Kalle Kahkonen
Professor of Construction Management and Economics at Tampere University of Technology (www.tut.fi), he is co-ordinator of a global research society CIB working commission W65 "Organisation and Management of Construction" and an active member of IPMA. Presently his research interests cover new dimensions and novel tools of project management and project based business.

Project Management for Construction: towards methods and tools meeting demands of modern construction operations
Il Project Management del processo edilizio: evoluzione di metodi e strumenti per le esigenze dei moderni interventi di costruzione

Project management standards are gradually moving to the direction where increasingly attention is put on cooperation and collaboration methods between different players involved in construction operation. Construction professionals and other experts i.e. in academia agree widely that this is essential. Construction business and its operations in general have not been isolated from the long term developments in different sectors such as outsourcing where core businesses is valued high and other operations are cut away. This has resulted in high number of specialized companies that on the other hand has increased the total number of partners in any kind of construction project. From the management viewpoint this is a different challenge and it has naturally provided the starting point for new kind of managerial tools and solutions. This paper provides discussion of the characteristics of modern construction and those as starting points for the development of new kind of construction management methods and tools.

La normativa e la prassi del Project management si stanno gradualmente muovendo nella direzione dello studio e sviluppo di metodi di cooperazione e collaborazione tra i diversi operatori del processo edilizio. Sia gli operatori professionali che altri esperti nei centri di ricerca concordano sull'importanza di questo aspetto. L'impresa di costruzioni e le sue attività in generale non sono state isolate dall'evoluzione che nel lungo termine ha portato nei settori industriali al fenomeno dell'outsourcing, ovvero al mantenimento del core business all'interno dell'impresa e all'espulsione delle altre filiere produttive. Questo ha portato alla parcellizzazione del processo produttivo in un grande numero di imprese specializzate ed ha aumentato il numero dei partecipanti impegnati nella costruzione di un opera. Dal punto di vista della gestione si tratta di una nuova sfida che ha fornito lo spunto per l'individuazione di nuovi tipi di strumenti e soluzioni gestionali. Questo articolo discute le caratteristiche del moderno intervento di costruzione e gli elementi base per lo sviluppo di una nuova categoria di metodi e strumenti di construction management.

Keywords*:* construction projects; construction management; project planning; complexity; company networks

Parole chiave*: costruzione; construction management; programmazione dei progetti; complessità; reti di imprese*

INTRODUCTION

Needs and requirements for construction management arise from many sources. The most important sources are the site and its processes, the company level requirements, and, the regulatory context (Winch 2010). As a profession with a specific "identity" construction management has been found to be a heterogeneous field of managers with diverse views, beliefs and practices (Brown & Phua, 2011). What construction managers actually do and what they value are dependent upon their personal conceptions of self and their profession.

Characteristics of site opeations originate from the business conditions, companies involved, their capabilities and commitment. The modern construction delivery is an interplay between many companies and their people. This interplay culminates in site operations where the final product gets its form and is finalized. In this the share of prefabricated parts and package deliveries including building parts and their assemblies has been increasing continually. Practically this means that there exists a continuous flow of new companies and their workers coming or leaving the construction site. In this situation the major challenge for the site management is to identify and eliminate in a pro-active manner all possible disturbances that would affect the performance of the flow of planned work.

The changing regulatory context is an example of a basis for new industrial standards which have implications in company practice. An example of such standards is the ISO 14001 "Environmental management system" standard that was published in 1996. Since then the biggest contractors have built and certified environmental management systems based on this standard. Small and medium-sized contractors have also needs to develop their management practices to same directions but they would need solutions that can be efficiently implemented and used with scarce amount of additional resources. Thus, a clear need exists for a cost efficient approach to improve the environmental performance for small and medium-sized enterprises.

This paper provides discussion of the characteristics of modern construction and those as starting points for the development of new kind of construction management methods and tools.

CONSTRUCTION AS A PROJECT BASED BUSINESS

The construction industry is a very heterogeneous combination of localised needs, various crafts, services, products and their professional providers. Even each service or product supplier can be seen as a business line of its own inside construction sector due to its specific characteristics, culture and terms of business. Different suppliers and other stakeholder are brought together around temporary projects in different stages of the production process. These conditions are often referred as fragmentation of the sector. On the other hand this is something we could also refer as construction project business that forms the main viewpoint of this study.

