The Systemic Implications of Emergent Strategic Objectives in Complex Planning Situations

Christine Groβe
Department of Information Systems and Technology, Mid Sweden University, Holmgatan, Sundsvall, Sweden

Keywords: Multi-level Planning, Critical Infrastructure Protection, Strategic Management, Emergency Response Planning, Decision Support, Styrel.

Abstract: This paper develops a model for analysing systemic implications of strategic objectives in the context of national emergency response planning for the case of an electrical power shortage. Drawing on evidence from the Swedish approach, *STYREL*, the study emphasises the need for a thorough consideration of the various interests that are involved in such a complex system of national multi-level planning. This model provides a novel approach for analysing strategic objectives in complex planning environments, thereby offering a context for a constructive dialogue about strategic objectives, reachable goals and appropriate means among actors who are involved in such planning as well as the stakeholders it affects. Even beyond national critical infrastructure protection (CIP), the contribution of this paper is twofold: it outlines a complex problem for operations research in general and suggests a systematic approach for examining strategic objectives in complex planning environments in particular. Hence, this paper encourages a discussion of systemic implications of these various interests and an enhancement of collaboration and mutual understanding to facilitate decision-making in public and private strategic management.

1 INTRODUCTION

Planning situations are regularly part of day-to-day business in private and public organisations. However, these situations can become more complex if many actors and stakeholders are involved and affected. The context of critical infrastructure protection (CIP) involves various interests, such as the protection of public values and private and economic concerns as well as political issues, both nationally and internationally (Boin and McConnell, 2007; Rinaldi et al., 2001). From a holistic perspective, such planning environments entail complexity, ambiguity and uncertainty, which interrelate to both a potential problem situation and a particular planning procedure (Renn, 2016). In addition, the fluid borders between prevention, mitigation and restoration planning for critical infrastructure further complicate the systemic conditions of the planning (Johansson et al., 2014; Johansson and Hassel, 2014). In such circumstances, these systemic conditions of the complex planning environment pose challenges to controlling efforts due to the specific properties of various strategic objectives that the interconnected sub-systems attribute to the planning process and its result.

In order to provide strategic management with decision aid for determining achievable goals and allocating appropriate means, this paper investigates a national emergency response planning approach that is dedicated to the case of power shortages and has been implemented in Sweden. The Swedish approach offers unique characteristics in its almost non-technical focus and the involvement of an immense number of actors from national, regional and local levels during a long-term, collaborative process. Through a case study of this exceptional example, this paper provides a twofold contribution. First, the description and analysis of the planning procedure explicate a new and currently important problem in the field of operations research. Second, the investigation suggests a conceptual model for assessing strategic objectives in complex planning environments. This model offers a context for a constructive dialogue about strategic objectives and may facilitate an alignment of goals and means towards them, both nationally and internationally.

The remainder of this paper presents the study as follows. Section 2 briefly reviews previous research

Große, C.
The Systemic Implications of Emergent Strategic Objectives in Complex Planning Situations.
DOI: 10.5220/0006646302870296
In *Proceedings of the 7th International Conference on Operations Research and Enterprise Systems (ICORES 2018)*, pages 287-296
ISBN: 978-989-758-285-1

regarding the impact of electrical blackouts on modern societies and emergency response planning. Section 3 outlines the case study that yields the evidence which Section 4 incorporates to develop the proposed conceptual model. Section 5 discusses the relevance of this context for a constructive dialogue in public strategic management and indicates additional implications of the illustrated problem for operations research. Section 6 concludes the paper and identifies issues for future research.

2 PROTECTION OF CRITICAL INFRASTRUCTURE

Because modern societies are critically dependent on a permanent power supply, this sector is considered to be central to other sectors of infrastructure which provide vital services to a nation (Rinaldi et al., 2001; Yusta et al., 2011). Recent studies have investigated topics such as measurements to prevent and restore the power distribution system after a failure (Negnevitsky et al., 2013; Tortos and Terzija, 2012), cascading effects of a technical failure (Hines et al., 2009; Vaiman et al., 2013) and resilience in power distribution systems (Maliszewski and Perrings, 2012). Apart from research on the economic costs of power outages (e.g. Küfeoğlu and Lehtonen, 2013), another study has explored how societal consequences of a power shortage should influence decisions regarding measurements to reduce the technical vulnerability of the Swedish power grid (Johansson et al., 2014). Other studies have emphasised the need for advances in societies' resilience in coping with rare events, such as an electrical blackout, that have catastrophic potential (Boin and McConnell, 2007; Wright et al., 2012). However, experiences from local power outages in the aftermath of two storms in Sweden have revealed that actors at municipalities and power grid providers expected households to be prepared; however, households did not recognise this responsibility to establish such preparedness (Palm, 2009). Nevertheless, the absence of severe large-scale power shortages or outages in the past has resulted in a lack of experience with such crisis events among people who are responsible for such preparedness planning at municipalities (Enander et al., 2015). Moreover, further research in Sweden has questioned the decision-making capacities of the regional board which is responsible for civil defence. (Wimelius and Engberg, 2015). Despite a repeated call for collaboration and co-ordination during crises, studies have revealed that this cross-functional co-operation results in frustration and several problems due to inadequate information paths, organisational biases and a lack of mutual understanding (Powley, 2009; Pramanik et al., 2015; Ödlund, 2010). In view of this, the present paper argues that analysing strategic objectives in complex planning environments can assist actors and stakeholders with creating a shared understanding, developing helpful decision aid and establishing appropriate and secure information paths.

