Systems engineering in a public agency

An exploratory study of the value of systems engineering in the initiative phase of an urban planning project at municipal level in the Netherlands

M.Sc. thesis

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Eric van Rooijen

Introduction

My graduation project slightly differs from most graduation projects in the department of Construction Management & Engineering of the University of Twente. Instead of a full report, I have written a paper to submit to a journal on systems engineering, thus it is assumed that the reader of my paper has some basic knowledge about systems engingeering. I choose a paper since I wanted my research project to be published. By doing I hope that my graduation project will have some value for the scientific community and inspires others to continue the work on systems engineering in public agencies.

Besides the paper I have written a Dutch summary of my project, to make my work accessible for those who do not speak English and cannot visit my (Dutch) colloquium.

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Nederlandstalige samenvatting

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Aanleiding

Twee grote Nederlandse opdrachtgevers in de grond-, weg- en waterbouw (GWW) sector, Rijkswaterstaat en Prorail, hebben hun opdrachtnemers verplicht de ontwerpmethodiek 'systems engineering' te gebruiken, wanneer zij een project voor hen uitvoeren. Helaas is er weinig kennis over de waarde van systems engineering in de GWW-sector. In dit onderzoek is een evaluatie uitgevoerd om de meerwaarde van systems engineering in de initiatieffase van een wegenbouwproject op gemeentelijk niveau te onderzoeken. Het betreft een mobiliteitsprobleem van een bedrijventerrein in een Twentse gemeente met een sterke focus op bedrijvigheid. Het probleem bevindt zich nog in de planningsfase. Het onderzoek is geïnitieerd door het Innovatie Platform Twente, dat meent dat toepassing van systems engineering de Twente bouwsector een concurrentievoorsprong kan geven ten opzichte van omringende regio's. Uit het onderzoek volgen tevens een aantal aanbevelingen voor de bestudeerde gemeente.

Methode

Voor het onderzoek is een evaluatieve casestudy uitgevoerd; hierin zijn twee ontwerpprocessen vergeleken gedurende een tijdsinterval van vier maanden, van november 2007 tot en met februari 2008. Beide ontwerpprocessen hadden tot doel een haalbaarheidsstudie te schrijven waarin het probleem werd gedefinieerd en alternatieve oplossingen werden gegenereerd. Het eerste ontwerpproces werd uitgevoerd zoals de gemeente dat altijd doet (*business as usual*), het andere volgde de principes van systems engineering; een *soft systems* benadering is toegepast. Dit houdt in dat de probleemdefinitie als problematisch en pluralistisch wordt beschouwd. Elke maand werden de ontwerpprocessen geëvalueerd op een aantal criteria.

Waardebepaling

Om de meerwaarde van systems engineering bij de gemeentelijke overheid te bepalen, is er een perspectief gekozen waarop meerwaarde kan worden gebaseerd. Dit perspectief luidt dat een ontwerpproces meerwaarde biedt als het bijdraagt aan goed bestuur in het democratisch besluitvormingsproces. Goed bestuur is een actueel thema in de Nederlandse publieke discussie (denk aan de Code Tabaksblad) en kan op veel manieren geoperationaliseerd worden. Voor ons onderzoek wordt onder goed bestuur in het bijzonder verstaan dat zij open en transparant, responsief (reagerend op de vraag vanuit de samenleving) en met een consensus georiënteerde houding richting betrokkenen werkt. Een ontwerpproces dat op deze aspecten beter scoort, meerwaarde levert.

Gebaseerd op dit perspectief is 'goed bestuur' geoperationaliseerd voor ruimtelijk ontwikkelingsproblemen. Dit heeft geleid tot zes evaluatiecriteria:

1. Probleemrijkheid. Onderzocht wordt welke facetten het centrale probleem heeft en welke aspecten hiermee samenhangen;
2. Probleemrepresentatie. Het aantal representaties (percepties van betrokkenen) dat ten grondslag ligt aan het probleem wordt geïdentificeerd;
3. Aantal betrokkenen. De betrokkenen met een belang bij het probleem worden geïdentificeerd;
4. Moment van betrokkenheid. Er wordt bepaald of betrokkenen voor of na het vaststellen van de probleemdefinitie worden betrokken;
5. Type betrokkenheid. Of betrokkenen interactief of niet-interactief worden betrokken in het proces, d.w.z. de mate waarin macht aan de betrokkenen wordt toegekend;
6. Acceptatie. De mate waarin betrokkenen de probleemstelling accepteren wordt bepaald via een oplopende trap: opgelegd besluit, compromis, consensus, consent of commitment.

Resultaten & analyse

Het 'business as usual' proces kende vele vertragingen; nadat na jarenlange discussie de gemeenteraad in november 2006 een bestuursopdracht had verstrekt, duurde het tot oktober 2007 voordat externe bureaus werden verzocht zich in te schrijven op de opdracht een haalbaarheidsstudie uit te voeren.

