Knowledge framework on the execution of complex projects
The development of a functional framework using a systems approach

Wiskerke, Jeroen; Veeke, Hans; Pruijn, Jeroen; Groen, C.; Hopman, Hans

Publication date
2017

Document Version
Final published version

Published in
Proceedings of the International Conference on Information and Knowledge Engineering (IKE 16) (2016 Worldcomp International Conference Proceedings)

Citation (APA)
Wiskerke, J., Veeke, H., Pruijn, J., Groen, C., & Hopman, H. (2017). Knowledge framework on the execution of complex projects: The development of a functional framework using a systems approach. In H. R. Arabnia, L. Deligiannidis, R. R. Hashemi, G. Jandieri, A. M. G. Solo, & F. G. Tinetti (Eds.), *Proceedings of the International Conference on Information and Knowledge Engineering (IKE 16) (2016 Worldcomp International Conference Proceedings)* (pp. 73-78). CSREA.

KNOWLEDGE FRAMEWORK ON THE EXECUTION OF COMPLEX PROJECTS

-THE DEVELOPMENT OF A FUNCTIONAL FRAMEWORK USING A SYSTEMS APPROACH-

J.Wiskerke, H.Veeke, J. Pruijn, C. Groen, H. Hopman
jeroen.wiskerke@damen.com, H.P.M.Veeke@tudelft.nl, J.F.J.Pruyn@tudelft.nl,
keesjan.groen@damen.com, J.J.Hopman@tudelft.nl

Abstract

This paper describes a functional framework that has been developed to realize a steady execution of a variety of complex projects. It provides knowledge to successfully intervene in a currently problematic situation. To achieve this, theory and practice have been equal constituents. The development is based on the Delft Systems Approach and the experience is gained from three executed projects at ship yards. The framework has been tested on project data and expert reviews, judging fit, relevance, workability and modifiability of the framework.

Keywords: Knowledge Management, Systems Approach, Framework, Complexity

Introduction

The relation between the multidisciplinary nature of a design or maintenance and repair (M&R) project and the mainly mono-disciplinary participants of the project team, is a major problem during execution. It leads to a clear misfit between intentions and perceptions of the project result. As long as the complexity of a project is relatively small, the misfit can be solved during execution. But with complex projects - as occurring in innovative design or non-recurring M&R - the misfit has consequences like unexpected results or costs exceeding the budget. In a former paper [Veeke, Lodewijks et al, 2006] conceptual modelling was proposed as a generic interdisciplinary activity rather than a domain-specific one, in order to bridge the gap. It was shown that the Delft Systems Approach [Veeke, Ottjes, et al, 2008] offers the basic models to describe any innovative design in a functional/conceptual way.
In this paper, the same approach is used for non-recurring M&R projects at shipyards. After analyzing three complex projects, executed at three different conversion yards, it appeared that the execution of complex projects requires not only a similar way to describe the project activities but also a different project organization.
Today's practices do not fit the requirements for these complex projects. This will result in a decrease of efficiency and introduce the need for a change in the current situation [Tushman, Nadler,1978]. Current project executions, often with a taken-for-granted nature as described in [Nelson, Winter, 1982], are still common practice at ship yards. They are executed as "normal" M&R projects and are enforced by local, historical influences. Suboptimal project executions are rooted in the past, and originated from historical traditions [Levering, Ligthart et al, 2012].
The misfit between current practice and demands shows most clearly in the execution of complex projects as they significantly differ from the normal M&R as described by both Senturk[2008] and Levering et al. [2012]. The execution in complex projects is yard specific, non-repetitive and there is no mutual learning curve between the different yards. Best practices and knowledge are rarely shared.
In order to investigate this problem further, we need to define complex projects at shipyards first. After that we will apply the models of the Delft Systems Approach to these complex projects and discuss the organizational consequences of them for the execution.

Complexity of M&R projects

The two most common types of complexity within projects concern the organizational and technological complexity.