Project based business and the required arrangements can be characterised as temporary systemic set-ups. The following list incorporates the main contextual factors of the economic logic behind project business (modified from Kujala et al, 2008).

CONTEXTUAL FACTORS IN PROJECT-BASED BUSINESS

Business environment level:

- Accepted methods of doing business in the market segment (industry dominant logic)
- Behaviour and business culture
- Competitive situation
- Customers' strategies and preferences
- The distribution of capabilities and resources in the value chain

Company level:

- Market and technological uncertainty

- Resource, market and technological interdependence between projects
- Discontinuity between delivered projects to a customer or market segment
- Relative size and frequency of project deliveries

Project level:

- Project novelty – newness of the technical solution to the market
- Project uniqueness – similarity of a project compared to previously delivered projects
- Technical and organizational complexity of a project
- Uncertainty related to project goals, technology or implementation process
- Distribution and total cost in project lifecycle

Global internet enabled electronic-commerce, resources and financing opportunities have created new business environment where business networking is essential for all lines of businesses. Thus the business networking, its management and relating research have been very popular topics in different research institutions and provided also sources for consultative operations. The research and empirical evidence from live business operations have provided grounds for improved knowledge on business networking. Examples of such studies are (Benkler, 2006; Friel & López, 2005; Gloor, 2005; Kelly et al, 2009). Table 1 presents a synthesis of various main types of business networks that have been identified by researchers. One should note that research community prefers to use term Inter-Organizational Relationships (IOR) since this as a term is more precisely expressing the phenomenon in question.

Development of service oriented professionals, their capabilities and relating products is an improvement area of key significance for the modern building construction sector (Barrett, 2005; ManuBuild, 2005). It looks obvious that the most desirable service products are the ones having characteristics such as approachability (scope easy to understand, easy contacting), transparency (content, accessing progress data) and reliability (minimal variances in time, cost and quality). Profound understanding of customer needs is always behind of the overall set-up of any service product. Standardisation is considered as a key avenue for the development of service products. The resultant service can be characterised as a system the development of which can have different needs (or their combinations) as listed on the following:

1. Packaging of processes and results according to the identified main needs,
2. Segmentation of service products towards different customer groups using key parameters,
3. Constant performance creation where processes are standardised for having highest possible reliability,
4. Integration of processes of several companies in the form of service products, and
5. Homogenisation of operations and enabling solutions (for example information systems) regarding service suppliers. On the other hand the homogenisation can mean also a standardised information source for accessing building data by any selected service provider.

CONSTRUCTION AS A NETWORKED OPERATION

Networking and collaboration in networks have created a high interest in both research and in practical applications during the last decade, especially in the eBusiness area. In parallel with the development and spreading of Internet technologies, traditional collaboration networks have found new leveraging tools and the new collaborative business forms have emerged. Although many solutions have been based on ad-hoc applications of available technology, there have also attempts to create some systematic approaches for understanding collaboration in networks. The European project ECOLEAD (European Collaborative Networked Organizations Leadership Initiative) have recently addressed the development of new kind of solutions for business networking based on the virtual organization concept Camarinha-Matos et al, 2008). ECOLEAD vision: “In ten years, in response to fast changing market conditions, most enterprises and specially the SMEs will be part

of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations."
Any construction operation can be characterised as a collaborative network where formal and informal relationships are all the time affecting the project in question (Figure 1). Degree of commitment, engament and appropriateness of skills of different companies involved are often a very dynamic all the time changing environment. Digitalised connections and communication between companies have formed another networking dimension that is changing the nature of operations gradually. Based on this new kind of Virtual Organzations (VO) can be created that can operate for purposes of interest.

