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Lifecycle driven planning of infrastructure: public and private experiences with more integrated approaches for managing project complexity

Sander Lenferink[1]
Radboud University Nijmegen, Institute for Management Research, Nijmegen, Netherlands

Taede Tillema[2]

Jos Arts[3]
University of Groningen, Faculty of Spatial Sciences, Groningen, Netherlands

Currently, many initiatives are under implementation in the Netherlands to integrate the stages of policymaking, plan development, construction, and operations and maintenance in the lifecycle of the infrastructure planning process by more explicitly involving business organizations. However, generally speaking, these integration initiatives stand alone and only connect a maximum of two stages at a time. In this article we explore whether and how contemporary lifecycle integration initiatives could be combined into a more integrated approach to be better able to address infrastructure planning complexities. We provide a framework for dealing with project complexity that distinguishes internal complexity, defined as the interrelatedness between project components, and external complexity, defined as the interaction of the project with its context. After assessing public and private experiences in combining single integration initiatives in complex settings by means of two focus group discussions, we conclude that current initiatives that connect stages in the planning process are suitable for addressing internal complexity. However, external complexity proves to be more difficult to adequately tackle when combining these lifecycle integration initiatives. We therefore recommend applying a more dynamic process management approach that stimulates continuous public-private interaction throughout the stages of the planning lifecycle. This could be facilitated by introducing alliances and cross-functional public-private teams.

Keywords: *complexity, lifecycle integration, market involvement, project management, public-private partnerships, road infrastructure planning.*

1. Introduction

Traditionally the approach to infrastructure planning and decision-making is highly directive and strongly organized in stages. Such an approach can help progress of a project or a process by defining manageable pieces (Cooper,1972; Prahabkar, 2008). However, Flyvbjerg et al. (2003) point to project failures, e.g. budget and time overruns. These seem to indicate that government's traditional directive and staged approaches often are inappropriate. This is even more so given

[1] A: P.O. Box 9108, 6500 HK Nijmegen, the Netherlands T: +31 243 611 477 E: s.lenferink@fm.ru.nl
[2] Paper written in personal capacity, address excluded for privacy reasons. E: taedetillema@hotmail.com
[3] A: P.O. Box 800, 9700 AV Groningen, the Netherlands T: +31 503 633 872 E: e.j.m.m.arts@rug.nl

the complexity in infrastructure projects which is considered to lead to project failure more frequently (Bosch-Rekveldt, 2011; Williams, 2002).

The traditional process can lead to implementation gaps (Dunsire, 1978) when stages, decisions and their involved actors are disconnected. Staged processes could lead to lock-ins (see Arthur, 1989), in the sense that concluding the stages in the process (i.e. the decision-making) becomes more important than delivering the end-product (i.e. the infrastructure development). By rigidly following the planning process, knowledge and experience from the later implementation stages can become shut out, and opportunities to better connect to practice could be disregarded. Integration of stages could help to link stages and overcome these implementation gaps. In practice this also implies more intensive interaction between different actors, since government traditionally plays a prominent role in plan-making whereas private market parties in many countries are strongly involved in later stages of the planning cycle, i.e. construction and maintenance. Overall, the expectation is that by integrating stages and by stimulating interaction between various actors, knowledge and expertise can be unlocked.

In this article we specifically focus on lifecycle integration through market party involvement. Such private business organizations may include design companies, contractors, financial institutions, engineering consultants and legal firms. Market parties possess knowledge and expertise from practice: they are what Teisman refers to as 'purposeful actors' (Teisman, 2000). By involving them earlier in the process through lifecycle integration, their knowledge and expertise can potentially be used to strengthen the infrastructure planning process and its outcomes (Lenferink et al., 2008) also in the light of project complexities.

In Dutch road infrastructure planning practice, several initiatives for lifecycle integration through market involvement have been applied recently. For example, the early policymaking and plan development stages in the lifecycle of infrastructure projects are integrated by pre-competitive market involvement instruments, such as market scans, market consultations and early design contests (Leendertse et al., 2012b). Lifecycle integration initiatives connecting the plan development and construction stages include the competitive dialogue procurement procedure, which specifically aims to facilitate public-private interaction (Lenferink et al., 2011; Hoezen et al., 2012). Integrated innovative contracts have also been introduced that include combined design, construction and maintenance of infrastructure (Bult-Spiering and Dewulf, 2006), for example through Design-Build-Finance-Maintenance contracts (DBFM).

Although lifecycle integration is meant to prevent implementation gaps and unlock knowledge and expertise, in practice it seems to remain limited to the ad hoc and isolated integration of a maximum of two planning stages at a time, without systematically considering the wider potential of combining a greater number of, i.e. more than two, integration initiatives. A more overarching approach to lifecycle integration, which looks into the possibility and potential added value of tailoring and integrating separate initiatives is currently absent. To investigate its potential in practice, it is crucial to gain insight into recently obtained experiences of public and private parties with separate integration initiatives. Building on those experiences, first insights into the potential of combining and tuning public private initiatives over the planning cycle can be explored. In this article, therefore we firstly aim to gain greater insight into public and private experiences with various lifecycle integration initiatives in practice, and, secondly we aim to explore the potential of integrating these initiatives throughout the planning cycle. Thereby, we specifically focus on experiences with integration initiatives in projects exhibiting a high degree of complexity.

The experiences are retrieved from two focus group sessions with a mix of infrastructure planning experts from the public and private sector. The current absence of insights into, let alone experiences with, a more overarching approach to lifecycle integration left us to choose for focus group discussions, where, through interaction and discussion, experts with overlapping

and partly complementary knowledge and experience were asked to explore the potential and characteristics of a lifecycle driven infrastructure planning. Although we base our analysis on experiences in Dutch infrastructure planning practice, this article is also relevant to the international debate on how to include the results of new public management (Lane, 2000; Pollitt et al., 2008) and private sector involvement (see Osborne 2000; Goldsmith and Eggers, 2004; Mosey 2008) into new modes of governance (De Bruijn et al., 2004; Kickert, 1997; Martens, 2007; Teisman et al., 2009).