Organizational complexity is caused by the engagement of several separate and diverse organizations for a finite period of time. This leads to a temporary multi-organizational structure to manage a project. The level of complexity depends on the differentiation, the interdependencies and the interaction within the organizational structure [Hall,1979]. Differentiation is, according to [Baccarini, 1996], caused by hierarchical structures and organizational units.
Technical complexity is caused by differentiation and interdependency as well. In this case, differentiation refers to the diversity of tasks.

We define a complex project in this paper as "a project with an estimated value of many millions of euro's, consisting of many interrelated and interdependent parties that work together as one whole. The project is executed under the supervision of a single shipyard, to convert – in the broadest sense – a vessel within a restricted timeframe and budget. It is more demanding than the normal M&R projects with respect to organization, legislation and technology"

A measure for complexity is not available yet within this definition. Complexity is usually expressed by means of cost, duration or numbers of people involved. These criteria however don't correlate well with management complexity [Duncan, 2013].

Originally GAPPS (Global Alliance for Project Performance Standards) developed a framework that categorizes projects based on their management complexity by seven factors. These are based on construction projects, so they are adapted slightly to fit the management of complex M&R projects in shipyards. The factors are:

A. Scope
   1. Stability of the overall project context.
   2. Number of distinct disciplines, subcontractors, methods or approaches involved.
   3. Environmental impact.
   4. Financial impact on the organization.

B. Client
   5. Client influence on organizational procedures.

C. Organization
   6. Experience on the type of work.
   7. Impact on planning and capabilities.

D. Subcontractors
   8. Cohesion between yard and subcontractors.

To qualify the complexity of a project these factors are rated on a point scale from 1 to 4 (1=Low, 2=Moderate, 3=High, 4=Very High). Of course, this system is somewhat subjective as it depends on the consistency of the assessor(s). Above that, it is subject to a learning curve in the execution of complex projects. But it is still useful in providing an aid to assess the complexity of a project and looking over specific difficulties causing the complexity. To deal with complexity caused by the factors 2, 3, 4 and 6, the approach as proposed in [Veeke, Lodewijks et al., 2006] would suffice. The other factors influence the complexity of management directly. In an unstable context and/or with little cohesion between yard and subcontractors, it is difficult to keep every participant directed into the right direction. Whenever a client has large influence on the project contents and/or until a late phase during execution, it is difficult to control time and budget of a project.

Case studies

Three executed complex projects are analyzed by means of the available project data. The complexity of the projects was qualified by the factors above and ranges from High to Very High.
The case studies analyzed the problem both from practice and theory. It appears that complex projects in the current situation are executed as enlarged M&R projects, show transient reactive behavior and lack appropriate project control and internal integration. The separate yards work at a certain basis level (S) with respect to their ability to carry out (complex) projects. This level differs from yard to yard and due to the lack of a mutual learning curve, this base is not shared and therefore does not, or only very limited, increase on group level. On the contrary, the introduction of complex projects requires a higher level of project execution which at this moment is not readily available. There is a certain growing gap, Δ, between the current level of project execution and the new demands. The need for a functional framework that provides a singular methodology for the execution of complex projects is identified, describing and covering the growing misfit Δ.
It should allow the tuning to a specific project, while keeping the relations and interdependencies similar.

Problem definition

Most literature only emphasizes correctional control. For example [Kerzner, 11] argues that control is a three-step process: measuring progress towards an objective, evaluating what remains to be done, and initiating the necessary corrective actions to achieve or even exceed the objectives. However, this definition does not include the feasibility check nor the control needed before anything will be done.

[In't Veld, 12] distinguishes four essential conditions that enable a process to be controlled properly:

1. There must be an objective; the expected result needs to be defined.
2. The system should be capable of realizing this objective (feasibility).
3. The behavior of the system should be adjustable
4. The interdependency and relations with the environment should be known.

The first two points express the need of feasible standards and maintaining them, while the other two points express the need of reactive potential in case of disturbances. In DSA these different controls are combined with the operational process into one single "steady-state model"; the model represents a general "function", which is a blueprint for anything happening in an industrial organization (fig. 1).