Eind februari 2008 stond de ambtelijke organisatie voor een keuzemoment: of het oorspronkelijke onderzoek gedeeltelijk stopzetten opdat de oorspronkelijke deadline zou worden gehaald, of een volledig onderzoek uitvoeren maar daarbij enige maanden vertraging accepteren.

Het team dat het systems engineering proces uitvoerde vergaarde in november 2007 alle informatie, organiseerde in januari 2008 een systems engineering workshop en verifieerde die resultaten door interviews met betrokkenen tot eind februari 2008.

De resultaten van het onderzoek kort samengevat zijn dat:

1. Het systems engineering proces de rijkheid van het probleem beter onderkent; het vergroot de probleemruimte en werkt responsief;
2. Het systems engineering proces meerdere probleemrepresentaties in haar ontwerpproces meeneemt, in tegenstelling tot het business-as-usual proces. Dit leidt tot een meer responsief, open en transparant proces,;
3. Beide processen dezelfde betrokkenen identificeren;
4. Het systems engineering proces betrokkenen betrekt voordat de probleemdefinitie is vastgesteld, in tegenstelling tot 'business as usual', dit vergroot de participatie en leidt tot consensusoriëntatie;
5. Het systems engineering proces in tegenstelling tot het business as usual process wel interactief werkt, wat leidt tot vergrote participatie van betrokkenen in het planningsproces (coproductie van beleid);
6. Het systems engineering proces leidt tot een hogere acceptatie van de probleemdefinitie bij de betrokken burgers.

De rode draad in deze bevindingen is dat system engineering leidt tot een participatieproces van betrokkenen met sterke focus op de inhoud waarbij wordt omgegaan met de complexiteit, terwijl het gemeentelijke proces de complexiteit probeert te reduceren en betrokkenen alleen via de verplichte procedures betrekt. Dit leidt tot discussies, waarbij de inhoud soms naar de achtergrond lijkt te verdwijnen.

Conclusie & aanbevelingen

De meerwaarde van systems engineering ligt in het erkennen van en het omgaan met de complexiteit van het mobiliteitsprobleem. Dit is transparant gemaakt door verschillende probleemrepresentaties expliciet te documenteren nadat ze waren geverifieerd bij relevante betrokkenen. Het heeft tot een effectief en efficiënt probleemoplossingproces geleid door vroeger dan gebruikelijke betrokkenheid van belanghebbenden. Er is meerwaarde geleverd door het systems engineering proces, omdat de beleidscyclus (het proces om tot beleid te komen) verbetert doordat er meer open en transparant, meer responsief en consensus georiënteerd wordt gewerkt. Dit vergroot tevens de legitimiteit van het democratisch besluitvormingsproces.

Op basis van dit onderzoek zijn tevens een aantal aanbevelingen geformuleerd voor zowel de gemeente waar dit onderzoek is uitgevoerd als voor verder onderzoek:

- Een systems engineering workshop met relevante ambtenaren is een waardevolle start van het ontwerpproces: belangrijke betrokkenen en hun probleemrepresentatie worden snel geïdentificeerd. Zij kunnen zo beter gemanaged worden;
- Politieke partijen bleken een dominante rol te spelen in de discussie, maar werden in het ontwerpproces op afstand gehouden. In de toekomst zouden zij expliciet als betrokkene worden geïdentificeerd.
- Verder onderzoek naar de meerwaarde van systems engineering kan plaatsvinden door een ander perspectief te kiezen waarop de meerwaarde van systems engineering wordt bepaald (bv. projectmanagement), of andere projectfasen te vergelijken (bv. definitiefase).
- Toekomstige projecten dienen meer tijd uit te trekken alle betrokkenen te betrekken in het planproces; door tijdsgebrek is dit in dit project niet gebeurd.

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Paper

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Abstract

In the Dutch civil engineering industry, systems engineering has recently been introduced, but little is known about its value. This paper presents an evaluative holistic single-case study to determine the value of systems engineering in the initiative phase of a civil engineering project led by a Dutch municipal government. To determine the value of systems engineering, we evaluated and compared two approaches to one and the same project carried out by different teams. The first team carried out the project as 'business as usual'. The other team conducted the same project with systems engineering. We evaluated both project approaches with six evaluation criteria based on a perspective of good governance. We conclude that systems engineering creates added value in two fields: it acknowledges the complexity of the problem and increases early participation of relevant stakeholders, leading to policy co-production.

Keywords: civil engineering, governance, public sector, systems engineering, urban planning, value.

Introduction

In the Netherlands, systems engineering has recently been introduced in the civil engineering industry; its use is even obliged in the design process for new and maintenance projects by two major governmental agencies (Rijkswaterstaat & Prorail, 2007), with a combined budget for 2008 of € 7.13 billion for maintenance and new infrastructural projects (Ministry of Transport, Public Works and Water Management, 2007). It is expected that systems engineering will increase transparency and deliver better project quality. For these reasons, the Innovation Platform Twente (IPT) wants to promote the knowledge about systems engineering in the region of Twente, in the east of the Netherlands, so that local companies can gain a competitive advantage in designing. The IPT therefore initiated this research project.

