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Master’s Thesis

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Decision making and decision support in service systems

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ABSTRACT

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This thesis is a literature study that develops a conceptual model of decision making and decision support in service systems. The study is related to the Ä-Logi, Intelligent Service Logic for Welfare Sector Services research project, and the objective of the study is to develop the necessary theoretical framework to enable further research based on the research project results and material.

The study first examines the concepts of service and service systems, focusing on understanding the characteristics of service systems and their implications for decision making and decision support to provide the basis for the development of the conceptual model. Based on the identified service system characteristics, an integrated model of service systems is proposed that views service systems through a number of interrelated perspectives that each offer different, but complementary, implications on the nature of decision making and the requirements for decision support in service systems. Based on the model, it is proposed that different types of decision making contexts can be identified in service systems that may be dominated by different types of decision making processes and where different types of decision support may be required, depending on the characteristics of the decision making context and its decision making processes.

The proposed conceptual model of decision making and decision support in service systems examines the characteristics of decision making contexts and processes in service systems, and their typical requirements for decision support. First, a characterization of different types of decision making contexts in service systems is proposed based on the Cynefin framework and the identified service system characteristics. Second, the nature of decision making processes in service systems is proposed to be dual, with both rational and naturalistic decision making processes existing in service systems, and having an important and complementary role in decision making in service systems. Finally, a characterization of typical requirements for decision support in service systems is proposed that examines the decision support requirements associated with different types of decision making processes in characteristically different types of decision making contexts. It is proposed that decision support for the decision making processes that are based on rational decision making can be based on organizational decision support models, while decision support for the decision making processes that are based on naturalistic decision making should be based on supporting the decision makers' situation awareness and facilitating the development of their tacit knowledge of the system and its tasks.

Based on the proposed conceptual model a further research process is proposed. The study additionally provides a number of new perspectives on the characteristics of service systems, and the nature of decision making and requirements for decision support in service systems that can potentially provide a basis for further discussion and research, and support the practice alike.

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Tämä diplomityö on kirjallisuustutkimus, jossa kehitetään palvelujärjestelmien päätöksenteon ja päätöksenteon tukemisen käsitteellinen malli. Työ liittyy Ä-Logi, älykäs palvelulogiikka hyvinvointipalveluihin tutkimusprojektiin ja työn tavoitteena on kehittää tarvittava teoreettinen viitekehys jatkotutkimuksen mahdollistamiseksi tutkimusprojektin tulosten ja materiaalin perusteella.

Työssä tarkastellaan ensin palvelun ja palvelujärjestelmien käsitteitä, keskittyen ymmärtämään palvelujärjestelmien ominaispiirteet ja niiden vaikutus päätöksentekoon ja päätöksenteon tukemiseen, tarvittavan perustan luomiseksi käsitteellisen mallin kehittämiselle. Palvelujärjestelmien tunnistettujen ominaispiirteiden perusteella ehdotetaan palvelujärjestelmien yhdistettyä mallia, joka tarkastelee palvelujärjestelmiä useiden toisiinsa liittyvien näkökulmien kautta, joista jokainen tarjoaa erilaisia, mutta toisiaan täydentäviä, näkökulmia palvelujärjestelmien päätöksentekoprosessien luonteeseen ja päätöksenteon tukemisen vaatimuksiin liittyen. Mallin perusteella ehdotetaan, että palvelujärjestelmissä voidaan tunnistaa erilaisia päätöksenteon konteksteja, joissa päätöksentekoa voivat hallita erilaiset päätöksentekoprosessit ja joissa voidaan tarvita eri tyyppistä päätöksenteon tukea, päätöksenteon kontekstin ja sen päätöksentekoprosessien ominaispiirteistä riippuen.

Työssä ehdotettu palvelujärjestelmien päätöksenteon ja päätöksenteon tukemisen käsitteellinen malli tarkastelee palvelujärjestelmien päätöksenteon kontekstien ja päätöksentekoprosessien ominaispiirteitä, sekä niiden tyypillisiä vaatimuksia päätöksenteon tukemiselle. Ensimmäiseksi, malli kuvaa palvelujärjestelmien päätöksenteon kontekstien ehdotetut ominaispiirteet Cynefin-viitekehyksen ja tunnistettujen palvelujärjestelmien ominaispiirteiden perusteella. Toiseksi, palvelujärjestelmien päätöksentekoprosessien luonteen nähdään olevan kahtiajakoinen, päätöksenteon palvelujärjestelmissä ehdotetaan perustuvan sekä rationaalisiin että luonnollisiin päätöksentekoprosesseihin, joilla molemmilla on tärkeä ja toisiaan täydentävä rooli palvelujärjestelmien päätöksenteossa. Lopuksi, malli kuvaa ehdotetut palvelujärjestelmien päätöksenteon tukemisen tyypilliset vaatimukset liittyen erilaisiin päätöksentekoprosesseihin ominaispiirteiltään erilaisissa päätöksenteon konteksteissa. Päätöksenteon tukemisen rationaaliseen päätöksentekoon perustuville päätöksentekoprosesseille ehdotetaan voivan perustua organisaatioiden päätöksenteon tukemisen malleihin, mutta päätöksenteon tukemisen luonnolliseen päätöksentekoon perustuville päätöksentekoprosesseille tulisi perustua päätöksentekijöiden tilanneymmärryksen tukemiseen, sekä järjestelmään ja sen tehtäviin liittyvän hiljaisen tiedon kehittämisen mahdollistamiseen.

Työssä ehdotetaan jatkotutkimusprosessia kehitettyyn käsitteelliseen malliin perustuen. Työ tarjoaa lisäksi useita uusia näkökulmia palvelujärjestelmien ominaispiirteisiin, sekä palvelujärjestelmien päätöksenteon luonteeseen ja päätöksenteon tuen vaatimuksiin liittyen, jotka voivat sekä tarjota mahdollisen perustan jatkokeskustelulle ja jatkotutkimukselle että tukea käytännön työtä.

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1. Introduction

1.1 Background on service and service systems

Service and service systems may seem like elusive concepts that have many different meanings associated with them in different disciplinary frames of reference, making them difficult to define and understand and to frame the study and practice. Depending on the chosen frames of reference, some of the definitions and associated meanings may even seem conflicting. Background for the present situation can be found in the history of service research. Until recently, service has been a subject of study in a number of academic disciplines (Spohrer and Maglio 2010b, p. 168), but there has been little integration and cross-fertilization of ideas (Vargo et al. 2010b, p. 136) between the different disciplines. This strictly disciplinary focus has led to a lack of cohesiveness in service research (Chesbrough and Spohrer 2006) and has given a rise to a number of different operational definitions for the concept of service due to the different meanings adopted by the different disciplines (Edvardsson et al. 2005). An example of the different disciplinary views, together with discussion about the different meanings associated with the concepts of service and service systems is provided by Spohrer and Maglio (2010b, pp. 168-170). A summary of the different views is provided in Table 1.

Table 1. Disciplinary views on service and service systems (adapted from Spohrer and Maglio 2010b, pp. 168-169)

Discipline	**Focus**
Economics	Service is a distinct type of exchange, providing a category for counting and analyzing jobs, businesses, exports, as well as inputs and outputs to measure productivity (Triplett and Bosworth 2004). Service is a change in the condition of a person or a good belonging to some economic entity, brought about as a result of some other economic entity (Hill 1977).
Marketing	Service is a distinct type of exchange, delivered by a distinct type of process and often characterized by customized human interactions with customers (Shostack 1977; Bitner and Brown 2006; Carlzon 1987). Service is the application of competence for the benefit of another (Vargo and Lusch 2004).
Operations management	Service is a distinct type of production process, characterized by dependence on customer input (Sampson and Froehle 2006).
Industrial and systems engineering	Service systems and networks present a distinct type of engineering problem, characterized by customer induced variability (Riordan 1962; Mandelbaum and Zeltyn 2008).
Operations research	Service systems and networks present a distinct type of modeling and optimization problem, characterized by dynamic and stochastic capacity and demand (Thomas and Griffin 1996; Dietrich and Harrison 2006).
Information systems	Service systems are socio-technical work systems that can be improved with properly managed information systems (Alter 2008).
Social sciences	Service systems are related to socio-technical systems, as well as systems engineering models of enterprises (Rouse and Baba 2006).
Behavioral sciences	Service is an experience, shaped by many factors including waiting in queues and customer expectations (Maister 1985; Chase and Dasu 2001).

Based on the summary of the different disciplinary definitions and their associated meanings, it is evident that none of the disciplinary views alone can provide a comprehensive operational definition nor fully describe the meaning of the concepts of service and service system. The different disciplinary views are rather providing a set of complementary perspectives that are each focusing on different aspects of the same phenomena. The problem of diverse views and need for integration among different disciplines has been pointed out by Chesbrough and Spohrer (2006), who argue that better understanding the concepts of service and service system and facilitating service innovation requires adopting a shared research agenda among different stakeholders and development of common terminology and methods for service research. The perceived problem is addressed by Service Science, Management, Engineering and Design (SSMED), in short service science, an emerging multidisciplinary approach to service research that aims to create an appropriate set of new knowledge to bridge and integrate various areas of service research (Spohrer et al. 2007; Maglio and Spohrer 2008; Spohrer and Maglio 2008; Maglio et al. 2009; Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011). Service science builds on the foundations laid by the existing disciplines and has an overall vision to discover the underlying principles of complex service systems and develop a shared framework that will allow systematic creation, scaling and improvement of service systems, provide basis for progress in academic studies, development of practical tools and addressing existing gaps in the necessary knowledge and skills (IfM and IBM 2008; Spohrer et al. 2010). These objectives are addressed by combining organizational and human understanding with business and technological understanding to categorize and explain many types of service systems that exist as well as how service systems interact and evolve to co-create value (Maglio and Spohrer 2008). Service science view on the concepts of service and service system builds on the conceptual foundation (Vargo and Akaka 2009; Lusch et al. 2008; Vargo et al. 2010b) provided by the Service-Dominant (S-D) logic (Vargo and Lusch 2004a; Vargo and Lusch 2006; Lusch and Vargo 2006; Vargo and Lusch 2008; Vargo et al. 2010a), which represents an emerging worldview or paradigm shift in economics and marketing, and in understanding the mechanisms and dynamics of value co-creation among different actors in the society (Vargo and Lusch 2006; Vargo et al. 2010a, p. 127).

1.1.1 Goods-Dominant logic view on service and service systems

Service research and management of service operations have been traditionally framed by the Goods-Dominant (G-D) logic (Vargo and Lusch 2004a; Lusch et al. 2008; Vargo et al. 2010a, pp. 127-129) or manufacturing logic (Normann 2001, pp. 15-25) and consequently characteristics of service and service systems have been commonly defined in relation to tangible goods and manufacturing systems (Edvardsson et al. 2005). According to the G-D logic, value creating economic activities and exchange within society are fundamentally concerned with production of units of output, or products, that are ideally standardized, can be produced in isolation from customers and inventoried to even out irregularities of demand in order to ensure manufacturing efficiency, have value embedded in them during the manufacturing process and can be sold in the market by capturing and stimulating demand in order to maximize profit (Vargo and Lusch 2004a; Vargo et al. 2010a, p. 128). The G-D logic can be thus viewed as fundamentally oriented toward operand resources (Constantin and Lusch 1994), usually static and inert tangible resources that need to be acted upon to create beneficial effects (Vargo and Lusch 2004a; Vargo et al. 2010a, p. 128).

From the G-D logic perspective services have been viewed either as a restricted type of product that is manifested as intangible output or as an add-on that enhances the value of a good (Lusch et al. 2008; Vargo and Akaka 2009; Vargo et al. 2010a, p. 129; Vargo et al. 2010b, p. 137). Service products have been commonly distinguished from goods based on their perceived characteristics: intangibility, heterogeneity, inseparability and perishability (IHIP) (Zeithaml et al. 1985), which appear to make them somewhat inferior compared to goods as an ideal form of output and make them difficult to handle with traditional goods-based models (Vargo et al. 2010b, p. 137) warranting special considerations in service research and management of service operations. Despite the earlier widespread acceptance and application of the IHIP characteristics to distinguish between goods and services and their perceived implications for service research and management of service operations, their usefulness in both differentiating goods from services and as basis for drawing theoretical and practical implications appears to be at best misguided and has been disputed (Vargo and Lusch 2004b; Lovelock and Gummesson 2004; Grönroos 2000, pp. 48-49). The IHIP characteristics can be rather viewed as the symptoms of service than the distinguishing characteristics of service (Sampson and Froehle 2006). It has been instead suggested that the more appropriate defining characteristics of service are the process nature of value creation and customer input and involvement in the value creation process (Grönroos 2000, pp. 47-48; Sampson and Froehle 2006; Lillrank 2010, pp. 346-347; Lillrank et al. 2011). Therefore, instead of viewing service delivery systems as closed manufacturing systems, they should be viewed as open systems (Fitzsimmons and Fitzsimmons 2006, pp. 29-32) where the customer input and involvement are the main source of implications for service research and management of service operations (Sampson and Froehle 2006).

The manufacturing orientation of the G-D logic has led to conceptualizing value creating service delivery systems as linear supply chains or supply networks (Lusch et al. 2010) and the typical units of analysis for the management, design and improvement of service delivery systems include individual organizations that are linked in the supply chains or supply networks, inter-organizational business processes and their tasks, intra-organizational cross-functional and individual processes and tasks, and even individual activities that are part of a single task performance (Lillrank 2010, pp. 339-341; Lillrank et al. 2011). This approach represents a reductionist perspective that attempts to divide complex service systems into separate interdependent, but loosely coupled parts that can be individually analyzed and improved, following an assumption that the elements of the system are the same when examined independently of the whole as when they are examined as the system, thereby allowing improvement of the system through optimization of its individual parts (Ng et al. 2011, pp. 17-19). Furthermore, the G-D logic implies a primarily internal focus on efficiency in the production of outputs for the benefit of the focal organization and its individual component parts at different levels of aggregation, with particular attention to the difficulties created by the perceived inefficiencies of services production compared to goods production, and with effectiveness for service beneficiaries being important, but secondary (Vargo and Akaka 2009).

1.1.2 Service-Dominant logic and service science view on service and service systems

S-D logic moves the understanding of value creating economic activities and exchange from a product or output centric to a service or process centric focus (Vargo et al. 2010a, p. 129). According to the S-D logic service is defined as the application of competences (knowledge and skills) for the benefit of another party (Vargo and Lusch 2004a; Vargo and Lusch 2006). While the G-D logic views services as products that are manifested as intangible units of output, the S-D logic views service as the process of doing something for and with another party and thus always a collaborative process (Vargo et al. 2010a, p. 129).

The S-D logic view on service and service systems is captured in a set of foundational premises that establish service as the basis of all exchange and view all economies as service economies (Vargo and Lusch 2004a; Vargo and Lusch 2006; Lusch and Vargo 2006; Vargo and Lusch 2008; Vargo et al. 2010a, pp. 130-135). In S-D logic the purpose of value creating economic activities is to provide service in order to obtain reciprocal service, that is, service is always exchanged for service (Vargo et al. 2010a, p. 129). Service as the fundamental basis of exchange may however be masked by indirect exchange and various intermediaries that facilitate the exchange (Vargo and Lusch 2008) between individual service systems in complex systems of service systems (Vargo and Akaka 2009). When goods are involved in this process, they are merely distribution mechanisms or appliances for service provision that embed and convey the necessary competences, but in either case, service provided directly or indirectly through a good, the knowledge and skills of the service providers and beneficiaries represent the essential source of value creation, not the goods, which are sometimes used to convey them (Vargo and Lusch 2008; Vargo et al. 2010a, p. 132). In S-D logic the operant resources, instead of operand resources (Constantin and Lusch 1994) are considered as the fundamental source of value creation and competitive advantage (Vargo and Lusch 2008). While operand resources, such as goods, are usually tangible and static and need to be acted upon to produce beneficial effects, operant resources, such as knowledge and skills, are usually intangible and dynamic and are capable of producing the beneficial effects (Vargo et al. 2010a, p. 132). Importantly, in S-D logic view, value creating resources are not confined to an individual organization, but it is recognized that various economic and social actors, including customers, suppliers and other stakeholders may also constitute operant resources and contribute to the value creation process (Vargo and Akaka 2009; Vargo et al. 2010b, p. 139). The S-D logic views customers as co-creators of value and thus service providers cannot themselves independently create and deliver value, but can only propose value through value propositions (Vargo and Lusch 2008) and provide service as an input to its realization within the context of the customer's value creation process (Vargo and Akaka 2009; Vargo et al. 2010b, pp. 139-140). The S-D logic thus views all economic and social actors as resource integrators (Vargo and Lusch 2008) and suggests that the service provided by one service system often represents only a subset of the resources that have to be integrated to create value to another service system, implying that neither the service providers nor the service beneficiaries have the adequate resources to create value in isolation, but value is created within a shared context of value creation that may extend outside the boundaries of an individual organization and its component parts at different levels of aggregation (Vargo and Akaka 2009).

The S-D logic and service science conceptualize value creating systems as service ecosystems (Vargo and Akaka 2009; Vargo et al. 2010a; Vargo et al. 2010b; Lusch et al. 2010), or service ecologies (Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011), and adopt the service system as the basic unit of analysis (Vargo and Akaka 2009; Vargo et al. 2010a; Vargo et al. 2010b; Lusch et al. 2010; Spohrer et al. 2007; Maglio and Spohrer 2008; Maglio et al. 2009; Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011). The term service ecosystem is adopted in this study. Service system is defined as dynamic value co-creation configurations of resources, including people, other internal and external service systems, shared information and technologies, all connected together with other service systems through value propositions (Spohrer et al. 2007; Maglio and Spohrer 2008; Maglio et al. 2009), the recursive definition highlighting the fact that service systems have an internal structure and external structure in which value is co-created directly or indirectly with other service systems (Spohrer et al. 2007; Spohrer and Maglio 2010b, p. 177). Service systems include one or more person and evolve a complex structure and interaction patterns between individual service systems, together forming a service ecosystem, which is viewed to represent a population of such service systems that, as a whole, are better off working together than working alone (Spohrer and Maglio 2010a, pp. 8-10; Spohrer and Maglio 2010b, p. 174). Service systems are open systems that are capable of improving the state of another service system through sharing and applying their resources, and capable of improving their own state by acquiring and integrating external resources (Maglio et al. 2009) and their normative purpose is to connect people, technology and information through value propositions with the aim of co-creating value for all service systems participating in the resource sharing and integration within and across individual service systems (Vargo and Akaka 2009; Vargo et al. 2010b, p. 135). Service systems are configurations of resources and are thus also a resource themselves that can act or be acted upon by other service systems (Maglio et al. 2009). There are many systems that can be viewed as service systems, or dynamic configurations of resources, including individual persons, families, business, non-profit, municipal and government organizations, municipalities, nations and economies (Spohrer et al. 2007; Maglio and Spohrer 2008; Maglio et al. 2009). The smallest service system is viewed as an individual person interacting with others, and the largest service system is viewed to comprise the global economy (Maglio and Spohrer 2008). The value creating system is thus viewed to be composed of systems of different types of interdependent and interacting service systems that are embedded in the service ecosystem at different levels of aggregation and connected through value propositions, and have the goal of providing input to the value creation processes of other service systems through service provision in order to directly or indirectly obtain reciprocal input (Vargo and Akaka 2009). Value in this context is viewed as the relative improvement in an individual service system, as determined by the system itself, or by its ability to adapt to its environment (Maglio et al. 2009) within the service ecosystem. Value creation is enabled through resource sharing and integration among service systems (Maglio and Spohrer 2008), and value is created through interactions among service systems and their resources, and is determined through experience that enables generation of new competences through feedback and learning (Vargo et al. 2010a, pp. 149-150; Vargo et al. 2010b, p. 151). Value creation within the service ecosystem can thus be viewed as a continuous process of resource and knowledge sharing, integration and generation that is largely influenced by culture, competences and context (Vargo et al. 2010a, p. 150).

