Tunnelling for a Better Life – Yan, Celestino, Thewes & Eberhardt (Eds)
© 2024 The Author(s), ISBN 978-1-032-80042-4
Open Access: www.taylorfrancis.com, CC BY-NC-ND 4.0 license

Development of an early contractor involvement selection tool for public owners

Carl Philipp Friedinger*
Bundeswehr University Munich, Neubiberg, Germany

Philip Sander
Bundeswehr University Munich, Neubiberg, Germany
RiskConsult GmbH, Innsbruck, Austria

ABSTRACT: Tunneling projects are complex and large-scale on a regular basis. Consequently, they pose challenges for contractors regarding risk management, cost calculation, and timely execution. These challenges often result in cost and schedule overruns on the part of public-sector owners. An opportunity to remedy these grievances are Innovative Project Delivery (IPD) models. A variation of IPD refers to the early involvement of contractors and suppliers. Early Contractor Involvement (ECI) can take different forms depending on the time of the initiation and the project. The initiation can occur at various points: during the preparation of the project; during the planning phase; and between the planning phase and the construction contract. ECI can influence several aspects positively: improving manufacturing methods; understanding, mitigating, and managing risks; reducing complexity, disputes, and backlog management; cooperation among all stakeholders; on-time execution within budget. This paper aims to identify specific characteristics projects must meet for ECI to be applied successfully. A selection system to determine whether the use of ECI makes sense is developed concerning the requirements of public-sector owners. Firstly, existing and applied forms of ECI are gathered by literature review. Secondly, a qualitative analysis of ECI projects and ECI variations is conducted. Characteristics leading to success or failure are identified by determining the appliance project's success. A selection system for public owners is created to determine whether using ECI is reasonable. Project scale, both financially and in complexity; the application of risk management; timeline; and workforce represent an excerpt of the determined hard characteristics. In comparison, in-house competence and cooperation capability represent soft characteristics. Based on determined characteristics the Contractor Involvement Tool (CIT) is created. The tool helps public owners choose the right variant of ECI for their projects. Therefore, applying the tool to public projects in Germany is the next step.

Keywords: ECI, Integrated Project Delivery, IPD, Project Delivery Model

1 INTRODUCTION

Complex large-scale projects regularly pose challenges to contractors in terms of cost calculation and on-time completion. This in turn leads to cost and schedule overruns on the part of the public owner and the associated negative publicity. One reason for this is the use of traditional project delivery models and unsuitable contracts, both do not meet the special requirements of complex large-scale major projects. Separating mechanisms of these models, coupled with the blinkered pursuit of particular interests, are is one reason of the fundamental problem (Breyer et al. 2020). Innovative project management models offer an approach to counteracting precisely these problems (Becker and Friedinger 2022; Becker and Roman-Müller 2022). Model like the "TIWAG alliance contract", used for a hydroelectric powerplant in Austria, has had a demonstrably positive effect on the construction time (Friedinger et al. 2023a). Prior to that particular project the German government realised the necessity for a change in project delivery, especially the delivery of major projects. Therefore in 2015 a governmental guideline was published to give public owners a helping hand in project delivery and to establish to use of innovative project delivery models. (Bundesministerium für Verkehr und digitale Infrastruktur 2015). Three years later in 2018 another guideline for

*Corresponding author: carl.friedinger@unibw.de

DOI: 10.1201/9781003495505-477

large-scale projects was published, going into detail even more by describing specific methods and instruments, like "integration of execution competence into the planning phase", to enable an improved project delivery. (Bundesministerium für Verkehr und digitale Infrastruktur 2018) So, the use of contractor know-how for the definition and optimisation of performance requirements in the early project stages has proven to be an powerful instrument as is also has an positive impact on project management in a spirit of partnership (Sander et al. 2022). Furthermore, changes in early planning phases have a significantly lower impact on costs and execution time than changes in the construction phase, the use of execution competence in early planning phases is particularly useful (CURT 2004). Thereby, helping to avoid costly planning errors and the overlooking of risks can be minimised (Bourn 2007). The involvement of the executing companies in the planning phase is weidly called Early Contractor Involvement (ECI) (Mosey 2009; Kinlan and Willems 2023). This form of implementation is already being used successfully in other European countries (Haghsheno 2020). The research questions addressed in this paper are:

1. What types and variations of Early Contractor Involvement are used in the public sector and which variations are suitable for public sector clients in Germany?
2. Which project requirements need to be fulfilled for the successful use of ECI?
3. How can the use of ECIs be promoted to public purchasers in Germany?