Unfortunately, the benefits of systems engineering are not completely clear. Honour (2004) shows that the value of systems engineering is intuitively understood, but that the perceived value is not based on a quantified measurement of value to the project. Large quantitative studies started recently, but their conclusions are not yet available (Frederick & Sauser, 2007).

However, it is interesting to study how systems engineering can contribute to current practice in the Dutch civil engineering industry, or in other words, what the value is of systems engineering in a Dutch context. To determine the value of systems engineering, we evaluated and compared two approaches to one and the same project carried out by different teams. The first team carried out the project as 'business as usual', using their traditional or usual routine. The other team conducted the same project using systems engineering.

The project deals with solving an accessibility problem of an industrial zone in a municipality with two towns and above-average business dynamics in the east of the Netherlands. The project can thus be characterized as a civil engineering project. It is in the initiative phase. In the initiative phase of civil engineering projects planning issues consume much time, therefore giving it the character of an urban planning problem.

We have stated the objectives of, as well as in, our research project. The objective in our research project is to gain insight into the qualitative value of systems engineering, by comparing a systems engineering process to a business-as-usual process in one and the same project, a civil engineering project at municipal level in its initiative phase. The objective of our research project is to gain insight into the value of systems engineering for municipalities in the initiative phase of civil engineering projects.

The scientific relevance of our research project is the first exploration of the value of systems engineering for civil engineering projects in the initiative phase at the lowest Dutch governmental level, the municipality. Although systems engineering is expected to increase transparency and project quality, it remains important to explore whether systems engineering delivers that, since a significant budget is spent on projects designed with systems engineering in future. Herein lies the societal relevance of our research project.

Based on these objectives, our research method is elaborated in the next section.

Method

The value of systems engineering is determined by evaluating the two design processes. Based on Weiss (1972) an evaluative framework is set up. Weiss (1972) proposes four steps for evaluation. First program goals have to be set, which describe the intended consequences of systems engineering. In our research, this is called the perspective to base value upon. As Weiss (1972) shows, indicators then have to be developed to measure the extent to which the intended consequences are achieved. In our research project, these indicators are called the evaluation criteria. The third step is the data collection; data was collected in a holistic single-case study using multiple data collection methods (triangulation) as will be elaborated below. Fourth and last is an analysis of the data.

As a research strategy, a case study was chosen. Yin (1984) defines a case study as: "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*". A case study is an appropriate research strategy, since our research object, the design process, is studied in depth and is interwoven with its context. Qualitative data was gained, according to the research objective. These characteristics of our research project are congruent with the characteristics of a case study (Yin, 1984).

Yin (1984) discerns four types of case study designs. For our research project a holistic single-case design ("type 1") was selected, since there is just one case, the accessibility problem in the municipality, and one unit of analysis, the design process used. Yin (1984) sketches the situations in which a holistic single-case is appropriate. He states: *"as an exploratory device or (…) a pilot case that is the first of a multiple-case study"*. Our research project is a pilot since it is the first project using systems engineering in the municipality, as well as one of the first studies exploring the value of systems engineering in the initiative phase of Dutch civil engineering projects at the lowest governmental level.

In our research project, two design processes were conducted in parallel for the same project.
Both design processes took place in the initiative phase of project management as defined by Groote (2000). Usually the initiative phase does not have a concrete starting point, but at the end of the initiative phase, project goal and justification have to be clear (Kor & Wijnen, 2000). Part of the initiative phase is the feasibility study, which starts after the initiative is officially taken. In a feasibility study, a problem-solving process is executed, which is a type of design process (Roozenburg & Eekels, 1995). Both the business-as-usual and the systems engineering process are therefore considered design processes.

In the business-as-usual process, a feasibility study was conducted using the usual routine of the municipality. In parallel, a feasibility study using systems engineering was conducted. The team using systems engineering considered the problem to be a 'real world problem' (Rosenhead, 1989; Smith, 1989; Fischer, 1995) which was solved using the assumptions underlying the 'soft' approach as Checkland (1981) describes. Contrary to the 'hard' approach, the problem definition is seen as problematic and pluralistic; the problem definition is multifaceted since different stakeholders frame the issues being addressed in a problem-solving process differently (Checkland, 1981; Pidd, 1996). This approach is in line with current planning practices (Rosenhead, 1989; Van Lente & Schot, 2003). Both studies take the accessibility problem, as decided on in November 2006 by the city council, as a starting point.