3 CASE STUDY

3.1 The Swedish *STYREL* Planning

The blackout in southern Sweden in September 2003 may have been the catalyst for the development of the national *STYREL* planning approach (Elkraft System, 2003; Larsson and Danell, 2006; Larsson and Ek, 2004; SvK, 2003). The national process was developed between 2004 and 2011 and currently involves many actors, as Table 3 illustrates. The procedure was executed in 2010/11 and 2014/15; the proceedings are suggested as follows (SEA, 2014):

As the governmentally entrusted actor, the Swedish Energy Agency (SEA) starts the iteration of the procedure. Subsequently, all national agencies make an inventory of critical infrastructure that they individually operate across the country and attribute a priority class to each asset. This priority class is selected from an eight-point scale, which is provided by the Swedish Civil Contingencies Agency and displayed in Table 1, in order to determine the importance of each asset's functionality for the national society. Then, the agencies distribute a separate list of these classified assets to each county administrative board (CAB) in which the assets are physically located. Simultaneously, the SEA informs the CABs about the current proceeding and imparts some guidance. The CABs in turn encourage the municipalities within their areas of responsibility to perform the planning and assist with guidance to some extent. In addition, the list from the agencies is divided into parts which correspond with each municipality's geographical area of responsibility. These assets are then included in the further local proceedings at the municipalities. For this purpose, individuals who are responsible at municipalities investigate local infrastructure in order to find and classify electricity-dependent critical infrastructure and services. The local ranking also applies the eight-point scale in Table 1.

Table 1: Priority Classes of Critical Infrastructure (MSB, 2010, p. 10).

N	Description
1	Power consumers that have a large impact on life and health in a short time frame (hours)
2	Power consumers that have a large impact on vital societal functions in a short time frame (hours)
3	Power consumers that have a large impact on life and health in a longer time frame (days)
4	Power consumers that have a large impact on vital societal functions in a longer time frame (days)
5	Power consumers that represent large economic values
6	Power consumers with major importance for the environment
7	Power consumers with importance for societal and cultural values
8	All other power consumers

During the course of the local ranking, local power grid providers are encouraged to assist with information regarding the relation of the critical infrastructure assets, as power consumers, to controllable power lines. As a result, the operational support system, which takes the form of a spreadsheet that applies an additive calculation, merges the ranked list of assets into a ranked list of controllable power lines. The municipalities check their consequential list of power lines and return it to their CAB. The CAB merges the lists from their municipalities in a manner similar to that indicated above, with attention to critical infrastructure of regional importance. Local interests in particular demand consideration against regional and national requirements, and vice versa. The CABs thus have a key role in the collaborative approach because they compile their part of the final list by incorporating local, regional and national information, which is then forwarded to the national power grid provider and the local operators. Whereas the national power grid provider only stores this information, the local providers are legally obligated to use the received lists in their contingency planning for manual load shedding (MLS) in case of a power shortage.

3.2 Methodical Proceedings

The evidence collected in this case study derives from several sources, such as publicly available documents, interviews and observations during the investigation.

First, Swedish documentation of the case was examined; this included legal regulations, guidelines and various reports. The previous section has described the proceedings as they are communicated through these documents. This document study provided a further basis for the interview study.

Second, a selection was made of three counties with distinctly different properties, for example relating to size, inhabitants and proximity to larger cities, to ensure a representative sample for obtaining data from interviews. Interviews were conducted with 57 individuals who act on behalf of several actors in this planning. Table 2 details the participant sample. The interview study included the three CABs of the counties and similarly invited all of the 50 interrelated municipalities, of which only three were not accessible. Interviews with the national power grid provider and a few local providers completed the data collection and represented the technical perspective in the planning.

Table 2: Current Participation in the Case Study.

Number of Interviewees	Affiliation
4	County Administrative Board (CAB)
46	Municipality
5	Local Power Grid Provider
2	National Power Grid Provider (SvK)

All informants participated in face-to-face interviews within their particular working environments, with the exception of two that took place via telephone. The interviews were semi-structured in nature and consisted of predetermined, open-ended questions, which allowed for a similar structure in each interview while still enabling participants to address any particularly relevant issue with regard to their own understandings of the *STYREL* planning. Twenty-eight of the respondents discussed the questions individually with the interviewer, and 14 interviews were performed in groups, with 13 of those involving two participants and one of them involving three. The interviews lasted for an average of one hour and were recorded and transcribed.