2 BACKGROUND AND FRAMEWORK

Traditional project management lacks a common and uniform understanding of the project on the part of both the contractor and the client. This leads to misunderstandings, and risks cannot be identified or dealt with in time (Friedinger et al. 2023b). This is partly due to the strict separation of planning and execution (Haghsheno 2020) as well as due to the common procurement practices. The following is a list two of core problems and the associated scientific theories:

First of all, it is impossible to fully complete the tender documents for complex mega projects for the tendering process. At this time point the planning isn't either complete enough or the planner lacks know how to fully plan all aspects of the project. This topic is connected scientific perception of complexity, which itself is a rather new field of research (Bandte 2007). Simple and even complicated systems are describable, whereas complex systems consist of many element, connections and multiple layers. To structure the elements, to connect them in the right way and to identify the relationships between the different layers and the to build a model and simulate the created system is the simplified aim of this research field (ibid.).

Regarding construction projects this approach can be used to structure the planning process, help to involve contractor know-how at the right time and also involve every other stakeholder on point.

Secondly, there is a fundamental conflict of objectives in the two-party system between client and contractor. Companies carrying out construction work are interested in maximising profits, while clients are only interested in the best possible performance of services within the given framework conditions at minimum cost (Faber 2014). This conflict of objectives is exacerbated by an asymmetry of information in favour of the contractor. Related to the situation in construction projects to the principal-agent theory, the information advantage is always exploited to one's own advantage according to the theory (Nister 2005; Faber 2014). In addition to this theory, the hold-up problem describes a problem scenario that also occurs frequently in the construction industry: when the contract is concluded, the actual motives and motivations of the contracting parties are not known to each other, which can lead to opportunistic behaviour in the ex-post contract phase. Dependencies can be exploited through the "lock-in effect" (Picot et al. 1998).

(Nister 2005) describes the development of trust as a solution to the agency problem. A possible solution might be the involvement construction companies at an early stage in the planning. Especially for projects classified as complex, this tends to be highly beneficial (Haghsheno 2020). Thereby, the know-how of the construction companies can be used in this way already in the planning phase. However, a fitting procurement method or model is required.

In Germany, the inclusion of execution expertise in the planning phase is discussed within the framework of partnering models (Hauptverband der Deutschen Bauindustrie e. V. 2005). One model, often referred to as a method, that is regularly used successfully in other countries within and outside Europe in order to utilise contractor know-how in the planning phase is "Early Contractor Involvement (Eadie and Graham 2014; Kinlan and Willems 2023). The implementation of an ECI can promote the following aspects: Use of innovative fabrication methods; Understanding, mitigating and managing risks; Reducing complexity, disputes and backlog management; Cooperation of all parties involved; On-time completion within budget (Bourn 2007). ECI can take different forms. It occurs as a contract model, as an element of a project management form or as a form of award (Walker and Lloyd-Walker 2012). In the private construction industry, a form of ECI known as "preconstruction" is already used in Germany (Smart Construction 2023). These circumstances lead to the third theory, decision theory. It was founded in business administration and enables the development of models that are intended to depict the economic effects of a decision in order to facilitate decision-making (Heinen 1972). In relation to this work, the principles of the theory are applied in the linking of decision criteria for a specific ECI variant.

3 EARLY CONTRACTOR INVOLVEMENT

3.1 *History and definition*

Early Contractor Involvement emerged in the 1990s in connection with project alliances. The term Early Contractor Involvement has a slightly different meaning in each country. In the simplest way ECI describes the involvement of construction companies in the early planning phases of a project. In Australia, the focus is in collaboration between client, planners and contractors is on the early project phases. As the project progresses, relationships evolve towards more conventional and traditional models. Whereas in the United Kingdom (UK), the collaborative nature of the relationship is maintained throughout project delivery (Buchal 2014). In both nations, ECI is regularly a two-stage process. Furthermore, ECI can be an element of another project delivery method or established as a stand-alone project delivery model. The term Early Contractor Involvement covers all variants of the involvement of construction companies in the project initiation phase, for example in an advisory capacity, as well as the examination of a complete planning by a construction company right before the execution phase with subsequent execution (Malvik et al. 2021).