The time to evaluate the design processes was limited, so an interval of study was chosen. The interval started at 1 November 2007 and ended on 29 February 2008. After each month in the interval of study, the design processes were evaluated. A baseline was created on the last day of the month. The baseline was created 'on site', while working within the municipal organization. In this way, both design processes could be followed and studied in detail and new developments could be recorded directly. All relevant policy documents were studied; other strategies to gather data for the evaluation were interviews with relevant stakeholders and the responsible civil servants within the municipal organization. These strategies for data collection are recognized as well by Weiss (1972) for evaluation research and Yin (1984) for case-studies. In consequence, the dynamics of the design processes were recorded and developments of the design processes could be studied. As Van de Ven & Huber (1990) call it, the black box between input and output is opened. The history of both design processes was evaluated as well by making a baseline beforehand, on 31 October 2007, to inventory the state of affairs, since the project as a whole did not have a concrete starting point. The data is presented in an overall table as suggested by Miles and Huberman (1994). They suggest that data should be presented in an overall table, since it is important to present information in an immediately accessible and compact form, so that developments in each process are comprehensible and conclusions are justifiable. Such presentation allowed us to easily analyse the data and draw conclusions.

Evaluating value

To determine the value of systems engineering, a perspective is needed on which to base the concept of 'value', because different perspective or viewpoints define value differently. So the perspective has to be clear. Based on Weiss (1972), a perspective is elaborated and explained, which describes the intended consequences of systems engineering. Then indicators are developed to measure the extent of which the intended consequences are achieved: the evaluation criteria.

Perspective

Because systems engineering is introduced in a public agency, it is assumed in our research that value is added when a systems engineering improves the processes in that public agency. Concretely it is done when a design process increases good governance in the democratic decision-making process of the public agency. Therefore good governance is shortly introduced.

Introduction 'good governance'

Many definitions of governance exist and many ways to look at governance (Hill & Hupe, 2002; Pierre & Peters, 2000; Voss, 2007). Colebatch (2002) discern two perspectives on governance: a vertical one referring to the process of authorized decision-making and a horizontal perspective referring to the process of structured interaction, but acknowledges that most usages fall somewhere in between. For this research, the World Bank definition is chosen since it started the discussion in the early 1990s (Van Montfort, 2004; Pierre & Peters, 2000), its definition endorses the vertical perspective and is applicable to our research. The World Bank (2008) defines governance as *"the traditions and institutions by which authority in a country is exercised for the common good. This includes (i) the process by which those in authority are selected, monitored and replaced, (ii) the capacity of the government to effectively manage its resources and implement sound policies, and (iii) the respect of citizens and the state for the institutions that govern economic and social interactions among them"*. Pierre & Peters (2000) show that the central argument for the debate about good governance is that the government is no longer the only or dominant actor in the fields of economic development and public policy, but still is expected to ensure the common public interest in these fields: Andeweg & Irwin (2005) and Hill & Hupe (2002) endorse this viewpoint. This reason corresponds to the second and third elements of the Wold Bank's (2008) definition.

In the Netherlands, the governance discussion started at the end of the 1990s (Andeweg & Irwin, 2005; Bossert, 2003; Van Monfort, 2004). The reason for the Dutch debate about good governance was the shift in the relations between government, citizens, civil society organisations and the private sector as a result of social and socio-economic developments. Particularly trends like individualisation, increasing international law and legislation and internationalization of money, goods and persons flows drove the tendency to fundamentally rethink the relations between government, citizens, civil society organisations and businesses (Van Montfort, 2004; Pierre & Peters, 2000; Voss, 2007). Bossert

(2003) argues that municipal governments face these problems as well. As a result, many ‘codes of good governance’ were introduced in the first half of the 2000s in the Netherlands (Netherlands Court of Audit, 2006; Peij & Duijzer, 2007). The codes should address the renewed relationship between government and external stakeholders (Netherlands Court of Audit, 2006).

‘Good governance’ made operational

As a result of these discussions, good governance was made operational for the Dutch public context with four ‘dimensions’ by Van Monfort (2004). They are based on earlier work of the Dutch Scientific Council for Government Policy (2001) and the UN (2002). The four dimensions are (Van Montfort, 2004):

1. Democratic principles: good governance has its basis in the parliamentary democracy and involves interested parties in policy-making, defines success criteria, is accountable for its responsibilities, works open and transparent;
2. Rule of law: good governance follows the law, is legitimate and practices the common principles of proper administration;
3. Common perceptions and values: good governance invests in consensus between stakeholders about values, and short and long-term objectives. It works in a consensus-oriented manner.
4. Execution: good governance works responsively (this means contiguous to a social question or a social problem), innovatively, effectively and efficiently, according to quality criteria and has competence to act.

Rationale for this perspective

This perspective was chosen for three reasons.

The first reason is that the feasibility study is the first phase of a larger project and a basis for a policy-making process to determine future directions of planning and traffic public policy. It takes place in a public organization: the municipal organization and the democratically elected city council. Public policy is made to solve or resolve policy problems (Fischer, 1995). Policy problems are social constructs with two characteristics (Van de Graaf & Hoppe, 1996); (1) a gap exists between a (desired) standard and the existing situation; (2) neither the standard, nor the situation – and thus the gap – are objective facts; they are subjected to value judgments. Since fact and values can differ, a good policy-making process should address this fact-value dichotomy (Fischer, 1995), leading to a better policy-making process (and outcome) by a consensus oriented process Fischer calls ‘political deliberation’. This argument is congruent with the third dimension of good governance.