The outline is as follows. In section 2, we provide a theoretical framework in which we elaborate on lifecycle integration, develop a typology of project complexity, and formulate four propositions on lifecycle integration. In section 3, the research design, we describe how these propositions were discussed in two focus group discussions with a mix of public and private sector participants. Subsequently section 4 provides practical perspectives from the focus groups on combining lifecycle integration initiatives for highly complex projects. In section 5 we discuss and draw conclusions.

2. Theoretical framework

2.1 Lifecycle integration and the planning process

Lifecycle integration revolves around the idea that by involving knowledge and experiences and connecting stages, learning loops can be established that provide for adaptiveness (see Argyris and Schön, 1978; Forrester, 2009). The learning loops help to prevent lock-ins in an overstructured approach with a focus on decision-making to conclude stages only. In such instances, the process is not performed to deliver an end-product, but is a goal in itself. In theory an overarching approach to lifecycle integration can help to keep the focus in the planning process, while managing interdependencies and differentiation between stages (as described by Lawrence and Lorsch, 1969; Mintzberg, 1991). Lifecycle integration could help streamline and adjust public-private interaction in various stages to each other and distribute knowledge and experiences over the full lifecycle of infrastructure planning (Arts, 2007; Lenferink et al., 2008) in an approach that combines the complementary elements of control and interaction (see De Bruijn et al., 2004). According to Teisman (2005) and Hertogh and Westerveld (2010), these elements of systems and interactive management are required in present-day complex environments and should be present in managers' core competences.

Lifecycle integration through market involvement potentially also has some disadvantages. The interdependencies created can increase the risk of standstills, which decomposition into a phased planning process could prevent (Prahabkar, 2008). Lifecycle integration could also increase transaction costs as a result of the prolonged involvement of the private sector (NAO, 2007; Solino and Gago de Santos, 2010). In addition the integration of stages combined with market involvement could scatter public and private roles and result in unclear responsibilities, which can negatively affect the democratic legitimacy of planning processes (Bexell and Mörth, 2010).

In order to assess the potential of combining lifecycle integration initiatives in practice, it is important to further discuss the stages in the lifecycle, the possible integration of these stages, and the potential role of market involvement in this. In line with the formal Dutch planning process (Dutch Ministry of Infrastructure and the Environment, 2011; Rijkswaterstaat, 2011a), we distinguish four stages in the planning lifecycle that can also be recognized internationally (see Ward and Chapman, 1995): policymaking, plan development, construction, and operation and maintenance, which we will discuss in the next section (see Figure 1). The nature of these stages in the planning lifecycle are diverse. Stages can be open or closed in terms of involvement of other parties, such as road authorities, governments, interest groups and the general public. They can also be focused on a single project or on the broader road infrastructure network, and they can be primarily focused on plan preparation or on project implementation. Figure 1identifies

four links between these stages including integration initiatives which involve business organizations and which are applied by Rijkswaterstaat[4] in Dutch road infrastructure planning (see Rijkswaterstaat, 2011a).

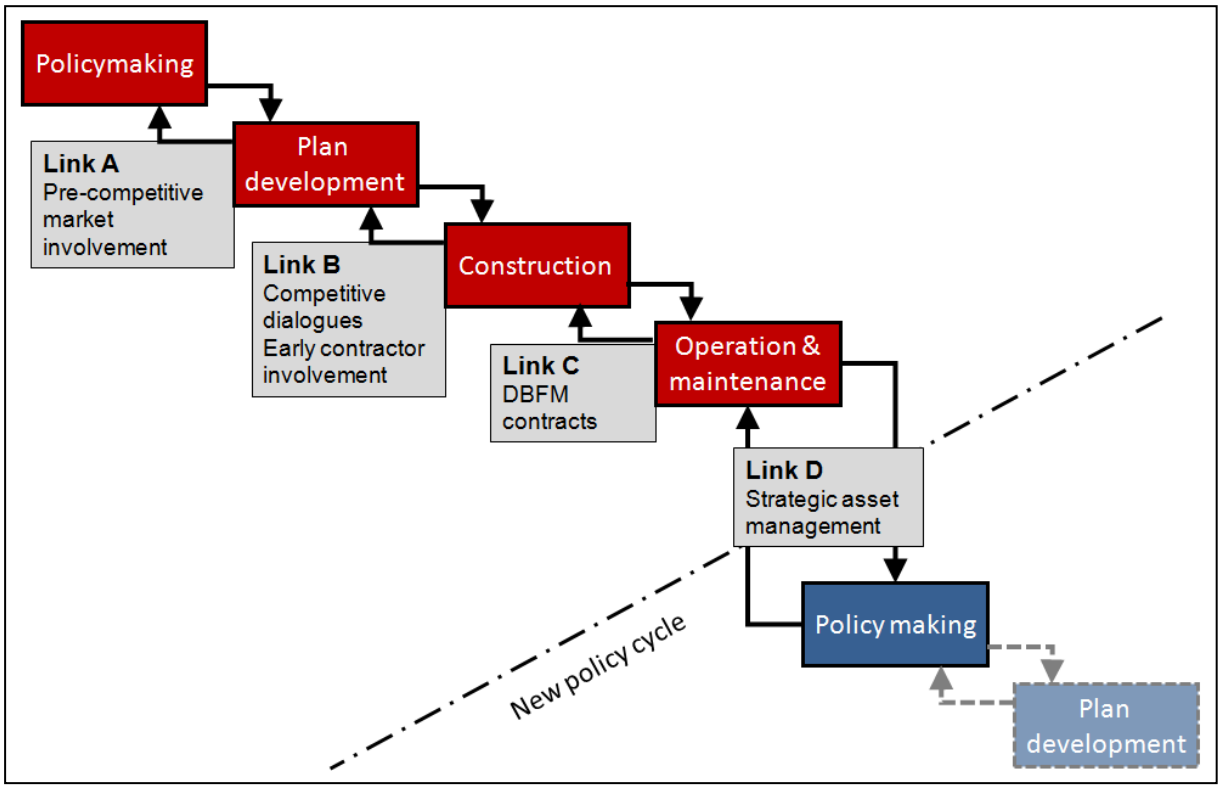

Figure 1: Lifecycle integration links investigated in practice

Generally speaking, the planning lifecycle develops from a more open stage of political and societal discussions to a more closed plan development stage. Link A considers the link between development of project plans and policymaking. Between these stages, policy is worked out into technical designs, which involves moving from an open stage of external negotiations to a closed stage in which projects are defined and the focus is on internal relations. Several models for pre-competitive market involvement are present in this link, including market scans, market consultations, early design contests and unsolicited proposals (for a detailed discussion of these instruments, see Leendertse et al., 2012b; Lenferink et al., 2012b).

