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Delivery Project in the Context of Product Life Cycle

Seppo Suistoranta
Wärtsilä Finland Oy
Ship Power, Merchant
Purokatu 3
FI-21200 Raisio
FINLAND
seppo.suistoranta@wartsila.com

Abstract
The complex products are typically delivered by projects. The scope of such a project ranges from a standard package to the entire plant, which includes engineering, purchasing, and construction. In literature, the project is typically treated as a practical endeavor, the aim of which is to deliver an accurately specified product or a service to the customer. From a designer's point of view many questions arise: how to understand the customer's feedback and identify real needs for product improvement; how to define the product's borders; and how to evaluate the project's deliverables. This paper is based on the experience we have gained in large delivery projects in the industry. It first discusses two different project models selected from the literature. Then, using the approach of design science a model for the delivery project is formulated in the product life cycle context. This model can later be used for developing tools to support the practical project management work.

Keywords: Project, management, product, process, life cycle.

1 Introduction
In general, project execution and management are perceived as practical work, for which direct, concrete and easily measurable targets can be set. A formal "science of project management" leans heavily on fundamentals of operations management: planning, problems solving, organizing, target setting and performance measurement. An important aim of this "scientific" project management has been to partition a complex endeavor into manageable tasks. The consequence has been a march of various sophisticated project management tools and software to support planning and operational project work. However, we need a scientific approach to develop the art of project management in the context of product life cycle.

2 Motivation and background
From these practical starting points it is difficult to see the link between "project" or "project management" and the phenomena during *product's* origination and life cycle processes. The background for this study is, on one hand, the practical experience we have gained from the industry on running large delivery projects. On the other hand, "projects" and "project management" are not much treated in design science; one would even claim that as such they have not been considered relevant in design science.

Hence, we present three important reasons why "projects" and "project management" should be studied within design science:

1. Most stringent customer feedback regarding the product’s design is expressed in so called project situations; i.e. in project meetings or while performing project tasks.
2. There are a multitude of players in large delivery projects, many of them supplying technical systems or services that are intended to function together. Customer’s demand for system integration leads in many cases to tedious and problematic task of determining the borders and interfaces between each supplier’s product specifications, and naturally raises the never ending discussions of how to share the costs and responsibility between the players.
3. Time, cost and quality are traditional triple constraints for a project. However, we claim that this point of view is too narrow within the increasing challenges of world’s future and therefore we suggest that the project constraints should be extended to involve the seven universal virtues.

3 Objectives

The objective of this study is to include project and project management as constituents of design science and link these common terms to the relevant terminology. Particularly, a project situation is modeled in order to develop a practical tool for identifying the feedback links from the customer.

4 Project models in literature

Project Management Body of Knowledge (PMBOK®)

Project Management Body of Knowledge [1] defines project as follows: “A project is a temporary endeavor undertaken to create a unique product, service, or result.” This definition is traditional and similar to those given by many professional institutions for education and development of project management.

The definition is further explained by underscoring the following words (by PMBOK),

- *Temporary*: Every project has a definite beginning and a definite end.
- *Unique products, services, or results*: A project creates unique deliverables, e.g. products. A product is perceived as artifact that is produced, is quantifiable, and be either an end item in itself or a component item. Uniqueness refers to the fact that the project and its outcome are individual.
- *Progressive elaboration*: developing in steps and continuing in increments. This means that at first the project’s scope, plan, and specifications are described broadly and then worked out into a more explicit and detailed form as the project progresses.

This definition and its further explanations are generic in the sense that they do not take into consideration the type of industry and/or project’s links to a wider business context. PMBOK separates projects from company’s operational work by stating that the purpose of operations is to sustain the business. Some companies may execute projects only occasionally, e.g. developing a new product and launching it to the market. By contrast, as stated by Pulkkinen [2], a *projecting company* bases its mode of operation on projects, participating in planning and executing consecutive projects.

The PMBOK perceives product as the project’s deliverable. This is presented in Figure 1, in which the product and the project evolve in a two-dimensional space. In this model the project phases elapse horizontally, and the outcome of the project (= the product) takes shape vertically.