Third, an analysis of the data collected through the document and interview studies, which were enriched by observations in the field, yielded insights that inform the composition of the conceptual model in the following section. These insights emerged from evidence regarding the involvement and participation of actors and stakeholders, including their interconnectedness and contexts. These system elements highlighted various strategic objectives, which the analysis addresses by identifying relevant properties and combinations of objectives that can potentially challenge controlling and governance efforts for Swedish CIP.

4 MODEL COMPOSITION

4.1 System Elements

When applying system thinking to planning for CIP, the resultant planning environment is a rather open system with fluid borders and which consists of system components and their interconnections within a system context (Bertalanffy, 1968, p. 141). The actors and stakeholders in the Swedish case can therefore be viewed not only as sub-systems within a broader planning space but also as belonging to their respective sub-context. Within these environments, the sub-systems maintain various interrelations.

Table 3: Actors in the Swedish *STYREL* Planning.

N	Actor	Area of Responsibility
1	SEA	Process development and initiation of process execution (national), direction and guidance
> 300	National Agencies	Identification and prioritisation of critical infrastructure that the particular agency operates, distribution of planning documents to the CABs where objects are physically located
21	CABs	Process execution (regional), distribution and compilation of planning documents, direction and guidance
291	Municipalities	Process execution (local), identification of critical infrastructure, collaboration with power grid providers (operating locally) as well as public and private operators of critical infrastructure (located locally), prioritisation of critical infrastructure assets and controllable power lines
Ca. 160	Power Grid Providers	Assisting municipalities with information how critical infrastructure relate to power lines, planning for MLS
1	National Power Grid Provider	Supervision of planning for and execution of MLS (which uses the results of *STYREL*)

First, the Swedish *STYREL* planning involves and affects a large number of sub-systems (Große, 2017). Table 3 specifies which actors the official documentation and guidelines identify as directly involved in the Swedish planning process. During a power shortage, the results of the planning can also affect other sub-systems in addition to these identified actors. For example, the execution of the process has hardly involved larger parts of civic society, neither non-governmental nor private organisations. The interviews indicated that such proceeding stipulates a workload that had surpassed the capabilities of the municipalities. Accordingly, most respondents indicated that critical infrastructure assets were mainly identified within municipal properties and enterprises.

Second, the identified sub-systems establish and maintain various formal and informal interconnections between them. The process guideline does address the role of the sub-systems in these interconnections, but it does not specify any formalities of these relations. This is instead delegated to the particular organisations and individuals, who must build a reasonably reliable network of co-operation and collaboration. Figure 1 demonstrates the intended formal relations between the actors in the planning process. It particularly illustrates that the multi-level planning lacks interconnections that are dedicated to feedback and collective learning, which raises questions regarding options for evaluation and further improvement.

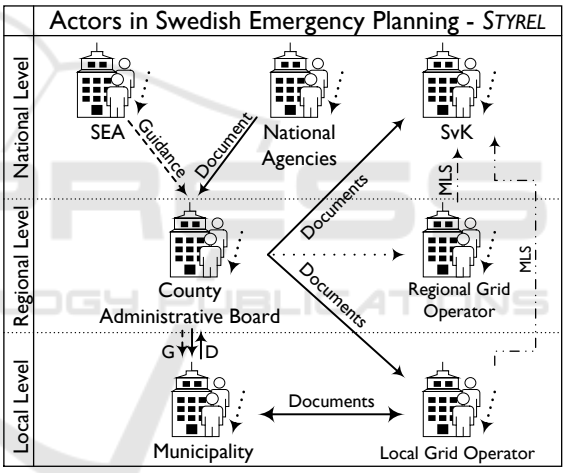

Figure 1: Formal Relations between Actors in the Swedish Multi-level Planning.

Evidence from the interviews suggests that apart from these intended formal relations, various informal relations have also been established, especially at the local level. For example, some planners have been in contact with local crisis management personnel, with individuals performing similar tasks in other municipalities or with private companies of local importance. Such contacts may influence the conduct of the planning as well as the potential re-application of insights from this planning to other local contexts.

Third, the sub-systems and interconnections are embedded in a system context. Although the planning environment of *STYREL* encompasses the sub-systems, the particular conditions of one sub-

system can differ from another because of specific local circumstances, such as the planner's placement in organisational structures or office environments. In addition, the interviews reveal substantial variety in individual levels of knowledge and experiences. Moreover, the four-year interval between planning iterations implies that planners concentrate on other tasks in the meantime, which can involve changes to working tasks, mind settings and belonging context of the individuals who conduct the *STYREL* planning. The extension of these sub-system contexts further embeds even the planning environment of *STYREL* into larger contexts, such as national security and European planning for CIP.

Considering these systemic conditions, there is the need for a structured dialogue about strategic objectives in such complex planning environments. This dialogue may support the development of constructive decision aid for local responsible planners to enable them to identify infrastructure assets and their criticality in accordance with common understandings.

