An Innovation and Engineering Maturity Model for Marine Industry Networks

Kim Jansson

An Innovation and Engineering Maturity Model for Marine Industry Networks

Kim Jansson[1]

[1] VTT, Technical Research Centre of Finland
Tekniikantie 2, Espoo, P.O.Box 1000, FI-2044 Finland, kim.jansson@vtt.fi

Abstract. There is only one way for the maritime cluster in Finland to survive. It has to be ready to respond rapidly to changes from the outside world. In order to prepare for the future, design companies and engineering consultants in the marine sector have to assess their current collaboration competence and continuously invest in increasing their engineering capability. It is becoming increasingly important to manage and develop competences for future new business environments. This paper presents a new approach to expanding the use of maturity models with the assessment of innovation and engineering capability. The paper reports on the development work of the new Innovation and Engineering Maturity Model and experience of using the model to identify fundamental and urgent competence development needs.

Keywords: Innovation and Engineering Maturity Model, marine industries, competence development, future business environment

1 Introduction

The Finnish marine industry has experienced tremendous metamorphosis during the last two or three decades. Outsourcing of activities at all yards has resulted in permanent restructuring of the industry. Thirty years ago, the shipyards produced almost everything themselves. Today, a whole network is needed. The yards have outsourced much of their activities. Today, the yards' main tasks are to manage customer relations from the network to the outside world. Project management and coordination of project operations are other important roles at the yards. The yards also offer facilities for turnkey partners to build large assemblies to their own internal design and planning. These partners have their own sub-networks of specialised partners. The restructuring has imposed new requirements on the partner network but also created new opportunities. Fig. 1 illustrates the development of the degree of outsourcing in outfitting work for large ship projects [1]. Using established

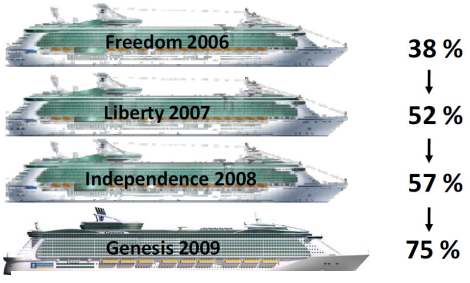

Fig. 1. Development of outsourcing in large ship projects

terminology from the Collaborative Networked Organisation (CNO) research community, the Finnish marine industry can be said to be a Virtual Organisations Breeding Environment (VBE) or Source Network [2], [3].

1.1 From Boom to Recession

The past two decades saw an immense boom in the production of cruise liners in Europe. The project Genesis 2009, illustrated in Fig. 1, materialised in the ship *MS Oasis of the Seas*, which surpasses the biggest cruise ships in size and is now the world's largest passenger vessel. Her sister ship was successfully delivered in November 2010. The past period was characterised by a shortage of labour, the use of foreign workers, engineering work overload, etc. Every company in the industry cluster was operating at full capacity.

The recent economic downturn hit the shipbuilding industry with its full strength. Newbuilding orders dropped to almost zero and the yards and the industry now face major restructuring. There is some light at the end of the tunnel, however, as shipowners placed some new cruise ship orders with European yards in 2011.

1.2 Research Programme

The maritime cluster in Finland has to be agile and ready to respond rapidly to changes from the outside world. Engineering and design companies will operate globally, to an even greater extent, with international customers. To respond to the changed industrial and business requirements, FIMECC Ltd. [4] is working to boost strategic research in metals and engineering industries. The aim of FIMECC Ltd. is to increase and deepen cooperation between companies, universities and research institutes in the area of top-quality research. The FIMECC Innovations and Network research programme was launched in the beginning of 2009 with special focus on marine industries. Its main objectives are to develop new innovations, methods, business models and processes through basic research and industrial innovations to be applied to future generations of prototypes and platforms. The goal is to create a business environment in which product design is based on concurrent engineering, open innovation and the use of global development and production networks. In this changing business environment, competence management is becoming crucial. VTT is contributing to the programme by developing an Innovation and Engineering Maturity Model that will be used to identify urgent innovation and engineering capability development demands.