The second reason is that the municipal government is a public organization, in which the city council is the highest power holder (Van Vugt, 1984). Van Vugt (1984) recognizes the risk of suggestibility in local politics. In our municipality this is a serious risk, since many members of the city council have influential positions in business; the accessibility problem influences their businesses. The principles of good governance, especially transparency, encourages ethical behaviour (Van Montfort, 2004; Lambsdorff, 2007; Netherlands Court of Audit, 2006) thereby increasing the legitimacy of the power, the authority, of the democratically elected local government (Beetham, 1991). Integrity is increased with dimensions one and two of good governance.

The last rationale for this perspective is the wish of the city council to stimulate citizen participation (CDA, PvdA, Gemeentebelang, 2006). This is in line with current Dutch planning practice, as Salet & Faludi (2000) show, and implies a shift from a vertical perspective on governance to a more horizontal one (Colebatch, 2002). Webler, Tuler & Krueger (2001) discern five discourses that they call ‘prerequisites’ for a good public participation process. These discourses are congruent with the dimensions of good governance; thus good governance is a prerequisite for a good public participation process.

It must be noted that the dimensions are closely related; it is not a one-dimensional term, it is a combination of the various aspects of the four dimensions (Van Montfort, 2004; UN, 2002).

Evaluation criteria

Following the perspective we will apply good governance to a civil engineering project in its initiative phase at municipal government by making the four dimensions of good governance operational based on relevant literature. In its adoption, the focus will be on the following characteristics of good governance: increased openness and transparency, increased consensus orientation and increased responsiveness. This has led to six evaluation criteria to determine the value of a design process for an urban planning problem. Due to time constraints, the evaluation criteria just focus on problem definition and stakeholder involvement. The criteria are defined as separately and independently as possible and as much as possible made operational to be useful for measuring process performance. However, they partially overlap and cannot be considered independently from each orther. The six evaluation criteria discerned are: problem richness, problem representation, number of stakeholders, moment and type of stakeholder involvement and acceptance by stakeholders. The next section discusses why we think these criteria are appropriate to evaluate the design process from a governance perspective.

Problem richness

Problem richness evaluates the boundaries of the problem, thus to what extent the complexity of the problem is coped with. It is widely recognized that complexity in civil engineering should be dealt with (Bertelsen, 2003; Geldof, 2005; Jacobson, 2001). Daft & Lengel (1983) argue that *"organizational success is based on the organization's ability to process information of appropriate richness to reduce uncertainty and clarify ambiguity"*. When more complexity is included in the problem definition, more relevant issues are included and dealt with and the richer the problem is defined. This can include subjective factors as well (Smith, 1989; Fischer, 1995). For our research the problem definition includes the 'central problem' as experienced and the issues concerning the central problem are called 'aspects'. In more detail this is done by defining and clarifying the boundaries of the problem, a type of mediating technique to cope with problem complexity (Volkema, 1983).

From this point of view, the richer the problem is defined, the more relevant issues are included in the problem-solving process, thus the wider the boundaries of the problem, the more value is added by a design process. This is coherent with the perspective, since broadening the problem scope will introduce extra relevant issues as experienced by citizens (responsiveness, dimension four) into the problem definition. Transparency (dimension one) is increased as well, since all relevant issues concerning the problem are made explicit.

Problem representation

Planning problems affect many citizens (Arnstein, 1969; Geldof, 2005). All citizens involved or affected will experience a different problem, since problems are considered partially subjective (Smith, 1989; Fischer, 1995). In consequence, problem representations are neither complete, nor objective (Visser, 2006). A good problem definition and problem-solving process should include these representations and address them if possible, since *"a problem that is defined with incorrect presumptions concerning needs and opportunities can result in significant losses as well as problem solving effectiveness"* (Volkema, 1983). Whelton & Ballard (2002) add the risk of oversimplification of the problem definition which can lead to premature solutions. Both Volkema's (1983) and Whelton & Ballard's (2002) situations are undesirable in the light of our perspective: it decreases the effectiveness and efficiency of the outcomes of the design process (fourth dimension) as well as not stimulating common perceptions (dimension three).

Value is added when a design process incorporates the various problem representations in the problem definition and the process to come thereto. As more representations are identified and dealt with, more insight is gained into the problem, which increases transparency, participation and creates chances for responsiveness and consensus. This contributes to good governance.

Number of stakeholders

Literature stresses the importance of stakeholder involvement in the concept phase of projects (Arnstein, 1969; Burby, 2003; Geldof, 2005). It argues that citizens are stakeholders who possess a certain power that should be considered before decisions are made.

Value is added when all citizens can participate in the process, thus when the number of stakeholders is high, since all citizens must be able to participate for reasons of political equity (Dahl, 1998). Adjusted for the Dutch situation of interactive planning, *relevant* stakeholders can participate, that are stakeholders who have a stake in the plan (Pröpper & Steenbeek, 1998; Salet & Faludi, 2000), although it is recognized that it is hard to determine all relevant stakeholders (Berveling, 1998). The civil servants in the municipal organization are counted as one stakeholder in totality; they – as a whole – represent the 'public interest' and officially have one opinion, i.e. what the established policy is. When all relevant stakeholders participate, the government increases legitimacy (dimension two), works in a consensus-oriented manner (dimension three) and responsively (dimension four).