4.2 Properties of Strategic Objectives

Departing from the description of the Swedish planning case and the systemic conditions that have been identified above, this study identifies ambiguity in several steps of the process. For example, specification of responsibilities, expected efforts and information paths remains unclear. Although a particular instantiation of the planning process may require adaptation to local conditions, the variety of local processes indicates that different interpretations of vague and *implicit* objectives result in different proceedings. Thus, concretising the tacit content and its significance can assist with converting these implicit objectives into *explicit* ones (Śliwa and Patalas-Maliszewska, 2015), which in turn can facilitate both the development and execution of the process.

From a process management perspective, strategic objectives can be decomposed into achievable goals, and preferably in a sequential order. However, in the context of complex planning, such goals must fulfil the meaning as *intermediate* objectives towards more extensive or long-term goals, here labelled '*advanced* objectives' (Watzka, 2017). In the *STYREL* case, the identification of critical infrastructure can be considered one such intermediate objective in pursuit of the advanced objective of obtaining a list of categorised power consumers.

The ambiguity and uncertainty that are involved in complex planning condense into strategic objectives that are *identical* in content and meaning but uniquely expressed and labelled. To reduce the portfolio of relevant objectives, an in-depth analysis must address and dissolve such identical strategic objectives, which could additionally enhance clarity in the complex environment. Similarly, *antinomic* objectives present insurmountable discrepancies with one another and must be considered carefully before deciding between them (Thommen et al. 2017). In consequence, the remaining objectives are basically *compatible*.

However, the means to reach these compatible strategic objectives can further impact the simultaneous achievement. Such an impact can emerge as a *beneficial*, *neutral* or *conflicting* side effect between the applied means. For instance, the interviews with individuals responsible for *STYREL* at municipalities reveal that some planners had contact with local crisis management, and in certain cases even shared a position with them. This enables the valuable reuse of results from the *STYREL* process for next-level planning, such as preparedness or continuity planning. Nevertheless, due to constraints regarding aspects such as time, budget, staff and knowledge, the means that have been applicable during the planning iterations have differed significantly. This implies that the conflict between the means for achieving the process objective, '*a plan that power-grid providers can use as basis for their response planning*' (SEA, 2014, p. 25), and the planning objective to '*alleviate consequences for society that emerge when manual load shedding must be executed*' (SEA, 2014, p. 7) is delegated to the respective local regional instantiation of the planning process. Therefore, the planning may result in considerably varied results due to individual interpretations regarding the expected granularity of infrastructure identification, the concrete application of the classification scheme, and adequate goals and means in pursuing objectives.

The following classification parameters summarise the above deliberations:

- **Manifestation:** Implicit or explicit
- **Sequence:** Intermediate or advanced
- **Logic:** Identical, compatible or antinomic
- **Side Effect:** Beneficial, neutral or conflicting

4.3 Challenges for Controlling Efforts

Since strategic objectives involved in the Swedish emergency response planning for CIP are numerous

and highly diverse as a result of the number of actors and stakeholders, many of these objectives will occur simultaneously. Such combinations of objectives can challenge efforts to control the planning process. These bundles characterise challenges as opportunities, risks and indefinites.

First, *opportunities* emerge from strategic objectives that are explicitly formulated, intermediate or advanced, and compatible. In particular, this type of bundle contains strategic objectives that utilise means with beneficial side effects among the objectives. Depending on the objectives and means that are involved, the benefit of such bundles can vary. Hence, this utility maximisation is one relevant task to increase the efficiency of national planning.

Second, *risks* arise from combinations of strategic objectives that are explicitly formulated but can be advance antinomic or advanced compatible. The combination of advance-antinomic objectives warrants particular attention, as under no circumstances can they be achieved simultaneously, and they should be treated first. The latter combination of advanced-compatible objectives becomes a challenge of the risk type if the means applied to reach them provide conflicting side effects. The range of such conflicting side effects can span from acceptable to disastrous losses; thus, loss minimisation is the second relevant task in pursuing effective usage of national resources.

Third, *indefinites* reside in the neutral middle ground between the former two challenges. Such indefinite combinations consist of strategic objectives that are implicit or explicit, intermediate or advanced, and basically compatible, and they apply means with neutral side effects. Strategic objectives in bundles of this type have no obvious economic effects on national planning, but they may still have an influence on the effectiveness of the planning process. Thus, a regular assessment is a third task to ensure the effectiveness of national planning.

4.4 Context for Constructive Dialogue

The previous sections have introduced the aspects of the conceptual model, which provides a context for a constructive dialogue about strategic objectives in complex planning environments. Derived from insights from the Swedish planning case, the model applies classification parameters to strategic objectives that emerge from systemic parameters. Moreover, their combination results in bundles that characterise challenges for controlling and national governance efforts. Figure 2 summarises the deliberations and represents the model in detail.