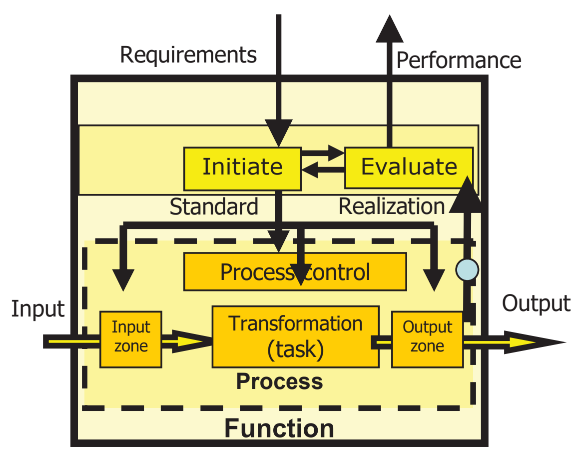

Fig. 1 Steady state model

The steady-state model represents all possible functional activities around one single material flow (it is a so-called "single aspect" model). The activities aim to make a product as required in a controlled repetitive way. When investigating logistic / industrial systems one often gets involved with three different flows:

The material flow: the production
The order flow: nothing is produced without an order
The resource flow: nothing can be produced without resources

In order to get an insight into the relations between these flows DSA contains the PROPER (PROcess PERformance) model, which visualizes the three separate but correlated flows. Each flow can be represented by a steady-state model, while the combination of flows is shown in the PROPER model.
The control functionality should be extended by a coordination control that cannot be present by definition in the steady-state model. Coordination control tunes the different flows to each other.

Both steady-state and PROPER-model are empty with respect to concrete content. So it is necessary to use the practical experiences for developing a functional framework with these models. The PROPER model is adapted to a specific model representing the process of the repeated execution of complex projects in the as-is situation. The cascade of control functions in the higher levels and the different product flows in the lowest level of the model provide insight in the functions and their interactions and interfaces.

On the top level of figure 3 – level V-, the environment is taken as the complement of actors and influences on all levels below. The environment is, but is not limited to: agencies, competitors, the market and governments. It represents everything that has a possible influence on the organization but they are taken into account in the model explicitly as the external requirements.

Level IV in the model is the first step in the cascade of control functions and consists of both the (potential) clients and the highest level of management. By means of acquisition, a client comes from the top level to this lower one with a set of requirements and possibly an Invitation To Tender (ITT) that enters the tender function at level III. Within the organization, at level IV, developments and changes in the requirements from the environment are analyzed and a suitable (long-term) approach is defined by a coordination control.

