Procurement for physical testing in new product development and collaboration with suppliers

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Purpose

A company procures prototypes or components for physical testing at various stages of product development. A long lead time for procurement of these items can cause a significant delay in the overall product development. The lead time is the time between placing an order and delivering an item from a supplier. The paper aims to report what causes a delay in placing the order and the consequences of increased lead time on other product development activities. And strategies for solving these issues are presented.

Research Approach

The empirical study was undertaken to identify critical issues that engineering manufacturing companies face regarding the procurement of physical prototypes or items required for physical testing in new product development and manufacturing. Three case studies were undertaken in a diesel engine design and manufacturing company, a forklift truck manufacturer, and a turbocharger manufacturing company. A thorough, in-depth case study was conducted on the diesel engine company to understand the current practice and areas of improvement. Other two case studies were conducted to corroborate the findings.

Findings and Originality

Clear, precise and timely release of specifications of testing requirements helps the supplier's product validation and testing process. The supplier's product validation testing can dramatically reduce the company's component level testing and how the overall product is tested. In an effective collaboration with suppliers, companies can use suppliers' knowledge and expertise to complement internal capabilities. This help reduces the time required to deal with quality problems and improve the overall testing effort and cost. This paper reports original findings from case studies and strategies that companies may use to improve current practices.

Research Impact

This work produces a comprehensive understanding of the complexity of prototype items' procurement processes for physical testing and their impact on the overall product development process. And the significance of coordination with their suppliers is needed at each stage of the product development process to deliver quality products on time.

Practical Impact

This paper offers practical impact by systematically highlighting from three case studies how a collaborative effort to integrate test plans, analysis results, and corrective action workflows across suppliers, manufacturers, and customers could benefit the overall product development process.

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Introduction

Testing is an important activity in new product development (NPD) to evaluate product concepts and designs. Testing activities can identify technical and customer-need related problems (Thomke and Bell 2001). In NPD, testing often starts early because later problem identification has potentially large cost penalties. And testing happens throughout stages of the development process for verification and validation (Tahera, Wynn et al. 2019). But testing can be the most time-consuming activity in the NPD process. Because testing, especially physical testing, are lengthy and requires procurement of items such as components, materials and test instruments. A long lead time for procurement of these items can cause a significant delay in the overall product development. The lead time is the time between placing an order and delivering an item from a supplier. To reduce procurement time and improve the quality of a new product, a common approach involves the integration of material suppliers early in the new product development cycle(Petersen, Handfield et al. 2003). But this study has identified that uncertainties in customers and technical requirements at the early stages of NPD can cause a delay in placing the order and consequently increase the lead time on other product development activities. This study investigates the strategies manufacturing industries take to tackle these challenges.

Background

A study by Cooper (2019) on "the drivers of success in new-product development" reports that 49% of new product failures were due to deficient product testing (Cooper 2019). Their data are from the physical and manufactured new products. They also identify testing as a critical driver of new product development success. Using build-test-feedback-revise iterations in each phase of the PD provides the opportunity to design the product right earlier and make necessary changes long before formal product testing begins (Cooper, 2019).

Physical testing in each phase of the PD requires procurement of items that needs testing, such as materials, components, prototypes, and often testing instruments. Therefore, timely procurement is central to the time-to-market success of NPD projects (Eriksson 2015, Brewer and Arnette 2017). And procurement plays a critical role in maintaining the organisation's supply chain(Brewer and Arnette 2017). The maintenance of supplier plays an important role in achieving companies' new product development (NPD) goals (Lawson, Krause et al. 2015) and positively impact an organisation's performance (Primo and Amundson 2002, Petersen, Handfield et al. 2005, Wang, Modi et al. 2021). Supplier integration enhances the information and material flow between manufacturers, and suppliers, leading to seamless processes and a strong supply base (Qi, Huo et al. 2017, Vanpoucke, Vereecke et al. 2017, Zhang, Guo et al. 2019).

Early and extensive involvement of suppliers in the NPD processes can improve development effectiveness and efficiency (Johnsen 2009). For example, accessing a supplier's additional

resources, skills and capabilities, especially by sharing design responsibilities, can improve productivity and reduce costs and cycle time (Fliess and Becker 2006). Especially understanding supplier capabilities allows for procurement lead time reduction (Tersine and Hummingbird 1995). Tersine and Hummingbird (1995) suggested that reducing lead time should start by identifying and minimising the bottlenecks of an organisation's internal functions and expanding into the contracted supply chain functions (Tersine and Hummingbird 1995).

