An approach to lean product development planning

Marcus Vinicius Pereira Pessôa [a1], Geilson Loureiro [b] and João Murta Alves [c]

[a]Departamento de Controle do Espaço Aéreo – DECEA, Brazil.
[b] Instituto de Pesquisas Espaciais – INPE, Brazil.
[b] Instituto Tecnológico de Aeronáutica – ITA, Brazil.

Abstract. A product development system (PDS) is based on two pillars: "do the thing right" and "do the right thing". While the former leads to operational efficiency and waste reduction, the latter guarantees the fulfillment of all stakeholders needs. On this context, Toyota's PDS has a superior performance. The lack of formalization of the Toyota PDS system, though, makes it difficult to replicate. Research on this system has resulted in the identification of several principles, tools and techniques, but did not present a way to make them systematic. This paper aims to propose a systematic way to make the lean engineering products development planning. The method allows the creation of an activity network, which provides at the same time value creation and waste reduction. The first part of the paper identifies of the needs to the lean development planning. In sequence the method conception is presented. Finally the method is evaluated against the identified needs and improvement opportunities observed on an aerospace product development example.

Keywords. development planning, product development, lean philosophy

1 Introduction

New product development (PD) can be understood as some kind of information based factory [1]. The goal of the PD process is to create a “recipe” for producing a product [2], which reduces risk and uncertainty at the same time with the target to gradually develop a new and error-free product which can then be realized by manufacturing, sold, and delivered to the customer.

PD is a problem-solving and knowledge-accumulation process, which is based on two pillars: "do the thing right" and "do the right thing". The former guarantees that progress is made and value is added by creating useful information that reduces uncertainty and/or ambiguity [3], [4], [5]. The latter addresses the challenge to produce information at the right time, when it will be most useful [6], [7]. Developing complex and/or novel systems multiplies these challenges; the coupling of individual components or modules may turn engineering changes in a

[1] Process Engineer, CCA SJ - DECEA (São José dos Campos), Campus do CTA, São José dos Campos, SP, Brazil; Tel: +55 (12) 3947 3668; Fax: +55 (12) 3947 5817; Email: mvppessoa@gmail.com; http://www.ccasj.aer.mil.br

component into “snowballs”, in some cases causing long rework cycles and turning virtually impossible to anticipate the final outcome [8].

Not surprisingly, overtime, over budget and low quality are commonplaces on PD projects. A great exception on this scenario, and benchmark on the automotive industry, is the Toyota Motor Company. Toyota has, consistently, succeeded on its PD projects, presenting productivity four times better then their rivals [9]. To deliver better products faster and cheaper, some firms are attempting to use the same principles as Toyota’s, and create “lean PD” processes that continuously add customer value (i.e., that sustain a level of “progress” toward their goals) [10], [11]. Unfortunately, unlike Toyota Production System (TPS), that was formalized by Shigeo Shingo and enforced by Taichii Ohno, the Toyota development system has not been well documented [12], [13].

This paper aims to propose a systematic way to make the lean engineering products development planning. The method allows the creation of an activity network, which provides at the same time value creation and waste reduction.

This work consists of three parts: (1) the identification of the needs to the lean development planning; (2) the method conception; and (3) the method evaluation against the identified needs and improvement opportunities observed on an aerospace product development example.

2 The needs to the lean development planning

Literature review allowed to understand the real needs to the lean development planning (LDP). First it was necessary to clarify the meaning of os value creation and waste reduction on the PD context. Next, the main issues on the PD processes, LPD prerequisites and PD projects planning were pointed.

2.1 Value creation and waste reduction

The value, as defined by the final client, is the basis of lean thinking. On a program or project, the value is the reason d’être of the project team, which means they must understand all the required product/service characteristics regarding the value that all stakeholders on the program expect to receive during the product life cycle [9], [6], [14].

There is no recipe, though, to value creation. Value is: (1) personal, because something of high importance to a group or person may not be valuable to others; (2) temporal, since it is not static, but evolve according to stakeholders’ change of priorities; (3) systemic and enterprise wide, as the parts, subsystems or company’s sectors only add value if they contribute for the whole; and (4) fuzzy at the beginning of the lifecycle, due to the few information available to determine the whole value and, sometimes, even the final client [6].

