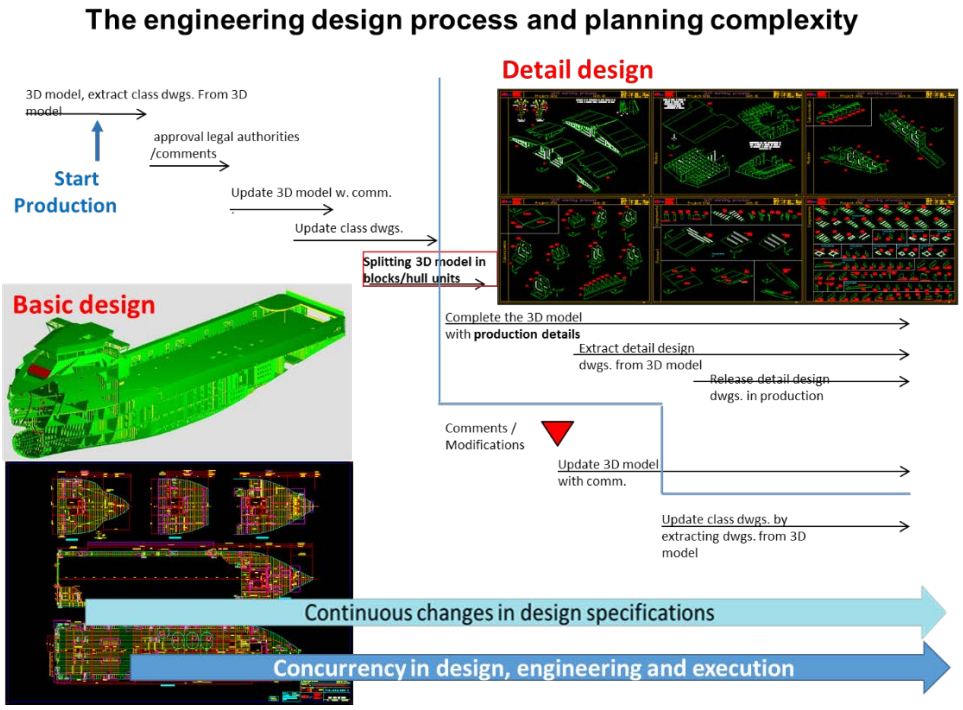
SINTEF

2018:00865 - Unrestricted

Resultatrapport NextShip

Robustness in shipbuilding planning and operations

Author(s) Hajnalka Vaagen



Date 30.05.2017

SINTEF

Address:

NO-
NORWAY

Enterprise /VAT No:

Report

Robustness in shipbuilding planning and operations

Summary Report NextShip

KEYWORDS:
Project Planning,
Design Planning,
Flexibility,
Lean,
Responsiveness,
Social network,
Resilience,
Team Behaviour,
Shipbuilding,
Project-based
production systems

VERSION
Version

DATE
Date

AUTHOR(S)

Other authors

CLIENT(S)
Norwegian research Council

CLIENT'S REF.
Project nr. 216418

PROJECT NO.
102001000

NUMBER OF PAGES/APPENDICES:
6 + Appendices

ABSTRACT

Abstract heading

The enablers of Norwegian shipbuilding excellence are cutting edge technology and proactive team behaviour to effectively share & combine resources and knowledge to quickly handle disturbances. That said, the average cost overrun of frequent changes in the industry is high, and with steadily increasing cost constraints in the Norwegian maritime industry, productivity increase is critical for future competitiveness. Therefore, the goal of the NextShip competence building project is to increase Norwegian shipbuilders' competitiveness, by creating operational excellence to deliver customized vessels on the edge of known technology, with competitive development lead-times and costs. This is achieved by integrating the systems engineering element with focus on optimizing tasks and resources, *and* the social abilities of project teams to proactively share &combine resources to handle changes and generate innovative solution. The research focus is particularly through the lenses of operations risk management and lean thinking to create lean and flexible processes.

PREPARED BY
Hainalka Vaagen

SIGNATURE

CHECKED BY
Frode Rømo

SIGNATURE

APPROVED BY
Gate Knutstad

SIGNATURE

REPORT NO.	ISBN	CLASSIFICATION	CLASSIFICATION THIS PAGE
2018:00865	978-82-14-06941-9	Unrestricted	Unrestricted

Table of contents

1. Background and main objective

Despite being localized in a high cost country, with suboptimal infrastructure and employment conditions, Norwegian shipbuilders are among the bests in flexibility, delivery precision and short delivery times. In this environment project work is the norm, and responsiveness to changes is critical for performance. Vessels may change substantially from contracting to delivery, by frequent and unsystematic client input and by frequent regulatory interventions, on the edge of known technology (Emblemsvåg, 2014). At the same time, since short delivery times are critical, almost every ship is put into engineering and production, before all technical uncertainty is resolved. The **planning complexity** is, as such, arising from frequent design changes *and* engineering taking place concurrently with production.