This research inquiry how the lead time for procurement of testing items can be reduced and the relations with suppliers.

Methodology

The quantitative research is based on three empirical case studies: a diesel engine design and manufacturing company, a forklift truck manufacturer, and a turbocharger manufacturing company. The outcome of this paper is partly from a PhD study carried out from 28th February 2011 to 21st February 2014 to investigate the role of testing in engineering product development processes (Tahera 2014). A further interview with the diesel engine company was conducted in April 2021 to corroborate the findings and their relevance to current practices in place. Semi-structured interviews, emails, phone conversations and document analysis were used to enquire about the current practice and collect data.

This case study-based research identifies internal challenges companies face in placing procurement orders and the consequences of increased lead time on other product development activities. And present the strategies that companies take for solving these issues.

Case study

For the specific example of engine design and manufacture, the key challenges are the development of sustainable technologies and new power generation systems that will allow compliance with exhaust emission standards whilst meeting ongoing needs to improve engine system efficiency and reduce owning/operating costs. Efficiency and customer satisfaction have always been at the forefront, but the issue of sustainability has become a critical factor for all three of these companies. Therefore, Voice of Customer(VoC), Voice of Regulation(VoR), and Voice of Business(VoB) drive the testing requirements.

The case study company has a structured gateway process for New Product Introduction (NPI) that has seven stages (see Figure 1), starting from "Launch" to "Gateway 7(GW7)". Each stage leads to a formal gate review. Based on prescribed criteria, a product must pass through gate review before the product development project proceeds to the next stage. Most of the testing occurs between stages 2 to stage 4. This means that testing happens from Gateway 1 (GW1) to Gateway 4 (GW4) and often until Gateway 5 (GW5).

In the early stages of the concept or system demonstration stage, alternative concepts are generated, analysed and evaluated against customer needs. A combination of old and new parts is built into a MULE engine. This MULE engine is tested to verify the performance of new parts. New parts are progressively incorporated into the engine to test parts' functionality. In detailed design, Design Verification tests aim to ensure that design outputs meet the given requirements under different use conditions. All the new parts and components are built into the engine to test the system's performance. In later stages, Product Validation tests validate

the product against customer requirements and specifications - a pass/fail monitor before the release for production. Production intended components are procured and tested at this stage.