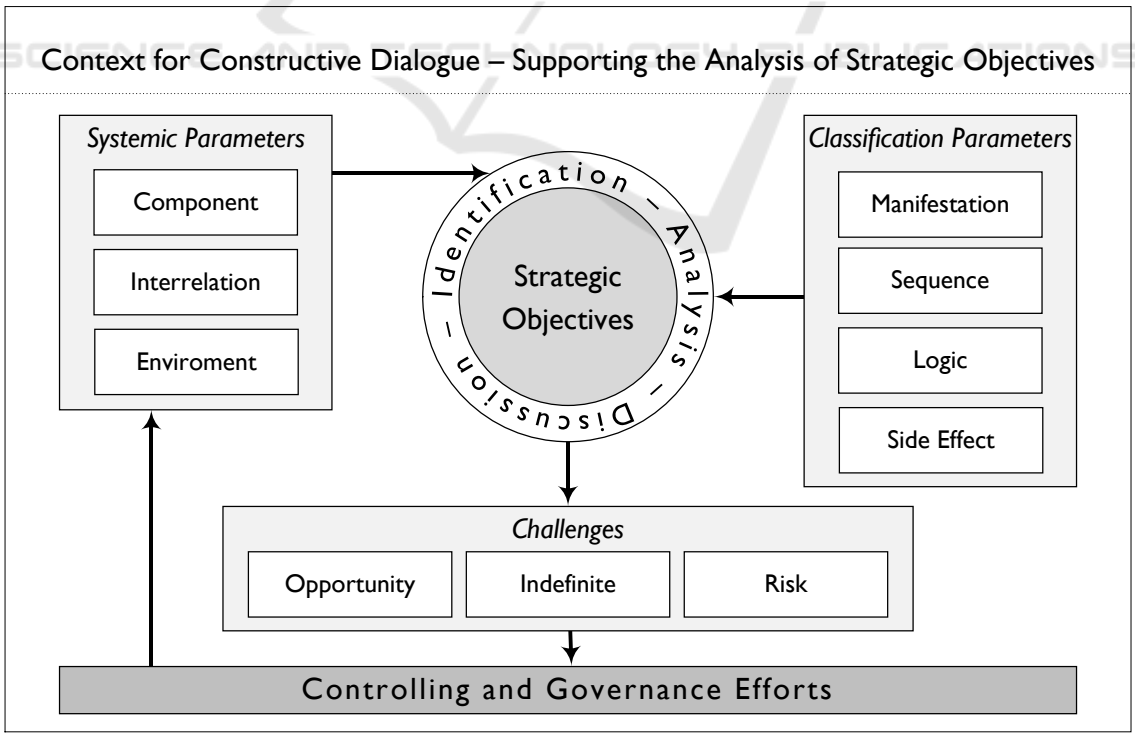

Figure 2: Context for Analysis of Strategic Objectives – The CASO Model.

To elucidate how the CASO model can assist with analysing strategic objectives, some examples illustrate the systemic implications for governance in the Swedish emergency response planning for power shortages. The examples below use five strategic objectives (1) – (5) from *STYREL*, which in bundles and by specific means can provide opportunities, risks or indefinites. Consequently, governance can address interrelated issues in several ways.

(1) Society protection
(2) List of ranked critical infrastructure assets
(3) Basis for preparedness and crisis management
(4) Power grid stabilisation by load shedding of non-priority assets
(5) Information security about vulnerabilities

A) Assuming that the bundle of (2) and (3) provides an opportunity, it implies that governance needs to focus on the transition of the *STYREL*-planning results into a next-level planning, which may involve considerations on the granularity of the processed information and on adequate access rights as well. In *STYREL*, the municipalities cannot fully rely on the planning results because it remains uncertain which effects emerge locally during a power shortage. This uncertainty stems from the providers' capability to control electricity across the power grid, the situation that actually occurs and the absence of feedback after a regional aggregation of power lines.

B) If the bundle (A) combined with (5) constitutes a challenge of the risk-type, it means that conflicting means are involved. For example, the transition of information between different levels of crisis management requires a certain openness, which provides a risk vector to information security. Therefore, governance must decide which level of security is adequate and must thereupon establish appropriate information paths with specified responsibilities and access control.

C) The bundle of (2) and (4) can be envisioned as indefinite. Balancing the power grid during power shortages does not primarily require a ranking of critical infrastructure. Otherwise, if (1) joins the bundle, such ranking can help to reduce the impact of power disturbances on society. In such case, the ranking can probably contain limited details because non-priority assets like households represent a large consumption that can be powered off to stabilise the grid. Nevertheless, such a bundle can progress toward being a type of risk or opportunity. For example, when a power shortage changes into a blackout, a detailed list facilitates the restoration of the current in a prioritised order. Such prioritised restoration though depends on the ranking list's actuality and the provider's possibilities to control the power supply through the grid. Hence, governance must regularly reflect about indefinites and needs to assess a possible progression to adapt planning processes to emerging issues, such as the expansion of infrastructure and new technologies.