The enablers of Norwegian shipbuilding excellence are cutting edge technology and a proactive team behavior to effectively share & combine resources and knowledge to quickly handle disturbances. That acknowledged, the average cost overrun of frequent changes in the industry is high, and with steadily increasing cost constraints, productivity increase is critical for future competitiveness.

The main goal of the NextShip project is to meet the described challenges and increase Norwegian shipbuilders' competitiveness, by creating operational excellence to deliver customized vessels on the edge of known technology, with competitive development lead times *and* costs. This is achieved by integrating the element of *systems engineering* (with focus on optimizing tasks and resources) and the *social abilities of teams* to effectively share &combine resources to handle changes and generate innovative solutions. Our focus is particularly through the lenses of operations risk management and lean thinking *to create lean and flexible processes*.

2. Major R&D activities, results and the partners involved into the developments

The NextShip project results are not a single tool or model, but rather a collection of and cautious use of various tools, approaches and insights, all focused on handling project uncertainty in planning, to improve flexibility and responsiveness. The nature of the research is multidisciplinary in nature, connecting the following main elements (summarized by Figure 1 below), treated in different but related fields:

- Operations risk management in the design and planning of shipbuilding engineering systems;
- The application of lean management principles as risk mitigation techniques to the design of engineering systems;
- Social-behavioural approaches to responsiveness and resilience in projects.

A. Operations risk management in shipbuilding engineering systems

***Key partners**: SINTEF, Stein Wallace/ NHH, VARD*

Shipbuilding planning and scheduling is a very complex problem, as a number of factors introduce a large degree of risk (changing customer requirements, design, technology, or production and supply chain performance). Concurrency in engineering, procurement and execution further complicates the problem.

In this research module we *first* identified major uncertainties and state-of-the-art approaches to handle uncertainty in projects, and *second*, approached the planning problem by small stochastic model instances, to learn what it is that makes solutions good (Vaagen et al., 2017). This enables finding good plans in the future without actually solving complex stochastic models, which is nearly impossible for large real projects. The results have great theoretical and managerial value by the following:

- The results suggest high value of flexible (proactive) strategies, with **quantified cost saving potential of over 35%** as compared to reactive approaches, where static (deterministic) plans are updated in light of new and relevant information.
- Developed **guidelines on where and when, and what type of flexibility to develop** to handle unforeseen changes. These guidelines are expected to be valuable input into judgmental decision-making and simulation approaches in real projects.

B. The application of Lean principles as risk-mitigation in engineer-to-order systems

***Key partners**: VARD, Glenn Ballard/ Univ. Berkeley, SINTEF, Høgskolen i Molde, Møreforskning*

Successful lean implementations in project-based production systems lead to great reduction of waste and time to market. However, companies often struggle with effective customization of lean principles to their individual context. The NextShip research addresses lean *first* from an implementation perspective (Emblemsvåg, 2014; Kjersem et al, 2014) and, *second*, from an uncertainty and change management perspective (Ballard and Vaagen, 2017). The research highlights particularly effective lean practices, and those that are less effective in our highly dynamic uncertain context. The less effective practices relate to uncertainty and changes that are difficult to anticipate (i.e. changes in design, scope and regulations) and, therefore, difficult to handle by common buffer strategies. This part of the research led to extending the scope of Lean Construction theory by explicitly integrating uncertainty and theoretical concepts from decision-making uncertainty. Future research recommendations in this direction are included into the Last Planner Benchmark study (Lean Construction's planning and control system); ref. Vaagen in Ballard and Tommelein (2016).

C. A social-behavioural approach to responsiveness and resilience in projects

***Key partners**: SINTEF, Høgskolen i Molde, Glenn Ballard/ Univ. Berkeley*

Recognizing the shortcomings in current theoretical perspectives on project planning, it was intuitive that the drivers of high responsiveness observed in practices are not connected to the decision-support provided by these planning models. Explorative case studies and participant observations led to *tacit knowledge and a proactive team behaviour to effectively share & combine resources*, as aspects and mechanisms facilitating responsive capabilities. We therefore extended the scope of project planning in Operations Management research to include social-behavioural approaches, and **demonstrated a way to study and better align the social capital to enable resilience and responsiveness to project uncertainty** (Vaagen, Borgen and Hansen, 2016).