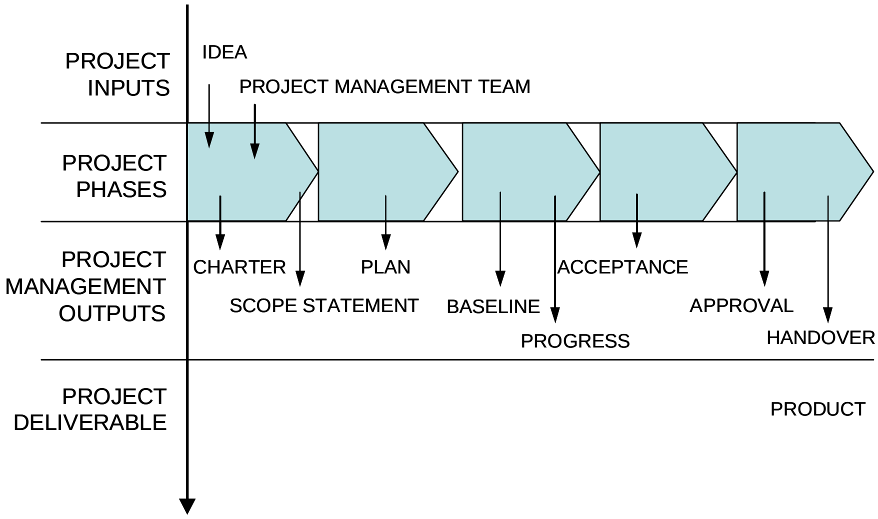

Figure 1. The traditional project model links product with project in two dimensions. Product is a deliverable of the project. Redrawn from [1].

Recursive model of functions (Genopersistation)

Dean [3], [4] presents a model of functions that are recursively applied to the system. For this, he introduces a new term, “genopersistation”, which is a compound word from “genesis” and “persist”. In general, to genopersistate an object means to bring forth, sustain, and retire that object. In the product life cycle context we may say that to genopersistate the product means to conceptualize, to evaluate, to market, to design, to prototype, to test, to produce, to deploy, to operate, to support, to evolve, to retire, and to manage the product.

In this recursive model the product is on the lowest level. Applying separately the product life cycle functions, the genopersistation of the product encompasses all that the product actually undergoes during its life cycle, i.e. the product is conceptualized, the product is evaluated, ---, the product is retired.

The next level up in the recursion model is the system that genopersistates the genopersistation of the product. This is interpreted that *every life cycle phase* of the product is genopersistated in turn, i.e. to conceptualize the conceptualization of the product, to evaluate the conceptualization of the product, ---, to retire the conceptualization of the product, ---, to retire the retirement of the product. Here Dean’s artificial word easily demonstrates its power; when decomposing it into individual life phase functions it would in writing extend to about 70 lines. Dean further terms the second level of recursion as “project”, see Figure 2. The recursion can be further extended to higher levels; their formulation, however, is not in this paper’s scope.

The recursive model assumes that the product exists at a certain level of abstraction and then it develops as a result of applying each life cycle function consecutively. Recursion means that the life cycle functions are applied also to the next higher levels of the product, i.e. to the project. This model can be used to explain both the origination of the product and the project that delivers it. However, the model does not explain how the life cycle function realizes the expected transformation (technology), or which operators participate in the transformation.

The recursive model of genopersistation function links the project with the product. In his research work Dean focuses on adopting this model in designing to cost of large technical (space and aviation) systems; he does not explicitly study the relationship between the project and the product as part of design science.

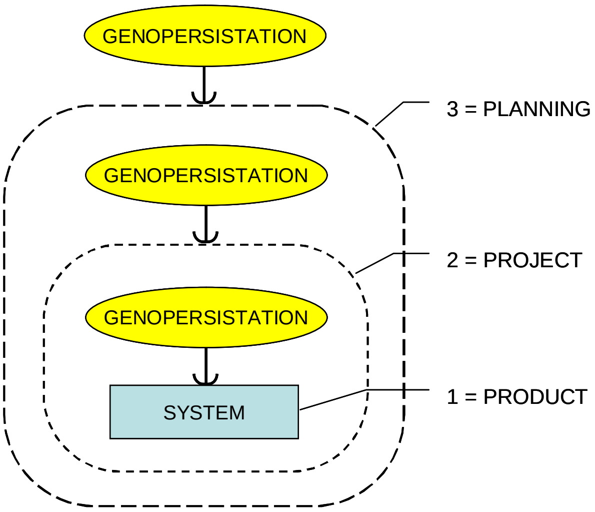

Figure 2. The recursive model of genopersistation function links the product with the project in two levels of abstraction.

However, the genopersistation function could be easily generalized to cover the whole continuum of product's life cycle as explained by Suistoranta [5]: "If we see the technical system's life cycle as a continuum of transformation systems, we can separate a piece thereof by setting boundaries around any life phase and name it after the life phase in question. These piecewise continuous transformation systems are called life phase systems."