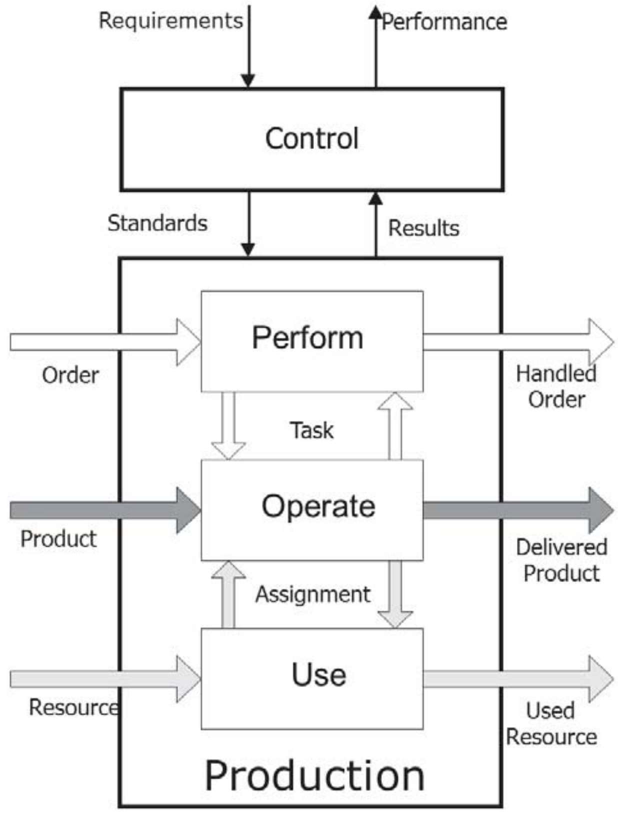

Fig. 2. Proper model

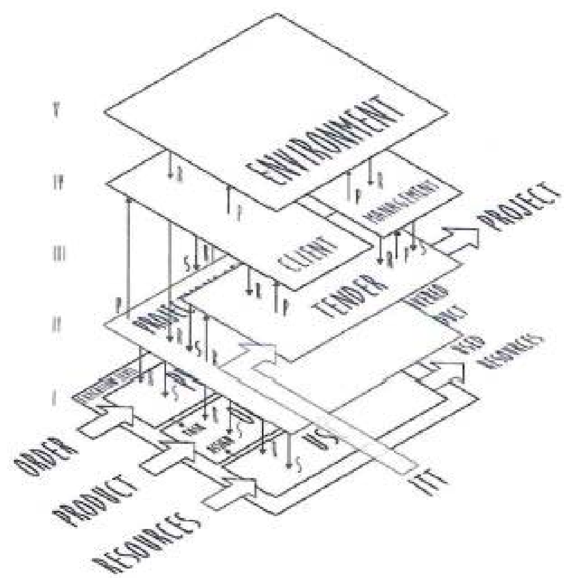

Fig. 3 PROPER-model for the execution of complex projects

At level III an extra perform (user-oriented) function has been incorporated within the control cascade that represents

ISBN: 1-60132-441-3, CSREA Press ©

the tender function. The function embodies the process in which a tender gets transformed into a project, with a certain conversion rate. Subject to the requirements received from management and client, the project specific Δ gets defined based on the basis level S of the executing yard. Performance on the tender process is referred back to client and management to tune the transformation to the (changing) requirements.

The second level involves project control in which the Δ and basis S are set received from the tender function respectively management function. They are translated into project specific standards (Δ +S) for the execution level below. The focus of this function is on the long term function controls, defining project specific standards and evaluating results to act upon possible structural deviations. Long term refers here to the part of the project that overlaps with the tender function.

At the lowest level, Level I, the project execution, three aspect flows are apparent: order, product and resource flow. These flows together transform the input into the output according the project specific standards. In the order flow the order gets translated into clear and executable tasks for the product flow in which the physical transformation/execution takes place. From the resource flow the correct resources are assigned to the product flow.

Framework

In an iterative approach between practice and theory, a framework is developed based on the PROPER model of Fig. 3. The resulting framework is shown in Fig. 4. below. Relations, interdependencies and functions within processes of complex projects become clear and support a controlled steady-state execution.

For the steady-state execution of complex projects both the downward convergence from requirements to standards and finally tasks and assignments have to be improved. The same holds for the upward convergence from execution to results and finally performance. Also the relations and interdependencies have to be defined clearly.

Improving the downward convergence is realized by an appropriate coordination function. The four factors enabling a control function as discussed earlier are incorporated in the framework and provide the necessary project control.

Objectives are formulated within the initiate functions at the different levels. In the perform function at execution level the scope is translated into clear and executable tasks, defining expected outcomes subject to the (Δ + S) standards. By defining and indicating the differences between normal and complex projects with the basis and extra set of standards the framework enables a capable project organization.

The new system allows adjusting its behavior in a pro-active approach; the developed model is empty and conceptual and therefore allows to be adjusted to a variety of projects while keeping the framework similar.

Interdependencies and relationships are defined in the framework and are constant for a variety of projects.

The upward convergence is realized by introducing a learning function with two elements; one being the implementation of a function control in the tender function; the second being the incorporation of an upward results flow by introducing separate evaluate and initiate functions at the different levels within the framework.