After plan development, a political decision has to be made and the procurement of a solution can start. In procurement the project structure is adopted, which is subsequently used to construct the project. Link B visualizes the connection of the construction and plan development stages. Between these stages project plans are worked out into constructed projects using technical designs from procurement. Both plan development and construction focus on the internal coordination of technical and legal issues and aim to minimize external influences, as plans are transformed into projects. Two forms of lifecycle integration initiatives can be identified. The first initiative is early contractor involvement, in which public planning and procurement procedures are combined (see Lenferink et al. 2012a). The second initiative is the competitive dialogue procurement procedure, in which pre-bid public-private interaction can help address project complexity (see Lenferink and Hoezen 2012).

[4] Rijkswaterstaat is the executive agency of the Dutch Ministry of Infrastructure and the Environment that is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands.

Once construction is completed, the closed and internal project focus is abandoned when the focus gradually shifts during operations and maintenance to managing external relationships in a part of the road network. Link C involves the connection of the operation and maintenance stage with the construction stage. In the Netherlands, integrated Design-Build-Finance-Maintain (DBFM) contracts are applied to connect these stages by combining the design, maintenance and operations activities into a single contract (Bult-Spiering and Dewulf, 2006).[5]

Finally, in the operation and maintenance stage, political and societal discussions can inspire new policymaking. Link D involves this connection between the operations and maintenance stage and the policymaking stage. Issues in operating and maintaining a part of the network can provide reasons for linking back to policymaking, thereby closing the lifecycle. This involves a shift from an internal focus on a project's relationships within a network to a more open focus on policymaking with new cycles of negotiations (see Figure 1). Connecting the operations and maintenance stage to the policymaking stage requires asset management from a network perspective (Mitchell, 2006; Herder and Wijnia, 2012). Such asset management has a strategic character as it involves a long term political choices.

2.2 A typology of project complexity

Harkema (2004) regards the inseparability of individuals and organizations, as advocated by the pragmatists Mead (1972) and Giddens (1984), as the foundation of complexity science. The coexistence of the determinism of structural functionalism and the indeterminism of individual action is central to the relationship between complexity and planning theory as displayed in the governance debate (see Portugali, 1999; De Roo, 2010). In project management, this coexistence is visible in the emergence of adaptive project management (de Bruijn et al., 2003). This type of project management is geared towards creating flexibility in projects, as a way to deal with the increasing project complexity that is considered to lead to project failure more frequently (Bosch-Rekveldt, 2011; Williams, 2002).

In relation to complexity in practice, various typologies can be made, such as those based on means and ends (Christensen, 1985), on differentiation and interdependency (Baccarini, 1996), on ordered and unordered domains (Kurz and Snowden, 2003), on the interaction intensity and stability of a system (Edelenbos et al., 2009), on agreement and certainty (Stacey, 2002),on spatial integration of the scope and the character of the problem (Rijkswaterstaat, 2011), and on detail and dynamic complexity (Senge, 2006).This article builds upon the distinction between detail and dynamic complexity as made by Senge (2006), which is used in project management literature to construct a typology of project complexity (Hertogh and Westerveld, 2010; see also Table 1). We apply this typology because it resembles the approach to traditional project management: defining project boundaries in an attempt to separate internal from external project complexity.

Table 1: Complexity typology with management strategy (after Hertogh, Westerveld, 2010).

		External complexity	
		Low	High
Internal complexity	High	*Complicated* (Systems management)	*Complexicated* (Dynamic management)
	Low	*Simple* (Internal/Content-focused approach)	*Context-Complex* (Interactive management)

[5] DBFM contracts combine the linking of the stages of construction and maintenance and operation (Link C) and, by including a design component, the link to the stage of plan development (link B). However, the design component is limited in the contract: in practice, it seems to only involve some limited engineering activities (Lenferink et al., 2013). Therefore, in this article, we situate the DBFM contract between the construction and maintenance and operation stages.

Internal complexity can be described as the interrelatedness between project components within the project scope, in which a high degree of interrelatedness corresponds with a high degree of internal complexity. In infrastructure planning this can be caused by a combination of technical, financial and legal factors that are included in the project scope. Projects with a high degree of internal complexity are also referred to as '*complicated*'; the appropriate management strategy to address internal complexity is systems management (see Kurtz and Snowden, 2003; Zuidema, 2011), which allows the exchange of knowledge and experience of the interrelated factors. In Dutch practice, a project that can be considered as complicated, because the project is primarily challenging from a technical point-of-view, is the A10 Second Coentunnel, which involves the construction of a second highway tunnel under the North Sea Canal.

External complexity can be defined as the interaction of a project with its context; i.e. the issues beyond the project scope (see Huys and Van Gils, 2010).Projects with only high external complexity are referred to as '*context-complex*'. In such settings, it is essential to manage the contextual interrelatedness of a project(see Kurz and Snowden, 2003) by achieving and increasing interaction in a strategy of interactive management (Hertogh and Westerveld, 2010). Such a strategy would especially focus on intensifying public-public interaction between different government organizations capable of acting at different levels, mainly associated with political decision-making (see Kingdon, 2002). An example of a *context-complex* project in Dutch practice is the A4 Midden Delftland, which in itself is relatively simple in technical, legal and financial terms, but is performed in an externally complex, dynamic environment with continuous social and political debates on the project's usefulness and necessity.

Based on the distinction between internal and external complexity, also '*simple*' projects (low internal and low external complexity) can be distinguished for which an internal and content-focused approach suffices (Hertogh and Westerveld, 2010). In infrastructure planning simple projects are smaller projects that are usually developed at the local level, where less actors and stakes are involved. At the national level, simple projects can be lane extensions and highway upgrades in rural areas, such as in the N31 Zurich-Harlingen road extension project in the Dutch rural province of Friesland (see Lenferink et al., 2012a). Intense interaction, be it public-public or public-private, is not required to successfully execute a simple project, as traditional directive approaches to project management suffice. Government and market parties can have strict client-contractor relationships where they traditionally perform their project management tasks.