Project management processes
PMBOK [1] makes a clear distinction between the project and the process. By PMBOK's definition, process is "a set of interrelated actions and activities performed to achieve a specified set of products, results, or services." This definition does not refer to the transformation that takes place in the process or to the operators that execute the actions; only the output is pre-specified. The type of operand is not limited but is obviously taken as information or data, not as the physical product that is delivered. Thus the process by this definition makes part of the controlling functions in the "management and goal system" as understood in design science.

PMBOK presents, in particular, project management processes for a project, categorizing them in five groups: initiating, planning, executing, monitoring and controlling, and closing process group. Each process group is a set of actions that are needed to produce the specified deliverable. The process groups are applied in a repetitive and iterative manner within the project boundaries.

5 Project management in practice
A company sets business targets in its strategic plan. Sometimes projects may be perceived as opportunities in penetrating new market areas or in introducing new technologies. Also the launching of new products calls for special projects. In short, projects may be used as tools for implementing the company's strategic plans. In addition to this, the projecting companies base their business on executing delivery projects.

By PMBOK’s definition every project is unique. However, the projects are coupled together through company-wide issues like target profit; strive for using resources efficiently, and financial limits. These are reflected in the expectations of the company’s senior management, which may prompt the project manager in his decisions within the project. Generally, this prompt manifests itself on three levels:

- Strategic level; through the company’s business idea, or market share.
- Tactical level; through targeted profitability, or product development policy.
- Operational level; within the individual project. This is the level at which the project manager and his team mostly do their daily work.

The decision making must always be fact-based, but to balance the prompt the project manager may use his intuition and skills of situational management.

6 Project as a transformation process

As discussed earlier, the product life cycle can be modeled as a chain of life phase systems. Each such system is composed of a transformation process and life cycle operators. Usually we give descriptive names to these life cycle systems, e.g. design, manufacturing, assembly, testing, distribution, installation, use, service, and disposal.

An important statement from PMBOK is that “generally a project life cycle is contained within one or more product life cycles”. In this, product life cycle actually means life phases of the product. This can be seen easily when we map the (delivery) project to the real product life cycle: the project’s tasks are fragmented in various life phases, i.e. in time and place. Globally operating industrial companies develop and manufacture the product in various places and under various time schedules. Further, as Pulkkinen [2] points out, the product may belong to a product family, which connects the project to the problems of managing product variety.

Therefore it is misleading to consider “project” or “project management” as a distinct *life phase* in product’s life cycle. The project contains elements from various life phases of the product. Theoretically we can group these elements together to form a *virtual* life phase. The elements are linked to each other by dispositional mechanisms. The input to this virtual life phase is the set of inputs at the various project situations and the output is the sums of the various outputs, respectively, see Figure 3.

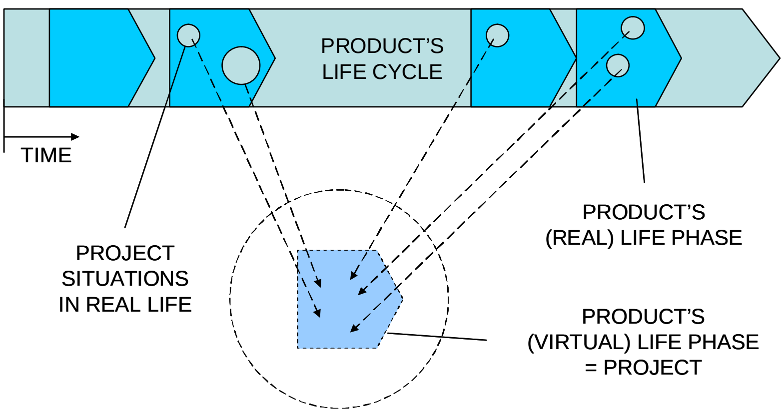

Figure 3. Project seen as a virtual life phase in product’s life cycle.

Project management as managing dispositions

Olesen [6] has extensively researched the interplay between product and manufacturing system. He introduces the theory of dispositions. An important element of this theory is the concept of *disposition*, which he defines as follows: "By a disposition we understand that part of a decision taken within one functional area which affects the type, content, efficiency or progress of activities within other functional areas."