These selected examples demonstrate that clarity about strategic objectives can help to mitigate the ambiguity in task descriptions and the uncertainty that is caused by lacks of knowledge. Moreover, these examples reveal that individual perceptions about this clarity can differ and even change over time. The CASO model intends therefore to support such suggested, regularly assessment.

5 DISCUSSION

5.1 Indications for *STYREL* Planning

By proposing the CASO model in the section above, this paper encourages a constructive dialogue among the actors and stakeholders who are involved in the Swedish planning approach *STYREL* for protecting critical infrastructure from the consequences of power shortages.

Evidence from the Swedish case particularly illustrates systemic and classification parameters. As Section 4.1 has explained, the systemic parameters consist of the actors and stakeholders as system components in addition to their interrelations and particular environments. As indicated, the Swedish approach does not yet comprehensively include all strategic objectives which the systemic parameters pose to the *STYREL* planning; therefore, greater effort is needed to identify hidden stakeholders and objectives that are interconnected with the planning.

Moreover, the study has discovered that the analysis of the strategic objectives is also incomplete. Although the interviews indicate that certain sub-systems follow an internal logic, the holistic system of governance appears underdeveloped with regard to the management of complexity, ambiguity and uncertainty. The proposed CASO model can assist Swedish controlling and governance efforts through the continuous process of identifying strategic objectives, analysing their properties and determining the direction of activities. In addition to dissolving identical objectives and eliminating antinomic strategic objectives, this also requires close consideration of the challenges which result from bundles of strategic objectives and which may

have consequences for Swedish society in an urban context, in rural circumstances or in both situations.

A subsequent in-depth analysis of these challenges could suggest further measurements to improve, for example, collective learning within and among sub-systems, decision support for identifying and prioritising critical infrastructure, public-private collaboration and preparedness planning, and public risk governance in Sweden.

5.2 Relevance for Complex Planning Environments

As the paper has outlined, combinations of strategic objectives can complicate the operation of complex planning environments. The classification of these challenges to controlling and governance efforts reveals three relevant tasks for system optimisation.

Utility maximisation is suggested as one significant task. A planner's perceptions of the relevance of the performed planning influences his or her commitment and effort level (Enander et al., 2015; Penrose, 2000), and resources for national planning are restricted by a budget, which further motivates the possible optimal usage. Through its orientation towards multi-level (national, regional and local) anchoring, the Swedish case can inspire similar complex planning in other contexts. Despite this study revealing shortcomings in co-ordination and alignment of strategic objectives in the Swedish planning for CIP, the existing system structures can serve as stable starting points for improving the usefulness and use-worthiness of the planning.

Loss minimisation appears to be another relevant focus which targets conflicting side effects of means for reaching compatible strategic objectives. The more negative end of such a portfolio analysis contains objectives that are antinomic, i.e. mutually exclusive. Attempts to reach such objectives can simultaneously result in significant economic losses. Thus, similarly to those involving conflicts, such antinomic strategic objectives must be addressed early in complex planning. However, the number of actors in the Swedish planning environment can hamper the identification of such risky strategic objectives as well as their mitigation. Therefore, the conceptual model that this study has developed suggests a context for a constructive dialogue in order to reduce the waste of national resources.

Although the former two tasks are pertinent for optimisation, the systemic conditions of the complex planning in Sweden result in constantly changing strategic objectives as well. Thus, indefinite bundles necessitate regular monitoring and assessment in order to identify further opportunities or risks that are interrelated with strategic objectives in complex systems of national planning for CIP. For example, staff changes can involve further objectives in view of the knowledge and experience of new employees.

Governance and leadership efforts could address planners' perceptions of the significance of the executed planning, for example by discussing implicit objectives to reduce ambiguity and considering articulated doubts. The insights that are obtained from such efforts can inform a regular dialogue about strategic objectives in order to develop a mutual understanding, and not only in the context of Swedish planning for CIP, for which the study suggests a systematic and integrative context.

5.3 Implications for Operations Research

Whereas the latter of the previously presented challenges for controlling complex planning environments can be considered a task for proper monitoring and leadership, the two former challenges are of particular interest for operations research. Since the appropriate use of national resources with optimal outcomes can also be viewed as a preferred national strategic objective, this requirement can lead to further investigation of the potential for optimisation. However, the plethora of sub-systems, interrelations and conditions that are involved in the complex planning in addition to the number of potential objectives, which is expected to be similarly high, has encouraged the conceptual representation of the constructed model as discussed in this study. Nevertheless, the problem that is presented provides a point of departure for further operations research. For instance, the outlined problem situation encourages the development of a mathematical representation which could enable the research community to discuss optimisation possibilities and potential consequences for national planning and the affected society. For this, two alternatives seem convenient: utility maximisation and loss minimisation. The former may address the usability, usefulness and use-worthiness of the planning process and the resulting plan, whereas the latter relates to economic resources, such as working hours, cognitive capacity, system development costs, information security measures and education and training of employees. Both alternatives can be more attentive to possible consequences of the planning in the case of an emergency, such as a power shortage situation like that under consideration by the Swedish planning. The question of how to optimise

such planning with regard to potential economic losses and loss of life in the case of a certain severe power shortage, or even a full outage, could further encourage the comparison of similar complex planning in other national contexts which scientific literature has not yet described in detail.