According to Chandler and Vargo (2011) value creating interactions between service systems within the service ecosystem can be viewed to be bound by a context at different levels of aggregation. The context influences value co-creation processes through its influence on the availability and service systems' capability to integrate resources, but also through its influence on service provision. When different service systems are connected with one another through value co-creation processes, they essentially join their different value networks together and the newly joined service systems and their value networks, through their service-for-service exchange constitute a context where the individual service systems come to occupy unique positions, and from those positions draw on resources for service-for-service exchange, both directly and indirectly. In this way, the context of each service system affects its ability to directly access and apply resources, and also its ability to indirectly access and apply resources beyond its immediate context. In other words, service provision of each service system depends on its context and each instance of service provision, or each unique application of uniquely integrated resources, represents value creation in a particular, unique context that is enabled by direct and indirect access to various types of resources. Importantly, as resources are drawn upon for service provision across various contexts, each context provides conditions under which different resources will and will not be valuable. According to the contextual perspective on value creation, value co-creation efforts and processes of individual service systems can be viewed as a function of their embeddedness within various levels of contexts within the service ecosystem, ranging from individual, distinct value co-creation processes and direct service-for-service exchange among individual service systems to simultaneous, interdependent and interacting value co-creation processes and indirect service-for-service exchange among constellations of service systems, where synergies of multiple direct and indirect service-for-service exchanges enable service systems to provision service in a particular context by drawing on their combined resources and competences, and applying them for a beneficiary in a particular context. The context of value creation can be as important to the creation of value as the resources and competences of the participating service systems, and it is important to note that the context is not limited to the resources and competences of the directly and indirectly participating service systems, but also various environmental resources, such as social, ecological and governmental surroundings can be relevant in the value co-creation processes and contribute to the participating service systems' capability to create value, although controlling all the aspects of the environment, such as time, weather and laws, may not be possible (Vargo et al. 2010b, pp. 147-148). Thus, context can provide a useful concept for studying value creation at different levels of embedded contexts that frame value co-creation processes among service systems within service ecosystems, ranging from the unique context and perspective of each individual service system to the context and perspective of the service ecosystem (Chandler and Vargo 2011).

The S-D logic and service science represent a systemic perspective that is concerned with the study of complex systems as wholes that exhibit interdependencies between their individual parts, such that as a result of these interdependencies properties emerge at the level of the whole that are not present in the individual elements of the system, when examined independently of the whole (Ng et al. 2011, pp. 19-20). Furthermore, the S-D logic and service science imply management focus on effectiveness and efficiency within the wider context of value creation, extending outside the boundaries of the focal organization and its individual parts, in service ecosystems of interdependent service systems and their various resource constellations and associated contexts of value creation, and thus expands the management role beyond that traditionally associated with manufacturing and related management roles (Vargo and Akaka 2009). However, the shift from the G-D logic to the S-D logic and service science view on service and service systems does not imply abandoning the existing concepts and models, but the S-D logic should be viewed as a transcending concept (Vargo and Akaka 2009; Vargo et al. 2010a, p. 141; Vargo et al. 2010b, pp. 141-142) that is superordinate to the G-D logic and establishes a relationship in which the G-D logic is nested within the S-D logic, implying that the concepts and models of the G-D logic are relevant, but not as deep or broad as those of the S-D logic, thereby broadening the conceptual framework through which service related phenomena can be studied (Vargo et al. 2010a, p. 141; Vargo et al. 2010b, pp. 141-142).

This study adopts the S-D logic and service science view on the concepts of service and service systems and makes a contribution to better understanding the nature of decision making and requirements for decision support in complex service systems. The study builds on the idea that different types of contexts of value creation at different levels of aggregation within the service ecosystem represent different types of decision making contexts and their characteristics largely influence the nature of decision making processes and determine appropriate forms of decision support that are necessary to support and facilitate value creation processes within those contexts.

1.2 Research context

This study is related to the Ä-Logi, Intelligent Service Logic for Welfare Sector Services research project (Tekes 2013a). The project is part of the Tekes Social and Healthcare Services program (Tekes 2013b) and was conducted as a joint research project between Lappeenranta University of Technology and Tampere University of Technology, together with participating case organizations South Karelia Social and Health Care District (Eksote) and the City of Mikkeli (Mikkeli). The program has the vision to renew healthcare and social services and increase business opportunities through the objectives of development of innovative solutions and activities that are aimed to facilitate increased effectiveness and customer orientation, more extensive preventive actions and diversified partnership and cooperation among different public and private sector actors in the healthcare and social services ecosystem (Tekes 2013b). In line with the program objectives, one of the objectives of the Ä-Logi project was the development of intelligent Information Technology (IT) solutions for the support of healthcare and social service management that innovatively utilize data, information and knowledge management in order to improve resource utilization and management of service operations in the healthcare and social services ecosystem in general, and in the case organizations in particular.

The case organizations are part of the Finnish public healthcare and social services ecosystem (Ministry of Social Affairs and Health 2013) and can themselves be viewed as complex service systems, which are embedded in the wider healthcare and social services ecosystem, which is also itself a complex service system that is further embedded in the wider service ecosystem formed by the surrounding society. Eksote (Eksote 2013) is a municipal consortium that is responsible for public healthcare and social service provisioning on behalf of the participating municipalities in the South Karelia area, in Southern Finland. The consortium has nine participating municipalities; the cities of Lappeenranta and Imatra, and the municipalities of Lemi, Luumäki, Parikkala, Rautjärvi, Ruokolahti, Savitaipale and Taipalsaari; and it serves the approximate 130 000 people living in their area. The services provided can be divided into healthcare services, family and social welfare services and services for senior citizens. At the time of the study, in the participating municipalities, primary healthcare services were mainly provided by local health centers, while specialized secondary medical care was provided by the hospital district hospitals. Both the primary and secondary healthcare share common support units that have an essential role in facilitating various clinical healthcare activities. In Eksote, the project focused on healthcare service provisioning, primarily from the point of view of the laboratory and medical imaging support units. The city of Mikkeli (Mikkeli 2013) is a municipality in the area of Southern Savonia, in Eastern Finland, that similarly to Eksote provides various healthcare and social services for the approximately 45 000 people living in its area. In Mikkeli, the project focused on social service provisioning, primarily from the point of view of the paratransit service provided for severely disabled people. The purpose of the paratransit service is to ensure that people with severe disabilities have a reasonable public transportation service at their disposal with the individually incurred costs similar to those paid by other citizens. The service provides the necessary transportation and escort service for people with severe disabilities in order to facilitate their participation in the work, study, communal, social and recreational activities, or for any other reasons necessary for their daily life. The transportation service covers transportation within the limits of the municipality and in the area of the neighboring municipalities.

The Ä-Logi project primarily focused on the perceived challenges in the management of service operations in the case organizations and their focal units, including perceived challenges in decision making and decision support necessary for the planning, control and coordination of operational activities in order to ensure effective and efficient service provisioning from the point of view of the case organizations, their focal units, their customers, and also the wider service ecosystem. Depending on the chosen management perspective on the nature of service, service systems and value creation, the perceived challenges in the case organizations and their focal units can be viewed differently. From the traditional G-D logic perspective both Eksote and Mikkeli can be narrowly viewed as distributed production and transportation systems with a focus on efficient processing of people. The focal units in both case organizations involve multiple actors, or individual service system entities, operating in a distributed manner, separated both temporally and spatially, working in different locations and facilities, whose tasks and activities necessary for service provision are linked through systems of cross-functional processes, and the performance of those tasks and activities and necessary collaboration between individual actors are assisted through different technologies. In the case of Eksote focal units, the main input to the system are people with perceived health related problems and concerns, who are referred to the focal units through the primary and secondary healthcare processes, and are processed by the focal units in order to produce an output of information in the form of laboratory test results and medical imaging results that in turn are a necessary input to the various clinical healthcare processes in the primary and secondary healthcare levels. In the case of the Mikkeli focal unit, the main input to the system can be similarly viewed as disabled people in the need of a transportation service and the output can be viewed as a change in their location. From this perspective, in both case organizations and their focal units, the primary goal of service provision can be viewed as efficient processing of people as measured through incurred costs, and perceived challenges in the coordination of service operations can be viewed as related to the coordination of people, material and information flows between different service facilities, and their actors linked through cross-functional processes in order to ensure efficient service provision from each focal unit point of view. From the S-D logic perspective the purpose and goal of the focal units can be viewed differently. The focal units in both case organizations are part of a complex service system and a wider service ecosystem that is composed of a number of interdependent service system entities, scaling from the level of individual people, up to the level of the whole society, and they should have the purpose and goal of facilitating efficient and effective service provision within the context of the entire service ecosystem in collaboration with other service system entities. This requires understanding about the shared context of value creation and adaptive capacity to take into account the individual competences, capabilities and needs of other service system entities as they participate in the ongoing value creation processes in different shared contexts of value creation, at different levels of aggregation within the service ecosystem. Within the service ecosystem, effective service provision is a result from ongoing interactions and collaboration between a number of service system entities involved in the ongoing value co-creation processes and coordination of service operations requires understanding about the characteristics of the shared context of value creation, that builds on information and knowledge about the past and present interactions between individual service system entities within the context. This information and knowledge about the relevant context characteristics, its past and present state and likely future evolution also forms the basis for decision making in different contexts and the associated cross-functional and individual processes, and their tasks and activities necessary for value co-creation within the service ecosystem. However, it was discovered during the research that in the case organizations and their focal units making the necessary information and knowledge available for the decision makers was beyond the capabilities of the existing information technologies, namely the existing information systems, that currently support planning, control and coordination of tasks and activities within and between cross-functional and individual processes and their associated actors, but are more focused on supporting the performance of individual tasks and activities and are rather hiding the wider shared context of value creation within the service ecosystem from the decision makers than making it visible.

1.3 Research process and objectives

A central part of the Ä-Logi research project was the development and evaluation of a new type of Decision Support System (DSS) design concept that is especially aimed for supporting decision making and collaboration related to the operational level tasks and activities in the case organizations and their focal units. The developed DSS design concept combines traditional data, model and knowledge based DSS concepts (Power 2002, p. 13), aimed primarily for supporting rational decision making processes (French et al. 2009, p. 353), with visualization of the relevant shared context of value creation and its dynamics, in order to enable the users to form an understanding about the operational environment and support their naturalistic decision making processes (Orasanu and Connolly 1993; Zsambok 1997; Lipshitz et al. 2001; Klein 2008) in a dynamic operational environment by helping them acquire and maintain an up to date situation awareness (Endsley 1995) about the relevant context. Furthermore, the DSS design concept is intended to enable collecting data about the present patterns of activities and the evolution of those patterns to facilitate continuous feedback and learning and generation of new knowledge about the system and its various contexts. The underlying principle of the developed DSS design concept is introduced in Figure 1.

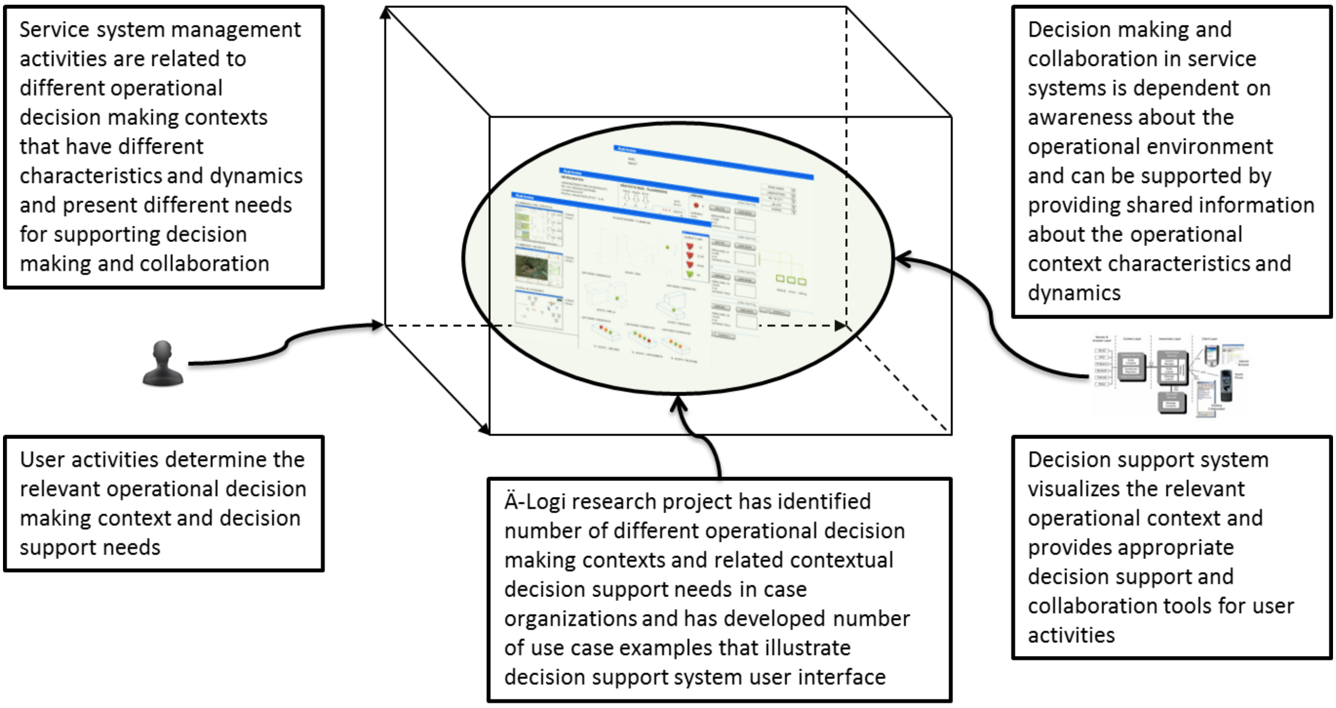

Figure 1. Ä-Logi decision support system design concept overview

The developed DSS design concept builds on the idea that there are a number of different types of shared contexts of value creation within complex service systems, where user decision making and collaboration requirements are determined by the context characteristics and the interdependent user tasks and activities performed within and across those contexts. The context related decision making and collaboration requirements determine user decision support needs and suggest appropriate forms of decision support. Traditional data, model and knowledge based DSSs focus on development of models and exploitation of explicit knowledge to support decision making in well understood contexts and their relatively independent tasks and activities. Based on the observations and analysis of the working practices in the case organizations and their focal units and the their perceived decision making and collaboration related challenges, decision support in many operational context, however, requires support for exploration of the context characteristics and the constantly evolving dynamics between different interrelated tasks and activities and context elements in order build tacit knowledge and understanding about the context and its past, present and likely future state. This requires different types of solutions compared to the traditional data, model and knowledge based DSSs. The developed DSS design concept addresses these perceived challenges through visualization of cognitively complex contexts with an aim to make the context characteristics and dynamics between different interrelated tasks and activities and context elements visible to the users, thereby supporting their learning and understanding about the relevant context of work and providing basis for decision making and effective and adaptive performance of interdependent tasks and activities in a dynamic environment. In addition to the visualizations, the DSS design concept combines appropriate data and model based DSS tools to the visualization models and provides the users with appropriate collaboration tools.

1.3.1 Research process

The DSS design concept development process can be viewed as one of the main activities during the Ä-Logi research project. Its results provide the motivation for this study, and can potentially provide basis for further research. The overall Ä-Logi research process, together with the research process of this study and potential further research is presented in Figure 2.

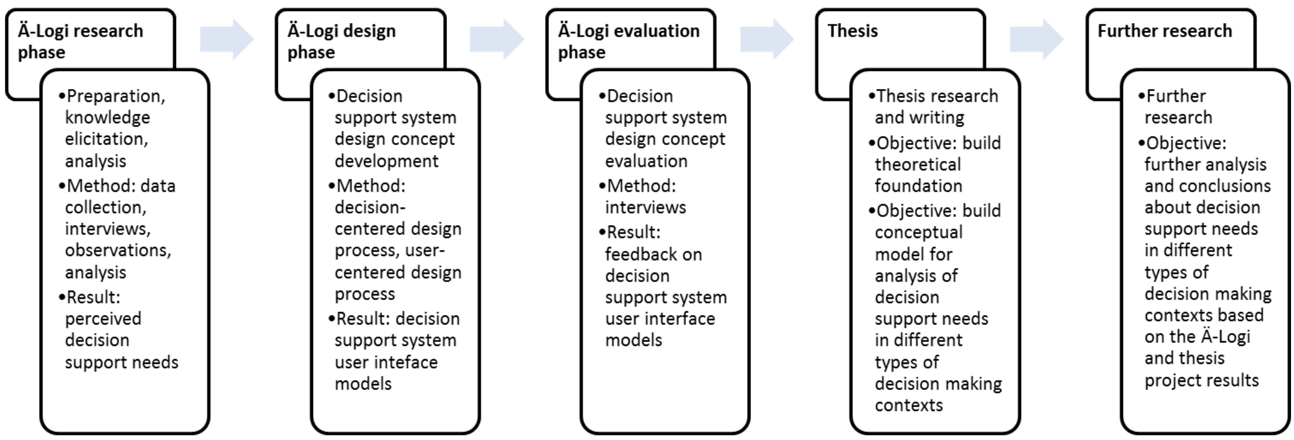

Figure 2. Research process overview

The Ä-Logi research process has similarities to the Cognitive Systems Engineering (CSE) approach to systems design (Hollnagel and Woods 1983; Rasmussen et al. 1994; Hoffman et al. 2002), a multidisciplinary systems design methodology that builds on a combination of cognitive science, human factors engineering and systems engineering knowledge in order to develop systems that can support a wide variety of cognitively demanding tasks and activities in different domains and have potential to improve decision making by speeding up decisions and making them more accurate and more adaptive, and by helping to take into account the characteristics of the performed tasks and activities and the relevant context (Crandall et al. 2006, pp. 173-174). There are a variety of CSE methodologies, including the Decision-Centered Design (DCD) process (Crandall et al. 173-181) and the User-Centered Design (UCD) process (Endsley and Jones 2012, pp. 43-59) methodologies. It is common for the CSE methodologies that they build on some form of Cognitive Task Analysis (CTA) that has the purpose of capturing human cognitive requirements of the work in the cognitively demanding tasks and activities within the relevant context (Crandall et al. 2006, pp. 2-3). According to Crandall et al. (2006, p. 10) a CTA study is usually trying to understand and describe how the participants view the work they are doing and how they make sense of the events within the context of their work. If they are managing complex circumstances well and are taking effective actions, the CTA should describe the basis of their skilled performance. If their performance has deficiencies and they are making mistakes, the CTA should explain what accounts for the deficiencies and mistakes. It is characteristic for CTA studies to try to capture what people are thinking about, what they are paying attention to, the strategies they are using to make decisions or detect problems, what they are trying to accomplish and what they know about the way the system works. A CTA study is essentially attempting to capture the tacit knowledge that experienced participants have about the domain and their tasks and activities within the relevant context, and typically includes three primary phases called knowledge elicitation, data analysis and knowledge representation. Knowledge elicitation phase uses a set of methods to obtain information about what people know and how they know it, including the judgments, strategies, knowledge and skills that underlie their performance (Crandall et al. 2006, p. 11). The following data analysis and knowledge representation phases focus on the critical tasks of structuring and displaying obtained data, identifying and presenting findings, and discovering and communicating their meaning (Crandall et al. 2006, p. 26) in order to make the CTA study results a useful input to the systems design process. The resulting knowledge about the cognitive requirements of the work is incorporated in the systems design process for the purpose of designing, developing and evaluating new technologies that are intended to amplify and extend human ability to make sense about the events in the relevant context of their work and improve their decision making ability and decision quality in cognitively demanding tasks and activities (Crandall et al. 2006, pp. 173-174). The Ä-Logi research process phases and activities can be mapped to the phases and activities of the DCD and UCD processes, but it is also possible to identify some limitations in the research process. The phases and activities of the Ä-Logi research process and their main results and potential limitations are discussed in the following. A detailed analysis of the research process is, however, outside the scope of this study.