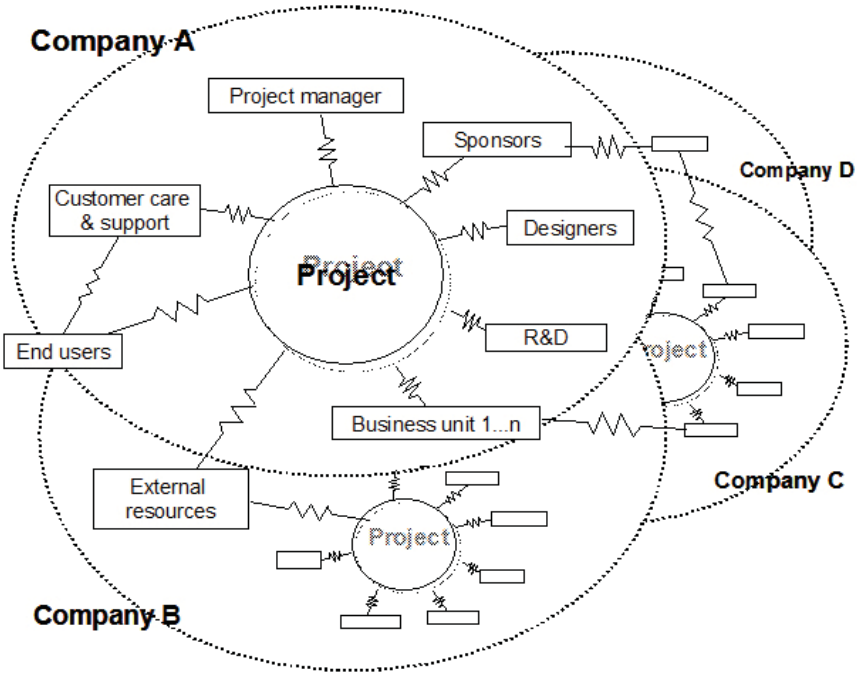

Figure 1: Construction project as a network system.

The effectiveness of the virtual organization (VO) creation process is a critical element in collaborative networks. It is considered of importance that researchers have found that the concept of virtual organization (VO) appears particularly well-suited to cope with very dynamic and turbulent market conditions. The underlying rational the possibility of rapidly forming a consortium triggered by a business opportunity and specially tailored to the requirements of that opportunity. Implicit in this idea is a notion of agility, allowing rapid adaptation to a changing environment. In order to make this possible, a VO creation process is designed in the context of a virtual organization breeding environment context. A framework for VO creation is thus introduced and a set of assistance services are designed and tools developed.

CONSTRUCTION COMPLEXITY

Complexity is an intriguing characteristic of construction projects. In almost every text on project management or its adjacent fields of studies such as estimating, scheduling, logistics, or supply chain management, the complexity of construction projects is mentioned (e.g. Bennett 1991,

Mubarak 2010, Sullivan et al. 2010). It has become a term such as “large” and “beautiful” where evaluation and understanding lie in the eyes of the beholder. Scores of articles have been written on complexity, alas there is no agreement!
It seems to be difficult to define complexity without a framework. A suitable one is Luhmannian system theory which understands the world as unmanageable due to its overwhelming complexity. Therefore, we are required to create systems in order to reduce complexity to a manageable degree. Construction projects are one type of system. Depending on how we draw the system borders of a construction project (one family home or petro-chemical plant) we are facing a remaining complexity, an eigen-complexity (Luhmann 1995). Drawing on the definition of Sargut / McGrath, we would like to add another dimension to the discussion, i.e. impact. It does matter whether a cause at one point of a system has a large or a small effect to the configuration of the system (Wilke 2000). The interactions between the elements are loaded or weighed (Geraldi 2008). This is, of course dependent on the diversity of the elements. Diverse elements allow for different types of impacts rippling through a system. Strength of impact is a more direct characteristic and therefore better suited for a definition than diversity.
In all cultural studies the point is to show how much the stakeholders’ cultural diversity influences project outcome. The more cultures meet in a project, the more complex it becomes since it requires coordination of an increasing number of different cognitive maps (Brockmann 2009); this we term “cultural complexity” (Table 1). Geraldi (2008) also refers to dynamism with regard to complexity. We subsume something like dynamic complexity under the term “task complexity”. A stable environment certainly facilitates all tasks.