6 CONCLUSIONS

This study has closely examined the Swedish planning environment, the purpose of which is to plan a response to power shortages with the intention of protecting national, regional and local infrastructure that are of key importance for the respective society. Derived from insights that the study has obtained from the Swedish *STYREL* case, this paper has developed a conceptual model that provides a context for a constructive dialogue about the strategic objectives that are involved in the Swedish planning approach.

Swedish planning for CIP consists of a multitude of actors and interconnections within particular environments at the local, regional and national levels. From such nested circumstances, a significant need has emerged to examine the challenging implications of the various strategic objectives for the governance of the Swedish planning process. As the evidence in Section 4 has demonstrated, conflicting side effects among strategic objectives are ignored similarly to beneficial ones in the *STYREL* process. Hence, by proposing the CASO model, this paper contributes to future systematic development of the Swedish *STYREL* planning. Moreover, this model can further assist with analysis of other similar complex planning environments.

On the one hand, the CASO model applies a holistic and integrative perspective of strategic objectives in such complex planning environments; therefore, this context presents a tool to analyse and discuss relevant preferences concerning the future state which such a multi-level planning process addresses. A constructive dialogue about the preferred future state may encompass actors from all planning levels, regardless of whether they are involved in process execution or responsible for its development. In addition, insights from such cross-level analysis and discussion can foster proper risk communication to further affected stakeholders, such as civic society in the Swedish context.

On the other hand, the conceptual model offers a point of departure for future research that is associated with operation and development of complex systems. A particularly interesting problem definition in the context of operations research emerges from the utility maximisation and loss minimisation that are associated with both the planning process and the result of the planning, i.e. the emergency response plan. As this paper has argued, strategic objectives that are involved in complex planning tasks challenge controlling and governance efforts in several ways. This paper has aimed to structure the systemic conditions of the complex planning environment in terms of sub-systems of actors, where changes result in variations in conditions and interconnections over time and fluid borders of a multifaceted context within and surrounding the planning environment. This can ultimately encourage joint efforts within the research community to examine possible solutions. By explicating this complex problem, this paper has thus contributed to dialogue and development in the field of operations research.

ACKNOWLEDGEMENTS

This study is supported by the Swedish Energy Agency alongside the project: ‘Från myndighet till medborgare och tillbaka: En studie av samverkan och kommunikation inom ramen för Styrel’, which is gratefully acknowledged.

REFERENCES

Bertalanffy, L. von (1968). *General System Theory: Foundations, Development, Applications.* New York: Braziller.

Boin, A., and McConnell, A. (2007). Preparing for Critical Infrastructure Breakdowns: The Limits of Crisis Management and the Need for Resilience. *Journal of Contingencies and Crisis Management, 15*(1), 50–59.

Elkraft System (2003). *Power failure in Eastern Denmark and Southern Sweden on 23 September 2003: Final report on the course of events.* Ballerup.

Enander, A., Hede, S., and Lajksjö, Ö. (2015). Why Worry?: Motivation for Crisis Preparedness Work among Municipal Leaders in Sweden. *Journal of Contingencies and Crisis Management, 23*(1), 1–10.

Große, C. (2017). Applying Systems Thinking onto Emergency Response Planning: Using Soft Systems Methodology to Structure a National Act in Sweden. In *Proceedings of the 6th International Conference on Operations Research and Enterprise Systems* (pp. 288–297). SCITEPRESS.

Hines, P., Balasubramaniam, K., and Sanchez, E. C. (2009). Cascading failures in power grids. *IEEE Potentials, 28*(5), 24–30.

Johansson, J., and Hassel, H. (2014). Impact of Functional Models in a Decision Context of Critical Infrastructure Vulnerability Reduction. In M. Beer, S.-K. Au, and J. W. Hall (Eds.), *2nd International Conference on Vulnerability and Risk Analysis and Management (ICVRAM) and the 6th International Symposium on Uncertainty, Modeling, and Analysis (ISUMA)*, 577–586.

Johansson, J., Svegrup, L., and Hassel, H. (2014). The effect of including societal consequences for decisions on critical infrastructure vulnerability reductions. *Proceedings of 12th Probabilistic Safety Assessment and Management Conference, Honolulu, Hawaii, USA*.

Küfeoğlu, S., and Lehtonen, M. (2013). Evaluation of power outage costs for industrial sectors in Finland. In IEEE (Ed.), *22nd International Conference and Exhibition on Electricity Distribution (CIRED 2013)* (paper 1030). Piscataway, N.J.: IEEE.