Mostly, however, ECI is understood as a two-stage or there-stage procedure. It may start after the building permit has been granted with a minimum planning stage. In the first stage, a construction company is selected according to criteria set by the client. A price for the construction work to be carried out is not requested at this point, but surcharges for general business costs and profit can be used as decision criteria. Likewise, calculation examples, implementation concepts or partnering concepts can be requested and evaluated by the client. After the selection of the construction company, the planning takes place in the second phase. This can be done together with the construction company or by the latter. In the planning phase, the price for the construction work is determined jointly. It is worth noting that the business relationship does not necessarily have to be continued after joint planning. Some literature points out the actual construction as the third a third phase (Becker and Roman-Müller 2022). However, depending on the contractual agreements made at the beginning, the client can also decide against a follow-up order or to end the cooperation (Riemann 2014; Karasek 2021). The term early contractor involvement is hardly used in Germany. It only appears regularly in connection with or as part of innovative project management models such as IPA (Becker and Roman-Müller 2022). The terms “use of contractor know-how” and “inclusion of execution competence in the planning phase”, which are used in partnership models, among others, are also understood to mean the inclusion of contractors in the planning phase in order to make their knowledge available to the client (Girmscheid 2005; Eschenbruch 2008).

Another definition of ECI was provided in 2022 by the Working Group 194 of the World Association for Waterborne Transport Infrastructure. In its guideline the ECI is described as a strategy that differs from project to project, from client to client, from project framework conditions, budget or time horizon, etc. The ECI is thus the project-specific strategy for the waterborne transport infrastructure. The ECI is thus the project-specific strategy for the meaningful involvement of executing companies in an early project phase. The timing, the depth of involvement and the scope of cooperation vary from project to project. The key points of the ECI strategy also form the framework for the design of the applied ECI model (PIANC 2022).

3.2 *Advantages of ECI*

The use of ECI has the potential to generate numerous advantages in and for project management. However, the application of ECI alone does not automatically lead to project success. The advantages and benefits of ECI must be actively worked out. They depend on the commitment of the project participants, their capacities, their organisational structures and, last but not least, their will to achieve the set goals (Wondimu et al. 2016). The mutual benefit and the associated intrinsic motivation to participate in the Early Contractor Involvement can only be generated if the project participants are involved in the project at the right time and are compensated for the provision of know-how [28, 30]. The following aspects, among others, can be positively promoted through the application of early contractor involvement (PIANC 2022):

- Mutual project understanding
- Reduction of complexity
- Reduction of disputes and supplementary management
- Promotion of cooperation and trust between all parties involved
- Reliable information on costs and execution times
- Fair execution within budget
- Use of innovative and sustainable production methods
- Initiation of a risk management system accepted and supported by all parties involved:
  - Mitigate risks
  - Risk sharing instead of risk allocation by the AG
  - Cost transparency

4 METHODOLOGY

Regarding “Early Contractor Involvement” a systematic literature review was conducted to identify the variations as well as the characteristics of these variations. In particular, a search was conducted for studies on Early Contractor Involvement.

Several research strings were established to search for literature in the search engines Scopus, SpringerLink and GoogleScholar The same search strings were also used on the platforms ResearchGate and Academia.eu. The number of hits was reduced by restricting the search parameters to the field of civil engineering. The actual relevant literature was identified by reviewing the abstracts. By evaluating these collected publications, it was possible to add further thematically relevant literature.

In the course of the literature evaluation, the types and variations of ECI were collected by the analysis of pre-existing studies on ECI. The variations of ECI are subdivided according to when they are implemented in the project. Additionally, the factors and criteria that favour the successful implementation of Early Contractor Involvement are identified. First, these factors are matched with the project properties and then, examined for their feasibility for public clients as they build the base of the selection tool. Based on the results a decision logic is developed and implemented in a new tool. This tool is an software application.

5 FINDINGS

5.1 *Early contractor involvement variations*

(Wondimu et al. 2020) already gives a great overview of the variants by listing 25 different kinds of Early contractor involvement. Within the framework of the systematic literature analysis 15 additional approaches were identified. All together 36 different variants of the early integration of execution competence into a construction project were identified. After identifying that many variants further active research for new forms was stopped.

The variants occur with varying frequency, some were only applied once in practice, others were mentioned several times in the literature. Due to the high implementation effort and the small number of practical implementations as well as the lack of experience reports, the frequency of mention cannot be used for categorisation. However, all identified variants can be differentiated according to time, type, scope and influence of the price on the selection of the contractor. Anyhow, the following list is far from complete as there are still emerging new forms or pre-existing variants under a new name every now end then.