In settings that are both internally and externally complex, interrelatedness results in an indeterminist character of limited understanding and predictability and settings we will refer to as '*complexicated*'. An example from Dutch infrastructure planning practice is the A2 Maastricht project, which combines the technically challenging construction of a stacked tunnel in the inner-city of Maastricht with urban development involving other external parties (see Lenferink et al., 2012a). A combination of interactive management and systems management within a dynamic management approach is considered an appropriate management strategy (Hertogh and Westerveld, 2010). This could offer organizational adaption (Levy, 2000) by stimulating creativity and learning capacity (Senge, 2006) through involvement of a broad range of actors, e.g. through a combination of public-public cooperation and public-private cooperation (see Rijkswaterstaat, 2011a).

Despite the structuring function which is provided by the complexity typology described above, in practice sharp and strict borders between internal and external complexities do not exist. Systems have open boundaries with higher level systems, which they are a part of. As a result, these nested systems influence each other and co-evolve (Gerrits et al., 2009) in a non-linear way (Portugali, 1999; Huys and Van Gils 2010). In essence, when connected to project management practice, project boundaries could be regarded as demarcation between internal and external complexity that, through time, may change and may cause the internalization of external complexities or the externalization of internal complexities. In addition, the nature of the

planning process changes over time, as is its complexity (in line with Shapira and Laufer, 1993). As described in section 2.1, for instance, the planning lifecycle develops from a more open stage of political and societal discussions, with its related complexities, to a more closed plan development stage, where projects are being formulated. After construction, the scope may broaden again from a constructed road link towards management of a larger infrastructure network, which may come with its own uncertainties and complexities.

Integrating initiatives throughout the planning lifecycle is the central topic in this paper. The focus of this article is on *complexicated* projects and settings, because both internal and external complexities with their potential interrelationships have to be dealt with in present-day planning. Moreover, the character of such internal and external complexity can change over time. In complexicated settings, new approaches to project planning and management are needed most, as the combination of the dominant classic, directive project management approaches and high complexity seems to increasingly leads to failure in practice (see Bosch-Rekveldt, 2011; Williams, 2002). Lifecycle integration could potentially unlock experience and expertise from later stages to establish a more extensive repertoire of actions (Roose, 2002) and therefore pose an adequate response to increasing complexity.

2.3 Investigating combinations of links in the planning lifecycle

Because it is difficult, if not impossible, to design a comprehensive approach to lifecycle integration from scratch, we investigated combinations of separate lifecycle integration initiatives(see Figure 1). Based on previous research into such integration initiatives, we formulated four propositions that helped to structure the focus group discussion meetings and to obtain a broad range of experiences from practice. To fuel discussions, these propositions were formulated quite bluntly. The first three propositions consider a combination of lifecycle integration initiatives and the conditioning of one initiative by the other. The fourth proposition concerns the complete lifecycle (see Table 2).

Table 2: Propositions and combination of links

Combination of links (see Figure 1)	Proposition
Links A & B	*After pre-competitive market involvement in the plan and policymaking stages, the project complexity has been addressed and projects can be procured traditionally (= without extensive public-private interaction).*
Links B & C	*Integrated lifecycle contracts (such as Design-Build-Finance-Maintain contracts) are currently too rigid to allow for the complexity of projects procured through a competitive dialogue (= with extensive public-private interaction).*
Links C & D	*The long period and detailed character of DBFM contracts limit the opportunities for asset management in a dynamic environment and limit plan-making for new or additional infrastructure.*
Links A, B, C & D (complete lifecycle)	*Lifecycle integration through market involvement increases the complexity of already complex infrastructure planning processes.*

The first proposition considers link A and link B in Figure 1: the possibilities for combining increased market involvement in the early preparatory stages (pre-competitive involvement) with procurement, to connect the policy making, plan development and construction stages. Pre-competitive models all aim to facilitate public-private interaction in project plan development and policymaking (Mosey, 2009; Lenferink et al., 2012b). These models appeal to the growing awareness that complexity can be addressed through public-private interaction in these early stages (Committee Elverding, 2008), if proper rewards and incentives are provided (Leendertse et al., 2012b). The market can bring in knowledge and expertise from later project implementation stages to help address complexity and move from open policy making towards a project with a more closed character. As a consequence of the precompetitive market involvement, potentially there is less need to facilitate extensive discussions between government and market parties in

subsequent procurement: complexity has been discussed and addressed in an earlier stage. Therefore, in the first proposition we suggest a disconnection between these stages, by stating that complexity can and should be addressed and controlled for in an open plan development stage with precompetitive market involvement, before performing a traditional closed procurement and construction stage.

The second proposition encompasses link B and link C: the subsequent stages of plan development, construction, and operation and maintenance. In Dutch infrastructure planning practice, the competitive dialogue is the standard procedure for procuring complex projects. The competitive dialogue is especially aimed at facilitating public-private interaction to openly discuss complex projects (Lenferink et al., 2011; Hoezen, 2012).The competitive dialogue is the standard procurement procedure for tendering DBFM contracts (Nagelkerke et al., 2009). However, the open, interactive character of the competitive dialogue seems to be difficult to combine with contracts. DBFM contracts stipulate, in detail, design, construction and maintenance activities over a long period up to 25 years. Previous research has revealed that the DBFM contracts tendered through a competitive dialogue are detailed and require considerable amounts of information upfront (Lenferink et al., 2013). This seems to make it difficult to make a transition from an open stage of innovative public-private interaction in the competitive dialogue to almost closed rigid contracts, as formulated in the second proposition (see Table 2).

The third proposition concerns the combination of links C and D: construction, operations and maintenance, and policymaking. Public-private interaction on the connection between the construction, operations and maintenance and policymaking stages can potentially provide added value. The long fixed DBFM contracts give opportunities for realizing efficiencies by adjusting design, construction and maintenance activities at the start of the contract. However, at the same time their rigidity may limit possibilities to cope with changes such as technological innovations in infrastructure maintenance and operations. Moreover, whereas current DBFM contracts often focus on individual road infrastructure sections, for optimal operations assets may need to be managed at network level. However, research by Lenferink et al. (2013) and Leendertse et al. (2012a) shows that by locking up small parts of the road network in closed, internally oriented DBFM contracts, opportunities for asset management, and, in the end new policy and plan making may be constrained. Proposition 3 addresses this issue and stimulates a discussion on how learning in the operational stages could provide input for a new policy cycle.