Olesen's general model of disposition unites functional areas by shared target rules and knowledge of the activities that are needed to perform in those areas. This model refers to an industrial company, in which the product originates and where the dispositional effects are considered in relation to a sequence of various phenomena in the production departments. The model can particularly be interpreted to involve the management's decisions within product's delivery project. Thus it may be generalized to apply to the product's *life phase systems* instead of only to the functions of a company.

"Project management" in the sense of "managing the project" can easily be seen as an operator system, which Hubka et al. [7] call a "management and goal system". The project manager and his team belong to this system. As discussed earlier, the project can be seen as product's virtual life phase. Thus, "project management" *operates* the project together with other operators; "customer", "competitors", "suppliers", "officials", "time and space", and the like. In the product life cycle context the project manager's decisions and the consequential actions become observable in later phases of the project. This means that in project management it is basically question of *managing the dispositions.*

The dispositional links overstep the (real) project boundaries. In reality, the events that take place *before* the project is started (kicked off) and also the ones *after* the project has been closed are more dominant for company's business planning. The decisions made within the project affect the parallel and the forthcoming projects, see Figure 4.

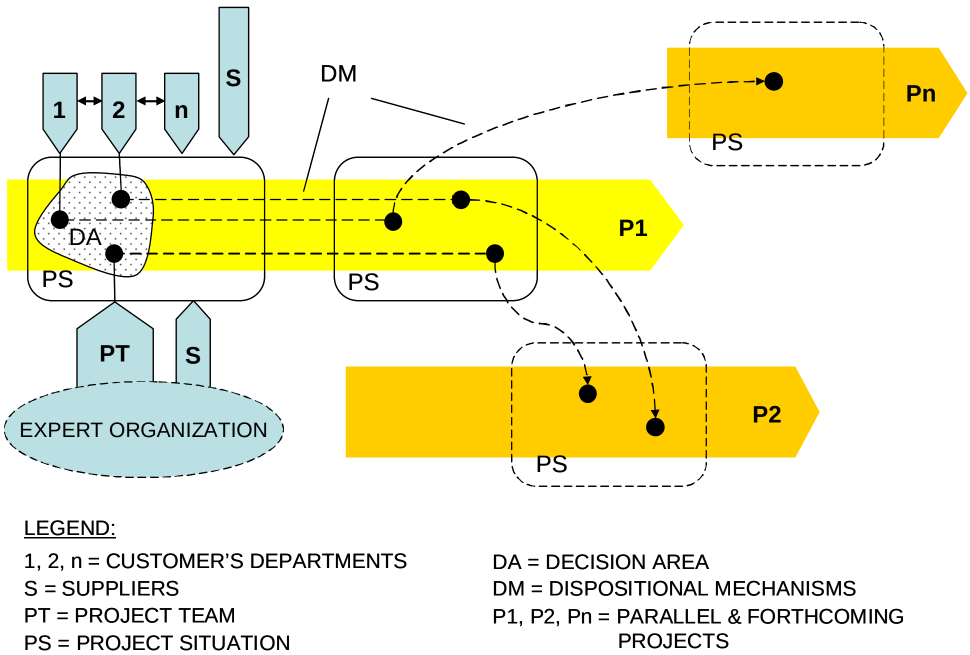

Figure 4. Dispositional mechanisms overstep the project boundaries and affect also the parallel and forthcoming projects.

7 Issues from real projects that can be treated in design science

Identifying the customer's needs for product improvement

The project manager often faces situations, in which the customer is expressing various demands to the seller: they can be claims arising from nonconformity, or requests for new properties or upgraded performance features. The project manager must consider these requests; either they are based on verifiable design deficiencies, or the customer is using them as a means to obtain some extra benefits, like price reduction or extended warranty.

In the time and cost pressure the project manager must first distinguish customer's factual motivation and then identify the issue. If the issue works out to be related to product's design it calls for analyzing the problem and finding its root cause. This process follows then the standard rules of engineering design, which might be too slow in project situations. The core question can be captured as follows: How can the project manager identify the nature of the issue, specify it in technical terms, take it to the design office, follow up the design process, and finally implement the new design as requested by the customer? To answer this question further studies are needed.

Product boundaries

In the real project situations the product's specification is frequently discussed and reverted. This problem of irresoluteness takes shape in how the product is defined and limited in relation to other systems, referring thus to product boundaries.