Project	Budget	Construction time	Number of subcontractors and suppliers
Helsinki airport / International terminal extension	143 milj. €	2007-2009	> 200
Helsinki Music Hall	140 milj. €	2008-2011	160

Table 1: Recent construction project examples

Two additional forms of complexity can also capture dynamics: cognitive and operative complexity. They both develop over time. Cognitive complexity mirrors how differentiated we think about a construction project; this increases with time as we understand a project better. Operative complexity is the degree of freedom for members of a project with regard to its operations and the project sponsors. Are most operations determined by the sponsors or does the project develop its own more specific operational approaches and thus become more complex?
A confined space influences task and social complexity. Restricted space for the tasks (i.e. a limited construction site) and social interactions (i.e. limited office space) increase these two types of complexity. All five types are becoming more complex as less time is available. This is a result of the decision-making perspective. The discussion can be summarized in a graph (fig. 2).
A word of caution needs to be added. We are only concerned about complexity when we have to consider it for decision-making. An esoteric view of complexity is never taken in this paper. The whole point of systems theory is creating manageable entities that enable us to make decisions. This has consequences since the work of Simon (1972); we deal with bounded rationality and incomplete information. The first one is seen as a human condition, the second one as a result of the system’s remaining eigen-complexity. Construction and construction projects appear to be systems where

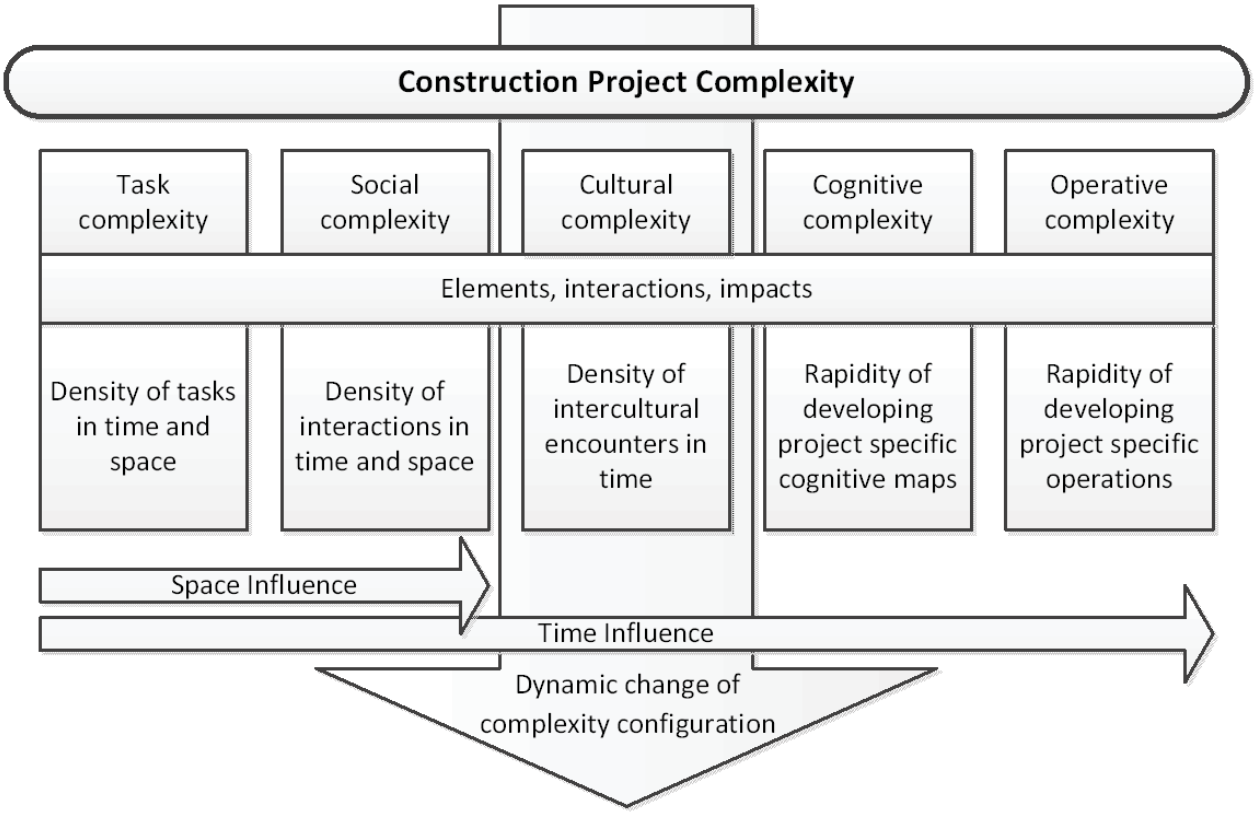

Figure 2 : Concept of construction project complexity

their complexity is linked to uncertainty of different actors and factors forming the actual system. It is likely that complexity management can be improved if the nature of complexity is identified and unnecessary complexity decreased (Pennanen & Koskela 2005).
Brockman and Kahkonen (2012) have defined Complexity = (def.) the number of elements, their interactions and the strength of impacts of a defined system with regard to decision making. It should be noted that this definition is a general one referring to any type of system. For a construct of construction project complexity we will find further determining factors. Complexity does not remain constant over the life-span of the project. In the end, the aim is to reduce it by decision-making.