The Ä-Logi research phase activities can be viewed as corresponding to performing a CTA in the case organizations. Performed activities are similar to the DCD methodology preparation, knowledge elicitation and analysis phase activities (Crandall et al. 2006, pp. 180-181). First, the preparation phase focused on understanding the domain of case organizations, including the role of the case organizations and their focal units in the wider service ecosystem, and their processes, tasks and activities, with a purpose of identifying potentially cognitively complex contexts and their tasks and activities, and the relevant Subject Matter Experts (SMEs) involved in performing those tasks and activities within the case organizations. Second, the knowledge elicitation phase focused on understanding the cognitively complex contexts and their tasks and activities, and identifying critical decisions and team structure and collaboration related requirements necessary for their effective and efficient performance. Followed methodology was based on observations of work in the case organizations and a series of structured interviews that were conducted with the selected SMEs in the case organizations. Finally, the analysis phase focused on identifying the central issues and themes related to the effective and efficient performance of tasks and activities in variety of contexts within the case organizations and individual SME decision making and collaboration requirements and related decision support needs. Performed analysis was based mainly on the analysis of the conducted interviews and on the accumulated tacit knowledge and partially subjective judgment of the researchers. In deviation from the more formal CTA methodologies, the identified decision making and collaboration requirements and related decision support needs were not systematically described and documented during the research project. Instead, the identified requirements were directly applied during the following systems design phase, which was conducted partially concurrently with the requirements analysis. Although the taken approach was deemed sufficient during the research project, it may potentially leave the results vulnerable to scrutiny about the validity and traceability of the identified individual requirements and has later proved to be an impediment in using the research project results as a basis for further research regarding the decision making and collaboration requirements and related decision support needs in the case organizations and in complex service systems in general.

The Ä-Logi design phase can be viewed as corresponding to the DCD methodology application design phase (Crandall et al. 2006, pp. 180-181) and the UCD methodology user interface design process, except for the test and evaluation phase (Endsley and Jones 2012, pp. 45-56). Purpose of the design phase was to develop a prototype DSS design concept based on the identified decision making and collaboration requirements and related decision support needs. The developed design concept consists of a set of static DSS user interface prototypes that depict the system operation in a variety of relevant case organization operational contexts. The design concept depicts user interface prototypes on a variety of different user devices, including tablet computers, mobile phones and computer displays, following a design philosophy to make the necessary decision support tools seamlessly available to the users on a variety of different devices in order to better address the individual requirements of their work. There are potential limitations in utilizing the design phase results as a basis for further research. First, the developed design concept functionality was represented only in terms of static images, which capture some aspects of the relevant operational context and its tasks and activities, but cannot fully depict the dynamics between the different interdependent tasks and activities and elements within the context, nor the evolution of the context state over time. Furthermore, human factors design guidelines were not meticulously followed during the user interface prototype development. Due to the limitations, it may not be possible to fully establish the effectiveness of the presented solutions in supporting user cognitive requirements, nor is there basis for fully evaluating impacts on the existing working practices within the case organizations (Endsley and Jones 2012, pp. 49-50).

The Ä-Logi testing phase can be viewed as corresponding to the DCD methodology evaluation phase (Crandall et al. 2006, pp. 180-181) and the UCD methodology test and evaluation phase (Endsley and Jones 2012, pp. 56-58). Purpose of the testing phase was to evaluate whether the developed prototype DSS design concept supports user decision making and collaboration requirements and fulfills their decision support needs within the various relevant contexts of their work. The phase was also intended to provide feedback for possible further research and experimental systems development on possible redesign needs necessary to address user perceived problems and to improve the level of decision support provided.

Testing phase methodology was based on structured interviews with the case organizations SMEs, which utilized the developed static DSS user interface prototype images that were presented to the SMEs to obtain their feedback. During the interviews, a set of relevant user interface prototype images was presented to the individual SMEs and their purpose and intended functionality was described by the researchers, the individual SMEs were then asked to provide their subjective opinion on whether they perceived the displayed design concept to be useful or not in the context of their work. Testing phase corresponds to subjective evaluation of design concepts (Endsley and Jones 2012, pp. 56-57), which can be a useful approach for identifying potential problems and redesign needs in the developed design concepts early on during a systems development project, but has the inherent limitation that without an opportunity to experience the working system the ability of the prospective users to give a realistic assessment on the usefulness of the design concepts may be very limited. Furthermore, many potential problems in the design concepts that can critically affect human performance may not be obvious to the users, leading to performance and workload issues (Endsley and Jones 2012, p. 57). A more comprehensive testing with a working system prototype would therefore be necessary to establish the potential effectiveness of the presented solutions to support user cognitive requirements and to evaluate their impacts on the existing working practices.

Despite the perceived limitations in the Ä-Logi research process, the project results and material can potentially provide basis for further research in terms of systematically describing and analyzing the developed DSS design concepts, preliminarily evaluating the potential problems and redesign needs in the design concepts, and their effects on the management of service operations in the case organizations, including their effects on the current decision making and collaboration practices and performance of value creating activities within various contexts of value creation in the case organizations. This can provide basis for identifying a subset of design concepts that would be the most potential subjects for an experimental systems development effort and further research. A lack of theoretical understanding and a suitable conceptual framework that would describe the nature of decision making and requirements for decision support in complex service systems has, however, proven to make the analysis, description and evaluation of the developed design concepts and their effects in the case organizations difficult. Due to the Ä-Logi research process primary focus on the design concept development and evaluation, the partially subjective judgment applied to identify the decision support needs and appropriate decision support solutions, and limitations in the available time and resources during the research process, only little effort was taken to build an understanding and a theoretical framework that would explain the studied phenomena. Therefore, a better theoretical understanding and a conceptual framework explaining the nature of decision making and requirements for decision support in complex service systems is required to allow better using the project results and material as a basis for further research and systems development.

1.3.2 Research objectives

This study addresses the perceived lack of theoretical understanding and a conceptual framework regarding the nature of decision making and requirements for decision support in complex service systems. A conceptual model is built based on literature that characterizes different types of decision making contexts within complex service systems and suggests that the nature of decision making processes and appropriate forms of decision support within different types of decision making contexts are dependent on both the inherent characteristics of the context and the knowledge pertaining to the context, possessed by the actors participating in the value creating activities within the context. The literature review and the conceptual model building are guided by the following research questions:

- What are the characteristics of complex service systems and what are their implications for decision making and decision support?
- What are the characteristics of different types of decision making contexts within complex service systems and what are their implications for decision making and decision support?
- What are the characteristics of different types of decision making processes within different types of decision making contexts within complex service systems and what are their requirements for decision support?

The goal of this study is that the developed conceptual model will enable further research based on the Ä-Logi research project results and material, by supporting the further analysis, description and evaluation of the developed DSS design concepts, and possible systems development. An analysis, description and evaluation of the developed design concepts, and possible system development are, however, outside the scope of this study.

1.4 Report structure

This study develops a conceptual model of decision making and decision support in service systems, based on literature. The report is divided into three main parts that are represented in Figure 3.

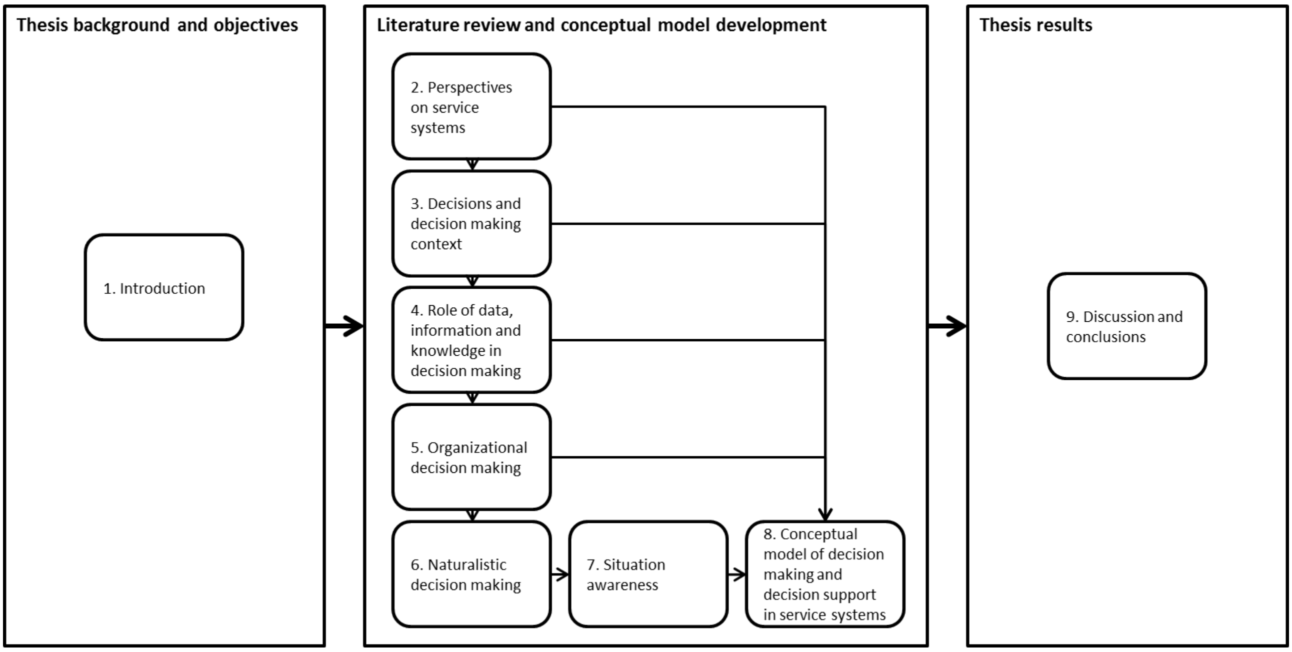

Figure 3. Report structure

Chapter 1 introduces the background and objectives of the study, providing the basis for the literature review and conceptual model development. The following chapters 2 through 8 focus on the literature review and conceptual model development, based on a synthesis of a variety of different complementary and interrelated theoretical backgrounds. Finally, the main results of the study are summarized, a further research and development process is proposed, and the conclusions of the study are presented in chapter 9.

2. Perspectives on service systems

Service science is viewed as a specialization of systems science that attempts to explain value co-creation in complex service systems (Maglio et al. 2009; Spohrer and Maglio 2010a, pp. 6-8). Complex service systems can be viewed as a type of hierarchical complex systems (Simon 1962) that, similarly to the concept of service, can be viewed from multiple complementary perspectives that focus on different aspects of the value co-creation phenomenon and view the individual components and subsystems of the system and their interactions through different concepts, each perspective offering different implications for the management of service operations, decision making and decision support within different types of value co-creation contexts at different levels of aggregation within the system. It is suggested that integration of a number of perspectives and understanding their mutual implications for the management of service operations is necessary to understand the nature and requirements of decision making and decision support within complex service systems. However, although a number of complementary models of complex service systems, based on various theoretical backgrounds, have been proposed in literature, there appears to have been little effort to integrate the different perspectives and explore their mutual implications for the management of service operations. In this study complex service systems are viewed from three distinct perspectives that build on different theoretical backgrounds, but are suggested to be interrelated, each offering complementary implications for the management of service operations. First, the service ecosystem perspective is based on the Service-Dominant (S-D) logic (Vargo and Lusch 2004a; Vargo and Lusch 2006; Lusch and Vargo 2006; Vargo and Lusch 2008; Vargo et al. 2010a) and service science (Spohrer et al. 2007; Maglio and Spohrer 2008; Spohrer and Maglio 2008; Maglio et al. 2009; Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011) view on the complex service systems as service ecosystems (Vargo and Akaka 2009; Vargo et al. 2010a; Vargo et al. 2010b; Lusch et al. 2010) or service ecologies (Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011) that represent value networks of service system entities, where value is co-created through interactions between different types of service system entities (Spohrer and Maglio 2010a). The term service ecosystem is adopted in this study. This perspective represents a systemic view (Ng et al. 2011, pp. 19-20) on complex service systems that captures the nature of complex service systems as complex adaptive systems (Plsek and Greenhalg 2001). Second, the production system perspective is based on the Goods-Dominant (G-D) logic (Vargo and Lusch 2004a; Lusch et al. 2008; Vargo et al. 2010a, pp. 127-129) or manufacturing logic (Normann 2001, pp. 15-25) view on the complex service systems. This perspective represents a reductionist view (Ng et al. 2011, pp. 17-19) on complex service systems that describes complex service systems as systems of processes that conceptualize the various interactions and activities necessary for value co-creation within and between different types of service system entities, providing basis for the necessary planning, control and coordination according to the principles of operations management (for example, Slack et al. 2010; Krajewski et al. 2010). Finally, the work system perspective views complex service systems as socio-technical systems (Trist 1981; Mumford 2000; Mumford 2006; Baxter and Somerville 2011) that are composed of work systems (Alter 2002; Alter 2008; Alter 2010; Alter 2011) embedded within the service ecosystem and building around the production systems' processes, enacting the activities necessary for value co-creation. The different perspectives and their perceived implications for the management of service operations are first discussed and then an integrated model of the different perspectives is proposed, that will provide the basis for studying the nature of decision making and requirements for decision support within various types of value co-creation contexts within complex service systems.

2.1 Service ecosystem perspective

The service ecosystem (Vargo and Akaka 2009; Vargo et al. 2010a; Vargo et al. 2010b; Lusch et al. 2010) or service ecology (Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011) perspective represents a systemic view (Ng et al. 2011, pp. 19-20) to the complex service systems. The basic characteristics of complex service systems and the systemic nature of value co-creation are captured in the definition of service systems as dynamic value co-creation configurations of resources, including people, other internal and external service systems, shared information and technologies, all connected together with other service systems through value propositions (Spohrer et al. 2007; Maglio and Spohrer 2008; Maglio et al. 2009) that evolve complex structure and interactions patterns between individual service systems, together forming a service ecosystem, which is viewed as a population of service systems that, as a whole are better off working together than working alone (Spohrer and Maglio 2010a, pp. 8-10; Spohrer and Maglio 2010b, p. 174). A service ecosystem model building on these characteristics has been proposed by Spohrer and Maglio (2010a) that introduces a number of foundational concepts and provides an overview about the systemic nature of value co-creation within complex service systems. The service ecosystem model is represented in Figure 4.

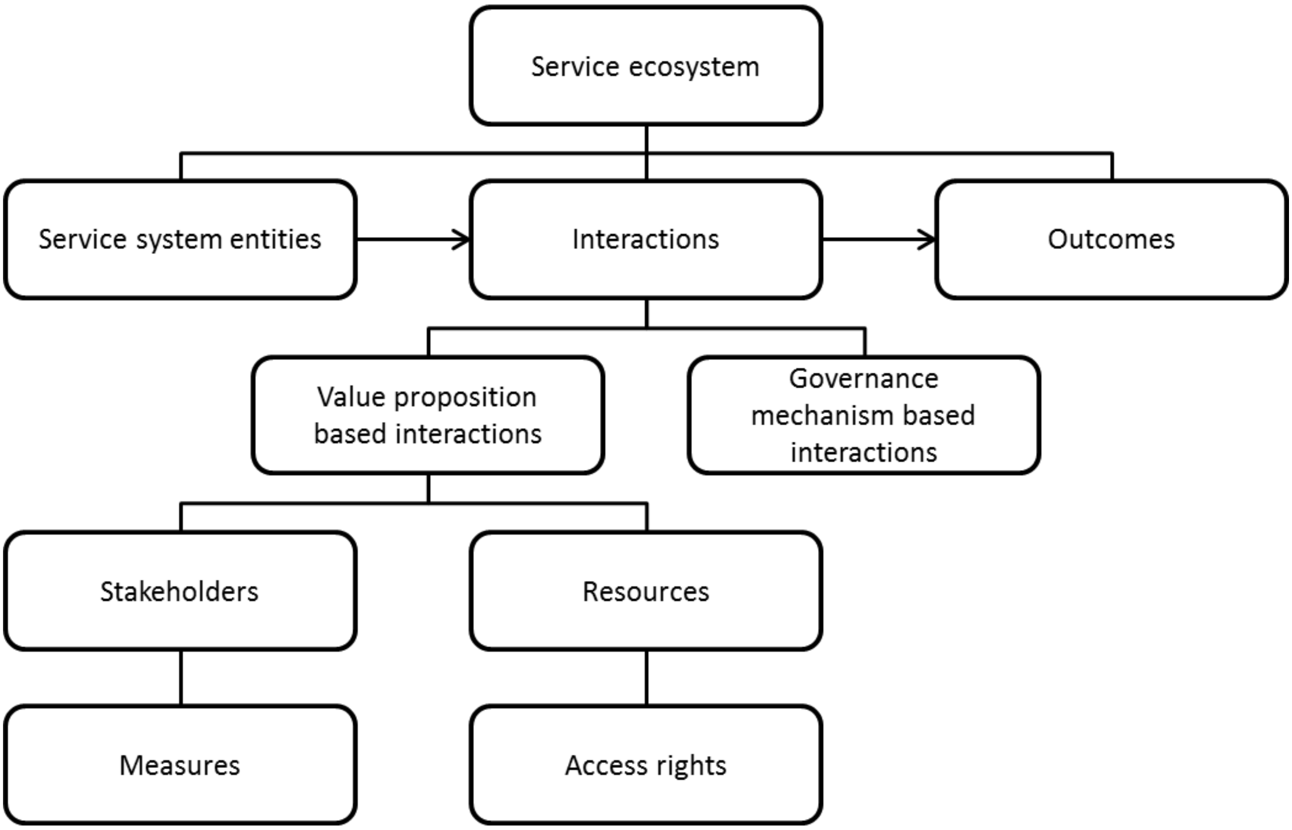

Figure 4. Service ecosystem foundational concepts (adapted from Spohrer and Maglio 2010a, p. 14)

Service ecosystem represents the highest level of aggregation and is viewed as the population of all the different types of service system entities that interact over time to co-creation outcomes. Types of service system entities that interact to co-creation value include both individual entities, such as people, and collective entities, such as organizations. Service ecosystem and its service system entities are path dependent and are conditioned by their history that is the trace of all the outcomes over time for all entities that interact. (Spohrer and Maglio 2010, p. 9)

Service system entities are viewed as dynamic configurations of resources, including people, organizations, shared information and technology (Spohrer et al. 2007; Maglio and Spohrer 2008; Maglio et al. 2009). There are a number of ways to combine these resources into various value co-creation configurations, and associated value co-creation contexts (Vargo and Akaka 2009; Chandler and Vargo 2011). All service system entities have at least one focal resource that has access, either directly or indirectly, to all the other resources in its configuration. In formal service system entities, such as organizations, the focal resource is typically a person or a group of people in some authoritative or formal role relative to the other resources. In informal service system entities, such as people, the focal resource can simply be an individual person or a group of people with shared interests or a shared idea. (Spohrer and Maglio 2010a, p. 9)

Interactions and their recurring patterns between both individual and collective service system entities lead to the development of value networks of service system entities. The interactions take place among different types of service system entities over time, and recurring and recognizable patterns of interactions within service system value networks may form over time that can be conceptualized as business models. An example of a simple service system value network is a customer and a provider connected by a single value proposition. More complex service system value networks include multiple customers, providers, authorities and competitors, as well as a myriad of value propositions that connect these entities and other stakeholders within the service ecosystem. (Spohrer and Maglio 2010a, p. 9)

Interactions produce value-creating outcomes and their normative goal is value co-creation for all entities participating in the interactions (Spohrer and Maglio 2010a, p. 9). Value in this context can be viewed as the relative improvement in a service system entity, as determined by the entity itself, or by its ability to adapt to its environment (Maglio et al. 2009).