Moment of stakeholder involvement

The moment of involvement is important for gaining the support of stakeholders (Driessen, 1997; Geldof, 2005). In most projects stakeholders are involved when a plan is completed or when legal procedures oblige the planner to involve the stakeholder (Burby, 2003; Geldof, 2005), but research shows that early involvement, leading to policy co-production, improves process performances (Driessen, 1997; Wolsink, 2003).

Value is added when a design process involves the stakeholders before a final decision about the problem definition is made. In this way problem representations of various stakeholders can be included in the problem definition, increasing the chance their problems will be solved (Brody, Godschalk & Burby, 2003; Whelton & Ballard, 2002). This is measured by identifying which stakeholders experience a problem and if they are involved early in the process. This creates the possibility for policy co-production. (If it really takes place is measured in the next criterion). This increased participation (dimension one) increases the responsiveness of the policy-making process (dimension four) and is line with the perspective.

Type of stakeholder involvement

In the early 1970s planning science faced crises (Rittel & Webber, 1973; Rosenhead, 1989);
Dutch planning practise did as well (Van Lente & Schot, 2003). This led to new planning concepts (De Graaf, 2005). Salet & Faludi (2000) recognize that for the field of spatial planning in the Netherlands, *"the interactive approach seems to have become the most accepted in practice during the 1980s and 1990s"*. The interactive approach introduced citizen participation in the planning process. The degree of citizens' influence can be measured against the 'ladder of interaction', as introduced by Pröpper & Steenbeek (1998). The four highest degrees of influence can be characterized as 'interactive', the lowest three cannot. The evaluation criterion is the score of a design process on the ladder of interaction, more precisely, whether the style is interactive or not.

Value is added when a design process practices an interactive style of policy making as defined by Pröpper & Steenbeek (1998). Again, this is coherent with our perspective since more value is assigned to the design process that increases participation in the democratic process. This is in accordance with first dimension of Van Montfort (2004).

Acceptance by stakeholders

Good governance works in a consensus-oriented manner, as Van Montfort (2004) shows in dimension three. During the 1970s it became difficult to reach consensus about planning problems (Rittel & Webber, 1973; Van Lente & Schot, 2003). De Graaf (2005) shows that this search for consensus was introduced in planning theories during the 1990s. This should lead to *"to new and collectively supported solutions that surpass the direct interests of the individual stakeholders"* (De Graaf, 2005). Wolsink (2003) states that consensus orientation is a characteristic of Dutch planning practice. Jongebreur & Floris (2008) discern five increasing types of acceptation: imposed decision, compromise, consensus, consent and commitment.
High acceptation of policy is part of good governance (dimension three) and thus valuable according to our perspective. Berveling (1998) notices that acceptance cannot be viewed without the number of stakeholders involved; the more stakeholders, the more difficult it is to reach consensus.

Value is added when a design process reaches maximum acceptance over the plan. High acceptance is a sign for satisfaction with a plan, and thus a good result of the policy-making and decision-making process. This is in line with the third dimension of good governance.

Results

An outline of both the business-as-usual process and the systems engineering process is given, followed by a table with the results of the evaluation, as proposed by Miles & Huberman (1994). The table provides a baseline of the scores of both design processes at the end of each month during the interval of study. When the table is read horizontally a design process' development on a specific evaluation criterion can be understood. Reading the table vertically provides insight into the number of activities and developments in a design process during a month during the interval of study. The history of both processes was captured on 31 October 2007, the last day before the interval of study started. It reproduces the state-of-affairs on that day; previous dynamics are not taken into account. Both processes took the decision of the city council (November 2006) as a starting point: that decision states that the industrial zone is facing an accessibility problem and focuses on the question whether (i) do nothing, (ii) upgrade existing infrastructure, (iii) a western ring road or (iv) a north-eastern ring road will solve that accessibility problem.

The business-as-usual process developed as follows: in the initial idea the city council decided about the scope of the accessibility problem (November 2006), and the responsible civil servant of the Department of Spatial Planning was commissioned to select an external engineering company to conduct a feasibility study and to facilitate that study. When the study was finished, it was to be approved at several levels within the municipal organization before sending it to the city council and thus would have been made public in November 2007; all according to the original time table. However, many delays occurred; the selection of an external engineering company only started in October 2007. Then new delays occurred in the selection process. At the end of February 2008 the municipal organization faced a difficult choice: either the study had to be partially cancelled to finish in time, or the study would be finished with considerable delays. The actual choice was made after our interval of study. In general it can be stated that little happened during our interval of study as the process was delayed considerably.

The team that conducted the design process according to systems engineering based their way of working on the California Department of Transportation (2007) handbook for ITS. They as well took the city council's 2006 decision as a starting point but due to their *soft systems* approach, gradually adjusted the scope of the project, due to input from local stakeholders.