In the beginning the customer specifies his needs of a large system, which is then built by several suppliers. Each supplier provides their own sub-system, which is based on their own design and intellectual property. How to make sure that the resulting, large system will be working as expected by the customer? The problem has been sketched in Figure 5. There are three sub-systems by various suppliers: 1, 2, and 3. The area closed by the bold line represents the overlapping sub-systems. It may provide excess redundancy, but it may also cause integration problems. In the beginning the customer's specification may be fixed, but becomes soon a dynamic document as his requirements evolve. These requirements may be based on upgraded needs or future expectations. Typically also the suppliers' products are under continuous development; therefore their sub-systems will be regularly updated, which means that new revisions and/or variations are introduced during the project.

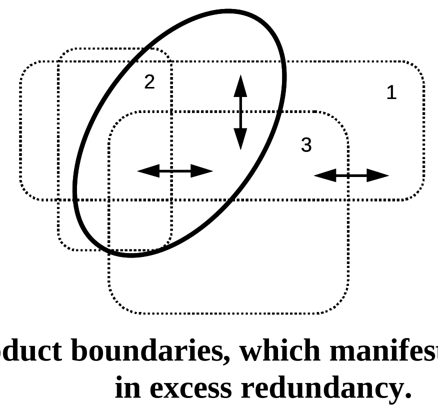

Figure 5. Problem of product boundaries, which manifests itself in lack of integration or in excess redundancy.

While this integration problem may be minimized by a rigorous project management and coordination it will always be product-related, too. Approaching the problem from the viewpoint of design science we should see each supplier's product as a technical system, which provides a transformation rather than specific effects, functions, or signals.

Project constraints

PMBOK defines the project constraint as “an applicable restriction or limitation, either internal or external to the project, that will affect the performance of the project or process.” The traditional project constraints are time, cost, and quality (sometimes “quality” is replaced by “scope” and placed in the middle of the triplet). In real projects the time is always limited and the cost constraint becomes concrete in the form of fixed budgets. Likewise, quality is designed to meet the specification, neither under nor over.

These three project constraints have also a more general, if not even strategic, meaning in the success of any manufacturing company, as explained by Cooper et al. [8]. They call time, cost (price), and quality the company’s *survival* triplet.

8 Towards extended project constraints

In order to meet the project’s performance targets, the project manager must balance within the three project constraints. In business context, these are often made commensurable by expressing them in terms of money. However, in design science this triplet is considered unbalanced and too narrow for a prescriptive set of constraints.

Andreasen [9] and Olesen [6] present seven quantities, which are measurable and present in all development projects and functional areas of an enterprise. They call them *universal virtues*, which are: costs, (throughput) time, quality, efficiency, flexibility, risk, and environment.

Andreasen also sees universal virtues as *abilities*, attaching them to the industrial company’s product development and production activities in the market. Olesen refers to joint development projects for a technical system and its manufacturing system, giving a manufacturing-related content to each universal virtue. Mørup [10] proposes in his considerations on DFX that universal virtues can be attached to all life phases of a product or to its life phase systems.

Universal virtues are not arithmetically commensurable and they cannot be reduced into costs in monetary terms, in particular. Suistoranta [5] constructs a new, extended concept of cost in design science. For this, we assume that an ideal product and ideal project exist. The extended cost is understood as the distance from the ideality; this distance is called *lost goodness* and it is measured in terms of universal virtues.

The concept of extended cost would make a new and improved basis for estimating project’s performance and the goodness of project deliverables. Shifting from the survival triplet to the survival septet would emphasize the factors that are becoming increasingly important for the world’s future and well-being.

9 Summary and conclusions

The impetus for this paper was the experience gained in large delivery projects for complex industrial products. Project management and project execution are typically seen as practical work and hardly treated in the literature of design science.

However, there are three main reasons why project management and project execution should be handled as constituents of design science: 1) The lack of systematic and easy-to-use tool for identifying the real product development needs, which are raised in a vague form in project situations; 2) The problem of defining the product boundaries, and 3) The unbalanced and narrow view of evaluating project’s performance by using the traditional project constraints cost, time, and quality.

In this paper we have sketched a model of a product’s delivery project as a virtual life phase, which connects various elements from product life phases with dispositional mechanisms. In this model the project management, the suppliers, the customers, the competitors, and time and place, are operators. The project management’s decisions are linked to later life phases of the product, overstepping also the project boundaries; therefore the parallel and forthcoming projects are also affected.

Further studies are proposed for developing a tool for identifying the real product development requirements. In order to mitigate the product boundary problem it is preferable to perceive the large systems as compositions of transformations. The increasing challenges of future world call for shifting from the survival triplet to the survival septet in evaluating the performance of the project and the product.

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