Interactions can be further divided into value proposition-based interactions and governance mechanism-based interactions. Value proposition-based interactions are value co-creation interactions among service system entities based on their value propositions, which are reasoned about and refined through trial and error and other mechanisms, such as feedback and learning that provide the basis for the generation of new operant resources (Constantin and Lusch 1994), such as knowledge and skills that can be applied during future interactions. Value determination is entity-dependent, history-dependent and context-dependent, and a good value proposition connects two service system entities in a mutually reinforcing manner, creating measurable outcomes as interactions occur over time. Governance mechanism-based interactions are value co-creation interactions that are often invoked by authorities as a remedy when value is not being created as mutually agreed, or when service system entities interact in non-normative ways. Authorities can use coercion in the governance of value proposition-based interactions. Within the context of value co-creation interactions all service system entities can view themselves and can be viewed by others from multiple stakeholder perspectives, including the customer, provider, authority and competitor perspectives. (Spohrer and Maglio 2010a, pp. 9-10)

Measures, such as various Key Performance Indicators (KPIs) can be developed to measure both the efficiency and effectiveness of the value co-creation interactions from different stakeholder perspectives. The four essential types of measures include quality (customer determines), productivity (provider determines), compliance (authority determines) and sustainable innovation (competitor determines). From the perspective of the service ecosystem value co-creation can occur when the KPIs of two or more service system entities become linked in ways that improve their KPIs together. Estimating the quantitative and qualitative values of KPIs and communicating these measures to others can therefore be viewed as fundamental competence of service system entities. (Spohrer and Maglio 2010a, p. 10)

Resources can be divided into four general types: physical with rights (such as people), physical with no rights (such as technology and environment), non-physical with rights (such as organizations, municipalities, governments and nations) and non-physical with no rights (such as information). Resources have a lifecycle and they may change and evolve during their lifecycle. All non-physical resources can be viewed to exist as localized or distributed patters in the physical states of physical resources and can be subject to coding errors, such as different interpretations of information due to different perceptions by the different stakeholders. The possible states of a resource are determined by a variety of a resource, and when two resources interact the variety can either increase of decrease depending on the nature of the interaction. (Spohrer and Maglio 2010a, p. 10)

Resources have access rights associated with them that determine a service system entity's capability to access and integrate them in their value co-creation processes, and the associated value co-creation context. A resource can be owned by an entity, be leased or contracted by an entity, have shared access among a number of entities or have privileged access limited to a specific entity alone. (Spohrer and Maglio 2010a, p. 10)

Although the service ecosystem model provides a set of foundational concepts and an overview of the systemic nature of value co-creation within complex service systems, the model alone offers little implications for the management of service operations and the nature of decision making and requirements for decision support within complex service systems. It is additionally necessary to understand the underlying principles that govern the interactions between service system entities and the behavior of the system. Service ecosystems are commonly identified as complex adaptive systems (Plsek and Greenhalg 2001) in the service science literature (Spohrer et al. 2007; Maglio et al. 2009; Spohrer et al. 2011) and their characteristics as complex adaptive systems are a source of a number of implications for the management of service operations. Complexity theory has gained attention in a number of fields, including organizational science, as an alternative to the traditional management thinking rooted on the principles of reductionism and a machine metaphor for an organization, based on the assumption that work and organizations can be thoroughly planned, broken down in units and optimized (Waldrop 1992). Similar principles are also viewed applicable for better understanding the interactions and behavior of the service system entities within the service ecosystem and the service ecosystem as a whole.

According to Plsek and Greenhalg (2001) complex adaptive systems are collections of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that actions of one agent change the context for other agents. Reflecting on the service ecosystem model, the agents can be viewed to correspond to different types of service system entities acting in different roles within different contexts of value creation at different levels of aggregation within the service ecosystem, whose interactions co-create value creating outcomes and in doing so shape each other's contexts. While the mechanical systems have fixed and well-defined boundaries, complex adaptive systems are different in that they typically have fuzzy boundaries, their memberships can change, and individual agents can simultaneously be members of several systems, acting in different roles. This often leads to unexpected behavior at the level of both individual agents and the system and complicates problem solving and decision making. In complex adaptive systems, individual agents respond to their environment using internalized sets of rules that drive their behavior, and in different types of systems, the sets of rules can be fundamentally different. For example, in biochemical systems, the rules are a series of biochemical reactions, but in social systems the rules can be expressed as instincts, constructs and mental models that drive the human behavior. These internal rules need not be shared, explicit, or even logical from the point of view of another individual agent or system, nor are the sets of rules fixed, but the rules may adapt and evolve over time, in response to varying situations encountered by the agents, and the changes in their mental models that shape their perception of their context. It is characteristic for complex adaptive systems that they are embedded within other systems, forming nested structures of individual agents and systems, where the evolution of one system influences and is influenced by that of other systems through changes in their relations and interaction patterns within a shared context. Since each individual agent and system is nested with other systems, all interacting and co-evolving, any of the individual agents or systems cannot be understood without reference to the others. Interactions among the individual agents and systems lead to tension and paradox that can never be fully resolved, but are inherent in complex adaptive systems. For example, in social systems, the seemingly opposing forces of competition and cooperation often work together in positive ways; competition within an industry can improve the collective performance of the participants. The overall behavior of a complex adaptive system as a whole emerges from the interactions among individual agents and systems, and the observable outcomes are more than merely the sum of the individual parts, often including elements of surprise, creativity and emergent phenomena that cannot be fully accounted for by the reductionist thinking, with a strict focus on the individual parts. Another important characteristic of complex adaptive systems is their non-linear behavior that is exhibited as large differences in the observed outcomes, when there are only small differences in the initial conditions between two similar situations. Because the individual agents and systems of a complex adaptive system are adaptive and co-evolve, their relationships are non-linear, their behavior emergent and sensitive to small changes in initial conditions, the detailed behavior of any complex adaptive system is fundamentally unpredictable over time. Therefore, the only way to know exactly how a complex adaptive system will behave in a particular situation and how its behavior will evolve over time is to observe the behavior of the system. Better understanding the behavior of a complex adaptive system is thus not a question of better understanding its individual agents and systems, of better models of the system or of more analysis. Despite the inherent lack of detailed predictability, it is often possible to detect overall patters in the behavior of a complex adaptive system that allow making generally true and practically useful statements about the behavior of the system. Although predicting the detailed occurrence of events within the system and their outcomes may not be possible, this detailed information is not necessarily needed to identify and deal with problems, instead the emerging patterns of behavior can be a valuable source of information for the management. The behavior of a complex adaptive system is often governed by special types of patterns, called attractors, that can provide a comparatively simple understanding of what first seems to be extremely complex behavior, and relatively simple attractors can alter the behavior of the system. Finally, it is characteristic for complex adaptive systems that their behavior is self-organizing through locally applied rules by the individual agents and systems interacting in a shared context, allowing order, innovation and progress to emerge naturally from the interactions among individual agents and systems, without a need for centrally or outside imposed order or rules. There is thus often no need for centralized detailed planning, control and coordination of every aspect of the system, but both the individual agents and systems themselves are able to behave adaptively in varying situations and perform various activities associated with their different roles in different contexts at different levels of aggregation within the service ecosystem.

2.2 Production system perspective

The production system perspective represents a reductionist view (Ng et al. 2011, pp. 17-19) to the complex service systems and builds on the foundation provided by the operations management (for example, Slack et al. 2010; Krajewski et al. 2010). Operations management can be defined as the activity of managing resources that are necessary for value creating activities within various types of organizations (Slack et al. 2010, p. 4), including complex service systems. Processes and the input-transformation-output model are central concepts in operations management and different types of production systems are commonly modeled as systems of interlinked and interdependent processes (Slack et al. 2010, pp. 11-17; Krajewski et al. 2010, pp. 25-27; Lillrank 2010, pp. 338-344; Lillrank et al. 2011), with similar principles also applied to the design, management and improvement of service systems (Lillrank 2010, p. 339; Lillrank et al. 2011). Processes and the input-transformation-output model are viewed as providing the necessary means to conceptualize value creating activities within production systems and link them together into value creating systems. Together they provide a structure that enables the necessary planning, control and coordination of various interlinked and interdependent value creating activities within a production system (Slack et al. 2010, pp. 270-272; Lillrank 2010, p. 338; Lillrank et al. 2011).

Not all the production systems and their processes, however, are the same, but their individual characteristics have different implications for the management of service operations. The differences between different types of production systems and their processes, and their implications for the management of service operations, are captured by the Unified Service Theory (UST) (Sampson and Froehle 2006; Sampson 2010a; Sampson 2010b). The UST builds on the foundation and concepts provided by the operations management (Sampson 2010a, pp. 35-41; Sampson 2010b, pp. 111-119). According to the UST, complex service systems can be viewed as production systems that are composed of service and non-service processes and it is inherent in this view that common operations management techniques and methods are generally applicable to the management of service operations, but it is additionally necessary to take into account the unique characteristics of service processes and their implications for the management (Sampson and Froehle 2006; Sampson 2010a, pp. 35-36; Sampson 2010b, pp. 111-113). The foundational core of the UST is that with service processes, the customer provides significant inputs to the production process, and the presence of customer inputs is both a necessary and a sufficient condition to define a production process as a service process (Sampson and Froehle 2006). This distinction between service and non-service processes due to customer inputs is viewed to be the main source of implications for the management (Sampson and Froehle 2006), and based on this distinction the main managerial significance of the UST is suggested to be that processes involving customer inputs possess concerns similar to one another, but involve different concerns from processes not dependent upon customer inputs (Sampson et al. 2010).

In the context of UST, production processes are viewed as sequences of steps, or productive tasks and activities, that provide value propositions and therefore warrant compensation; inputs are viewed as resources that come into a production process and are used by the process to produce some benefit; and customers are viewed as individual or collective entities that determine if the organization shall be compensated for production, being either direct beneficiaries of the service provision, or decision makers (Sampson 2010b, p. 113) that seek to indirectly benefit from the service provision and may control service provision through a defined policy for different types service provision, such as the public policy for the provision of health care and social services. According to the input-transformation-output model, inputs are necessary components for a specific unit of production (Slack et al. 2010, pp. 11-14) and depending on the nature of the production process can include both customer input and non-customer input components (Sampson and Froehle 2006; Sampson 2010a, pp. 35-37; Sampson 2010b, pp. 111-115; Lillrank 2010, pp. 346-347) in different proportions. Customers can provide a variety of different types of input components to a production process (Sampson and Froehle 2006; Sampson 2010a, pp. 36-37; Lillrank pp. 346-347; Wemmerlöv 1990). According to Wemmerlöv (1990) the three general types of customer input components that have been commonly distinguished in literature are: the customer's self, customer's belongings or other tangible objects and customer's information. In each of the three cases the customer input components are viewed to be transformed by the process, together with any other necessary input components, into an output that provides benefit to the customer (Sampson 2010a, pp. 36-37).

According to Lillrank (2010, pp. 346-348) customer participation and their influences in a production process are determined through customer inputs and customer involvement. Customer inputs in a service process are proposed to generally take three forms: a signal, such as a due date for a regular service provision event; scripted behavior, such as selecting from a set of predefined alternatives of service provision following established rules; or negotiations, such as reaching a mutual agreement on a service provision event. Customer involvement is viewed to correspond to the three general types of customer input components proposed by Wemmerlöv (1990). An important implication of customer's personal involvement in a service process is that they can provide new or different input components to the service process during service provision (Lillrank 2010, p. 347) requiring that the service process has the necessary capacity to adapt to the changes in the customer input components that can vary in both quality and quantity. This is consistent with the view that service systems and their service processes are open systems (Fitzsimmons and Fitzsimmons 2006, pp. 29-32) that cannot close their boundaries from relevant additional inputs, but are subject to unexpected inputs that may necessitate changes in the process (Lillrank 2010, p. 347). The different customer input and involvement permutations can thus create varying situations of interaction between producers and customers, which differ in terms of how the involved parties are informed about and influenced by each other's activities (Lillrank 2010, p. 347).

An important concept related to the customer inputs and the UST is customer intensity, which recognizes that different customer input components can impact the production process to different degrees (Sampson 2010a, pp. 38-40; Sampson 2010b, p. 116). Customer intensity is viewed as the degree to which variation in customer input components causes variation in the production process (Sampson 2010a, p. 38), which is often perceived to translate into increased costs and to cause increased complexity in the management of service operations (Sampson 2010b, p. 116), implying that high levels of customer intensity are generally undesirable. A number of different types of variations can be associated with the customer input components, including the timing of their provision, the condition of the inputs, the degree to which the inputs need to be improved and the degree of customer involvement during the production process (Sampson 2010b, p. 116). Although the degree of customer intensity can have a number of potential implications for the management of service operations, its main implication is viewed to be its influence on the variability of the production process and the related requirements to manage customer influences on the ability to produce (Sampson 2010b, pp. 116-119). While non-service processes, such as traditional manufacturing processes, can be managed for maximum operational efficiency, utilizing high levels of division of labor, high amounts of repetition and relying on significant learning curve effects, service processes represent a different challenge for management, because they can vary from one unit of production to the next when customer inputs vary from one customer to the next (Sampson 2010a, pp. 39-49), effectively limiting the potential for operational efficiency (Chase 1981). Since the presence of customer inputs and interactions in service processes implies unavoidable and often uncontrollable variation, management of service operations should instead focus on ensuring that service systems and their service processes are sufficiently robust, and can function efficiently and effectively despite customer induced variability (Sampson 2010, p. 41), implying that both the service systems and the service processes should possess sufficient adaptive capacity to enable them to adapt to the variations in the input components between individual input cases and co-evolve following the changes in the shared context of value creation.

According to Sampson (2010, pp. 115-116) another important aspect of the UST is realizing that processes rarely occur in isolation, but rather exist in different types of production systems wherein each process is linked with and feeds other processes. Production systems can include pure service process configurations and pure non-service process configurations, but most production systems are hybrids in a sense that they contain both service processes and non-service process configurations and require that each configuration types and their interactions should be managed accordingly. Complex service systems are thus viewed as production systems that are composed of different types of production processes, including both service and non-service processes, at different levels of aggregation, that through their direct and indirect interactions with customers and each other within a shared context of value creation are linked into constellations of different types of processes that together contribute inputs to the customers' and each other's value creation processes through service provision.

Customer interactions with the service system and their input and involvement are not necessarily limited to a single service process within the service system, but customer's value creation process may include a number of interactions with the service system and its various service processes at various points in time and space, that may also exert indirect influences on the associated non-service processes. These interactions can be conceptualized as customer episodes (Lillrank 2010, pp. 353-355; Lillrank et al. 2011). Customer episodes describe the sequence of customer activities (Lillrank 2010, p. 353) as they interact with the service system and its various service processes through their input and involvement. Episodes can either be perceived to be random, or they can follow explicit or implicit scripts and established rules, based on knowledge and understanding, and expectations and preferences (Araujo and Spring 2006). The situations where a service system and its service processes and an episode intersect are called service events (Lillrank 2010, p. 354), or service encounters (Bitner 1990). Service events provide inputs to the customer's value creation process through service provision, requiring that service system resources are mobilized for a service event in an appropriate configuration (Lillrank et al. 2011). An episode can thus be viewed as a time sequence of customer activities and the related service events that describes customer interactions with the service system across a constellation of service processes (Lillrank et al. 2011) that all contribute inputs to the customer's value creation process through service provision, the outputs of each individual service event being compounded into the overall outcome of the episode, which determines the overall value provided by the service system (Lillrank 2010, p. 354). The concept of customer interaction with a service system through customer episodes and associated service events is represented in Figure 5.

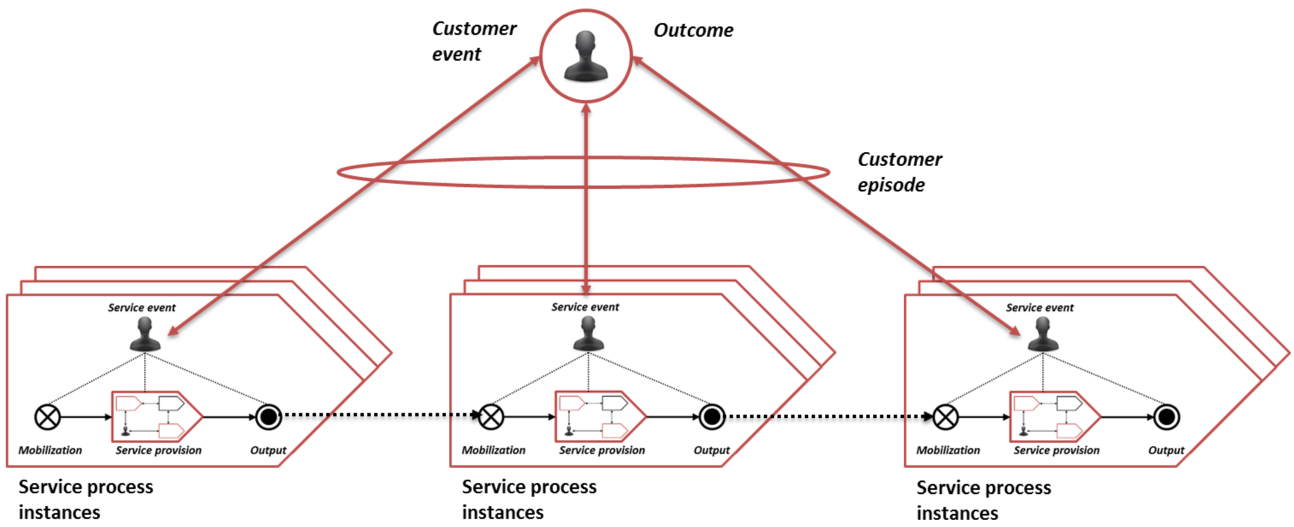

Figure 5. Customer interaction with service system through episodes and events (adapted from Lillrank 2010, p. 359)

According to Lillrank et al. (2011) the difference between managing processes and episodes can be found in the focus of planning, control and coordination of production steps and events. In a process, the production steps follow a known logic, allowing preplanned sequences of usually well-defined tasks and activities. There are, however, situations of customer induced variability where the episode follows its own logic and becomes the focus of planning, control and coordination. Varying customer events call for different service events that can be produced by mobilizing resources of the service system in different configurations, enabling the system to adapt to the customer induced variability. In these situations, accessing the required resources within a limited time frame becomes the focus of coordination effort. An episode and event perspective on customer interactions with a service system and its various service processes thus focuses attention to interactions and mobilization of resources, and the identification and interpretation of the inputs and signals that should activate a service event and the mobilization of resources within the service system.

Due to their inherently variable nature, service processes are often not arranged to specified layouts, such as non-service manufacturing processes commonly are, but consist of human competences (knowledge and skills) and various technologies, embedding competences that are necessary for the performance and facilitation of the various tasks and activities necessary for service provision, that have been arranged so that they can be mobilized to achieve desired results (Callon et al. 2002). According Lillrank (2010, pp. 355-357) mobilization can be defined as the synchronous gathering and configuration of the necessary competences, resources and input components, and different types of mobilization events can be generally viewed from three perspectives: first, as an action in a familiar situation, where various competences, resources and inputs meet and a service event commences based on recognition of the situation; second, as a distinct mobilization event, where various competences, resources and inputs necessary for the service event are assessed and an action plan for the service event is confirmed; and finally, as a continuous activity during the service event, where the involved parties need to monitor progress to assure that the mobilization for the service event remains valid. If new unanticipated input components turn up during a service event, then a new mobilization based on the changed input components must be made to adapt to the changed situation. These types of situations can lead to an event cascade, where one event produces an input to the next in rapid succession, requiring a number of adaptions to the service process, through successive mobilizations following each other. The responsiveness, or adaptive capacity, of a service process can be viewed as its capability to identify new inputs and create new mobilizations based on those inputs. A service event can thus be viewed as a unit of activities that is activated or altered by one mobilization of the necessary competences, resources and input components, and that lasts as long as the information provided by the mobilization remains valid. If the present situation changes and new input components appear, a new service event is started and a new mobilization of the necessary competences, resources and input components in a new configuration is needed in order for the service process to adapt to the changed situation.