1. Alliance competitive
2. Alliance pure
3. Allowing variant solutions by the bidders during tendering phase
4. Announcing with alternative technical solutions
5. “Bauteam”
6. Construction Management
7. CMR
8. Competitive dialog (CD) procedure
9. Consolation
10. Contractors promote their ideas to the owner in the early phase
11. Cost Led Procurement
12. Design-build contract
13. Design-bid-build contract (DBB)
14. direct contract with front-end phase of projects
15. Framework
16. Front-end partnering process
17. Idea competition
18. Indirect approaches
19. Information meetings
20. Integrated Project Insurance
21. IPD
22. Multiple (dual) TCC/CLP
23. Negotiated procedure
24. Novated design and construction contract
25. Optimization phase after the award
26. Partnering
27. PPP (many sub variations)
28. Public announcment
29. Relational project delivery agreements (RPDAs)
30. Selection based on qualifications and price
31. Selection based on only qualifications
32. Single TCC
33. Supply Chain Collaboration
34. Two-stage TCC/ a tow-stage tender process/ two-stage open book
35. Vladres Model
36. Workshops (with the contractors after design phase but bevor plan approval process starts)

Depending on the ECI model used, an appropriate reimbursement system must be selected for the construction but especially in the case that know-how-transfer from contractor to client takes place. Cost-Plus -Incentive-Fee (CPIF), Cost-Plus-Award-Fee (CPAF), Cost-Plus-Fixed-Fee (CPFF) are suitable reimbursement systems for a joint planning phase. Fixed-Price Prospective Price Redetermination, CPIF, CPAF and CPFF represent a suitable remuneration system for a construction project following early contractor involvement (Becker and Friedinger 2023).

5.2 *Levels of ECI*

Figure 1 illustrates the depth of involvement and the influence of price by distinguishing four levels. Level 1 has the least depth and the smallest scope of cooperation. A construction company is involved in the project planning in an advisory capacity. The public announcement of a major project or participation in the tender process by answering bidders’ questions also fall into this category. Price is the main criterion for selecting the contractor in Level 1 (Friedinger and Becker 2023). Level 2 includes models in which selected companies are invited to bid and there is an intensive exchange between the client and the bidder. At this stage, the contractor may already be involved in the design. A functional tender would be assigned to level 2. Level 3 includes those types of ECI where the contractor is selected

in a two-stage procedure and the design is carried out jointly. At level 4, in addition to the execution. In Level 4, the expertise of other key companies in the supply chain is used in addition to the execution expertise of the construction company. From Level 1 to Level 4, the importance of the construction price in the selection of project partners decreases, while at the same time the risk mitigation increases from Level 1 to Level 4.

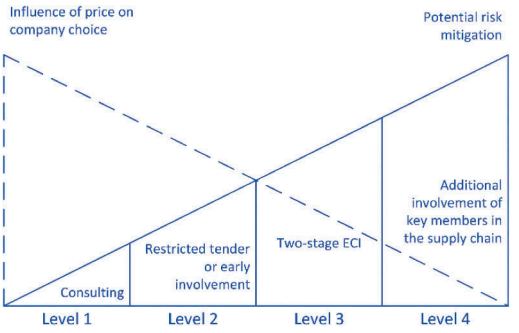

Figure 1. Level of Involvement based on (PIANC 2022).

5.3 *German procurement law*

The volume of construction work for which an ECI makes sense is generally above the threshold for a threshold value for a Europe-wide invitation to tender. In this paper, it is assumed that a Europe-wide invitation to tender is also required for the tendering of an ECI. In accordance with § 119 (1) No. 3-7 of the German Act against Restraints of Competition (GWB) five types of procedure are available: the open procedure, the restricted procedure, the negotiation procedure, the competitive dialogue and the innovation partnership. The rules are specified in the VgV and the VOB/A (Breyer et al. 2020).

If an ECI is to be carried out, it must be taken into account when choosing the award procedure that price must not be the sole decision-making criterion. A procedure must be chosen that allows a decision on the basis of other criteria. Therefore, only the competitive dialogue and the negotiated procedure can be considered for an award in the sense of the ECI.

5.4 *Variants for German public owners*

The 35 identified models were analysed in regards to their usability for Germany Public clients. An important aspect is the. The most important aspect is the compatibility of the variants with German public procurement law.