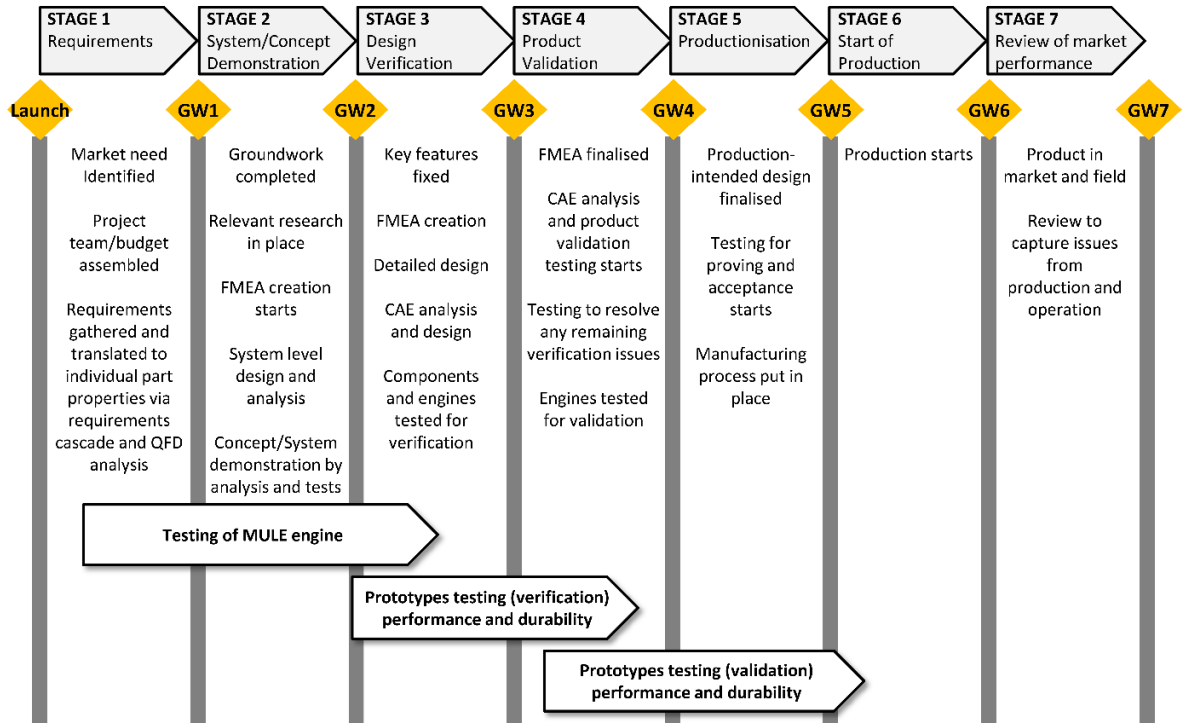

Figure 1 Stages of NPD process in the Diesel engine company.

Figure 2 presents the critical activities in stages of the NPD as time-limited boxes. Among a large number of activities in these stages, Re/Design, Computer-Aided Engineering (CAE) (e.g. Simulation), and Procurement (of test prototypes) are considered as drivers for testing. The Design and CAE analysis run iteratively throughout the entire period, components and items are procured, and testing goes on almost continuously, in parallel to these activities.

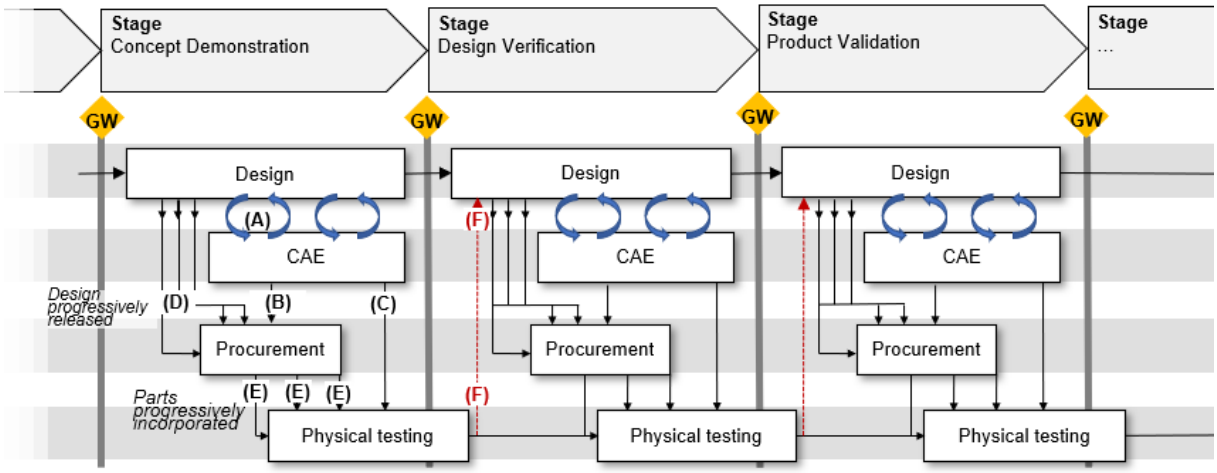

Figure 2 A schematic of the product development activities from GW2 to GW4

Suppliers mostly conduct initial component testing. Some suppliers are expected to perform the validation testing for a component or module. The company defines specific software and certain verification and validation processes for the supplier who validates their product against these criteria. For the example of a pump, which will be used in a specific engine, the company will define the working and boundary conditions and expect the supplier to perform all the durability analysis and reliability assessment based on the boundary conditions.

In analysing the company's NPD processes, two key issues emerge that cause delays in each stage. Firstly, the long lead time procurement and, secondly, the long duration of physical tests.

Long lead-time for procurement

The lead time referred to here is for procurement of items or prototype systems for testing. It is the time between placing an order and delivering an item from a supplier. As physical testing needs physical objects, the company must procure prototypes or produce intended components from the supplier. The company allows at least three months for core components, like – the cylinder head and cylinder block. Any delay in placing the order increases the lead time. Further, changes in the component's specifications can significantly increase the lead time. Change and or uncertainties in customer requirements is one of the key reasons for the changes in component specifications.