The inherent complexity on the development of complex engineering products is a serious obstacle to value creation. By concurrent engineering principles when a product is conceived it already constrains its life cycle processes and the organizations that perform those processes, creating a total perspective where the product plays only part of the whole complexity [15]. Thus the “total” value

includes not only the product's perceived benefits, but also the benefits achieved through the life cycle processes and performing organization. Value for a stakeholder, then, is the total and balanced perception of all benefits provides by the results from the life cycle processes; as a total perception are considered not only the results related to the product, the processes and the performing organization, but also the fulfillment of all functional, cost, schedule and risk requirements [16].

Concerning waste, in manufacturing for instance, Toyota has established a set of seven waste categories that make easier the task of waste finding and elimination. These categories were further adapted to the PD environment [1], [11], [17]. Table 1 shows the seven wastes countermeasures from the PD perspective [16].

Table 1. Wastes countermeasures on product development

Waste	Product development perspective
Overproduction	Synchronize the information and resources capability and schedule. Use pull events instead of phase gates.
Transportation	Define optimized information flows (what, when, to whom and how). Avoid multitasking.
Waiting	Include only dependencies that represent the value flow.
Processing	The project network must include all and only the activities from and to support the value flow. Guarantee the allocation of the right people and materials.
Inventory	Define clearly what, when and who will perform each task. Execute resource leveling.
Unnecessary Movement	Avoid micro planning that may lead to information inconsistency.
Defective Product	Create a verification and validation plan to check the right value delivery.

2.2 Issues to the Lean Product Development Planning

The identified issues are related to the PD process, to the lean prerequisites to PD and to the traditional planning methods.

A PD process has to be capable to deal with: (1) product complexity, as customers demand products more and more complex; (2) process complexity, regarding integrated development, process standardization, amount of information involved, etc.; and (3) uncertainty between supposed and verified characteristics and ambiguity due to multiple and conflicting interpretations.

In order to be lean, the PD process must adhere to the lean principles (Table 2) and avoid traps such as [6]:

- The 'preconceived solution': a solution that has worked in the past and that has become institutionalized as a 'monument'.
- The existence of a powerful advocate with a vested interest in a specific design approach or solution to a problem.
- The tendency to underestimate the difficulties in developing a new technology, particularly if this occurs simultaneously with the development of a new product or system base don that technology.

Table 2. Lean principles applied to development planning.

Specify value	The value (as defined earlier) to all stakeholders must be identified and balanced into a solution.
Identify the value flow	The best value creation sequence must be identified, allowing the information to flow and consequent value delivery.
Guarantee the flow	Remove the obstacles from the value flow, avoiding waste and synchronizing the development activities.
Work with a pull system	Instead off pushing scheduled activities, which themselves push information and materials through the development process, pull events must be defined. Pull events differ from phase gates by not damming information, but allowing its flow.
Seek perfection	The development process continuous improvement is achieved by the capability of the process and effective knowledge management.

Finally, traditional planning falls short on lean development due to:

- To guarantee the 'schedule stability' a point and low risk solution has to be frozen early in the process in detriment of others viable solutions [9].
- The planning main objective is the control and not the execution [18]. Thus, more importance is given to the activities themselves instead of their results [9], [19].
- It incorporates a transformation view, by assuming that translating a plan into action is the simple process of issuing and executing 'orders', analogously to a MRP (Manufacturing Resource Planning), ill guarantee the project success [20].
- The systemic vision loss caused by successive product and work decompositions [16].

3. A lean perspective on the development process

The ideal PD process should work analogously the single-piece flow in manufacturing [21], representing a value flow from conception to production, without stops due to bureaucracy and loop backs to correct errors. On PD, adding customer value can be less a function of doing the right activities (or of not doing the wrong ones) than of getting the right information in the right place at the right time [9], [10]. Hence, the focus of lean must not be restricted to activity "liposuction" (waste reduction), but address the PD process as a system (value creation) [10]. Value creation can be divided into three phases: value identification, value proposition and value delivery [6]. Figure 1 shows the elements on these three phases [16].