Apart from a public announcement of a major project, which only aims at arousing the interest of construction companies in a subsequent call for tenders, there is currently no possibility for public contracting authorities to involve construction companies at level 1 in the planning. Level 2 includes types of project management and tendering such as functional tendering. This is of course available to public clients, but by applying these models, their influence on the planning is lost. Although the execution competence is brought in at an early stage of planning, it is not in the way it is thought of in the common understanding of ECI. The “restricted invitation to tender” of Level 2 can be added to a “competitive tendering procedure followed by a restricted procedure” if the bidders’ proposals for optimisation become part of the invitation to tender. However, an ECI in the true sense is not achieved in this way. Only an implementation of your Level 3 model represents an ECI in the true sense. This is mapped within the framework of innovative project management models such as IPA. These innovative models are currently being tested and evaluated in pilot projects. To include the know-how of key companies of the supply chain in the planning in addition to the execution competence, as described in level 4 of the ECI, is too capacity-binding and complex for public clients at the present time. These ECI variants are used e.g. by private clients in the construction of oil rigs (Laryea and Watermeyer 2016; Wondimu et al. 2018; Wondimu et al. 2020; PIANC 2022).

In principle, several ECI variations are compliant with public procurement law and can be implemented. However, their use requires very good knowledge of public procurement law. Additional some variations are rather easy to implement and only turn out to be a form of ECI on closer inspection like the public announcement, like the public announcement.

5.5 *Success factors and criteria*

Early Contractor Involvement is not suitable for every project and every client. In 2016 Wondimu identified six factors (Wondimu et al. 2016):

1. The right timing is crucial, contractors need to be involved early enough. 2.
2. The risk transfer to the contractors must be kept at an manageable level.
3. The contractor must be adequately remunerated for the contribution of his execution competence. This is the only way to create an incentive to transfer know-how to the client.
4. Mutual trust, akin to partnering models,
5. The contractor must have the technical qualification to carry out or evaluate the planning
6. The client must have sufficient competence and capacity.

Furthermore, a consensus on fair risk sharing must be fundamentally anchored. Accordingly, an effective, efficient and sustainable risk management, which is developed in the ECI and continued during construction, is essential. The project must also have a certain

complexity and investment volume to justify the increased effort in the planning phase (Rahman and Alhassan 2012; Nibbelink et al. 2017; Narum et al. 2022; PIANC 2022; Rahmani et al. 2022).

6 CONTRACTOR INVOLVEMENT TOOL (CIT)

6.1 *Purpose and benefit*

The tool provides support for public clients in choosing the adequate form of early contractor involvement for their specific project. It also provides help and additional information for every step to be taken and guides a public client through the complete procurement process.

6.2 *Software application*

In software development one can choose between either a desktop or a web application. For this research a desktop application was chosen. Implementing a standalone application has the following advantages (Sander 2012):

- It is executed directly by the operating system (without a browser as a "man in the middle");
- This allows greater complexity with good performance.
- Concentration on a single platform (Windows) that can be used by all users. users. This is especially true for testing, which does not need to be performed on multiple browsers and operating
- operating systems, which would be very time consuming.
- Possible use of the specific functionality of the operating system and direct cooperation with software packages
- Cooperation with software packages (OFFICE) that run on this system.
- Better availability of GUI elements that can be used to increase usability.
- Connection to a central database is still possible

6.3 *Programming language .NET*

The .NET Framework is an evolution of the Win32 API, which provides access to all the functions of the of the WINDOWS operating system. NET applications access

NET Framework class libraries (file management, graphics output, data processing, etc.). Plus, all of Microsoft's popular programming languages (C#, Visual Basic, C++ and F#) can access the .NET Framework (ibid.). To generate an language-independent code the Common Language Specification (CLS) is used. In this code different languages have equal rights and deliver the same result. Being an open standard the CLS enables the porting of other languages to .NET (Kofler and Nebelo 2008) as shown in Figure 2.

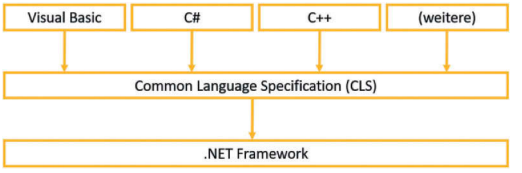

Figure 2. Independent CLS (Kofler 2008).