2 Research Methodology

The overall long-term objective is to develop approaches to support efficient operation in **collaborative design project environments** for marine industries. The objective of the research and development of the Innovation and Engineering Maturity Model is to deliver methods to measure and improve networked design and

innovation competence. The scope of the work is limited to engineering design projects, product development and innovation activities, and collaborative and networked engineering activities for marine products and services, including:

- Physical products, possibly extended with services
- Marine and offshore structures, subassemblies and components
- Ship modifications, re-buildings, retrofits and modernizations

The research methodology advances through the following steps:

- Scoped definition
- Review of existing maturity models
- Definitions of requirement for the Innovation and Engineering Maturity Model
- Collecting input for the first model based on company interviews
- Defining the first set of process areas
- Prototype tool development
- Defining the marine industry domain's first reference model
- Positioning interviewed companies in the first model
- Verifying the model through a web questionnaire or web testing
- Improving the model
- Dissemination (continuous)

3 About Maturity Models

A maturity model is a framework that describes a number of levels of sophistication at which activities can be carried out for a specific area of interest. Maturity models focus on different disciplines that an organization can address to improve its business [5]. A maturity model defines a structured collection of elements that describes the characteristics of effective processes. A model can show what is to be done but it does not specify how it is to be done. It is often used to achieve two objectives:

- Help set process improvement objectives and priorities
- Appraise organizations for the sake of improvement

3.1 Previous Work on Maturity Models

Due to the limited space available, this section only references a limited number of previous works in the large domain of maturity models. There are many software-tool-supported maturity models. These models differ from each other in terms of their factors and characteristics: there is no standard related to these models [1].

Pikka describes a five-level maturity model as a framework for the development and assessment of regional business networks. The maturity levels of a business-enabling network are *Initial, Existing, Established, Managed* and *Optimizing* [7]. Essmann et al. describe an innovation capability maturity model. Now more than ever, organizations are required to grow and mature their innovation capability – rending consistent innovative outputs. The process of developing an innovation capability maturity model is presented in [8] and [9]. Narasimhalu also describes a research capability maturity model for managing technological innovations. The

suggested maturity model has five layers: *Ad-Hoc, Directed, Managed, Optimized* and *Outsourced.* All research organizations are likely to operate at one of these five levels [10]. Turner et al. describe experimental learning practices adopted by project-based organizations and consider whether they deliver improved project management maturity [11]. Williams states that innovation as a management practice is more diversified than other management methods. Innovation practices can be viewed within the framework of a maturity model. The dimensions and contexts of innovation are very wide and hard to synthesize into a single model however [12]. Stark also suggests a maturity model for PDM implementation with four stages of evolution: *Traditional, Awakening, Adapting* and *Modern* [13]. Tapia presents a two-dimensional, five-level maturity model. It addresses five levels of maturity and four domains to which these levels apply to assess and improve the maturity of business IT alignment in collaborative networked organizations [14].

The COIN project is currently developing an Enterprise Collaboration Maturity Model (ECMM). The ECMM is a process-improvement maturity model that focuses on **Collaboration and Interoperability** capabilities. It consists of a set of best practices that enables the improvement of the collaboration and interoperability capabilities of organizations and networks [15].

3.2 Conclusions of Analysing the Existing Maturity Models

Levels are often used in maturity models to describe an evolutionary path recommended for an organization that wants to improve the processes it uses. In maturity models, process areas can be organized into one of two 'representations': a *continuous* representation or a *staged* representation.

The staged representation offers a systematic, structured way to approach process improvement at company level, one stage at a time. Achieving each stage ensures that an adequate process infrastructure is laid as a foundation for the next stage. The continuous representation offers greater flexibility. An organization may choose to improve the performance of a single process-related trouble spot or to work on several areas that are closely aligned to the organization's business objectives. The continuous representation also allows an organization to improve different processes at different rates.

Many of the models use a five-level approach. The optimum level of maturity is recognised as being the level that delivers the organization's strategic objectives most effectively and efficiently, which does not necessarily mean level five. Most of the software on the market is subject to a usage fee and is not open source. A continuous representation involving five levels was selected as the basis for the new Innovation and Engineering Maturity Model.

4 Requirements of the Innovation and Engineering Maturity Model

Based on the review of existing models and interaction with marine industrial companies, the requirements for an Innovation and Engineering Maturity Model can be summarized as:

- supporting development of competences according to the needs of the future business environment
- accepted by marine industrial companies
- flexible and configurable
- easy to use, intuitive and self-explaining
- web-based benchmarking
- allowing international benchmarking
- free of charge for the marine sector

4.1 What is the Future Business Environment?

The question 'what is the future business environment?' has been addressed in two different endeavours at VTT. The first was conducted with the objective of assessing whether a national development programme was needed to strengthen *project management* capabilities in different industrial sectors. VTT conducted a large number of interviews (>25) on development needs within marine industries. It must be noted that the research was carried out during the boom period, as described above. The main findings were that clustering has made it possible to build, e.g., the two largest passenger ships in the world. Taking care of and further developing the networked organization and collaboration is vital to existence in the future. Based on the research, three general themes emerged that require development effort: 1) technological competence in international and global operations, 2) networking, collaboration and sharing, (re) organising work in large units and 3) sustainable development, green values and security. These themes are by no means new or surprising, but they still require attention.