According to Lillrank (2010, pp. 357-358) service processes can be classified according to how similar or dissimilar their repetitions are based on mobilizations. A mobilization event can be viewed to be divided into two distinct parts. First, the perceived input components are assessed to determine whether they are acceptable, authorized and relevant, and to make a decision to proceed with the service event based on the situation assessment. Second, an algorithm is performed to classify the situation based on the perceived input components into some predefined category to which certain actions and available resources can be assigned. After the assessment and classification of the situation have been performed, service system resources are mobilized for a service event in an appropriate configuration and value creating activities necessary for service provision are performed. Depending on the similarity of their repetition, and the knowledge and understanding of the associated service event requiring mobilization, service processes can be classified into standard, routine and non-routine processes.

- In standard processes, the perceived input components are viewed to represent a familiar situation that is always classified into one predefined category, which has predefined actions associated with it. A standard process is thus always repeated in identical ways, following a predefined sequence of activities. (Lillrank 2010, p. 357)
- In routine processes, the perceived input components are viewed to represent a situation that is subject to judgment based on appropriate existing knowledge and understanding, but can always be classified into two or more predefined categories, which each have predefined actions associated with them. A routine process can thus be repeated in a number of distinct ways, but following the classification can turn into a standard process. When the next input case arrives a new classification of the situation is always made based on the perceived input components and the appropriate existing knowledge and understanding of the situation. (Lillrank 2010, pp. 357-358)
- In non-routine processes, the perceived input components can be viewed to represent a situation that is subject to interpretation, but has no clear meaning based on the existing knowledge and understanding, and thus cannot be classified into any of the predefined categories. In this case, the perceived input components are subject to negotiations of meaning, sense making (Weick 1995) or iterative problem solving, which can eventually lead to a classification that turns the process into a routine or a standard process. If that is not the case, adaptive capacity is required to adapt the service process to the perceived situation. (Lillrank 2010, p. 358)

Wemmerlöv (1990, pp. 31-32) proposes a similar classification of service processes into rigid and fluid service processes, mainly based on the level of customer induced variability and its influence on the service process characteristics. Rigid service processes are viewed to be subject to a relatively low level of variability and therefore usually exhibit a low level of task variety. These types of processes normally require only a low level of technical skills and involve only a low level of information exchange between the service provider personnel and the customer in order to determine the requirements for service provision in a particular input case. There are thus only a few judgmental decisions made by the service provider personnel, because the service process itself is relatively narrowly defined. Fluid service processes, on the other hand, are viewed to be subject to a relatively high level of variability and therefore usually exhibit a high level of task variety. In these types of processes a relatively high level of technical skills is required and there is a need for a relatively high level of information exchange between the service provider personnel and the customer in order to determine whether to proceed with the service event or not, and to specify the exact requirements for service provision in a particular input case. There are thus more judgmental decisions made by the service provider personnel, often requiring search and interpretation of the inputs, in order to determine how the service system resources should be mobilized for the service event. Compared to the classification proposed by Lillrank (2010, pp. 357-358) rigid service processes bear similarities to the standard service processes, both implying less variability between the input cases, and thus requiring less knowledge, information exchange and information processing for interpreting the inputs in a particular input case in order to understand the requirements for service provision and to make a decision about the mobilization of service system resources for a service event. Fluid service processes, on the other hand, are more similar to the routine and non-routine service processes, all implying that increasing levels of knowledge, information exchange and information processing are required in order to understand the requirements for service provision and make a decision about the mobilization of service system resources for a service event, as the variability between the input cases increases.

In complex service systems there can be situations, where a customer episode involves and links together a number of service events and associated mobilizations that are produced by different types of service processes (Lillrank 2010, p. 358). It is therefore not only the difference between non-service and service processes, but also the presence of different types of service processes in different constellations within a service system that has implications for the management of service operations. According to Lillrank (2010, p. 358) service system productivity depends on the characteristics of its service processes and productivity can in general be improved when non-routine service processes are routinized and routine service processes are standardized. Non-routine service processes frequently require interpretation, search for new inputs, iterations and experimentation, consuming a lot of resources and requiring high level of coordination. Non-routine processes can, however, be viewed as an opportunity for learning and generation of new knowledge that can improve the adaptive capacity of the service system when similar input cases are encountered in future. With learning from experience and generation of new knowledge, there exists a potential for eventually routinizing non-routine processes or their subprocesses. Routine service processes are interrupted for classification at the arrival of each new input case, but they operate with predefined classes and activities and can usually be improved for efficiency. Standard service processes can often be automated and repeated efficiently in high volumes. Based on the perceived differences between different types of service processes the normative goal of the management could be viewed to be pursuing efficiency through routinization and standardization of individual service processes. Many service systems, however, may be constantly facing a variety of different types of input cases, due to the inherent differences in its customers' value creation processes. In this type of environment, effectively meeting an individual customer's requirements for service provision requires that the service system and its service processes are able to adapt to the level of customer induced variability that is imposed by the differences between individual customers' value creation processes. It is therefore viewed that in many service systems, in the same time with pursue for efficiency, it is necessary to maintain and develop adaptive capacity of the service system and its service processes in order to be able to ensure effective service provision in a variety of different types of input cases and to allow the service system and its service processes to co-evolve following changes in its customers' value creation processes and the shared context of value creation.

2.3 Work system perspective

The work system perspective represents a socio-technical systems (Trist 1981; Mumford 2000; Mumford 2006; Baxter and Somerville 2011) view on complex service systems. Socio-technical systems are composed of interrelated social and technical subsystems that need to be jointly optimized in order to achieve efficient and effective performance of the system as a whole (Trist 1981), implying that design, management and improvement of socio-technical systems should take into account factors related to both their social and technical systems (Mumford 2000; Mumford 2006; Baxter and Somerville 2011). This is an especially important consideration in organizational systems, where it is critical to ensure that the interdependent social and technical systems, involving people working individually and in teams and various supporting and facilitating technologies, will be able to provide their expected contribution to the goals of the organization (Baxter and Somerville 2011). According to Trist (1981) socio-technical systems can be analyzed at various levels of aggregation, including macrosocial systems, such as the service ecosystem, organizational systems embedded within the macrosocial system, and primary work systems that represent configurations of people, technologies and other resources as identifiable and bounded subsystems of an organization that perform various activities with a recognized purpose, which unifies the people and the activities. The socio-technical nature of complex service systems is captured by the work system framework (Alter 2002; Alter 2008; Alter 2010; Alter 2011) that provides the foundation for the work system perspective. According to the work system perspective complex service systems are viewed to be composed of a number of interdependent work systems (Alter 2008; Alter 2010; Alter 2011) that build around the production system processes, and enact the value creating activities necessary for service provision at different levels of aggregation within the service ecosystem.

According to Alter (2008) service systems can be viewed as work systems, in which human participants or machines perform work using information, technologies and other resources to produce products and services, or provision service, for internal and external customers. The work system framework was originally developed to allow business professions analyze and understand Information Technology (IT) – dependent systems within organizations, but the framework also provides useful concepts for analyzing and understanding the nature of socio-technical systems that perform value creating activities within service systems. The work system framework views organizations as hierarchical nested structures where work systems exist and can be analyzed at different levels of aggregation. Work systems within an organization can often be subdivided in successively smaller subsystems, which can then be analyzed and described using the work system framework. Decomposition in successively smaller work systems can be useful for analyzing systems that are easily divisible, but becomes meaningless at the point when the subsystem contains only one activity that is worth analyzing. The work systems framework can thus provide a systems-oriented view on any socio-technical system that performs work within an organization. In the work system framework the individual work systems are represented through nine basic elements and their interdependencies, which are viewed to be essential in understanding a work system and its context of value creation within an organization. The work system framework is represented in Figure 6.

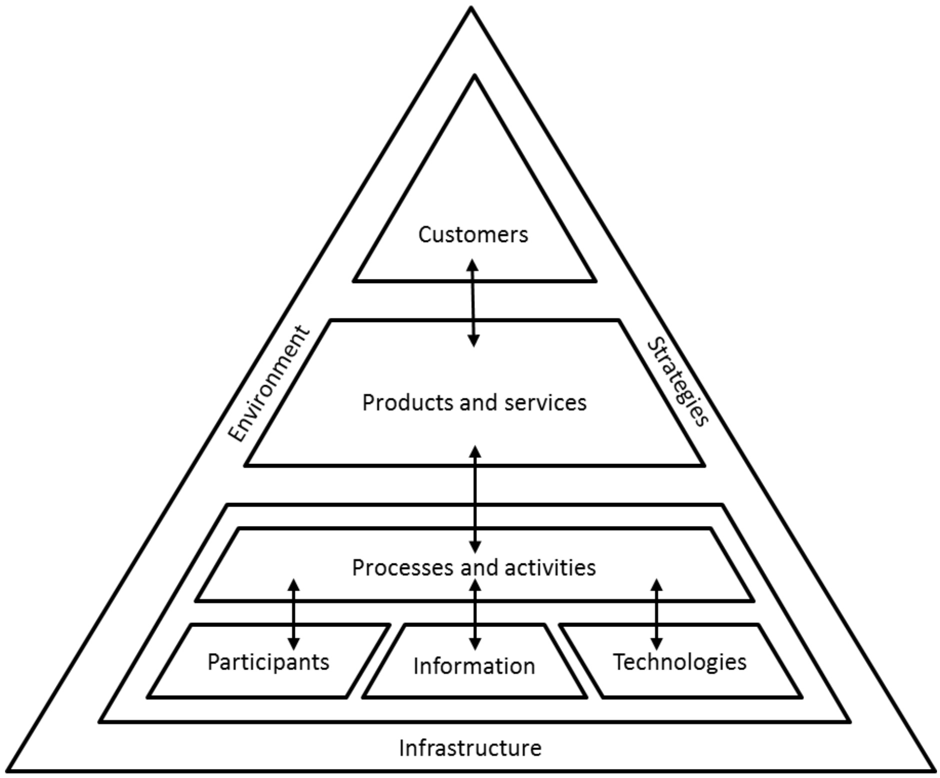

Figure 6. Work system framework (adapted from Alter 2008)

The primary purpose of a work system is to produce products and services, or provision service, for its customers. Depending on the nature of the work system, its context of value creation within an organization and its value creating processes and activities, its customers can include both internal and external customers, being either direct beneficiaries of service provision or decision makers, whose interest and involvement with the service provision and the work system processes and activities are indirect. Although customers are not depicted being part of the work system, the work system framework does not preclude the possibility that a customer will participate in the value creating work system processes and activities, because a customer can also act in a participant role in the work system. (Alter 2008)

The work system enacts the value creating processes and activities, and besides the processes and activities is composed of the participants, information and technologies. It is recognized in the work system framework that the processes and activities can include a variety of situations that might range from well-defined and highly structured processes with predefined sequence of activities, to less well-defined and unstructured processes whose sequence and activities are more dependent on the participants' perception and understanding of the situation, based on their expertise and competences (knowledge and skills), and individual judgment. The information in the system may include databases, documents, shared knowledge and even unrecorded discussions and commitments, while the technologies may include various types of technologies embedding competences necessary for the performance and facilitation of the value creating work system processes and activities. (Alter 2008)

The context of the work system within an organization is defined by three additional elements, including the environment, infrastructure and strategies that influence, support and facilitate and provide a direction for the performance of the value creating work system processes and activities. The environment includes organizational culture and relevant regulations, policies and procedures, competitive issues, organizational history and technological developments. Infrastructure consists of various human, information and technological resources that are used by the work system, but are shared with other work systems and are managed outside the work system. Strategies at the level of an organization and the work system direct performance of the value creating work system processes and activities, by defining value propositions of the work system for its internal and external customers, and its strategy for service provision. (Alter 2008).

According to the work system framework the different elements of a work system are interdependent and, therefore, there is a need for alignment between the individual elements. This is reflected in the framework through the double-headed arrows connecting the individual work system elements that highlight the path through which a change in one element might affect another element. In particular, the value creating work system processes and activities are viewed to be interdependent with the participants, information and technology, implying that a change in the characteristics of the processes and activities might also necessitate change in any of those elements and vice versa. (Alter 2008)

In complex service systems various work systems and their processes and activities are viewed to be associated with different types of production processes, including both service and non-service processes, with inherently different characteristics. Due to the interdependencies and the need for alignment between the individual work system elements, an important implication of the work system framework to the management of service operations is viewed to be that in service systems the required expertise and competences of work system participants, including both customers and service provider personnel, and the required information and the types of technologies necessary to support and facilitate the performance of value creating work system processes and activities depend on the characteristics of the service processes that the work systems are associated with. According to the customer episode and event conceptualization of customer interactions with a service system (Lillrank 2010, pp. 353-355; Lillrank et al. 2011) customer episodes may include different types of service events, with varying levels of customer intensity between individual episodes and their service events, that are associated with different types of service processes and require different mobilizations of service system resources. Mobilization event is viewed as a decision making point where the service system resources are committed for the performance of value creating processes and activities in a particular configuration, based on the knowledge and understanding about a customer's value creation process and the associated shared context of value creation, which together determine the requirements for service provision. In their characterization of different types of service processes both Lillrank (2010, pp. 357-358) and Wemmerlöv (1990) imply that with different types of service processes, different types of knowledge, information exchange and information processing, and supporting and facilitating technologies are required both for making the mobilization decision and for the performance of the value creating processes and activities. According to Wemmerlöv (1990) the required participant competences and the types of supporting and facilitating technologies are markedly different between rigid and fluid service processed, implying different requirements for work systems associated with different types of service processes.

Rigid service processes are inherently structured and can be designed for narrow range of activities that are largely predetermined and are repeated similarly from one mobilization for a service event to another. Due to their repetitive nature, especially in environments with low customer contact with the service system, the processes and their supporting and facilitating technologies can be designed to handle repetitive tasks at high volumes, making them candidates for automation and mechanization. In rigid service processes, resource requirements can in general be modeled and forecasted, allowing centralized planning, control and coordination of value creating activities. Making a mobilization decision for an individual service event thus involves less discretion and individual judgment by the service provider personnel, implying that the required level of expertise and knowledge of the personnel is relatively low. In these types of environments, controlling service quality becomes largely a matter of controlling the quality of used materials, and design and execution of service processes. (Wemmerlöv 1990)

Fluid service processes are inherently unstructured and must therefore possess a large element of flexibility, or adaptive capacity, to be able to perform a variety of activities, that may not be predetermined, but depend on the situation and may vary from one mobilization for a service event to another. Due to their variable nature, especially in environments with high customer contact with the service system, the processes and their supporting and facilitating technologies must be able to handle varying volumes and task difficulties, making them difficult to automate or mechanize. In fluid service processes, resource requirements are difficult to model and forecast, making centralized planning, control and coordination of value creating activities difficult. Decision making authority concerning mobilization of the service system resources and performance of value creating activities for an individual service event is typically instead delegated to the service provider personnel, who are required to exercise a considerable amount of autonomy and individual judgment, implying that a relatively high level of expertise and knowledge is required from the personnel. In these types of environments service quality can in general be controlled by setting standards for the used materials and followed procedures, and by ensuring that the service personnel have the necessary competences through requirements for minimum education, certification, licensing and regular training programs. (Wemmerlöv 1990)

Furthermore, it is not only required that the participants possess a high level of technical expertise and competences, related to the performance of value creating work system processes and activities, but that the service provider personnel also have a large degree of sensitivity to the customers' needs (Wemmerlöv 1990). This is viewed to imply that not all the customer inputs are always explicitly articulated, but some of the inputs to service processes may be implicit in their nature, their perception and understanding depending on the information available to the service provider personnel and their expertise and knowledge in interpreting that information. Therefore it is viewed that making a mobilization decision for a service event depends on the level of customer involvement in the service process and both the explicitly articulated customer inputs and the implicitly perceived customer needs that are determined by and the perception of which requires information, knowledge and understanding regarding the customer's value creation process and the associated shared context of value creation in a particular situation extending both within and outside the boundaries of an organization and its individual work systems.

2.4 Integrated model of complex service systems

It is proposed that complex service systems are hierarchical complex systems (Simon 1962) that can be viewed through multiple complementary perspectives, at different levels of abstraction, that focus on different aspects of the value co-creation phenomena and view the individual components and subsystems of the system and their interactions through different concepts, each perspective offering different implications for the management of service operations, decision making and decision support within different contexts of value creation at different levels of aggregation within the system. It is further proposed that integration of a number of perspectives is necessary to understand the nature of decision making and requirements for decision support within complex service systems. Building on the service ecosystem, production system and work system perspectives an integrated model of complex service systems is proposed that views the different perspectives as being interrelated. The proposed integrated model is represented in Figure 7.