Customer requirements changes can be modelled using two factors: 'understanding of requirement' and 'formal contract/agreement has signed'. 'Understanding of requirements' can be structured or unstructured. Understanding a requirement is structured when the customer clearly defines the requirement, and the company clearly understands the customer's expectations. An unstructured/ill-structured understanding of requirements means a customer is uncertain about their needs or the company is not completely clear about the customer's expectations. At an early stage, a customer requirement can be unstructured or ill-structured. A customer might not be completely clear about their expectations, or customers' requests are fully understood. As the development time of an engine last spans 3-4 years, customers request changes in the requirement, ask for something new or even want to remove some requirements. Changes in customer requirements can cause changes in product requirements and specifications. The requirements changes are challenging after a formal contract or agreement has been signed. Because when a contract is signed, the company formally starts the subsequent process of designing and procuring items, especially prototype parts and components for testing. Any delay in formalising the customer requirements and formal contract sign-off can cause a delay in placing the order with the suppliers, increasing the lead time of the procurement process.

Strategies for solving procurement lead time issues

Three strategies are followed to solve the issues with increased lead time: (1) accurate product specifications to the supplier, (2) freeze design continuously, and (3) maintain good communication with the supplier.

Better specification to the supplier

To minimise long-lead-time procurement, a clear and accurate product specification is required. The company uses CAE analysis and makes virtual prototypes with many iterations to enable the first physical prototype to be built closer to the target. CAE tools enable collaboration and communication among teams and suppliers (Marion and Fixson 2021). CAE analyses

allow the company to optimise earlier in the product development cycle (front-loaded) and improve product specification to the supplier. Clear, precise and accurate specification of product and testing requirements help supplier product development and validation process and reduce procurement time.

Continuous design freezing

The final design is frozen and released for procurement when these tasks are completed and signed off. Design changes are restricted after the final design freeze. But the company employs continuous design freezes (see in Figure 2). Component specifications are initially released to the supplier based on the CAE analysis as a basis for actions and occur as early as possible. These specifications are continuously improved through design iterations and detailed CAE analysis. These design specifications are also developed and changed based on collaborative information exchange between the company and its suppliers. The company's continuous design freeze process allows the suppliers to react to design changes ahead of the final design freeze. This can reduce the lead time in the procurement process.

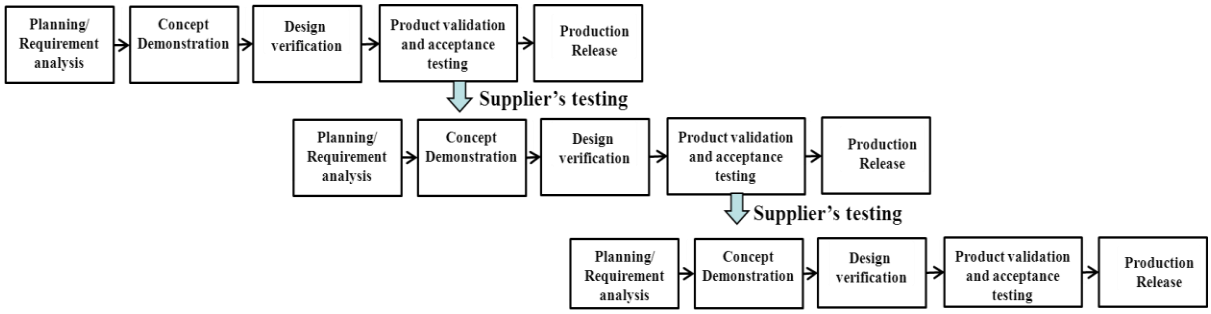

Figure 3 Involving suppliers in the process of product testing

Good communication

Effective collaboration allows the company to use the knowledge and expertise of suppliers to complement internal company knowledge and capabilities. Suppliers became active in exchanging problem and solution-specific information with the company. Good communication with suppliers enables the company to promptly access information about any design issues; as a result, the company can perform any design changes with suppliers' validated results (as seen in Figure 3). Further, good communication can provide possibilities for negotiation about changes and modifications. Good communication is considered a key factor for companies to reduce the procurement time of prototype components.

Conclusion

Effective collaboration with suppliers enables the organisation to suppliers' knowledge and expertise to complement the organisation's internal capabilities. This strategy helps reduce the lead time for procurement and the time required to deal with quality problems and improve the overall testing effort. Clear, precise and accurate specification of testing requirements helps the supplier product validation process. The supplier's product validation testing can dramatically reduce component-level testing in the main company. Access to the supplier testing results and data can bring a better understating of components' performance and

behaviour. Therefore a collaborative effort to integrate test plans, analysis results, and corrective action workflows across supplier, internal, and customer is beneficial.

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