A second series of company interviews was carried out with the FIMECC programme. The interviews conducted in the recession period also revealed development needs. The results of the interviews gave the first view of industrial companies on the drivers for change in current business operations. A common opinion emphasizes the importance of continuous development of innovative offerings to customers and their customers. Only the forerunners are capable of offering something new each time, and this calls for both technical and conceptual innovations.

5. First Model Defined

The first version of an Innovation and Engineering Maturity Model for Marine Industry Networks (IEMM) was defined based on the stat-of-the-art review and company interviews. A comparison of the interview findings from two different market situations does not show any significant change in the views on the future business environment. The success factors of tomorrow can be summarised and grouped into:

1. Capability to offer solutions to new markets outside shipbuilding (Innovation dimension)
2. Having the courage to act globally, being present in the market close to the customer (in practice, going to Asia) (Internationalisation dimension)
3. Networking and collaboration in efficient supplier relations (Collaboration dimension)
4. Improving the designers' project management skills and capabilities in supervision of work, and awareness of costs and consequences (Project Management dimension)
5. Superior technical knowledge and quality of engineering, and taking environmental issues into consideration (Technology dimension)
6. Knowledge management (PDM dimension)

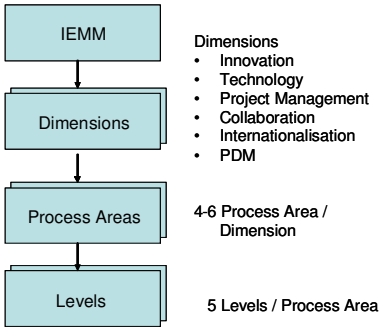

Fig. 2. First maturity model

The six dimensions were then further divided into four to six process areas per dimension; see Fig. 2. For each dimension and process area, five levels of maturity have been defined. Fig. 3 is a partial extract from the model.

Internationalisation dimension			
Process Area:			
Customers	**Staff & Personnel**	**Experience**	**Organisation Nationality**
1 Local customers only.	1 The staff & personnel have no international interaction.	1 Has no international business experience.	1 Has only one office or facility.
2 National customers only.	2 Language skill limit internationalization.	2 Has recognized the need for internationalization.	2 Has more the one nationally located office or facility.
3 Customers within one industry segment only.	3 The staff & personnel have project based interaction with customers abroad.	3 Has project-based international experience.	3 Also has offices or facilities abroad.
4 Customers world wide.	4 The staff & personnel have an open attitude towards international contacts.	4 Capable to manage independently global projects.	4 Has an international presence
5 Business units established near the main customers' base.	5 The staff & personnel are multicultural.	5 Conducts only international business.	5 Also has offices or facilities co-located with customers abroad.

Fig. 3. An extract from the IEMM model

With this model structure, a web questionnaire consisting of 59 questions was established. In the questionnaire, companies were asked to position themselves for each process area '**Today'** and '**Where you want to be in two years from now'**. In addition, they were asked the relative importance of each dimension. All FIMECC partners were invited to participate in the questionnaire, and 23 answers were collected.

5.1 Results of the Model Evaluation

The graph in Fig. 4 gives a summary of the average maturity of the responders. The preliminary analysis reveals that most development is needed in the dimensions: Innovation, Technology and Project Management.

Figs. 5 and 6 serve as examples of results from work the 'Product and services' process area in the Innovation dimension.