Additionally .NET applications run independently on Windows systems (Sander 2012), which is a major advantage in usability.

6.2 *CIT in DigiCon*

DigiCon is a software platform developed as part of the "Digital Performance Contracting Center" research project at the University of the Bundeswehr Munich, see Figure 3. The software is still under development. Its aim is to digitally model the mechanisms and processes in public procurement developed in the research project. The Contractor Involvement Tool (CIT) uses the DigiCon platform as a base to model and depict the whole involvement process.

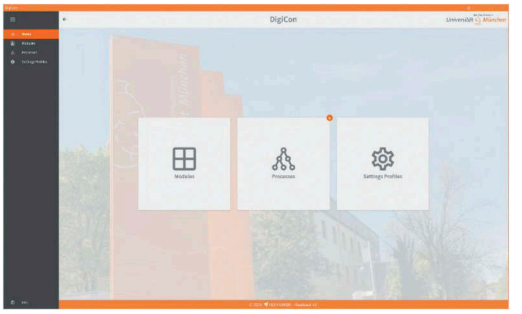

Figure 3. Image of DigCon platform.

DigiCon enables the use to create modules and connect them in a process as they see fit. It also gives the opportunity to choose the logic when combining different modules, shown in Figure 4.

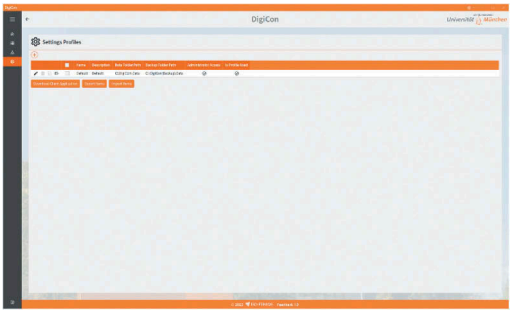

Figure 4. Module creation in DigiCon.

Regarding this research DigiCon as a platform and CIT in particular models a project enquiry in the first place. The enquiry compares the project specifications and properties with the success factors of ECI. Of particular importance are risk management, the client's own expertise and its own capacities. Depending on the result, CIT proposes several suitable ECI variants to the user. The application process is also shown for each variant and additional detailed information can be called up for each individual process step.

The user is responsible for the final selection of the variant, as CIT is not a management tool but a support tool for project management.

7 SUMMARY AND OUTLOOK

The ECI is only suitable for handling large and complex projects, as it entails considerable additional work in the tendering and planning phases. In addition, the client must provide sufficient competence and resources of his own and sufficiently reward the contribution of the execution competence in order to be able to carry out a project successfully with the ECI. Apart from the simple and straightforward variants, which can only be assigned to the ECI on very close examination, the legal regulations in Germany only allow two award procedures for the implementation of an ECI. Nevertheless, it can be stated that the early involvement of construction companies in the planning phase is possible in principle. The next steps are to finish de development of the DigiCon software-platform.

The selection processes must then be precisely defined and modelled in CIT. As soon as CIT is ready for use, it must be tested in practice by public clients. This will hopefully lead to more ECI projects in Germany, which will generate more data on ECI for public owners. However at this point there is more research required regarding the joint planning in ECI as CIT just shows the way to the joint planning. With regard to the transparent settlement with open-book, the joint calculation, the structure of the joint risk management and the risk allocation during the ECI should be examined and described in detail.

ACKNOWLEDGMENTS

This research paper on the project DigiPeC is funded by dtec.bw – Digitalization and Technology Research Center of the Bundeswehr. dtec.bw is funded by the European Union – NextGenerationEU.

REFERENCES

Bandte H, 2007. Komplexität in Organisationen. Organisationstheoretische Betrachtungen und agentenbasierte Simulation. Zugl.: Braunschweig, Techn. Univ., Diss., 2006 u.d.T.: Bandte, Henning: Organisationen und Komplexität: organisationstheoretische Betrachtungen zur angemessenen Handhabung von Komplexität in Organisationen unter Berücksichtigung agentenbasierter Simulation (1. Aufl.). Dt. Univ.-Verl., Wiesbaden, 373 p.

Becker SC, Friedinger CP, 2022. Application of Alternative Contracting Methods for Large Infrastructure Projects as example Project Alliancing. In: (ICPMA) (ed.). Sustainable Mobility Infrastructure (Porto, 2022), 23.05.2022-24.05.2022.