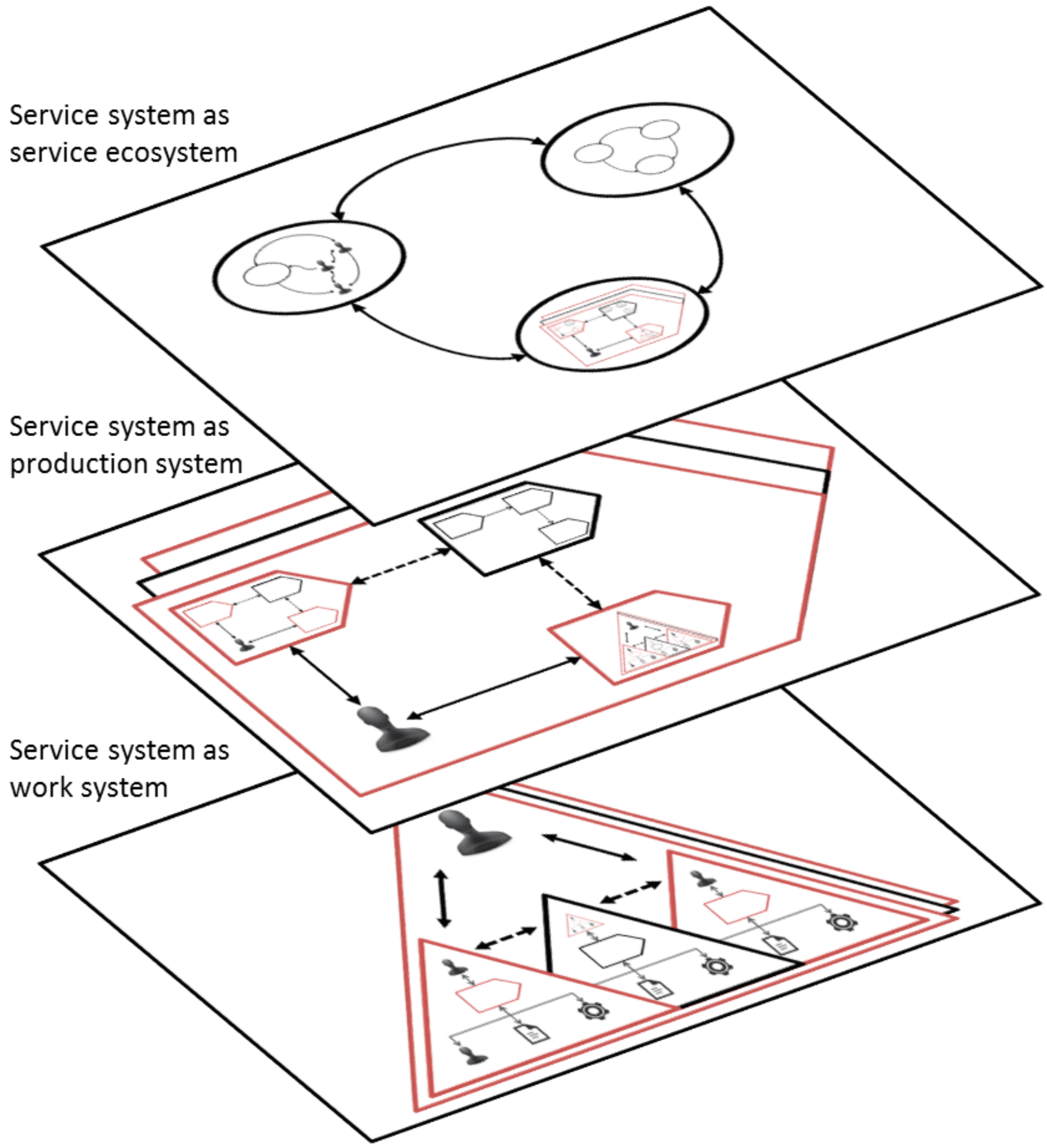

Figure 7. Integrated model of complex service systems

The service ecosystem perspective builds on a view of complex service systems as service ecosystems (Vargo and Akaka 2009; Vargo et al. 2010a; Vargo et al. 2010b; Lusch et al. 2010) or service ecologies (Spohrer and Maglio 2010a; Spohrer and Maglio 2010b; Spohrer et al. 2011) that are represented as value networks of different types of service system entities, where value is co-created through interactions between the service system entities that produce value creating outcomes (Spohrer and Maglio 2010a). Based on the service science definition of service systems, the service ecosystem perspective views complex service systems as dynamic value co-creation configurations of resources, including people, other internal and external service systems, shared information and technologies, all connected together with other service systems through value propositions (Spohrer et al. 2007; Maglio and Spohrer 2008; Maglio et al. 2009), that evolve complex structure and interaction patterns between individual service system entities, together forming the service ecosystem, which is the population of service system entities that, as a whole, are better off working together than working alone (Spohrer and Maglio 2010a, pp. 8-10; Spohrer and Maglio 2010b, p. 174). The service ecosystem perspective provides a systemic view (Ng et al. 2011, pp. 19-20) on value creation in complex service systems and captures the nature of complex service systems as complex adaptive systems (Plsek and Greenhalg 2001). The characteristics of the service ecosystem as a complex adaptive system are a source of a number of implications for the management of service operations, decision making and decision support within complex service systems. According to the definition and characteristics of complex adaptive systems provided by Plsek and Greenhalg (2001) service ecosystems are viewed as collections of different types of individual service system entities that act in ways that are not always totally predictable, and whose actions are interconnected so that actions of one service system entity change the context of others. The individual service system entities can simultaneously be members of several subsystems within the service ecosystem, acting in different roles, within a shared context with other service system entities. The behavior of the individual service system entities is driven by internalized sets of rules, which shape their perception of and sense making about the shared context of value creation, and through which they respond to their environment. With social entities, such as people, the rules can be expressed as instincts, constructs and mental models that drive the human behavior, but the rules may vary between different types of service system entities, and they need not be shared, explicit or even logical from the point of view of other individual service system entities, nor are the sets of rules fixed, but they may adapt and evolve over time, in response to varying situations encountered by the individual service system entities and their outcomes. Because the individual service system entities are nested with others, all interacting and co-evolving within a shared context, any of the individual service system entities cannot be fully understood without reference to the others. The overall behavior of the service ecosystem as a whole emerges from the interactions among individual service system entities and the observable outcomes are more than merely the sum of the individual parts. Therefore, the detailed behavior of the service ecosystem and its individual service system entities is fundamentally unpredictable over time and the only way to know how the system will behave in a particular situation, and how its behavior will evolve over time, is to observe the behavior of the system. Despite the lack of detailed predictability it is often possible to recognize patterns in the behavior of the service ecosystem and its individual service system entities interacting within a certain, shared context that allow making generally true and practically useful statements about the behavior of the system. Although predicting the detailed occurrence of events within the system and their outcomes may not be possible, this detailed information is not necessarily needed to identify and deal with problems, but emerging patterns of behavior can serve as a valuable source of information for the management. Finally, behavior of the service ecosystem and its individual service system entities is self-organizing through locally applied rules by the individual service system entities interacting within a shared context of value creation. Therefore, there is often no need for centralized detailed planning, control and coordination of every aspect of the system, but the individual service system entities themselves are able to behave adaptively in varying situations and perform value creating activities associated with their different roles in different shared contexts of value creation at different levels of aggregation within the service ecosystem.

The production system perspective builds on a foundation provided by operations management (for example, Slack et al. 2010; Krajewski et al. 2010) and represents complex service systems as production systems where value is created through interactions between customers and various service system processes that transform inputs into value creating outputs that, in turn, provide inputs to the value creation processes of customers and each other. The production system perspective provides a reductionist view (Ng et al. 2011, pp. 17-19) on value creation in complex service systems and describes them as systems of processes that conceptualize the various interactions and activities necessary for value creation within and between different types of service system entities at different levels of aggregation within the service ecosystem and link them into value creating systems, providing a structure that enables the necessary planning, control and coordination of various interlinked and interdependent value creating activities within the system (Slack et al. 2010, pp. 270-272; Lillrank 2010, p. 338; Lillrank et al. 2011). According to the characterization of service systems and their processes provided by the Unified Service Theory (UST) (Sampson and Froehle 2006; Sampson 2010a; Sampson 2010b), and Lillrank (Lillrank 2010; Lillrank et al. 2011) and Wemmerlöv (1990) complex service systems are viewed as production systems that are composed of different types of production processes, including both service and non-service processes, that through their direct and indirect interactions with customers and each other within a shared context of value creation are linked into constellations of different types of processes that together contribute inputs to the customers' and each other's value creation processes through service provision. Complex service systems are opens systems (Fitzsimmons and Fitzsimmons 2006, pp. 29-32) that are subject to customer interactions with and inputs to their service processes, the customer interactions and inputs being the defining characteristic of service processes and a source of management concerns different from non-service processes in closed manufacturing systems devoid of customer inputs. During their interactions with a service system, customers can provide a variety of different types of inputs to its service processes that can impact the processes to different degrees causing variation in the processes and requiring that service processes have the necessary capacity to adapt to the variations and changes in the customer inputs that can vary both in quality and quantity, creating varying situations of interaction between the customers and the service system and its service processes. Customer interactions with a service system are not necessarily limited to a single service process within the service system, but customer's value creation process may include a number of interactions with the service system and its various service processes, that may also exert indirect influences on the associated non-service processes. These sequences of customer interactions with a service system can be conceptualized as customer episodes that describe the sequence of customer activities as they interact with the service system and its various service processes, and associated service events that identify the situations where a service system and its service processes intersect with an episode. An episode is thus viewed as a time sequence of customer activities and the associated service events that describes customer interactions with the service system across a constellation of service processes that all contribute inputs to the customer's value creation process through service provision, the outputs of each individual service event being compounded into the overall outcome of the episode, which determines the overall value provided by the service system. The episode and event perspective on customer interactions with a service system and its service processes focuses attention to interactions and mobilization of service system resources for service events, and the identification and interpretation of inputs and signals that should activate a service event. Mobilization involves the synchronous gathering and configuration of the necessary competences (knowledge and skills), resources and input components that are required for service provision for a particular service event in a particular situation, and is viewed as a decision making point where service system resources are committed for service provision in a particular configuration. Different types of service events require different mobilizations of service system resources and can be associated with different types of service processes, depending on the similarity of their repetition for different input cases, that imply different requirements for the knowledge and understanding of the customer's value creation process and the shared context of value creation, and differences in the decision process for making the mobilization decision. In service processes that have less variability between the input cases, typically less expertise and knowledge, information exchange and information processing are required for interpreting and the inputs in a particular input case in order to understand the requirements for service provision and make the mobilization decision for a service event. These types of service processes and their customer inputs are also typically relatively narrowly defined, and there are typically only a few judgmental decisions required. As the variability between service process input cases increases, typically also increasing levels of expertise and knowledge, information exchange and information processing are required, together with better knowledge and understanding about the customer's value creation process and the shared context of value creation. In these types of service processes interpretation of the customer inputs is frequently subject to negotiation of meaning, sense making (Weick 1995) or iterative problem solving and making the mobilization decision typically involves more judgmental decisions. Service system productivity as a whole depends on the characteristics of its service processes and its efficiency can generally be improved by decreasing the variability of its service processes and their input cases. Many complex service systems, such as the health care and social services service system, may, however, be constantly facing a variety of different input cases, due to the inherent differences in their customers' value creation processes and effectively meeting an individual customer's requirements for service provision may often require that the service system and its service processes are able to adapt to a certain level of variability that is imposed by the differences between individual customer's value creation processes. Therefore, in many service systems, in the same time with pursue for efficiency it is necessary to maintain and develop adaptive capacity of the service system and its service processes in order to be able to ensure effective and efficient service provision in a variety of different types of input cases and to allow the service system and its service processes to co-evolve following changes in its customers' value creation processes and the shared context of value creation.

Finally, the work system perspective builds on a view of complex service systems as socio-technical systems (Trist 1981; Mumford 2000; Mumford 2006; Baxter and Somerville 2011) that are composed of a number of interdependent work systems (Alter 2008; Alter 2010; Alter 2011) that are associated with production systems' processes, and enact value creating activities necessary for service provision at different levels of aggregation within the service ecosystem. As socio-technical systems service systems and their work systems include interrelated social and technical subsystems that need to be jointly optimized in order to achieve efficient and effective performance of the system as a whole (Trist 1981). According to Alter (Alter 2008; Alter 2010; Alter 2011) service systems are viewed as work systems, in which human participants or machines perform work using information, technologies and other resources to produce products and services, or provision service, for internal and external customers. Work systems exist in service systems at different levels of aggregation and can be analyzed using the work system framework (Alter 2002; Alter 2008; Alter 2010; Alter 2011) that represents individual work systems through nine basic elements and their interdependencies, which are viewed to be essential in understanding a work system and its context of value creation within an organization. The primary purpose of a work system is to produce products and services, or provision service to its customers. The work system is composed of four elements, including the value creating processes and activities, participants, information and technologies that are necessary for the support and facilitation of the value creating work system processes and activities. The context of a work system within an organization is defined by three additional elements, including the environment, infrastructure and strategies that influence, support and facilitate and provide direction for the performance of the value creating work system processes and activities. Due to the perceived interdependencies and the need for alignment between the individual work system elements, it is viewed that an important implication of the work system framework to the management of service operations is that in service systems the required expertise and competences (knowledge and skills) of a work system participants, including both customers and service provider personnel, and the required information and types of technologies necessary to support and facilitate the performance of the value creating work system processes and activities depend on the characteristics of the service processes that the work system is associated with. In different types of service processes, different types of knowledge, information exchange and information processing, and supporting and facilitating technologies are required both for making a decision about the mobilization of service system resources and for the performance of the value creating work system processes and activities (Lillrank 2010, pp. 357-358; Wemmerlöv 1990), implying that the nature of decision making processes and requirements for decision support are different in work systems associated with different types of service processes. Furthermore, it is viewed that making the mobilization decision within a work system depends on the level of customer involvement in the associated service process and both the explicitly articulated customer inputs and the implicitly perceived customer needs (Wemmerlöv 1990) that are determined by and the perception of which requires information, knowledge and understanding about the customer's value creation process and the associated shared context of value creation in a particular situation both within and outside the boundaries of a service system and its individual work systems.

Decision making in service systems and their work systems can be supported through various technologies and a number of other means (Alter 2004). Decision support within organizations and their various work systems is commonly associated with Decision Support Systems (DSS) that are commonly identified as having the following three characteristics (Alter 1980): first, they are designed to facilitate decision making processes; second, they should support rather than automate decision making, and; third, they should be able to quickly respond to the changing needs of decision makers. Although a number of different types of systems and classifications of DSS are proposed in the literature, there is no universally accepted definition for the concept of DSS, but DSSs may be viewed more narrowly as interactive computer-based systems that are intended to help decision makers solve particular types of decision problems, or more broadly as an umbrella term to describe any information system that supports decision making within an organization (Turban et al. 2011, p. 16) and its various work systems (Alter 2004). An example of a narrow definition is provided by Gorry and Scott Morton (1971; 1989) who view DSSs as interactive computer-based systems, which help decision makers in utilizing data and models to solve unstructured decision problems. According to Power (2002, p. 1) DSSs can be more broadly viewed as interactive computer-based systems, which help people use computer communications, data, documents, knowledge and models to solve problems and make decisions. It is viewed by French et al. (2009, p. 83) that a more selective definition is necessary to fully capture the nature of decision making and the requirements for decision support within organizations. Decision support is not just a matter of information systems, but also a matter of supporting the evolution of decision makers' judgment and understanding, and therefore a DSS should address as much about modeling and understanding the perspectives, views, preferences, values and uncertainties of the decision makers as helping them utilize data and models. Based on this view DSSs can be defined as information systems that support the decision making process, by helping the decision makers to understand the problem before them and to form and explore the implications of their judgment, and hence make a decision based upon understanding (French et al. 2009, p. 83) of a particular decision situation within a particular context. It is also viewed by Alter (2004) that decision support within service systems and their work systems should not be viewed just as a matter of information systems, according to the traditional view of DSS as a technological artifact and one of the work system technologies, but a broader view of decision support as a matter of using any means for supporting and facilitating making better decisions within service systems and their work systems should be adopted instead. Therefore, decision support in service systems and their work systems can be viewed as the use of any plausible computerized or non-computerized means for improving sense making (Weick 1995) and decision making in a particular repetitive or non-repetitive decision situation within a particular context. Furthermore, focus on decision support rather than adopting the traditional view of DSS expands the landscape to include decision improvement interventions and strategies that might or might not involve a technological artifact called a DSS. Based on the work system framework, decision support can come from many different aspects of a work system through variations and modifications in any of the nine work system elements, and the resulting improvements might be measured in terms of decision quality, efficiency and effectiveness of the value creating work system processes and activities, the psychological well-being of the work system participants, the satisfaction of the customers, or other possible performance measures. A summary of potential sources of decision support in work systems is provided in Table 2.

Table 2. Potential sources of decision support in work systems (adapted from Alter 2004)

Work system element	**Potential decision support sources**
Customers	Better ways to involve customers in the decision making process and to obtain better understanding about their needs
Products and services	Better ways to evaluate potential decisions and their impacts
Processes and activities	Variations in the processes and activities, their sequence of steps, and methods used for performing particular steps
Participants	Better training, better expertise and competences (knowledge and skills), higher level of commitment, and better real time or delayed feedback
Information	Better information quality, information availability, and information presentation
Technology	Better data storage and retrieval, models, algorithms, statistical or graphical capabilities, and better computer interaction
Environment	Better methods for incorporating concerns from the surrounding environment
Infrastructure	More effective use of shared infrastructure
Strategy	A fundamentally different operational strategy for work system

Based on the integrated model it is proposed that complex service systems can be viewed from multiple complementary perspectives, including the service ecosystem, production system and work system perspectives, the different perspectives being interrelated and each perspective focusing on different aspects of the value co-creation phenomena, viewing the individual components and subsystems of the system through different concepts and offering different implications for the management of service operations, decision making and decision support within different contexts of value creation within the system. Within complex service systems there are different types of work systems that are associated with different types of production systems' processes, enact value creating activities necessary for service provision and make decisions about the mobilization of service system resources, within different contexts of value creation at different levels of aggregation within the service ecosystem. Depending on the characteristics of a work system, its associated processes and activities and its context of value creation, there are differences in the nature of decision making processes and requirements for decision support between different types of work systems. It is therefore proposed that different types of work systems, associated with different types of processes and activities and operating in different contexts of value creation within service systems are associated with different types of decision making contexts where different types of decision making processes dominate and different types of decision support are required, depending on the characteristics of the decision making context.

3. Decisions and decision making context

Decision making is influenced by the characteristics and context of decision situations (Payne et al. 1993, pp. 3-4) and it is viewed that understanding the characteristics of different types of organizational decision making contexts is a necessary prerequisite for understanding the nature of decision making processes and requirements for decision support within different types of decision making contexts. An overall context for organizational decision making is provided by the surrounding society and organizations themselves, but there are further levels of decision making contexts in organizations, in which different organizational units, teams and individual decision makers plan, control and coordinate their activities and make decisions (French et al. 2009, p. 349). There are a number of ways to characterize different types of decision situations and their associated decision making contexts within organizations. Traditionally organizations are viewed as hierarchical structures, where different types of decision situations and their decision making contexts are associated with different levels of organizational activities that are viewed to largely determine their characteristics and to be the main source of influences for the nature of decision making processes and requirements for decision support within different types of decision making contexts (Daft 2006; Cooke and Slack 1984; Power 2002; French et al. 2009; Turban et al. 2011; Gorry and Scott Morton 1971; Gorry and Scott Morton 1989). Another perspective on the characteristics of different types of decision situations and their associated decision making contexts is provided by the Cynefin framework (Snowden 2002; Kurtz and Snowden 2003; Snowden and Boone 2007), which views that different types of decision making contexts are associated with different knowledge spaces, and that the inherent characteristics of the decision making context and the decision makers' knowledge regarding the context together determine the perceived characteristics of the context and are the source of influences for the nature of decision making processes and requirements for decision support in a particular decision situation within a particular decision making context. Furthermore, it is recognized by the Cynefin framework that characteristics of a particular decision situation and its decision making context cannot be taken for granted, but variations and evolution of the decision making context and differences or changes in the decision makers' knowledge both imply changes in the perceived characteristics of the decision making context and therefore also imply differences in the nature of the decision making processes and the requirements for decision support. It is viewed that the two frameworks can together provide the basis for understanding the characteristics of different types of decision situations and their associated decision making contexts within complex service systems, and will provide the necessary basis for studying the nature of decision making processes and the requirements for decision support within different types of decision making contexts within complex service systems.

3.1 Traditional perspective on framing organizational decisions and decision making contexts

The traditional perspective and a framework for categorizing organizational decisions in the management and decision support literature (Daft 2006; Cooke and Slack 1984; Power 2002; French et al. 2009; Turban et al. 2011; Gorry and Scott Morton 1971; Gorry and Scott Morton 1989) is based on the categories of management activities within an organization (Anthony 1965) and the types of decision problems (Simon 1977*)* that are associated with those activities. According to the framework, management activities at different levels of an organization can be associated with hierarchical levels of decisions and decision making contexts within an organization, while types of decision problems identify the general characteristics of different types of decisions and decision making contexts that are perceived to be commonly encountered at different levels of the organizational decision hierarchy and suggest typical ways of dealing with those decision situations. Together these two perspectives allow framing decisions and decision making contexts within an organizational context in relation to the purpose and focus of different management activities and the typical ways in which the managers deal with different types of decision situations.

3.1.1 Organizational decision hierarchy

According to Anthony (1965 in Gorry and Scott Morton 1971) management activities at different levels of an organization can be classified within three broad categories: strategic planning, management control and operational control. Planning activities generally define where the organization wants to be in the future and how to get there, and involve defining goals and objectives for future organizational performance and deciding on the tasks and use of resources needed to attain them (Daft 2006, p. 8). Control activities generally aim to ensure that the organization is moving towards its goals, they involve monitoring organizational activities, determining whether the organization is on target towards its goals and making corrections as necessary (Daft 2006, p. 10). Planning and control activities should be, however, seen more like the two sides of the same coin and therefore both planning and control activities are necessary at all the organizational levels (Gorry and Scott Morton 1989). The main purpose and focus of the management activities at different levels of an organization are the following (Anthony 1965 in Gorry and Scott Morton 1971):

- Strategic planning activities involve the process of deciding on the overall goals and objectives of the organization, on the resources that are used to attain these objectives and on defining organizational policies (Anthony 1965, p. 24).
- Management control activities involve the process by which managers assure that resources are obtained and used effectively and efficiently to accomplish given organizational objectives (Anthony 1965, p. 27).
- Operational control activities involve the process of assuring that specific tasks carried out effectively and efficiently (Anthony 1965, p. 69).