In September and October 2007 their design process was designed. In November 2007 all relevant information was collected and in December 2007 the team started with organizing a systems engineering workshop which took place at the beginning of January 2008. Results from the workshop were verified during interviews with the all relevant stakeholders in February 2008.

Results

	Dimension	Process	History	November	December	January	February
Problem richness	Number of central problems, number of aspects concerning the problem	BAU	1 central problem, 6 aspects	-	-	-	?
		SE	-	1 central problem	2 central problems	3 central problems, 14 aspects	3 central problems, 15 aspects
Problem representation	Number of problem representations included	BAU	2 representations included	-	-	-	?
		SE	-	1 representation included	-	2 representations included	5 representations included
Number of stakeholders	Number of stakeholders involved	BAU	2	-	-	-	-
		SE	-	-	1	-	4
Moment of stakeholder involvement	Before / after problem definition is definitive	BAU	Relevant civil servants, city council as a whole	-	-	-	-
		SE	-	Relevant civil servants	-	-	External stakeholders that influence the political agenda; individual political parties
Type of stakeholder involvement	Interactive / non interactive	BAU	Non-interactive	-	-	-	-
		SE	Non-interactive	-	-	-	Interactive
Acceptance by stakeholders	Score on ladder of acceptance	BAU	Compromise	-	-	-	?
		SE	-	-	-	-	Compromise

Legend

BAU = Business-as-usual design process
SE = Systems engineering design process
- = No change in score
? = Internal discussion whether to delay the project or to cancel some parts of the intended study.

Analysis

As mentioned before, the two design processes were evaluated based on six evaluation criteria. At the end of each month the current state of affairs was evaluated and written down in the results table. Our analysis is divided in two parts; a horizontal analysis of the table discussing the dynamics of the design processes per evaluation criterion, and a vertical one discussing the developments per month during the interval of study.

Horizontal analysis

In this analysis, all six evaluation criteria are discussed and their value is determined in accordance with the perspective.

Problem richness

In the business-as-usual process, due to delays, the problem richness was a point of discussion at the end of February since it was a serious option to cancel the feasibility study partially. It was a possibility that only a computer simulation of future traffic flows and its influence on future accessibility should be conducted. Other aspects such as finances would be left out of the problem, so the study would not be delayed. When partially cancelled, problem richness would be decreased, when delays would be accepted, problem richness would not change.

In the systems engineering process, the problem was continuously enriched. As stated above, the starting point was the accessibility problem, but soon it turned out to be a planning problem as well; the industrial zone was not allowed to expand on its current location and the reason for many stakeholders to strive for a ring road was that it connected the old and new zones quickly. Later on it turned out to be a perceived problem as well; citizens experienced decreased accessibility and complained about it, although actual counting of traffic showed that the road capacity was not exceeded.

It can be seen that the systems engineering process added issues in the scope of the project and thereby increased complexity, whereas the business-as-usual process discussed the possibility to decrease the complexity of the project, using a smaller scope. Transparency was increased since all relevant issues were acknowledged officially, and the possibility of responding to the societal needs was introduced as aspects concerning the problem. Therefore, value is added for the systems engineering approach.

Problem representation

The business as usual process – at the end of October – included two representations, that of the municipal organization and the city council. When partially cancelled, the process would only include one representation. The systems engineering process included several representations throughout the interval of study: those of stakeholders who experienced a problem and put it on the political agenda.

In terms of value, the systems engineering process adds value by inclusion of various representations, increasing responsiveness (dimension four) and participation (dimension one).

Number of stakeholders

Both design processes identified the same stakeholders; and both did not invite all stakeholders in the problem definition process. The business-as-usual process intended to involve all stakeholders when the feasibility study started (as Dutch legislation prescribes) whereas the systems engineering process only involved those stakeholders with a publicly expressed strong opinion about the accessibility problem due to time constraints. In this case, the systems engineering process did not add value.

Moment of stakeholder involvement

In the business-as-usual process no external stakeholders were invited; in the systems engineering process they were, because the systems engineering workshop showed that external stakeholders held strong opinions about the project. Results from the workshop were verified and new issues could be brought to the agenda before a definitive problem definition was given.

According to our perspective, value was added by the systems engineering process as a result of this early involvement.

Type of stakeholder involvement

The business-as-usual process worked consultatively, whereas the systems engineering process works participative.

Thus according to Pröpper & Steenbeek (1998), the systems engineering process is interactive, and the business-as-usual process not. Due to its interactive style, the systems engineering process adds value.

However, the scores on the "ladder of interaction" differ by just one step on a ladder of seven (business as usual: third step, systems engineering: fourth step). In absolute terms the difference is thus relatively small; consultatively is just below the 'interactive' line, participative just above. So it is disputable *how much* value is added by the systems engineering process.