During value identification the value demanded by each stakeholder is understood and decomposed into value items that are unambiguous and verifiable through measures of effectiveness.

While creating the value proposition, teams are defined according to the development scope (set of value items). A set of pull events is also defined, in order to allow a pulled development. Examples of pull events are important deliverables and major verifications. Activities are defined in order to allow the

execution of the pull events. Activities are performed by the teams whose deliverables incorporate the value items in the scope of the pull event.

The value delivery occurs while the activities are actually performed and the resulting deliverables benefits are perceived by the stakeholders.

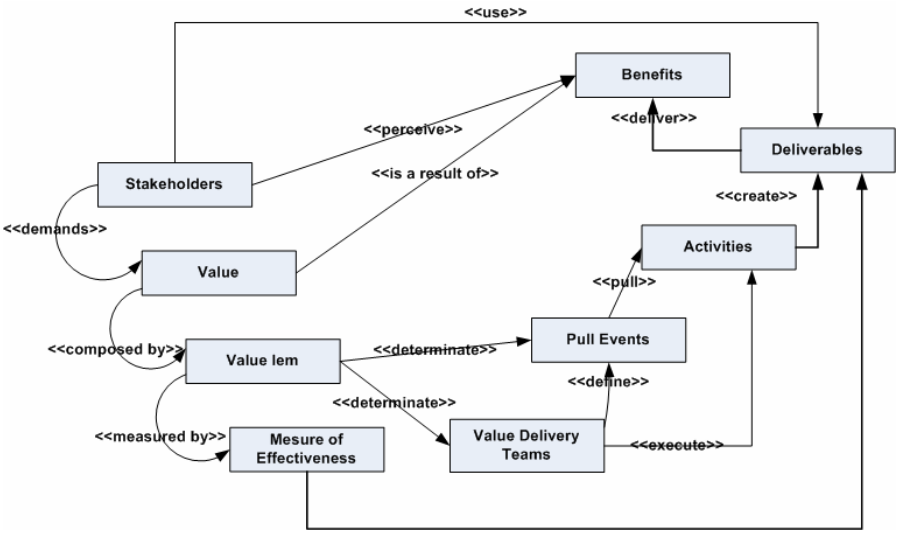

Figure 1. Lean perspective on PD process [16].

3 The Method

The approach described in this section applies the lean principles, based on value creation and waste reduction, to derive a project activity network that is based on a value creation sequenced set of confirmation events that pulls only the necessary and sufficient information and materials from the product development team. The purposed method has four steps (Figure 2):

(1) **Value determination**: having the product vision as an input, this process defines the Value Breakdown Structure – VBS. The VBS differs from the usual WBS, where the latter decompose the work, to make major project deliverables or perform project phases, into smaller and more manageable chunks, and the former deploys the stakeholders' value into unequivocal and verifiable parameters, called value items.

(2) **Set-based Concurrent Engineering (SBCE) prioritization**: determines the most critical product modules or organizational processes, which will be developed through a set of alternatives. During SBCE, the development team does not establish an early system level design, but instead establishes sets of possibilities for each subsystem or process, many of which are carried far into the product and process design.

(3) **Pull events determination**: No process along the value flow should produce an item, part, service or information without direct request from the following processes. The pull events arte associated to physical progress evidences (i.e., models, prototypes, start of production, etc.) and are important moments to knowledge capture. Differently from tall gates where information batches are created, pull events guarantee the value flow, make quality problems visible and create knowledge.

(4) **Value creation activities sequencing**: the activities to be performed are defined and sequenced based on the pull events.