Becker SC, Friedinger CP, 2023. Analyse potenzieller Vergütungsmodelle und Anreizsysteme für die Integrierte Projektabwicklung (IPA), unpublished.

Becker SC, Roman-Müller H, 2022. Integrierte Projektabwicklung (IPA). Schnelleinstieg für Bauherren, Architekten und Ingenieure. Springer Vieweg, Wiesbaden, 61 p.

Bourn J, 2007. Estimating and Monitoring the Costs of Building Roads in England. NAO Information Centre, London.

Breyer W, Boldt A, Haghsheno S, 2020. Alternative m Einheitspreisvertrag für die Vergabe von Bauleistungen durch die öffentliche Hand. Forschungsprogramm: Zukunft Bau, ein Forschungsprogramm des Bundesministeriums desInneren, für Bau und Heimat.

Buchal T, 2014. Early Contractor Involvement (ECI) and its Implementation, unpublished. Technische Universität Prag, Prag.

CURT (Construction Users Roundtable) (ed.), 2004. Collaboration, integrated information and the project lifecycle in building design, construction and operation, Cincinnati, OH.

Eadie R, Graham M, 2014. Analysing the advantages of early contractor involvement. International Journal of Procurement Management, 7 (6), 661.

Eschenbruch K (ed.), 2008. Partnering in der Bau- und Immobilienwirtschaft. Projektmanagement- und Vertragsstandards in Deutschland. Kohlhammer, Stuttgart, 335 p.

Faber S, 2014. Entwicklung eines Partnering-Modells für Infrastrukturprojekte. Ein Beitrag zur Optimierung der Abwicklung von Bauprojekten im öffentlich finanzierten Infrastruktursektor in Deutschland. Zugl.: Kassel, Univ., Diss., 2013. Kassel Univ. Press, Kassel, 241 p.

Friedinger CP, Becker SC, 2023. Early Contractor Involvement für öffentliche Auftraggeber – Chancen für eine effizientere Projektabwicklung, unpublished.

Friedinger CP, Mitteregger K, Sander P, 2023a. Probabilistic Analysis of the Delivery Models Unit Price and Alliance applied at the Project Gemeinschaftskraftwerk Inn with Focus on the Construction Time. In: Schubert W, Kluckner A (eds.). Proceedings of the ISRM 15th International Congress on Rock Mechanics and Rock Engineering & 72nd Geomechanics Colloquium. Challenges in Rock Mechanics and Rock Engineering, October 9-14, 2023, p. 202–207.

Friedinger CP, Sander P, Becker SC, Villinger T, 2023b. Analyse und Gegenüberstellung der Vortriebsdauern von Einheitspreisvertrag und Allianzvertrag beim Druckwasserstollen des Projektes Gemeinschaftskraftwerk Inn. Forschungsbericht, Neubiberg.

Girmscheid G, 2005. Partnerschaften und Kooperation in der Bauwirtschaft. Chance oder Irrweg? Der Bauingenieur, 80, 103–113.

Haghsheno S, 2020. Integrierte Projektabwicklung in Mehrparteienverträgen. Tagung „Bauen statt Streiten", Würzburg.

Heinen E, 1972. Industriebetreibslehre als Entscheidungslehre. Erster Teil. In: Heinen E (ed.). Industriebetriebslehre.

Entscheidungen im Industriebetrieb. (Zweite, durchgesehene Auflage). Gabler Verlag, Wiesbaden, p. 25–75.

Karasek G, 2021. Bauvertrag: Klassisches Modell oder…? In: Agile Digitalisierung im Baubetrieb. Springer Vieweg, Wiesbaden, p. 511–525.

Kinlan D, Willems K, 2023. Applying early contractor involvement in marine infrastructure procurement. TERRA ET AQUA, 169, 6–17. Accessed on 12.06.2023, https://www.iadc-dredging.com/wp-content/uploads/2023/03/terra-et-aqua-169-complete-spread.pdf

Kofler M, 2008. Visual Basic 2008 (1. Aufl.). Addison-Wesley, München, 1344 p.

Kofler M, Nebelo R, 2008. Excel 2007 programmieren. Anwendungen entwickeln und Abläufe automatisieren mit VBA; [sofort einsetzbares Add-in zur Nachbildung der klassischen Menüleiste (7. Aufl.). Addison Wesley in Pearson Education Deutschland, München, 921 p.