3. Project execution and resource utilization

The project partnership tackled the challenges posed by the necessary integration of the multidisciplinary components, knowledge transfer and promotion through national and international network building. The project execution was carried out through:

- Yearly research seminars (two per year in the main project period 2012-2015) involving VARD representatives, established scientists and PhD students. External scientific expertise Glenn Ballard/ Univ. California Berkeley and Stein Wallace/NHH participated at most seminars;
- Dedicated lean implementation and social-behavioural studies, case studies and participatory observations in VARD outfitting and hull constructor yards;
- Scientific research work with workshops and individual follow-p work, involving the core research personnel dedicated to a particular scientific task. Participation and presentation of the project results at scientific conferences has been an integrated part of the project.

4. Relevance and benefit to the scientific community, to competence development, and to the industry and society at large

The project developed multi-disciplinary knowledge and moved scientific state-of-the-art in the fields of Operations Risk Management and Lean Construction. The expected impact goes beyond the involved partners, and it will influence external (scientific and industrial) communities to adopt a more proactive behavior to planning dynamically changing engineer-to-order projects. For example, and partly motivated by the NextShip findings, the Last Planner (Lean Construction's planning and control system) benchmark study (Ballard and Tommelein, 2016) published at Univ. California Berkeley Lean Construction Institute, intensifies the need for further research on how to handle uncertainty and changes within the Lean Construction theory.

The project developments particularly contribute to solving scientific and industrial challenges related to the following:

- Increasing cost constraints and demand for shorter development and building lead times;
- The central role of 'difficult to predict and therefore to manage' cutting-edge technology in planning complex projects;
- The design risk and design planning problem;
- The role of the social capital in handling uncertainty and disturbance under pressure.

From an industrial perspective, the findings on the social-behavioural characteristics of project work confirm the strong handcraft traditions in the Norwegian shipbuilding industry, and also highlight the improvement potential by industrialization through craftmanship. A such industrialization process is the scope of the current change program at VARD, with focus on reorganizing the project organization to better align to the existing social capital, and to better connect stakeholders and main project activities (i.e. design, procurement and engineerin) to create lean and flexible processes. Design planning is most commonly separated from project scheduling, in both theory and practice, mainly because shipdesign and engineering are still considered the domain of naval architects &engineers.

5. Dissemination & exploitation

The type of knowledge disseminated and the dissemination & exploitations channel vary according to the needs and interests of the stakeholders, mainly through the following channels:

a) A popular scientific brochure with the main research elements and results is planned to be developed for dissemination (Hajnalka Vaagen/NTNU).
b) Teaching material and cases for master level academic courses in Project Management and Operations Risk Management. This is enabled by Hajnalka Vaagen, currently Associate Professor at NTNU/Ocean Operations and Civil Engineering, involved into the development of the discipline-based master program Advanced Marine Operations. Stein Wallace, Professor at NHH/Management Science, and Glenn Ballard, Research Director Lean Construction Institute/ Berkeley are also involved into dissemination through teaching master students and executives at NHH, Berkeley and NTNU.
c) Planned scientific publishing in line with publication history of the participants. Typical journals: European Journal of Operational Research, Operations Management, LEAN and design science.
d) Presentations of the research results at scientific meetings: Advances in Production Management Systems, Operations Research conferences, such as EURO and INFORMS, Lean Construction and Lean Design conferences.
e) Contact with users via multiple channels:
    - Via SINTEF and their industrial users, achieved by the involvement of SINTEF personnel.
    - Via NTNU Ocean Operations, and its close collaboration to the maritime cluster GCE Blue Maritime.
    - Via VARD GROUP AS, their partners and stakeholders.
f) Ongoing and planned innovation projects
    - The CRAFT project with VARD under NRC agreement 245868, directly connected to the NextShip project and results;
    - Planned project initiative for advanced simulation studies for project-based production systems, through NTNU Ocean Operations and collaboration with Offshore Simulation Center, Ålesund.
g) Dissemination and exploitation through international collaboration with Glenn Ballard/ Berkeley.

The following results are expected to be finalized after project closure:

- Popular scientific brochure with the main research elements and results.
- PhD dissertation Kristina Kjersem – thesis planned submitted by end 2017, with PhD defense by medio 2018.

- Industry report on the cognitive aspects in project planning, and scientific paper on "Collective intelligence in project groups" to de submitted in august 2017 to the International Journal of Project Management. This work is based on the study of PhD student Morten Hansen (under Vaagen's and VARD supervision), by following the building and delivery process of the largest offshore vessel in VARD's history.
- Scientific publication in extending the Lean Construction theory with uncertainty, and a follow-up paper of the Vaagen, Kaut and Wallace (2017) work on project planning under uncertainty.