The fourth proposition attempts to bring together the three previous proposition and stimulate a discussion on the possibilities of connecting all stages and combining all initiatives. The three previous propositions have been posed in order to be able to discuss the preconditions, the limitations, the advantages and the disadvantages of an overarching approach to lifecycle integration. An implicit focus of the proposition is how to manage project complexity in relation to lifecycle integration. In this proposition we purposely adopt a critical standpoint towards lifecycle integration, which stimulates discussion of its overall added value.

3. Research design

As described in the previous sections, lifecycle integration has only been applied on an ad hoc basis in infrastructure planning. As a consequence, there is limited insight into what the practical perspectives on an overarching approach to lifecycle integration are. The interactive approach of focus group discussions allows us to provide these practical perspectives, or as Fern (2001) describes it, to generate knowledge for applied research. Focus group discussions combine interaction, obtained through participant observation, with in-depth knowledge of experiences, obtained through in-depth interviewing (Morgan and Spanish, 1984). The group interaction between the public and private experts who took part in the discussions is a necessary part of the explorative research conducted into the potential added value of an overarching approach to

lifecycle integration, which could not be gained by simply combining findings from case studies. The experts need group interaction to formulate their opinions on lifecycle integration, which is a subject at the border of their expertise and at the border of their knowledge. The discussions aimed at providing an overview of opinions and issues concerning lifecycle integration, and as such they were not designed to achieve information saturation.

We applied two focus group discussions with six participants each. The composition of the focus groups is presented in the Appendix. The groups were chosen to be relatively small, because larger groups would have caused the discussions to be too cluttered. The small size was compensated for by what Fern (1983) describes as the articulateness and fluency of the experts that participated in the focus group. In addition, there are only a limited number of experts in Dutch practice able to oversee the full planning lifecycle and its integration initiatives. The composed focus groups reflected the integral perspective of the subject. The participants were carefully chosen from public and private bodies. Public participants included policymaking officials, legal experts and contract managers. The private participants were part of tender organizations or were involved in project construction, project management and the line management of the private companies. The participants carefully reflected a range of disciplines, technical, legal, financial and organizational, and were involved in different stages of the project lifecycle (see Appendix).

4. Experiences with lifecycle integration and project complexity

In this section we will present the results of the focus group discussions using quotes from the transcripts that reflect the opinions given in the group discussions. We describe the public and private experiences of lifecycle integration in relation to project complexity. This is done for each combination of link in the planning lifecycle and its respective proposition (see Table 2), in paragraphs 4.1 to 4.4.

4.1 Link A & B

> *Proposition 1: After pre-competitive market involvement in the plan and policymaking stages, the project complexity has been addressed and projects can be procured traditionally (= without extensive public-private interaction).*

The public parties acknowledged that they cannot define and work out complex projects fully by themselves. In their opinion, public-private interaction in policy making, plan development and procurement can help control time, costs and quality and deal with internal complexity. A public official stressed the role of knowledge in the decision to apply public-private interaction in procurement: '*It depends on the type of knowledge necessary to make the technical* [internal] *complexity controllable. If this is market knowledge, then do not make things difficult by trying to do it yourself, but ask the market*' (public participant). Public participants see, however, that pre-competitive interaction in settings with high external complexity has its limitations, as it is not a panacea to all complexity issues in policymaking and plan development: '*pre-competitive market involvement is regarded as the answer to all of the government's questions. However, in a* [external] *complex setting, this is impossible*' (public participant). Public participants nevertheless stress the importance of early stage interaction for complexicated projects, because in procurement, '*you will merely obtain tactical knowledge because of its competitive nature*' (public participant). Therefore, possible solutions have to be found before competition becomes dominant in the procurement stage: '*Do not look for the solution in the competition, but arrange something pre-competitively*' (public participant). Public participants feel that, if disintegrated from procurement, such pre-competitive market involvement can provide for innovative ideas and concepts to help deal with complex societal and political issues and enable for better decision-making.

The private participants stressed the fact that the noncommittal character of pre-competitive market involvement will not deliver hard results capable of being used to reduce internal complexity: '*We just mention the first things that cross our mind, because we are not responsible for our input*' (private participant). Therefore, they suggest to include specific financial and legal issues by integrating precompetitive involvement and procurement to commit private parties to their input. This prevents government from specifying the project in isolation and '*take all the risks by itself*' (private participant) through traditional procurement. Private parties felt that competition in procurement can '*result in sharpness, in both price and quality*' (private participant). Integrating the plan development stages and procurement can provide early insights into the ideas and proposals of private parties: '*Exactly this insight* [in proposed private solutions] *is extremely useful, even in projects with a less complex character*' (private participant). Although the on-going public-private interaction created through lifecycle integration will prolong procurement procedures and increase transaction costs, '*the market is willing to make transaction costs if they can earn back their investment*' by showcasing their creativity in addressing complexity. However, in cases of settings with high degrees of external complexity, the private parties stress that they do not want to become involved too early as they do not want to bear the political risks. Without political certainty and public-public agreement on a project, it is unclear whether precompetitive investments by the private parties will pay off. Public parties need to make choices, which the market cannot make for them. The private parties indicate that it is impossible to extract complexity from projects through pre-competitive market involvement: '*The world is ever-changing. After analysing the problem and understanding each other, you are never certain that your design is the right solution* […]. *The feedback is essential*' (private participant). Private parties are therefore cautious when it comes to early public-private interaction in policy-making and plan development because of transaction costs involved, but regard it as essential once public outlines have been set and procurement is performed in order to deal with complexity.

In conclusion to Proposition 1, the public and private participants agreed that complexity can be addressed and better controlled for by lifecycle integration. However, they both feel that internal complexity needs to be tackled through interaction in procurement and not at an earlier stage, through pre-competitive market involvement, as illustrated by this quote: '*addressing the complexity in procurement is a more logical choice than beforehand in the plan development stages*' (public participant). Participants felt that this will prevent unnecessary transaction costs, while offering the public and private parties opportunities to interact on concrete project issues in procurement that do not exist in traditional procurement. The public participants considered interaction to be always necessary for dealing with high external complexity. However, private parties suggested to keep a close watch on the transaction costs and the added value of the integration, and argued for focusing on interaction in procurement (i.e. through the competitive dialogue procurement procedure) instead in the precompetitive stages, increasing the chance that their private investments will pay off. Therefore, the proposition is not confirmed for settings with a high degree of external complexity: public-private interaction is considered necessary, especially in the subsequent stage of procurement since complexity cannot be effectively tackled beforehand, which excludes performing traditional procurement procedures.