Larsson, S., and Ek, E. (2004). The black-out in southern Sweden and eastern Denmark, September 23, 2003. In E. L. Allgower and K. Georg (Eds.): *Vol. 45. Classics in applied mathematics, IEEE Power Engineering Society general meeting* (pp. 1668–1672). Piscataway, N.J.: IEEE.

Larsson, S., and Danell, A. (2006). The black-out in southern Sweden and eastern Denmark, September 23, 2003. In *IEEE Power Systems Conference and Exposition (PES)* (pp. 309–313). Piscataway, N.J.: IEEE.

Maliszewski, P. J., and Perrings, C. (2012). Factors in the resilience of electrical power distribution infrastructures. *Applied Geography, 32*(2), 668–679.

MSB (Swedish Civil Contingencies Agency) (2010). *Styrel - inriktning för prioritering av elanvändare: DNr 2009-3054*.

Negnevitsky, M., Voropai, N., Kurbatsky, V., Tomin, N., and Panasetsky, D. (2013). Development of an intelligent system for preventing large-scale emergencies in power systems. In IEEE (Ed.), *Power and Energy Society general meeting (PES)* (pp. 1–5). Piscataway, N.J.: IEEE.

Palm, J. (2009). Emergency Management in the Swedish Electricity Grid from a Household Perspective. *Journal of Contingencies and Crisis Management, 17*(1), 55–63.

Penrose, J. M. (2000). The role of perception in crisis planning. *Public Relations Review, 26*(2), 155–171.

Powley, E. H. (2009). Reclaiming resilience and safety: Resilience activation in the critical period of crisis. *Human Relations, 62*(9), 1289–1326.

Pramanik, R., Ekman, O., Hassel, H., and Tehler, H. (2015). Organizational Adaptation in Multi-Stakeholder Crisis Response: An Experimental Study. *Journal of Contingencies and Crisis Management, 23*(4), 234–245.

Renn, O. (2016). Systemic Risks: The New Kid on the Block. *Environment: Science and Policy for Sustainable Development, 58*(2), 26–36.

Rinaldi, S. M., Peerenboom, J. P., and Kelly, T. K. (2001). Identifying, understanding, and analyzing critical infrastructure interdependencies. *IEEE Control Systems Magazine, 21*(6), 11–25.

SEA - Statens energimyndighet (Ed.) (2014). *Styrel: Handbok för styrels planeringsomgång 2014–2015*. ET2013:23.

Śliwa, M., and Patalas-Maliszewska, J. (2015). Model of converting tacit knowledge into explicit knowledge on the example of R+D department of the manufacturing company, including evaluation of knowledge workers' usefulness. *Journal of Theoretical and Applied Computer Science, 9*(3), 25–34.

SvK - Swedish National Power Grid Provider (Ed.) (2003). *Elavbrottet i södra Sverige och i östra Danmark 2003-09-23: Preliminär rapport om händelseförloppet som ledde till avbrottet.*

Thommen, J.-P., Achleitner, A.-K., Gilbert, D. U., Hachmeister, D., and Kaiser, G. (2017). Unternehmensziele. In J.-P. Thommen, A.-K. Achleitner, D. U. Gilbert, D. Hachmeister, and G. Kaiser (Eds.) *Allgemeine Betriebswirtschaftslehre. Umfassende Einführung aus managementorientierter Sicht* (8th ed., pp. 43–49). Wiesbaden: Springer Gabler.

Tortos, J. Q., and Terzija, V. (2012). Controlled islanding strategy considering power system restoration constraints. In IEEE (Ed.), *Power and Energy Society general meeting (PES). New Energy Horizons - Opportunities and Challenges* (pp. 1–8). Piscataway, N.J.: IEEE.

Vaiman, M., Hines, P., Jiang, J., Norris, S., Papic, M., et al. (2013). Mitigation and prevention of cascading outages: Methodologies and practical applications. In *IEEE Power and Energy Society general meeting (PES)* (pp. 1–5). Piscataway, N.J.: IEEE.

Watzka, K. (2017). Betriebswirtschaftliche Zieltheorie. In K. Watzka (Ed.), *Zielvereinbarungen in Unternehmen. Grundlagen, Umsetzung, Rechtsfragen* (2nd ed., pp. 9–14). Wiesbaden: Springer Gabler.

Wimelius, M. E., and Engberg, J. (2015). Crisis Management through Network Coordination: Experiences of Swedish Civil Defence Directors. *Journal of Contingencies and Crisis Management, 23*(3), 129–137.

Wright, C., Kiparoglou, V., Williams, M., and Hilton, J. (2012). A Framework for Resilience Thinking. *Procedia Computer Science, 8*, 45–52.

Yusta, J. M., Correa, G. J., and Lacal-Arántegui, R. (2011). Methodologies and applications for critical infrastructure protection: State-of-the-art. *Energy Policy, 39*(10), 6100–6119.

Ödlund, A. (2010). Pulling the Same Way? A Multi-Perspectivist Study of Crisis Cooperation in Government. *Journal of Contingencies and Crisis Management, 18*(2), 96–107.