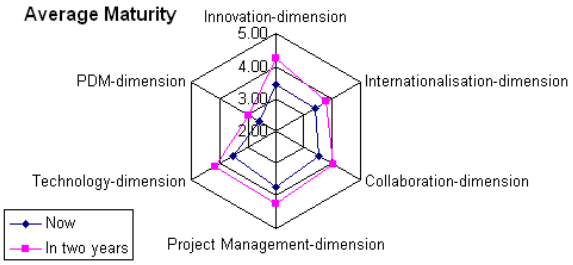

Fig. 4. Average maturity levels

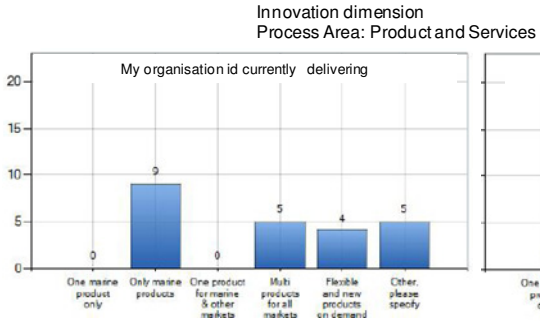

Fig. 5. Current products and services

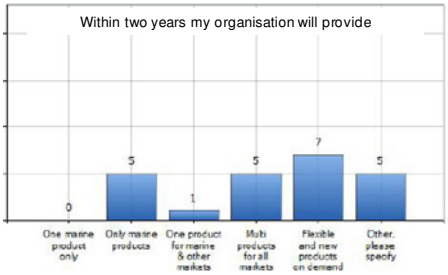

Fig. 6. Products and services within two years

6. Conclusions and Future Work

VTT, together with a number of industrial organizations in the marine sector, has defined and developed an Innovation and Engineering Maturity Model for Marine Industry Networks. The model has been evaluated through an online questionnaire. The preliminary analysis and feedback on use from the questionnaire confirm the usefulness of the model. In the future, effort will be put into enhancing the IEMM and possibly extending it with more process areas. The IEMM must be seen just as a tool, however, keeping in mind that the use of the tool must result in real implementation of competence development actions.

Much valuable and irreplaceable experience and knowledge are already available in the cluster. One question that needs attention is that of how to capitalize also in the future and how to support young people entering the industry branch. The next steps will be to review engineering knowledge transfer methodologies, map them to the Innovation and Engineering Maturity Model and find appropriate suitable knowledge transfer methodologies.

Acknowledgement

This work has been partly funded by Tekes (the Finnish Funding Agency for Technology and Innovation, Finland) through the FIMECC Ltd (Finnish Metals and Engineering Competence Cluster) I&N Programme. We would also like to acknowledge our gratitude and appreciation to all the companies for their contributions to the interviews during the development of the concepts presented in this paper.

References

1. Degerman, T.: Aker Yards, Presentation at the Merike Programme seminar at the Manuo Koivisto Center, Turku Finland (2006).
2. Camarinha-Matos, L.M. and Afsarmanesh, H. (eds.): Collaborative Networks: Reference Modeling. ISBN-13: 978-0-387-79425-9. Springer, New York (2008).
3. ECOLEAD. IST FP6 IP Project 506958 ECOLEAD, European Collaborative Organizations Leadership Initiative. http://virtual.vtt.fi/virtual/ecolead/
4. FIMECC: Finnish Metals and Engineering Competence Cluster http://www.fimecc.com/fi/index.php/Etusivu
5. CMMI. The Carnegie Mellon Software Engineering Institute, Pittsburgh, the United States. CMMI® for Development, CMU/SEI-2006-TR-008, ESC-TR-2006-008, Improving processes for better products.
6. Khoshgoftar, M. and Osman, O.: Comparison of maturity models. In: ICCSIT2009 2nd IEEE International Conference on Computer Science and Information Technology, pp. 297-301 (2009).
7. Pikka, V.: A Business Enabling Network, A Case Study Of A High-Tech Network; Its Concepts, Elements And Actors. Oulu University Press. Oulu 2007, ISBN 978-951-42-8391-8 (PDF).
8. Essmann, H. and Preez, H.: An Innovation Capability Maturity Model – Development and Initial Application. World Academy of Science, Engineering and Technology 53, pp. 435-446 (2009).
9. Essmann, H. and Preez, H.: Practical Cases Of Assessing Innovation Capability With A Theoretical Model: The Process And Findings 23rd Annual SAIIE Conference, Conference Proceedings 28-30 October 2009, pp. 42-56. ISBN: 978-0-86970-667-1 (2009).
10. Narasimhalu, A. D. A.: Research Capability Maturity Model For Managing Technological Innovations. PICMET 2006 Proceedings, 9-13 July, Istanbul, Turkey (c) 2006, pp. 761-766 (2006).
11. Turner, J. R., Keegan, A. E. and Crawford, L.: Delivering Improved Project Management Maturity Through Experimental Learning. Project Management Vol. 8 no 1, pp. 72-81 (2002).
12. Williams, R.: Innovation Maturity. Boeing Phantom Works. ILN Network – Baltimore, MD, March 10 (2009).
13. Stark, J.: Maturity Model for PDM. Product lifecycle management: 21st century paradigm for product realisation. Springer-Verlag New York, LLC ISBN-13: 9781852338107. ISBN: 1852338105 (2004).
14. Tapia, R. S.: ICoNOs MM: The It-Enabled Collaborative Networked Organizations Maturity Model. IFIP Advances in Information and Communication Technology Springer Boston. Volume 307/2009, ISBN 978-3-642-04567-7, pp. 591-599.
15. COIN. IST FP7 IP Project 216256 COIN, Collaboration and Interoperability for Networked Enterprises. http://www.coin-ip.eu