4.2 Link B & C

> *Proposition 2: Integrated lifecycle contracts (such as Design-Build-Finance-Maintain contracts) are currently too rigid to account for the complexity of projects procured through competitive dialogue (= with extensive public-private interaction).*

Public participants acknowledge the rigidity of integrated DBFM contracts mentioned in the proposition: '*After procurement, a DBFM contract is as flexible as a lead door*' (public participant). However, they regard integrating the design, construction, and maintenance stages in a DBFM contract as logical for settings with high internal complexity, because stages can be adjusted to each other resulting in lifecycle optimizations. Including a financial component can be an extra

check on the adjustment of stages in the activities of contractors. The competitive dialogue procedure is used to fit to the specified and robust DBFM contracts: it is carried out by the public parties with a strong focus on controlling and specifying the outcome, as illustrated by this quote: '*If you take the Rijkswaterstaat line, nothing is allowed* […]. *In that case, everything is predefined in guidelines*' (public participant). The public participants acknowledge that the detailed and rigid interpretation of DBFM contracts and competitive dialogue limits the flexibility to deal with settings with high external complexity: '*you want the solution to be robust, because in the implementation of the DBFM contract you do not want to carry out changes to the contract*' (public participant). DBFM contracts and competitive dialogue are seen as a logical combination of integration initiatives, and especially the competitive dialogue procedure is regarded as fitting for dealing with external complexity. However, the public participants find it difficult to apply the procedure: '*You find that it is difficult to formulate a request for a* [dynamic] *complex project which is fully and immediately understood by the market parties*' (public participant). In the experience of public participants, the combination of these integration initiatives in practice does not provide sufficient opportunities for interaction and flexibility because of the cautious legal interpretation. Therefore, public participants stated that, as currently applied, the integration initiatives are not well suited to deal with setting with a high degree of external complexity.

The private party participants are certain that DBFM projects can accommodate internal complexity, if they are combined with a competitive dialogue procurement procedure, which enables to '*explore the boundaries of a project* […] *and research the rigidity of the contract*' (private participant). The private parties were aware of the added value of competitive dialogues for complexicated settings, as indicated by a private participant: '*It is one of the few opportunities within the European guidelines in which you have dialogue with each other. That is why it is a good procedure, regardless of the type of contract*'. However, they experience differences in the way DBFMs and competitive dialogues are handled by clients: '*Some are very rigid and others, which could even be part of the same organization but from a different department, are very flexible*' (private participant). In addition to the sometimes rigid public attitude, the financial institutions involved can also limit public-private interaction in DBFM and competitive dialogue. The financial institutions aim to limit risks and uncertainties by managing technical, legal and financial factors in setting up and controlling the execution of an integrated DBFM contract, which fits the systems management approach to dealing with internal complexity. In the view of the private contractors, financial institutions lack the entrepreneurial spirit to take risks and thereby negatively influence the opportunities for flexibility offered in competitive dialogues to deal with external complexity, as illustrated by this quote: '*We dare to take risks and we see chances. Banks need to see everything as well-founded and see risks everywhere. If we take risks, banks increase their charges*' (private participant). The private participants suggest to increase the adaptiveness by including alliance elements in the DBFM contracts, which will enable to share risks and responsibilities and jointly search for ways of dealing with complexity.

In conclusion, experience is gained with the combination investigated in the second proposition, because the competitive dialogue procedure is considered standard for procuring internally complex Dutch DBFM projects: '*If you opt for a DBFM contract* […] *you will always have to perform a competitive dialogue procurement procedure. That is the line within the Dutch road infrastructure agency*'. Public and private participants feel that the combination of DBFM and competitive dialogue integration initiatives contains interaction elements that are crucial for dealing with the combination of high internal and high external complexity. However, they experience that, as currently applied, combining competitive dialogues and DBFMs results in legally cautious conservative procedures and over-detailed contracts, which cannot handle high degrees of external complexity. The proposition is confirmed by the participants: the inherent focus on legal and financial certainties is considered to be particularly obstructive to utilizing opportunities to increase adaptiveness and address external complexity.

4.3 Link C & D

> *Proposition 3: The long period and detailed character of DBFM contracts limit the opportunities for asset management in a dynamic environment and limit plan-making for new or additional infrastructure.*

The public participants felt that a DBFM contract is suitable for optimizing maintenance in the asset management of internally complex infrastructure projects. '*In a contract with a longer contract period, market parties will perform effective asset management because of the financial incentives in the contract*' (public participant). Public participants felt that including a financial element in DBFM contracts can also increase the rigidity of asset management too much. The long period of DBFM contracts probably requires contracts to be changed during their term, which can have great financial consequences.[6] Public participants suggest to decrease the length of the contract to increase flexibility, '*because when you follow up a contract with a new one, you have the opportunity to make changes*' (public participant). However, this could decrease the strength of the incentive to adjust design, construction and maintenance activities to each other. A public participant mentioned the example of setting the wrong incentives in a DBFM contract, which is: '*not the fault of the contractor or the fault of the DBFM contract as such. That is something government is responsible for*'. Public participants note, however, that the increased rigidity by the longer term of the contract is not always experienced as negative: '*Perhaps that is something you want as a network manager* […], *it could help politicians stick to political agreements and provide insight into the financial consequences of earlier political choices*'. The public participants regard stimulating process flexibility by including partnering arrangements in DBFM contracts as a second option to deal with externally complex settings, which fits the strategy of interactive management. Such arrangements could provide more flexibility to manage the performance of the DBFM contracts at the interfaces in the infrastructure network.

