol. 4, no. 4, pp. 360-389, 2010.

[12] Institute of Configuration Management, "White Paper CMII-805G: CMII/IPE Versus Other CM Training and

Certification Programs," Institute of Configuration Management, 2016.

[13] Lean Enterprise Institute, Inc., "Key Concepts of Lean," 2018. [Online]. Available: https://www.lean.org/Workshops/WorkshopDescription.cfm?WorkshopId=13. [Accessed 3 March 2018].

[14] S. Lee, Y. MA, G. Thimm and J. Verstraeten, "Product lifecycle management in aviation maintenance, repair and overhaul," *Computers in Industry*, vol. 59, no. 2-3, p. 296–303, 2008.

[15] V. Krishnan and K. T. Ulrich, "Product development decisions: A review of the literature," *Management Science*, vol. 47, no. 1, pp. 1-21, 2001.

[16] A. Cartile, *Process mapping approaches for high-value safety-critical aircraft modification design and development: A case study*, MASc. Thesis, Gina Cody School of Engineering and Computer Science, Concordia University, Montreal, QC, 2018. [Online]. Available: https://spectrum.library.concordia.ca/984276/

[17] G. A. Rummler and A. P. Brache, Improving Performance: How to Manage the White Space on the Organization Chart, 2 ed., San Francisco: Jossey-Bass Publishers, 1995.