The function control within the tender function is the central body of knowledge in the execution of complex projects. By the evaluation of executed projects and the initiation of new possibilities, the Δ is defined and improved in the tender group.

The basis level (S) is provided by the yards, and defined by means of the results of both the execution of complex and normal projects and improved by yard specific developments. To obtain these results, evaluation and compare functions have been incorporated in the model.

All these functions are shown in the model of fig. 4.

These functions serve two purposes. Firstly they should offer a correct convergence of the results to other functions in the upward direction, for up-to-date control and learning; secondly they should enable an efficient transformation within the same function by correctly defining possible deviations on which appropriate actions can be taken by the corresponding initiate function.

The Δ is defined by an analysis of the complex projects, both in expected future and in past experience, and by the basis levels(S) at the different yards. The analysis of executed projects is based on results received from project management and important for the correct definition of the deviation from internal standards. The deviation should be used to improve the standards for the transformation from ITT to Project resulting in a better definition of the Δ set and an improved hand-over.

The learning function and the structured process together will enable continuous improvement of the execution of complex projects. They will finally realize a steady-state execution of a continuous flow of complex projects. The experienced complexity will decrease, according to De Leeuw [2000]. Complexity is a multidimensional concept that concerns interdependency, uncertainty, controllability and heterogeneity; all four will improve by the introduction of the model of Fig. 4.

Results

The framework enables a steady-state execution of a flow of complex projects at different yards. It introduces a singular methodology and centralizes the knowledge by defining the Δ set at the tender group and the basis (S) at the yards. Together they realize a learning function that is verified to prevent up to 14% of the project's cost value. The integrated project control is expected to realize a significant reduction in discrepancy between ambition and realized income.