6. References

1. Ballard, Glenn and Iris D. Tommelein (2016). Current Process Benchmark for the Last Planner System. Project Production Systems Laboratory, University of California Berkeley. Available at p2sl.berkeley.edu.
2. Ballard H.G. and Vaagen H. (2017). "Project Flexibility and Lean Construction." Forthcoming In: Proc. Lean & Computing in Construction Congress (LC3), Vol. 1 (CIB W78), Heraklion, Greece, pp. xx–xx. DOI: xxxx/xxx/xx.
3. Emblemsvåg, J., 2014. Lean project planning in shipbuilding. Journal of Ship Production and Design. 30 (2), 79-88.
4. Kjersen K, Halse L., Kiekebos P., Emblemsvåg L., 2014. Implementing lean in engineer-to-order industry : a case study. Advances in production management systems : innovative production management towards sustainable growth : IFIP WG 5.7 International Conference, APMS 2015 Tokyo, Japan, September 7?9, 2015, Proceedings, Part II.
5. Vaagen, H, Borgen, E., Aas, B, Kjersem, K., 2014. SINTEF F27156 VARD Engineering - an explorative case study.
6. Vaagen, H., Borgen, E., Hatling, M., 2014. SINTEF F27155 NextShip Nettverksanalyse i VARD Søviknes Engineering.
7. Vaagen, H., Kaut, M., Wallace, S.W., 2017. The impact of design uncertainty on planning. European Journal of Operational Research. 261 (3), pp. 1098–1109.
8. Vaagen, H., Borgen, E., Hansson, M., 2016. A social-behavioural approach to project work under uncertainty. IFAC-PapersOnLine (ISSN 2405-8963), 49(12), 203-208.

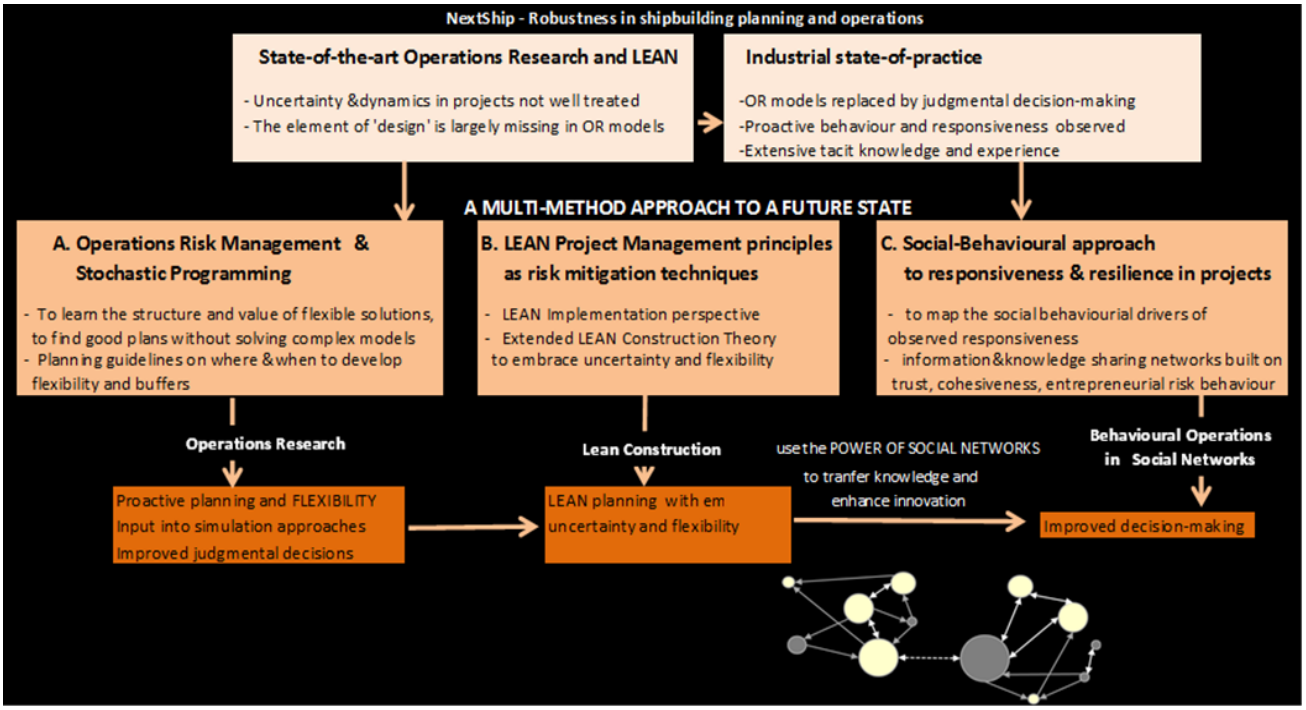


Figure 1 The NextShip research elements and main results

SINTEF

Technology for a better society

www.sintef.no