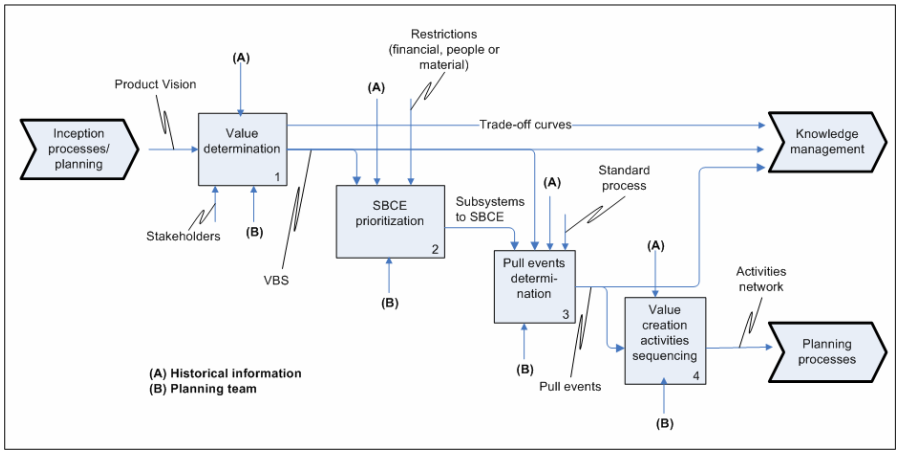

Figure 2. The purposed method.

4 The method evaluation

The method was evalueted according its capacity to fulfill the previously presented needs (Table 3):

(1) **Value determination**: this step guarantees the value specification principle; it avoids preconceived or any other solution that does not match the expected value; the focus on value is the basis to planning to execution; finally, analogously to the others steps, it uses and generates historical information that contributes to continuous improvement.

(2) **Set-based Concurrent Engineering (SBCE) prioritization**: the multiple alternative development prevent the early abandonment of promising solution and gives room to the coexistence with preconceives and advocated alternatives as well; it helps to guarantee the flow, since reduces rework cycles.

(3) **Pull events determination**: the pull events are the back bone of the value flow and have the main role to fulfill the pull work principle; by pulling the value delivery they allow the planning to execution.

(4) **Value creation activities** the pulled value creation activities are the value flow itself; by being put in motion, they are the very planning to execution.

Table 3. The method coverage on the identified issues.

		Value determination	SBCE prioritization	Pull events determination	Value creation activities sequencing
Lean Principles	Specify value	x			
	Identify the value stream			x	x
	Guarantee the flow		x		x
	Pull the value			x	
	Seek perfection	x	x	x	x
Traps to value creation	Preconceived solution	x	x		
	Powerful advocate with vested interest	x			
	Develop a new product with new technology		x		
Issues on traditional planning	Early solution freeze		x		
	Planning to control and not execution	x		x	x
	The transformation view			x	x
	Systemic vision loss	x		x	x

As the basis for a contrived example of development planning, was used the data collected from a finished and successful project, which produced a stall recovery system to be used during flight tests. Table 4 presents a comparative analysis of the original planning and the resulted by the method application. On this particular example there were better results on each of the four steps.

Table 4. Lean principles applied to development planning.

Step	Original Planning	With the Method	Impact
Value determination	Only client's needs related to the final product were considered.	All the stakeholders' needs related to the final product, life cycle process were considered.	Create Value
SBCE prioritization	Only one solution alternative mainly describes in the contract.	Many alternatives on the parachute launching subsystem (critical to SBCE) would reduce the rework that actually happened.	Reduce waste
Pull events determination	Homologation and test activities were superficially defined.	The test and homologation events were best sequenced and scoped.	Create Value Reduce waste
Value creation activities sequencing	The p plan was focused on activities based on the standard process.	The plan was focused on value and based on the value flow.	Create Value Reduce waste

9 Conclusions

The research method presented in this paper provides a useful approach to planning to complex engineering products development. Conclusions are that the developed method: (1) fits the product development environment; (2) adheres to the lean principles; (3) faces the traditional planning deficiencies; (4) exploits the improvement opportunities from the studied example.

This work contributes to the PD discipline by the appliance of the lean principles, based on value creation and waste reduction, to derive a project activity network that is based on a value creation sequenced set of confirmation events that pulls only the necessary and sufficient information and materials from the product development team.

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