In addition to the organizational management activities that are focused on planning and control, a fourth level of organizational activities that are related to operational performance is also identified (Anthony 1965 in Gorry and Scott Morton 1971). These activities are related to the daily performance of operational activities, which are necessary to fulfill the higher level organizational goals and objectives (Power 2002, p. 38).

A similar four level classification is proposed by Jacques (1989 in French et al. 2009, pp. 6-7) who argues that the tasks and decision making undertaken by staff at different levels within an organization may be characterized by the longest time span of discretion required by their roles. The time span of discretion roughly relates to the length of time before the consequences of a decision have their full impact. Organizations are best able to achieve their objectives when members of the organization work at levels with time spans of discretion within the limits of their ability to envisage the future. There are four distinct domains of organizational activity that are characterized by different time spans of discretion: the corporate strategic domain, which sets the guiding values and vision and develops strategy to guide the organization towards these; the general domain, which develops an implementation plan for the strategy; the operational domain, which organizes the detailed delivery of the strategy; and the hands-on work domain, which delivers the work.

Following the hierarchical categorization of organizational activities, organizational decisions can be represented as a decision hierarchy that reflects the relationship between different levels of organizational goals and objectives that guide the organizational activities and decision making at different levels of an organization (Simon 1997, p. 4). Decisions corresponding with the highest three levels of the hierarchy are commonly identified as strategic, tactical and operational decisions (French et al. 2009, pp. 4-5) and decision making processes at these levels are commonly associated with the organizational decision making models. The fourth level of decisions corresponding with the operational performance and hands-on activities is however also important for the performance of operational activities that deliver the work necessary to meet the organizational goals and objectives and implement the strategy. According to French et al. (2009, pp. 5-6) decision making processes at this level can be often associated with naturalistic decision making models, and the corresponding decisions are termed instinctive decisions. The relationship between different types of organizational activities and corresponding categories of organizational decisions is represented in Figure 8.

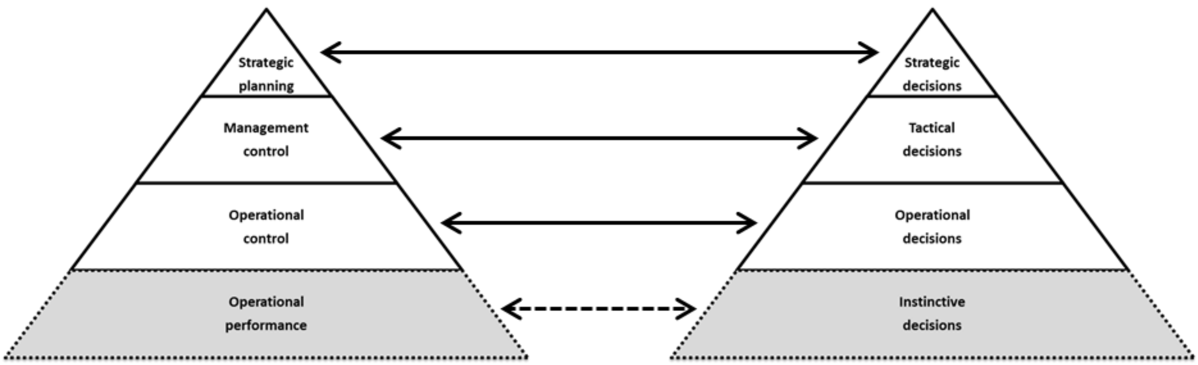

Figure 8. Organizational decision hierarchy (adapted from Power 2002, p. 38; French et al. 2009, p. 5)

Within the organizational decision hierarchy, strategic level decisions define overall organizational goals and objectives and set the direction for an organization, they essentially define a broad framework, in which more detailed decisions can be taken. Tactical, operational and instinctive decisions fill in the necessary details for meeting the organizational goals and objectives. (French et al. 2009, p. 5)

3.1.2 Organizational decision problem types

According to Simon (1977, pp. 45-46) organizational decision problems can be classified into programmed and non-programmed decisions, or more appropriately, represented as a continuum between these opposing classes of decisions. Programmed decisions are often called structured decisions and non-programmed decisions unstructured decisions (French et al. 2009, p. 5). The characteristics and typical treatment of organizational decision problems at the opposite ends of this continuum can be defined as follows (Simon 1977, pp. 46-47):

1. Programmed decisions are repetitive and routine decisions that are well understood and have a definite procedure developed for handling them. Therefore, there is no need to treat them as a new decision problem each time they occur. (Simon 1977, p. 46)
2. Non-programmed decisions are novel, unstructured and unusually consequential. There is no definite procedure for handling the problem, either because it has not occurred before or because its precise nature and structure are elusive or complex or because it is so important that it deserves a customized treatment. In non-programmed decision situations, decision makers have no predetermined procedure to follow, but the decision making process instead requires general capacity for intelligence, adaptive and problem oriented action. (Simon 1977, pp. 46-47)

The types of organizational decision problems can be associated with different levels of the organizational decision hierarchy. According to Simon (1977, pp. 45-49) strategic level decisions are more commonly associated with unstructured or non-programmed decision problems, while operational level decisions are usually much more structured or programmed decision problems. According to French et al. (2009, pp. 4-9) there are also a number of other distinctions that can be made regarding the characteristics of decision problems at different levels of the organizational decision hierarchy. First, the importance of individual decisions increases towards the top of the decision hierarchy. The potential consequences of individual strategic level decisions are much more significant than those of individual operational or instinctive decisions. Second, the frequency with which decisions are faced increases towards the base of the decision hierarchy. Operational and instinctive level decisions are typically much more common than strategic level decisions. At the operational and instinctive level similar decisions are also often recurring. Finally, decisions at different levels of the decision hierarchy have different time span of discretion (Jacques 1989 in French et al. 2009, pp. 6-7). Strategic level decisions are typically associated with longer time span of discretion and operational and instinctive level decisions with shorter time span of discretion. The relationship between organizational decision problem characteristics and different levels of the organizational decision hierarchy is represented in Figure 9.

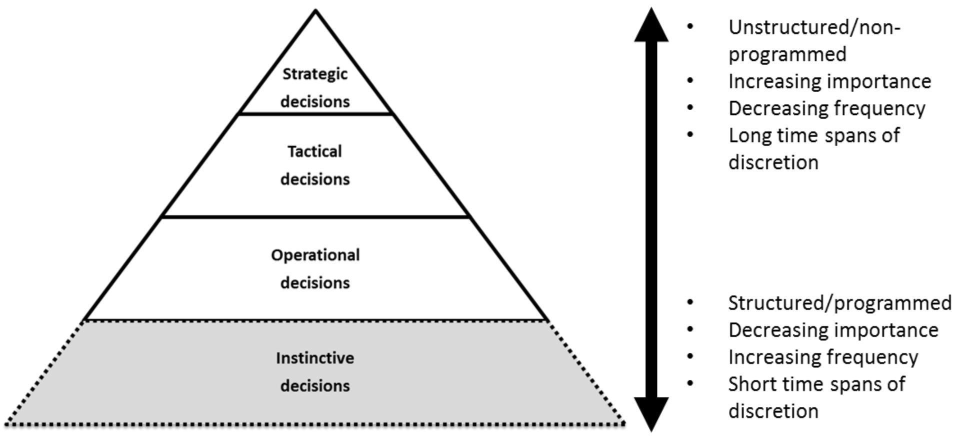

Figure 9. Organizational decision problem characteristics (adapted from French et al. 2009, p. 5)

The proposed relationship between different levels of organizational decision hierarchy and types of decision problems implies that characteristics of decision situations commonly encountered at different levels of an organization, their associated decision making context and their associated decision making processes are inherently different. Because decision situations at the operational and instinctive levels are assumed to be mostly structured, they can be expected to be mostly familiar and well understood by the decision makers, and therefore decision making processes at these levels can mostly rely on identifying familiar situations and applying an existing solution approach. Decision situations at the strategic and tactical levels, on the other hand, are assumed to be frequently unstructured and can be expected to be less familiar to and less understood by the decision makers, and therefore it is mostly at these levels that decision making processes require more analytical and adaptive approach. These assumptions may suit well to the traditional manufacturing organizations, but may not always be valid in complex service systems, where various work systems, including those performing operational activities, may frequently face both structured and unstructured decision situations depending on the type and variations of service processes that they are associated with. Therefore, it is viewed that adopting a less restrictive framework for categorizing different types of decision situations and their associated decision making contexts within complex service systems is necessary.

3.2 Cynefin framework perspective on organizational decisions and decision making contexts

Another perspective on framing different types of organizational decisions and decision making contexts is provided by the Cynefin framework (Snowden 2002; Kurtz and Snowden 2003; Snowden and Boone 2007). The framework was originally developed for the purposes of organizational knowledge management and identifies four distinct knowledge spaces: known, knowable, complex and chaotic (Snowden 2002). These knowledge spaces can be associated with five different types of organizational management and decision making contexts: simple, complicated, complex, chaotic and disorder (Kurtz and Snowden 2003; Snowden and Boone 2007). The primary application of the framework was originally envisioned as a collective sense making framework in organizations, which allows considering dynamics of situations, decisions, perspectives, conflicts and changes in order to come into consensus for decision making under uncertainty (Snowden 2002; Kurtz and Snowden 2003). The framework can, however, also be valuable in broadening the traditional approach to organizational management and decision making by identifying the inherent characteristics of different types of organizational management and decision making contexts and providing guidance on the appropriate management and decision making approaches depending on the prevailing context characteristics (Snowden and Boone 2007).

3.2.1 Cynefin framework decision making contexts

The Cynefin framework identifies the contextual nature of management activities and decision making in organizations. By helping the managers and decision makers to identify the inherent characteristics of the prevailing context, it allows them to adapt their management and decision making style to the characteristics of the context. The five management and decision making contexts identified by the framework are primarily defined by the nature of cause and effect relationships in each context. Four of these contexts: simple, complicated, complex and chaotic; represent distinct domains for management and decision making that require diagnosing the prevailing context characteristics and acting in contextually appropriate ways. In simple and complicated contexts an ordered world is assumed, where cause and effect relationships are perceptible and right answers can be determined based on the facts. These contexts represent the domain of fact-based management. The complex and chaotic contexts assume an unordered world, where there is no immediately apparent relationship between cause and effect and the way forward needs to be determined based on emerging patterns. These contexts represent the domain of pattern-based management. The fifth: disorder; applies when it is unclear which of the four other contexts is predominant, but the nature of the context makes it difficult to recognize when one is in it. There, different perspectives alternate in a seemingly unordered manner and management is not able to diagnose context characteristics. The way out of this domain is to break down the situation into constituent parts and assign each to one of the other four domains. Managers can then make decisions and act in contextually appropriate ways. (Snowden and Boone 2007)

3.2.2 Cynefin decision making context characteristics

Characteristics of the different Cynefin framework contexts have different implications for the management and decision making within organizations. The Cynefin framework is represented in Figure 10.

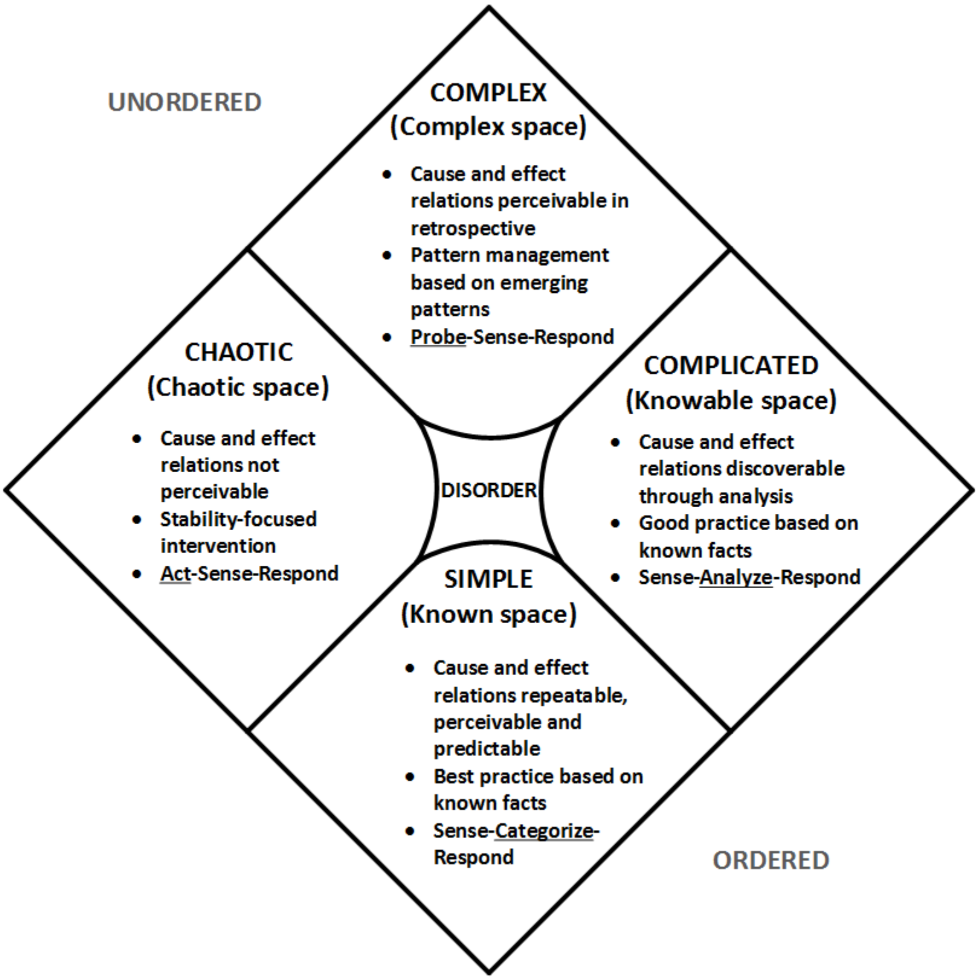

Figure 10. The Cynefin framework (adapted from Snowden and Boone 2007)

Simple contexts

Simple contexts in the known knowledge space are characterized by clear and stable cause and effect relationships that can be easily perceived and understood by everyone. Right answers are often self-evident and undisputed and consequences of actions can be fully predicted. This space can also be called the realm of "known knowns" where management and decision making is based on known facts and decisions are often unquestioned because all parties share an understanding about their consequences. Operational activities that are heavily process oriented and little subject to change, such as standard business processes, usually belong to this space. (Snowden and Boone 2007)

Known space represents the domain of best practice (Snowden 2002) where existing knowledge can be captured and embedded in structured processes to ensure consistent performance (Kurtz and Snowden 2003). In this space, cause and effect relationships are generally linear and empirical in their nature and they have a considerable degree of stability and repeatability, which allows development of predictive models that describe the behavior of the system (Kurtz and Snowden 2003). Within the known space, it is therefore possible to both predict and prescribe system behavior and make systems that would otherwise be complex or chaotic into known systems by imposing structure and order through directives and practices that have sufficient universal acceptance to create predictable environments (Snowden 2002). Management activities within the known space should therefore focus on ensuring efficient and effective performance through structured techniques (Kurtz and Snowden 2003).

Decision makers are most familiar with simple contexts where their repeated exposure to and experience with recurring decision situations has enabled them to have learned their behaviors and underlying cause and effect relationships sufficiently well to have developed models of typical situations that allow them to both recognize typical situations and predict consequences of any action with a near certainty, therefore decision making tends to take the form of recognizing recurring patterns and responding to them with well-rehearsed actions (French 2013). Decision making model in simple contexts is to sense, categorize and respond to the situation (Kurtz and Snowden 2003; Snowden and Boone 2007). Decision makers should assess the facts of the situation, categorize the situation and then base their response on an established practice (Snowden and Boone 2007).

Complicated contexts

Complicated contexts in the knowable knowledge space have stable cause and effect relationships, but not everyone can perceive and understand them. Instead of shared understanding and self-evident right answers, there may be multiple right answers. This space can be called the realm of "known unknowns" where management and decision making can be based on known facts, but requires expert knowledge and investigating several alternative courses of action, many of which can be excellent. (Snowden and Boone 2007)

Knowable space represents the domain of good practice where management must rely on expert knowledge (Snowden 2002). In this space, there are existing cause and effect relationships that are discoverable, but they may not be fully known, or they may be known only by a limited group of people with relevant experience (Snowden 2002; Kurtz and Snowden 2003). In general, cause and effect relationships are separated over space and time and connected with linkages that are difficult to discover and understand without analysis and expert knowledge (Kurtz and Snowden 2003). Management activities within the knowable space may again focus on imposing structure and order to make the system more predictable, but the system will remain more fluid than in the known space (Snowden 2002). Although in principle everything in this space can be moved to the known space, in practice necessary time and resources cannot always be afforded and management must instead continue to rely on analytical techniques and experts and their knowledge (Kurtz and Snowden 2003).

Decision makers are less familiar with complicated contexts, where they are facing decision situations where the underlying cause and effect relationships can be discovered and understood, but for any specific situation there is a need to gather and analyze further data to predict the consequences of a course of action with any certainty (French 2013). Decision making model in complicated contexts is to sense, analyze and respond to the situation (Kurtz and Snowden 2003; Snowden and Boone 2007). Decision makers should assess the facts in the situation, analyze the situation and then base their response on expert advice or interpretation of that analysis (Snowden and Boone 2007).

Complex contexts

Complex contexts and knowledge space are characterized by multiple interacting cause and effect relationships that cannot be always fully perceived and understood. Right answers cannot be always found and consequences of actions cannot be fully predicted. This space can be called the realm of “unknown unknowns” where constant change and unpredictability are the main sources of complexity and therefore management and decision making cannot be fully based on known facts, but must instead rely on discovering and managing emerging patterns. (Snowden and Boone 2007)

Complex space represents the domain of managing patterns that emerge through interaction of many interconnected entities (Snowden 2002). In this space, there are existing cause and effect relationships between the individual entities, but both the number of individual entities and the number of relationships defy categorization and analytical techniques (Kurtz and Snowden 2003). There are so many interacting causes and effects that predictions of system behaviors are subject to considerable uncertainty and the range of actions available may be very unclear, such complexity typically arising in social systems (French et al. 2009, pp. 7-8) that are behaving as complex adaptive systems (Plsek and Greenhalg 2001). Although it is possible to break down existing patterns and create conditions under which new patterns will emerge by increasing information flow, variety and connectedness between the individual entities, the nature of emergence is never fully predictable (Snowden 2002). Emergent patterns can be perceived, but it is generally only possible to understand their underlying cause and effect relationships in retrospect. Structured methods that rely upon retrospectively coherent patterns and codify them to procedures may only be confronted with new and different patterns for which they are ill prepared. Although similar patterns may repeat over time, there is no certainty that they will continue to repeat indefinitely, because the underlying sources of patterns are difficult to perceive. Therefore, relying on existing expert knowledge based on historically stable patterns is insufficient and only prepares managers to recognize and act upon expected patterns. Instead, understanding this space requires gaining multiple perspectives on the nature and behavior of the system. Management activities within the complex space should focus on gaining new perspectives and understanding on the situation before acting, rather than relying on the entrained patterns of past experience to determine a course of action. The methods, tools and techniques of known and knowable spaces do not work in the complex space. (Kurtz and Snowden 2003).

Decision makers are never entirely familiar with complex contexts, where they are facing decision situations with many interacting causes and effects that are difficult to discover and understand and therefore every situation may appear to have some unique elements and unfamiliarity (French 2013).

Decision making model in complex contexts is to probe, sense and respond (Kurtz and Snowden 2003; Snowden and Boone 2007). Decision makers should create probes that make patterns or potential patterns more visible, sense those patterns that emerge and respond by stabilizing those patterns that are found desirable, by destabilizing those that are not wanted and by seeding the space so that patterns that are wanted are more likely to emerge (Kurtz and Snowden 2003).