The participating private experts see problems and opportunities in linking the stages of maintenance and operation. Private participants found that all involved parties focus on limiting uncertainties in the construction and maintenance stages, as expressed by a private participant: '*The public parties still have the impression that if they specify requirements at the nuts and bolts level, it will provide certainty, while this is the perfect recipe for 20 years of misery* […]. *The contractor involves a private technical advisor, who thinks the same way: certainties come first*'. Although the long maintenance component can give balance to DBFMs,[7] private participants expressed the difficulties for public parties in adjusting local DBFM projects to the asset management strategy of the national road infrastructure network. Especially defining maintenance and operation criteria in procurement is difficult as it leads to problems in the management of the interfaces between DBFM contracts at a higher road network level.[8] The private participants indicated that this also affects their relation with the financial institutions involved: '*they want to know everything upfront and are a much harder client to satisfy than the public parties are*' (private participant). The private participants felt that these attitudes do not suit settings with high degrees of external complexity and recognize two options for dealing with this. The first involves dealing with each other differently through a different reward system, because currently '*in DBFM contracts, it is always first penalties and then rewards*' (private participant). Private participants felt that '*cooperation is what you should reward*' (private participant).The second is to formulate requirements at two levels: traditional project requirements and requirements at a higher network level.[9] They acknowledged that formulating such requirements in externally complex settings in a resilient fashion is difficult. The requirements must function on the long-term and also enable to link forward to possible new planning cycles. The participants indicate that a step

[6] '*Financial institutions can threaten to pull the plug on a project. Rijkswaterstaat would never do this because of the political background it operates in'* (public participant).
[7] '*I think that the long periods of maintenance and operation included makes the contract balanced*' (private participant).
[8] '*Rijkswaterstaat must regard asset management from a more functional perspective*' (private participant).
[9] As also proposed in the concept of dynamic contracting, see Volker et al. (2011).

in this direction could be the introduction of DBFMO contracts, which internalize operation activities and enable its adjustment with other stages in the planning lifecycle.

In conclusion to Proposition 3, participants felt that the internal complexity of a project can be accommodated in DBFM contracts and that, through control of financial actors, quality in operations and maintenance improves. However, all participants agree the high costs of changing contracts can result in decreased political freedom because DBFM contracts lock up larger parts of the network for longer periods. In addition, the interfaces between DBFM contracts within the road network can cause difficulties in external complex settings. Because an asset management vision at the road network level is currently missing,[10] it is difficult to deal with interfaces between operation and maintenance stages and to connect to the dynamic stage of policymaking. Suggested solutions also include increasing flexibility through process agreements that reward cooperation. This way, as a public participant notes, interaction in the competitive dialogue '*can be continued into the construction and maintenance stages, which would make the approach similar to alliances*'.

4.4 Link A, B, C & D

> *Proposition 4: Lifecycle integration through market involvement increases the complexity of already complex infrastructure planning processes.*

The public participants noticed tendencies within the public organization to increase control over internal complexity in projects, which corresponds to a systems management approach that aims '*to go from external complex projects to simple projects as quickly as possible*' (public participant). Public parties felt that lifecycle integration through pre-competitive market involvement can help streamline procurement and limit its transaction costs by stimulating the government to '*think about which elements you want to interact about in procurement and on which elements you want competition*' (public participant). However, in order to better deal with high degrees of external complexity, public participants felt that a private partner should be contracted earlier, in order to jointly develop project plans[11], possibly in an alliance or partnering model, and saw possibilities for including such alliance elements in less rigid combinations of competitive dialogues and DBFM contracts. Public parties felt that lifecycle integration in later construction and operational stages can provide the necessary control to address internal complexity. However, alliances are not common practice so far in the Netherlands, which according to the public participants is caused by a political fear of commitment: '*Fear of choosing one partner, fear of a lack of competition*' (public participant). Politicians also do not prove to be reliable partners on the basis of whom a private partner can be selected early, as illustrated by an understatement of a public participant: '*Plan development is enormously politically driven, where a sudden mood change can determine the outcome*'.

Private participants found the lifecycle integration initiatives of competitive dialogues and DBFM contracts quite rigidly applied, which makes dealing with complexicated settings difficult. They suggest extending integration through increased systems management by increasing the spatial scope of contracts, which decreases the number of contracts and interfaces that can cause problems in asset management: '*If you increase the area and part of the network included in a DBFM […] you have fewer problems than with small DBFMs*' (private participant). This would integrate external factors in the system and therefore become a matter of internal complexity In line with this, private participants suggested specifying availability in contracts at higher, network levels. Such network level DBFM contracts also increase the systems management boundaries to include operation, into a DBFMO contract.. Besides systems management solutions, private participants

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[10] Such a road network management vision is currently in preparation as part of the implementation of the Rijkswaterstaat business plan: 'Ondernemingsplan 2015' (Rijkswaterstaat, 2011b).

[11] '*We will work together in a partnering or alliance model with the private party who turned out to be the best*' (public participant).

also recognised the added value of alliances and, as a private participant noted, '*alliance systems are reward systems*'. Another private participant relates to experiences with alliances in the rail infrastructure sector in which: '*Everyone was optimizing their performance, and we all became rich: government, business and citizens. It was a DBFM with a different payment system.*' However, private participants saw two main limitations to forging alliances. The first is that '*in politics the market is still approached by dictating what needs to happen*' (private participant). Secondly, financial institutions could obstruct alliances through their control-oriented and certainty-driven attitudes.

In conclusion to Proposition 4, participants felt that combining lifecycle integration initiatives does not necessarily lead to additional complexity, but can provide added value in dealing with internal complexity. However current combinations of lifecycle integration initiatives, and especially the way these are applied in Dutch practice, seem to be not suitable for complexicated settings with high external complexity. Competitive dialogues and DBFM contracts, for example, can effectively be combined to align public-private interaction and deal with internal complexity. In order to deal with external complexity, it is suggested to apply competitive dialogues less rigidly and introduce more flexibility by including alliance elements in the detailed and systems control-oriented DBFM contracts. This would ensure, as a public participant noted, that "*we would think about plans, construction, maintenance and operation and the market would do so as well* […]. *Problems that occur along the way would be tackled at once and in an integrated way*'. However, participants agreed that control-oriented attitudes can make it difficult to achieve this in complexicated settings.