Laryea S, Watermeyer R, 2016. Early contractor involvement in framework contracts. Proceedings of the Institution of Civil Engineers - Management, Procurement and Law, 169 (1), 4–16.

Leitfaden Großprojekte, 2018, unpublished, Berlin, 134 p.

Malvik TO, Wondimu P, Kalsaas BT, Johansen A, 2021. Various Approaches to Early Contractor Involvement in Relational Contracts. Procedia Computer Science, 181, 1162–1170.

Mosey D, 2009. Early contractor involvement in building procurement. Contracts, partnering and project management. Ames Iowa, Chichester, West Sussex, 316 p.

Narum KB, Engebø A, Lædre O, Torp O, 2022. Collaborative Project Delivery With Early Contractor Involvement and Target Cost. In: Proc. 30th Annual Conference of the International Group for Lean Construction (IGLC), 27. 07.2022-29.07.2022. International Group for Lean Construction, p. 984–995.

Nibbelink J-G, Sutrisna M, Zaman AU, 2017. Unlocking the potential of early contractor involvement in reducing design risks in commercial building refurbishment projects – a Western Australian perspective. Architectural Engineering and Design Management, 13 (6), 439–456.

Nister O, 2005. Die baubetrieblichen und bauökonomischen Aspekte des Vertragswesens der Projektentwicklung aus der Sicht „Unvollständiger Verträge“. Zugl.: Dortmund, Univ., Diss., 2005, Dortmund.

Partnering bei Bauprojekten - Langfassung, 2005, unpublished.

PIANC, 2022. A framework for a early contractor involvement in infrastructure projects. General Secretariat of PIANC, Brussels, 183 p.

Picot A, Dietl H, Franck E, 1998. Organisation. Eine ökonomische Perspektive (1. Nachdr). Schäffer-Poeschel, Stuttgart, 368 p.

Rahman M, Alhassan A, 2012. A contractor's perception on early contractor involvement. Built Environment Project and Asset Management, 2 (2), 217–233.

Rahmani F, Khalfan M, Maqsood T, 2022. A Conceptual Model for Selecting Early Contractor Involvement (ECI) for a Project. Buildings, 12 (6), 786.

Reformkommission Bau von Großprojekten Endbericht. Komplexität beherrschen - kostengerecht, termintreu und effizient, 2015, unpublished, Berlin, 112 p.

Riemann S, 2014. Ansätze zur Nutzung des Unternehmer-Know-hows bei öffentlich finanzierten Infrastrukturprojekten in Deutschland mit besonderem Fokus auf der Planungsphase. Zugl.: Kassel, Univ., Diss., 2014. Univ. Press, Kassel, 300 p.

Sander P, 2012. Probabilistische Risiko-Analyse für Bauprojekte. Entwicklung eines branchenorientierten softwaregestützten Risiko-Analyse-Systems. Zugl.: Insbruck, Univ., Diss., 2012 (1. Aufl.). innsbruck univ. press, Innsbruck, 207 p.

Sander P, Becker SC, Friedinger CP, Riemann S, Ditandy M, Spiegl M, 2022. Risikomanagement bei Großprojekten im Tunnelbau. Teil 3: Gestaltung von Anreizmechanismen für die Integrierte Projektabwicklung. tunnel, 2022 (04), 12–23. Accessed on 03.01.2022, https://www.tunnel-online.info/de/artikel/tunnel_Gestaltung_von_Anreizmechanismen_fuer_die_Integrierte_Projektabwicklung_3816274.html

Smart Construction, 2023. Realisierung – Smart Construction, 13.06.2023. Accessed on 13.06.2023.

Walker DH, Lloyd-Walker B, 2012. Understanding early contractor involvement (ECI) Understanding early contractor involvement (ECI)procurement forms. In: Smith SD (ed.). Proceedings 28th Annual ARCOM Conference. 3–5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, UK, p. 877–887.

Wondimu PA, Hailemichael E, Hosseini A, Lohne J, Torp O, Lædre O, 2016. Success Factors for Early Contractor Involvement (ECI) in Public Infrastructure Projects. Energy Procedia, 96, 845–854.

Wondimu PA, Hosseini A, Lohne J, Laedre O, 2018. Early contractor involvement approaches in public project procurement. Journal of Public Procurement, 18 (4), 355–378.

Wondimu PA, Klakegg OJ, Lædre O, 2020. Early contractor involvement (ECI): ways to do it in public projects. Journal of Public Procurement, 20 (1), 62–87.