Acceptance by stakeholders

At the beginning of the interval of study, the problem definition in the business-as-usual process was a compromise between the political parties in the city council, laid down in an official decision. At the end of the interval of study, the municipal organization was in doubt whether to cancel the original feasibility study partially. In that case, an imposed decision was made. In the systems engineering process, the opposite happened: the result was a compromise between stakeholders. Even more stakeholders were involved in that compromise than in the business-as-usual process. Therefore, the systems engineering process adds value according to the perspective (consensus-oriented, dimension three; participation, dimension one)

A disadvantage of the systems engineering process is that its problem definition was more vaguely defined. All stakeholders could compromise, since each stakeholder could find their own perception into the problem definition. Real consensus was not reached in the process, although that is more favourable according to our perspective.

The theme throughout this horizontal analysis is that the systems engineering process combined, as a result of verification techniques, the participation process with the contents of that process, whereas the business-as-usual process, due to its long history, seemed to get bogged down in its legislative procedures and internal discussions thereby losing the real contents of the problem and all related aspects. Value is delivered by the systems engineering process to the citizens of the municipality; by recognizing the complexity – or the non-existence of the problem – of the accessibility problem, better, and more effective and efficient, policy can be produced to resolve the problem.

Vertical analysis

For the business-as-usual process, the baseline on 31 October presents the state of affairs after years of discussion. It is followed by a period of inactivity between November 2007 and January 2008. This is due to Christmas holidays and high work load; priorities were established to other projects. In February 2008 the municipal organization faced the choice of delays or partially cancel the study; evaluation scores changed to a question mark, since the outcome was not clear at the end of our interval of study.

The results show that the systems engineering process developed relatively slowly; in the last month of the interval of study all evaluation criteria changed. This was caused by a slow start of the process due to lack of motivation in combination with high work pressure in the municipal organization to cooperate with this new design process. Therefore the systems engineering workshop had to be postponed, which led to delays for the verification interviews.

Conclusion

The systems engineering process recognized and acknowledged the complexity of the accessibility problem and made it transparent by documenting it after verification with relevant stakeholders. This led to effective and efficient policy co-production earlier in the initiative phase of project management than usually happens in Dutch planning practice at municipal level. Acceptance for the outcome of the process grew. According to the four dimensions of good governance, the systems engineering process added value with this routine. Unfortunately, due to time constraints not all stakeholders could be involved in this process, leading to political inequality of citizens. This is a point of attention for future work. Value is added for the citizens of the municipality; it they benefit from the fact that the dimensions of good governance are better served which will lead to better policy and an increased legitimacy of the democratic decision-making process.

Discussion

For the municipal organization, the following recommendations can be made. First, a systems engineering workshop with civil servants to inventory the various problem representations can be a quick and valuable means of starting a design process of the feasibility study. Relevant stakeholders can be identified and managed more effectively.

Second, in this project politicians had a dominant role; this fact influenced the objective character of the feasibility study. In the business-as-usual process they played a major role with ideologically driven arguments, which did not seem to be in accordance with the factuality. In the systems engineering process politicians were confronted with the factuality and this confrontation leaded to better understanding of the problem and increased problem richness, since politicians could express their concerns explicitly. For future situations it is advised to involve individual politicians earlier in the process, because of their influential role in the decision-making process. In this way they can be better managed as well.

Last point of discussion is de outcome of the studies. The business-as-usual process had low problem richness and a predetermined set of alternative solutions, all of the same type. Since the systems engineering process explored the problem with a more open attitude, the problem could be defined much richer with increased the solution space to three different types of alternative solutions. However, it turned out that these different types of solutions are hardly comparable with each other and surpass the responsibilities of the responsible department. For this reason, the municipal organization stated that is difficult to deal with the other types of alternative solutions.

Further research

Not all citizens were treated equally in the systems engineering process, since only those stakeholders are involved who put the accessibility problem on the political agenda. This is a large hiatus in the systems engineering process since it is contrary to the fundamentals of the democratic order (Dahl, 1998) and the characteristics of good governance (Van Montfort, 2004; UN, 2002). This was done because time was lacking to involve all possible relevant stakeholders during the interval of study. Further research should reserve more time to give all citizens the possibility to participate.

For this research, early involvement of stakeholders is considered to add value. However, early involvement increases the duration of the initiative phase. This is in line with literature about participation processes (Brody, Godschalk & Burby, 2003; Geldof, 2005; Whelton & Ballard, 2002) and systems engineering literature (Honour, 2004). Although it is assumed that the early involvement is worth its investment, since it pays off in later phases of a project; for this phase efficiency decreases. In that case, the dimensions of good governance seem to conflict. This conflict is recognized in literature (Dror, 1999; Van Montfort, 2004) and asks for further research to deal with.

For our research value was defined based on a perspective on governance. Another perspective may lead to other evaluation criteria to measure ‘value’. We strongly support adopting other perspectives as well, as it will increase our understanding of design processes, for example about project management or stakeholder satisfaction. Future research could focus as well on extra evaluation criteria to make the dimensions of good governance operational for other aspects of civil engineering projects. In this research, focus was on the planning-oriented initiative phase of those projects. Future research can both focus on other urban planning aspects for the initiative phase, as on other phases of the project.

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