5. Discussion: towards more integrated approaches for managing project complexity?

In this article we aimed to first gather public and private experiences with separate lifecycle integration initiatives in Dutch road infrastructure planning practice. Secondly we aimed to explore the potential of integrating these initiatives through the planning lifecycle, because at the moment, there is only limited experience with combining lifecycle integration initiatives. These limited experiences only pertain to combining a maximum of two initiatives at a time. We applied focus group discussions to gain deeper insight in the role of internal and external complexity, and the interrelations between these, by investigating settings that incorporate a high degree of internal and external complexity: so called '*complexicated*' projects. New approaches to project planning and management are especially needed in such settings, because in present-day planning both internal and external complexities and the interrelationships between these have to be dealt with more often in current dynamic society.

Many factors contribute to project complexity and these factors can diverge or contradict the interests of parties involved (Leijten et al., 2010), which can make it difficult to classify and bracket projects under a relatively simple typology. The distinction between internal and external complexity, simplifies a project management practice which is much more diverse. For example, combining integration initiatives can be difficult due to the diverse characters of the lifecycle stages (e.g. legal, financial or technical) throughout which the focus differs (i.e. a predominantly internal project level focus or a more external network level focus). Also certain attitudes can dominate over others in certain stages as numerous small differences between the market involvement instruments are to be recognized (see Rijkswaterstaat, 2011a). For example, the competitive dialogue is dominated by competition (Hoezen, 2012; Lenferink and Hoezen, 2011),which can cause strategic behaviour and conservative attitudes in procurement (Mu et al., 2010). Moreover, projects can evolve in character and focus over time, thereby changing in typology. For example, simple projects can evolve into context-complex and even complexicated ones, because of increased political pressure. However projects can also evolve from

complexicated through complicated to simple, by providing for clear project outlines and planning processes in decision-making.

Experiences with lifecycle integration illustrate that the initiatives can assist in addressing complexity by unlocking expertise and innovative ideas from the market parties about the project and the process to be followed, which can subsequently improve project management and decision-making Participants felt that rigidly applying the current lifecycle integration initiatives, such as the competitive dialogue and the DBFM contracts, can provide control to address internal complexity. In the focus group discussions, participants specifically stressed the role of involving financiers to increase control and to reduce risks, and suggested to internalize the operations in integrated DBFMO contracts to increase control over complex settings. Combining contemporary lifecycle integration initiatives in the Dutch planning process can, according to the participants in the focus group discussions, result in added value for dealing with internal complexity. However, from the perspective of the participants, it can be concluded that current lifecycle integration initiatives and their possible combinations cannot easily deal with settings of high external complexity. The detailed nature of the DBFM contract and the rigid application of the competitive dialogue, for example, makes the current approach more directly aimed at control, which is increased by the risk-limiting behaviour of involved financial institutions. As a result, the opportunities for stimulating flexibility and interaction between involved public and private parties, which are provided by the precompetitive involvement instruments and the competitive dialogue, are not seized. It appears to be necessary to find a more open approach to market involvement in lifecycle integration, which combines control with interaction in order to address external complexity through more continuous public-private interaction. For example, participants share the urge to combine precompetitive market involvement to generate flexible and adaptive solutions with more open interaction in the competitive dialogue procedures. However, market parties are not willing and able to bear the high political risks in early stages, and also the transaction costs involved in integrating the policy making and plan development stages, currently restrict a combination of such integration initiatives in practice.

An important point that emerges from this study is to investigate whether and how the approach of decomposition and compartmentalization of the planning process into stages, which is common in current project management and the starting point of this article, can be supplemented by more lifecycle-driven instruments. Two specific research directions were provided by the focus group participants. First alliances could provide continuous public-private interaction to address external complexity throughout the planning life cycle, because, as stated by Forrester (2009. p.327), "*while we often have (relatively) complete technical knowledge of the engineering processes we lack understanding of the social processes involved*". Such understanding is especially relevant because the external project context becomes more important in an increasingly complex network society (Castells, 2002) in which the boundaries between public and private are becoming blurred (Goldsmith, Eggers, 2004).The participants proposed to stimulate the inclusion of alliance elements in the current rigid DBFM contracts. Although alliances have been around for years in other parts of the world (see Love et al., 2010; Regan et al., 2011), application in the Netherlands has been scarce to date. Participants indicated that the strong financial focus on limiting uncertainties, the public organizations' fear of committing to a single private party and a political tendency to prescribe products, limit the application of alliances in Dutch planning practice.

A second research direction, provided by the focus group participants, is to further investigate the possible added value of setting-up cross-functional teams (see Denison et al., 1996). In such teams, public-private interaction can be performed from an integrated lifecycle perspective by including all relevant functions and public and private actors, without limiting competition, and involve them throughout the planning process. Potentially, cross functional teams could combine

Lindblom's concepts of incremental change (1959) and mutual partisan adjustment (1965) with learning loops (Forrester, 2009) to fit dynamic, interactive processes (Klijn, 2008; Verhees, 2013).They could especially help to improve the connection of infrastructure projects (and their operational contracts) with the more strategic asset management in the road network, and thereby link the lifecycle back to the initial policy making stage.

By exploring these two research directions of alliances and cross-functional teams further, the divide between traditional decomposed and directive project management and the dynamic challenges offered by complexity can be bridged by instruments that adopt a more integrated lifecycle perspective. These instruments can stimulate a continuous public-private interaction across the lifecycle that can increase the flexibility and adaptiveness, while simultaneously control can still be provided. This could help to manage both internal and external project complexity in current infrastructure planning.

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Appendix A: Composition of focus groups

Table A1: Focus group 1

Role	Organization	Public/private	Expertise
Public planning expert	Rijkswaterstaat: knowledge and advisory division	Public	Planning, evaluation
Project management expert	Rijkswaterstaat: implementation division	Public / private	Project management, Market structures
Technical expert	Rijkswaterstaat: implementation division	Public	Pre-competitive market involvement
Policy expert	Rijkswaterstaat: policy staff	Public	Policy
Contracting expert	Construction company	Private	Tender management
Legal expert	Rijkswaterstaat: knowledge and advisory division	Public	PPP: Contracting and contracts

Table A2: Focus group 2

Role	Organization	Public/private	Expertise
Financial expert	Construction company	Private	PPP investments
Contracting expert	Construction company	Private	Tender management
Public planning expert	Engineering consultancy	Private	Planning, evaluation
Project management expert	Project consultancy	Public/Private	Planning, project management
Contracting expert	Rijkswaterstaat: implementation division	Public	Contracting
Contract management expert	Rijkswaterstaat: implementation division	Public	Project contract management