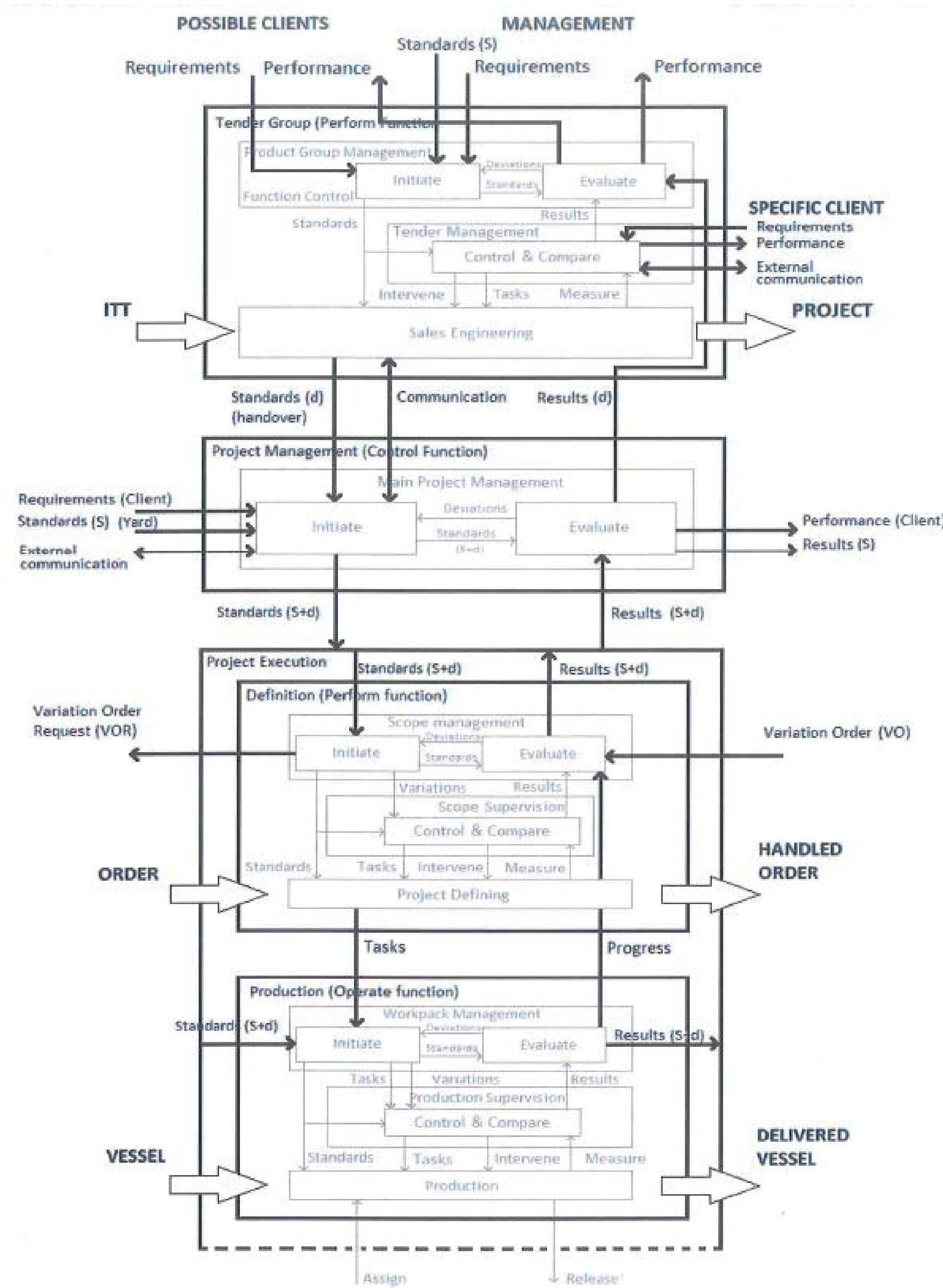

Fig. 4. Functional framework for the improved execution of complex projects

The framework enables the definition of an appropriate project organization for the execution of complex projects.

The framework is functional,, and provides a theoretical basis for the implementation of a singular methodology for conversion yards. Implementing this methodology is currently being done at a yard, and contributes significantly to knowledge gathering and registering experience.

References

[1] Veeke, H.P.M., Lodewijks, G., Ottjes, J.A., “Conceptual Design of Industrial Systems - An approach to support collaboration”, 2006, Research in Engineering Design, Vol. 17, Issue 2, pp 85-101
[2] Veeke, H.P.M., Ottjes, J. A., Lodewijks, G., “The Delft Systems Approach”, 2008, Springer, ISBN 978-1-84800-176-3
[3] Tushman, M.L., Nadler, D.A., “Information processing as an integrating concept in organizational design”, 1978, Ac. Of Management Review, y3, no. 3, pp. 613-624
[4] Nelson, R.R., Winter, S.G>, “An evolutionary theory of economic change”, 1982, Harvard University Press, Cambridge
[5] Levering, R., Ligthart, R., Noorderhaven, N., Oerlemans, L., “Continuity and change in inter-organizational project practices: The Dutch Shipbuilding industry”, 2013, International Journal of project management, y31, pp. 735-747
[6] Senturk, O.U., “The interaction between the ship repair, ship conversion and shipbuilding industries”, 2008, Council working party on shipbuilding
[7] Hall, R.H., “Organizations: Structures, Processes and Outcomes”, 1979, New Yersey: Prentice Hall
[8] Baccarini, D., “The concept of project complexity – a review”, 1996, International Journal of Project Management, Vil. 14, nr. 4, pp. 201-204
[9] Duncan, W.R., “A guide to the project management body of knowledge”, 2013, Boston, Project Management Institute
[10] Kerzner, H., “Project Management. A Systems Approach to planning, scheduling and controlling”, 1995, US, Thomson Publishing Inc.
[11] Veld, J. in ‘t, “Analyse van organisatieproblemen: Een toepassing van denken in systemen en processen”, 2002, Houten, The Netherlands, Wolters Noordhoff
[12] Leeuw, A .C.J. de, “Bedrijfskundig management”, 2000, The Netherlands, van Gorcum

Acknowledgement
We would like to thank Damen Ship Repair and Conversion for the opportunity to do this research and providing case studies by which valuable data could be gathered and derived.