ARISING NEW TOOLS AND SOLUTIONS

This paper has provided a discussion of characteristics of modern construction operations. Particular attention has been put on growing total number companies that are participating any kind of construction project. This is seen as an evidence of need for new managerial tools and solutions where cooperation between involved organizations is in focus and of primary interest. This is widely acknowledged and has already resulted in some changes in industrial standards such as ISO 21500 “Guidance on project management” and PMI PMBOK (5th edition) which have introduced stakeholder management as one core element of project management.
We may also classify Last Planner (Last Planner®) methodology also as a collaboration tool where the main planning viewpoint is not a single company but a group of companies (Ballard, 200). Use of Last Planner on projects and within both design and construction firms has increased continuously that is demonstrating the need for this kind of cooperative planning solutions. Moreover the recent

interest and local success of new procurement forms such as IPD (Integrated Project Delivery) is another example of movement towards cooperative practices.

CONCLUSIONS

Modern construction operations where the number of participating companies is clearly higher than it used to be a decade ago has created new kind of managerial challenges. It seems that the only way to move forward successfully and improve practice is to put attention on cooperative construction planning and management. As a whole this means new kind of construction business culture where trustworthiness and openness are not only words but basis of operations.

BIBLIOGRAPHY

Ballard, G. (2000) The last planner system of production control, PhD Thesis, School of Civil Engineering, Faculty of Engineering, The University of Birmingham, UK

Benkler, Y. (2006) The Wealth of Networks - How Social Production Transforms Markets and Freedom, Yale University Press.

Bennett, J. (1991) International construction project management: General theory and practice, Oxford: Butterworth-Heinemann.

Brockmann, C. (2009) Using cognitive maps for better success in post-disaster relief situations, in: Proceedings of the Symposium on Post-disaster Reconstruction, Surabaya.

Brockmann, C. and Kahkonen, K. (2012) Evaluating Construction Project Complexity, Proceeding of CIB Joint Symposium 2012, Montreal, Canada.

Brown, A.D & Phua, F.T.T. 2011. Subjectively construed identities and discourse: towards a research agenda for construction management, Construction Man-agement and Economics, vol 29, no. 1-3, pp. 83-95.

Camarinha-Matos L.M., Afsarmanesh H., and Ollus, M. (eds.) (2008). Methods and Tools for Collaborative Networked Organizations. ISBN 978-0-387-79423-5. Springer, New York.

Friel, D. and López, D. (2005) Towards an Understanding of Different Types of Business Networks, La Universidad de San Andrés Working paper 55, Buenos Aires, Argentina.

Geraldi, J. (2008) The thermometer of complexity, Project Perspectives 2008, 4 – 9.

Gloor, P. (2005) Swarm Creativity: Competitive Advantage Through Collaborative Innovation Networks.

Kelly, J.F., Pryke, S., Rigby, J. and Winch, G. (2009) Project Coalition as a Network Organisation, Proceedings of IRNOP IX (The International Research Network on Organizing by Projects), Berlin 11-13 October 2009.

Kujala, J., Artto, K. and Parhankangas, A. Factors influencing design and performance of the business model of a project-based firm , Project Perspectives, Vol. XXXI, 2008, 14-17

Luhmann, N. (1995) Social Systems, Stanford: Stanford University Press.

Mubarak, S. (2010) Construction project scheduling and control, 2nd edition, Hoboken: Wiley.

Sullivan, G., Barthorpe, S. and Robbins, S. (2010) Managing construction logistics, Chichester: Wiley-Blackwell.

Winch, G.M. 2010, Managing construction projects, Blackwell Publishing Ltd. United Kingdom.

Wilke, H. (2000) Systemtheorie I: Grundlagen, Lucius & Lucius: Stuttgart.