Chaotic contexts

Chaotic contexts and knowledge space are characterized by unstable cause and effect relationships that cannot be perceived and understood. There are no manageable patterns and it is therefore pointless to search for right answers. This space can be called the realm of "unknowables" where extreme turbulence and unpredictability make discovering and managing patterns impossible and therefore immediate management activity should not be to attempt to discover any patterns, but to work to restore the order. (Snowden and Boone 2007)

Chaos may represent the consequences of excessive structure in a highly dynamic environment or may be caused by a massive and sudden change, which can both cause the underlying cause and effect relationships to break down and require crisis management (Snowden 2002). In this space, there are no perceptible relationships between cause and effect and therefore nothing to analyze. Although there is underlying potential for order, waiting for the patterns to emerge and stabilize is a waste of time. Management activities should instead focus on an intervention to restore order. Depending on the nature of the situation, the trajectory of intervention may differ. An authoritarian intervention may attempt to control the situation and move it to the knowable or the known space, or alternatively there may be a need to focus on multiple interventions to create new patterns that move the situation to the complex space. (Kurtz and Snowden 2003)

Decision makers are not familiar with chaotic contexts, but are facing decision situations that involve events and behaviors beyond their current experience with no obvious candidates for cause and effect (French 2013). Decision making model in chaotic contexts is to act, sense and respond (Kurtz and Snowden 2003; Snowden and Boone 2007). Decision makers should take quick and decisive action to reduce turbulence, sense immediately the reaction to that intervention and respond appropriately. (Kurtz and Snowden 2003)

3.3 Relationship between different frameworks

According to French et al. (2009, pp. 7-9) it is possible to associate decisions at different levels of the organizational decision hierarchy with the decision making contexts of the Cynefin framework. Strategic level decisions are typically associated with unstructured, unfamiliar decision situations and are therefore aligned with the complex and even chaotic contexts of the Cynefin framework. Tactical, operations, and instinctive level decisions are each assumed to have increasing structure and occur with increasing frequency, making them more familiar to decision makers, and they can be therefore more clearly aligned with the simple and complicated contexts of the Cynefin framework. There may not however always be precise mapping between strategic, tactical, operational and instinctive level decisions and one of the four Cynefin framework contexts. Therefore, the boundaries between the four contexts of the Cynefin framework should not be taken as hard, but different decision situations may instead have some characteristics of the adjacent contexts of the Cynefin framework. The proposed relationship between the different frameworks is represented in Figure 11.

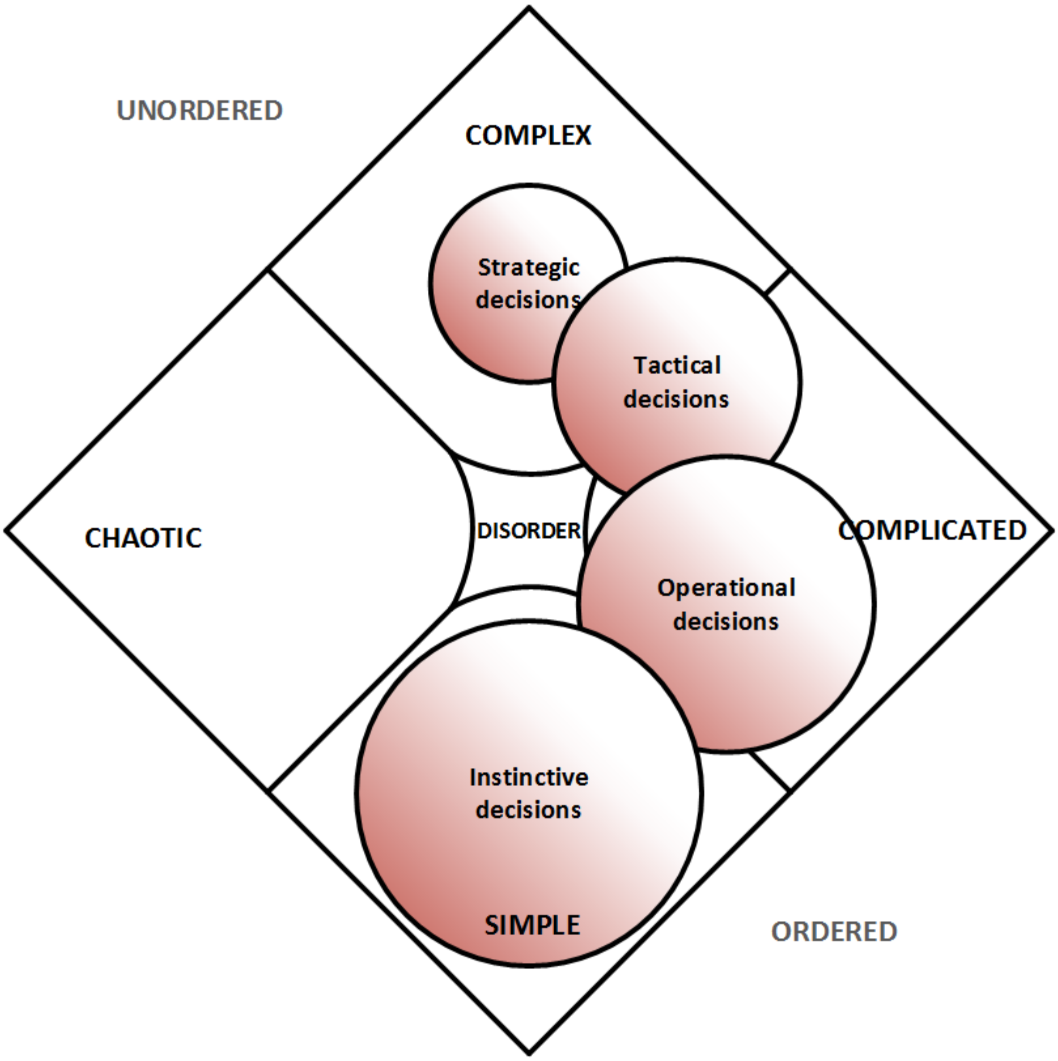

Figure 11. Relationship between traditional framework of organizational decisions and Cynefin framework (adapted from French et al. 2009, p. 9)

The proposed relationship between the different frameworks implies that the ideas of the Cynefin framework are in many ways parallel with the traditional framework. In comparison to the traditional framework the Cynefin framework is viewed to be especially valuable in providing an intuitive representation of decision making context characteristics that focuses attention not only on the inherent characteristics of the decision making context, but also on the types of knowledge and information that are available for decision makers in different knowledge spaces and the corresponding decision making contexts. In addition, the Cynefin framework allows representing the dynamics of a sequence of decisions in an evolving environment. When decision makers' knowledge and understanding of the decision situation changes, the decision makers are effectively moving into a different knowledge space, implying a need or an opportunity for a different approach for decision making. (French et al. 2009, pp. 8-9)

4. Role of data, information and knowledge in decision making

Data, information and knowledge are mandatory prerequisites for decision making, and their roles are interrelated during the decision making process, but different types of data, information and knowledge are needed and dominate the decision making processes in different types of decision situations and their associated decision making contexts (French et al. 2009, p. 91). It is viewed that understanding the interrelated role of different types of data, information and knowledge, and their influences on the characteristics of the decision making processes, provides the necessary basis for studying the nature of decision making processes and the requirements for decision support within different types of decision making contexts within complex service systems.

4.1 Distinction between data, information and knowledge

According to French et al. (2009, pp. 95-96) there is often no clear distinction made between data, information and knowledge. Although there may be a feeling of increasing value for the user passing from data to information to knowledge, this leaves their characteristics vague. More precise definitions are necessary to allow distinguishing their characteristics and discussing and understanding their role during the decision making process:

- Data are facts about things, events, activities and transactions that are not organized and do not relate to any specific context (French et al. 2009, p. 95; French 2013). Because data alone has no contextual meaning, it does not provide sufficient input to the decision making process. Decision makers need to understand the meaning of data within a specific context to make it useful information for decision making.
- Information is formed by selecting, organizing and summarizing data so that it becomes meaningful and useful within a specific context (French et al. 2009, p. 95; French 2013). Information provides a necessary input for the decision making process, but both the process of forming information and the decision making process itself require that decision makers have knowledge.
- Knowledge is more generic and longer lasting form of information that may be relevant in many different contexts. Knowledge includes the theories and models of science, which suggest how data should be organized into useful information, inferences drawn and forecasts made in a range of contexts. Knowledge also includes the understanding, skills and values of the decision maker, which direct the decision makers to recognize new understanding in forming and using information in specific contexts. Information may become new knowledge when decision makers recognize new understanding derived from it. Having knowledge implies having developed a level of understanding, experience and expertise that are useful in specific contexts. (French et al. 2009, pp. 95-96; French 2013)

A further important distinction between data, information and knowledge is that data and information can be always made explicit and codified, but knowledge always cannot (French et al. 2009, p. 96). This is reflected in the knowledge management literature through distinction between explicit and tacit knowledge. According to Nonaka (Nonaka 1991; Nonaka et al. 2000) explicit knowledge can be expressed in the forms of data, information, scientific theories and models, specifications, manuals and other such means. Given its characteristics, explicit knowledge can also be processed, transmitted and stored relatively easily. Tacit knowledge is highly personal, hard to formalize and therefore difficult to communicate to others. This category of knowledge includes personal skills, values, insights and judgment that are developed as a result of experience and learning. Tacit knowledge also has an important cognitive dimension, it consists of mental models, beliefs and perspectives that are so ingrained that we take them for granted and therefore cannot easily articulate them. These implicit models are profoundly shaping how we perceive the world around us. A summary of key distinctions between data, information and knowledge characteristics is presented in Table 3.

Table 3. Distinction between data, information and knowledge (adapted from French et al. 2009, p. 96)

	Data	**Information**	**Knowledge**
Description	Observation of states and events in the world.	Data endowed with relevance to a context.	General learning and understanding drawing on experience through reflection and synthesis.
Characteristics	Easily captured; easily structured; easily represented; often quantifiable; raw resource.	Needs agreement on meaning; built with analysis; reduces uncertainty within a context.	Transferable between contexts; some knowledge explicit – e.g. science; some tacit and personal – e.g. skills; hard to store and communicate.
Method of acquisition	Observation.	Judgment.	Experience.

4.2 Role of data, information and knowledge in decision making

Decision making requires data, information and knowledge, and their roles are interrelated in the decision making process. According to Boisot (1998, pp. 12-13) knowledge provides perceptual and conceptual filters that decision makers use to first select and organize data into information, and then to use that information to support decisions. During this process, it is necessary for the decision makers to depend on different types of knowledge. According to Nonaka et al. (2000) tacit and explicit knowledge are complementary and it is not possible to use explicit knowledge without the application of some tacit knowledge. In other words, knowing how to apply explicit knowledge is itself a tacit skill and any type of application of explicit knowledge involves some aspects of tacit knowledge. Therefore, the decision makers necessarily depend on both explicit and tacit knowledge during the decision making process, but the dominating type of knowledge may also depend on the characteristics of the decision making context (French et al. 2009, pp. 97-98). The relationship between data, information and knowledge within the decision making process and related tasks of making inferences and forecasts is represented in Figure 12.

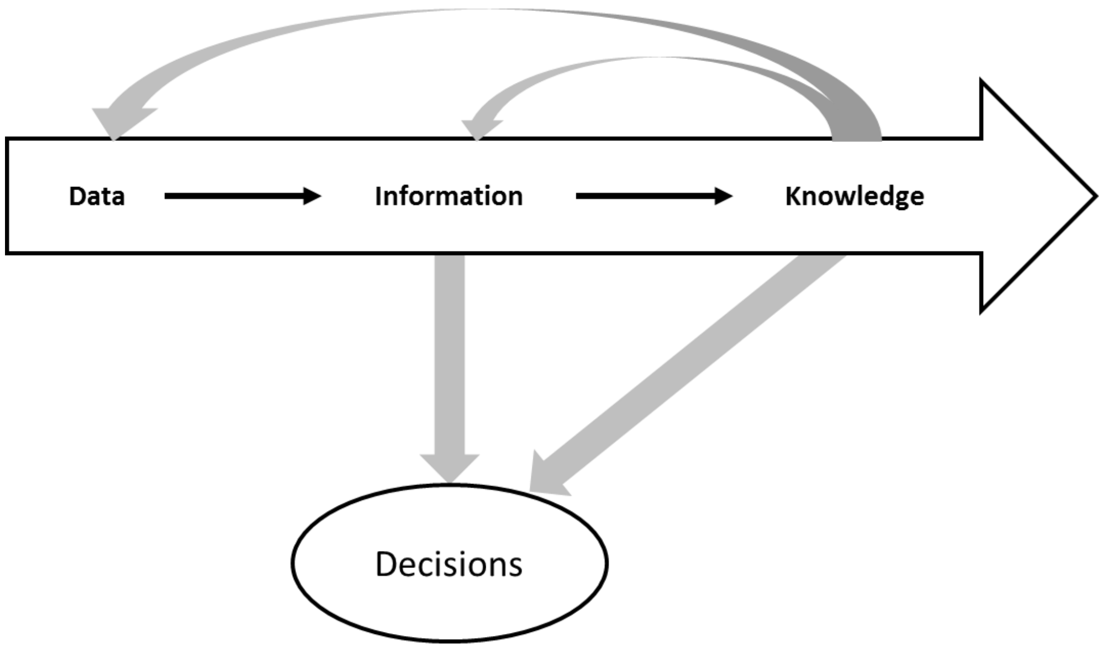

Figure 12. Relationship between data, information and knowledge in decision making (adapted from French et al. 2009, p. 98)

Decision makers rely on knowledge during the decision making process to select and organize data into useful information, and to use that information to formulate a sufficient understanding about the decision situation they are facing and to make judgments that allow them to reach a decision and implement a course of action. However, depending on the characteristics of the decision making context, the decision making process may be dominated by different type of knowledge. In the simple and complicated decision making contexts of the Cynefin framework many decision situations may be relatively familiar to the decision makers, and the decision making process may be a well-rehearsed task that can rely more on explicit knowledge. In the complex decision making contexts decision situations become less familiar, and the decision makers will need to draw more on their personal judgment, experience and creativity to make sense of the situation, relying more on their tacit knowledge. (French et al. 2009, pp. 97-98; French 2013)

It is also possible to view the decision making process as learning and knowledge creation process. After repeating the process a number of times, decision makers may recognize common patterns in several of the decision situations and decision making contexts. These patterns may suggest new generic insights about the common nature of the decision problems, that is, new knowledge, which can be applied in the future in similar decision situations and decision making contexts. (French et al. 2009, pp. 97-98; French 2013)

4.3 Knowledge creation as a prerequisite for decision making

Besides the appropriate existing data, information and knowledge, knowledge creation is viewed to be another important prerequisite for decision making within the organizational context. Within the organizational context much knowledge is created and applied through the social processes of discussion, learning and sharing (French et al. 2009, p. 98). According to the SECI (Socialization, Externalization, Combination, and Internalization) –model of organizational knowledge creation (Nonaka et al. 2000) knowledge is created through interactions between explicit and tacit knowledge, rather than from tacit or explicit knowledge alone. These interactions between the two types of knowledge are called knowledge conversion processes:

- Socialization is the process of creating new tacit knowledge through shared experiences. Because tacit knowledge is often difficult to formalize and is often context specific, it can be acquired only through shared experience, such as spending time together or through interactions in a shared environment. Socialization typically occurs in a traditional apprenticeship, where apprentices learn the tacit knowledge necessary in their work through hands-on experience, rather than from written manuals or text books. Socialization may also occur in informal social meetings outside of the workplace, where tacit knowledge such as world views, mental models and mutual trust can be created and shared. Furthermore, socialization is not limited to the organizational boundaries, but it is possible to acquire and take advantage of tacit knowledge embedded in, for example, customers or suppliers by interacting with them. (Nonaka et al. 2000)
- Externalization is the process of articulating tacit knowledge into explicit knowledge. When tacit knowledge has been made explicit, it can be shared with others, and it becomes the basis for new knowledge. (Nonaka et al. 2000)
- Combination is the process of converting explicit knowledge into more complex and systematic sets of explicit knowledge. Explicit knowledge is collected from different sources from both inside and outside the organization and then combined, edited or processed to form new knowledge that is then disseminated among the members of the organization. (Nonaka et al. 2000)
- Internalization is the process of embodying explicit knowledge into tacit knowledge. Through internalization, explicit knowledge created is shared throughout an organization and converted into tacit knowledge by individuals. Internalization is closely related to learning by doing, explicit knowledge has to be actualized through action and practice to make in meaningful in a specific context. For example, training programs can help trainees to understand an organization and themselves. By reading documents and manuals about their jobs and organizations, and by reflecting upon them, trainees can internalize the explicit knowledge written in such documents to enrich their tacit knowledge base. Explicit knowledge can also be embodied through simulations or experiments that trigger learning by doing. When tacit knowledge is internalized to become part of individual's tacit knowledge bases in the form of shared mental models or technical know-how, it becomes a valuable asset. This tacit knowledge accumulated at the individual level can then again set off a socialization process when it is shared with others. (Nonaka et al. 2000)

The SECI model of knowledge creation can be represented as a continuous process where different knowledge conversion processes are interacting (Nonaka 2000; French et al. 2009, pp. 98-99). The relationship between different types of knowledge and the interacting knowledge conversion processes are represented in Figure 13.

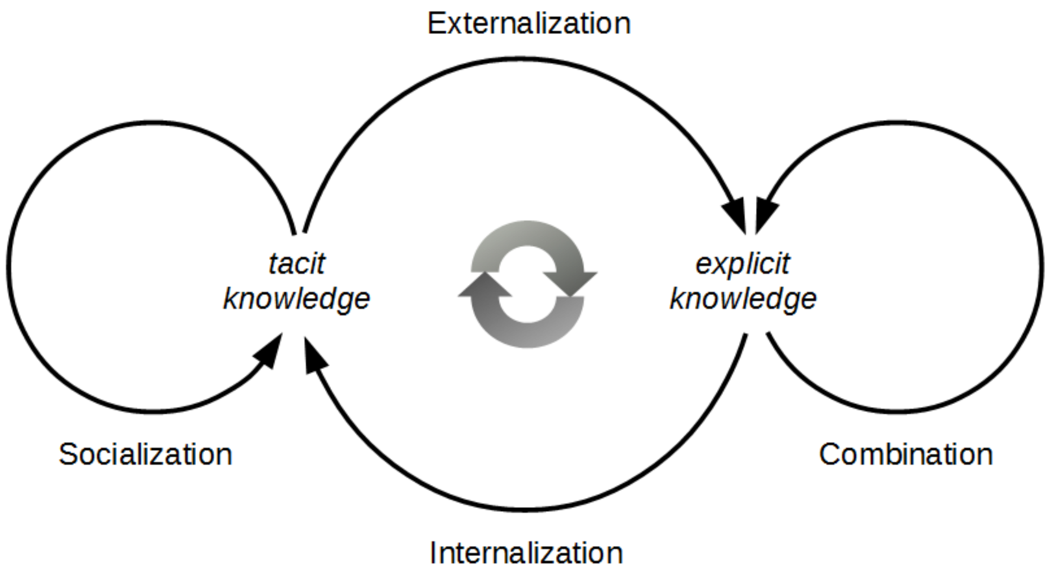

Figure 13. SECI model of organizational knowledge creation (adapted from French et al. 2009, p. 99)

According to French et al. (2009, pp. 98-99) organizational learning and knowledge creation through interactions between different knowledge conversion processes provides the basis for decision making within an organizational context. However, because the dominating types of knowledge required for decision making in different types of decision making contexts are different, also the dominating types of knowledge conversion processes and the required types of decision support in different types of decision making contexts are viewed to be different (French et al. 2009, pp. 109-110; French 2013). The proposed relationship between the dominating types of knowledge and knowledge conversion processes, and their implications for the types of decision support in different Cynefin framework decision making contexts are represented in Figure 14.

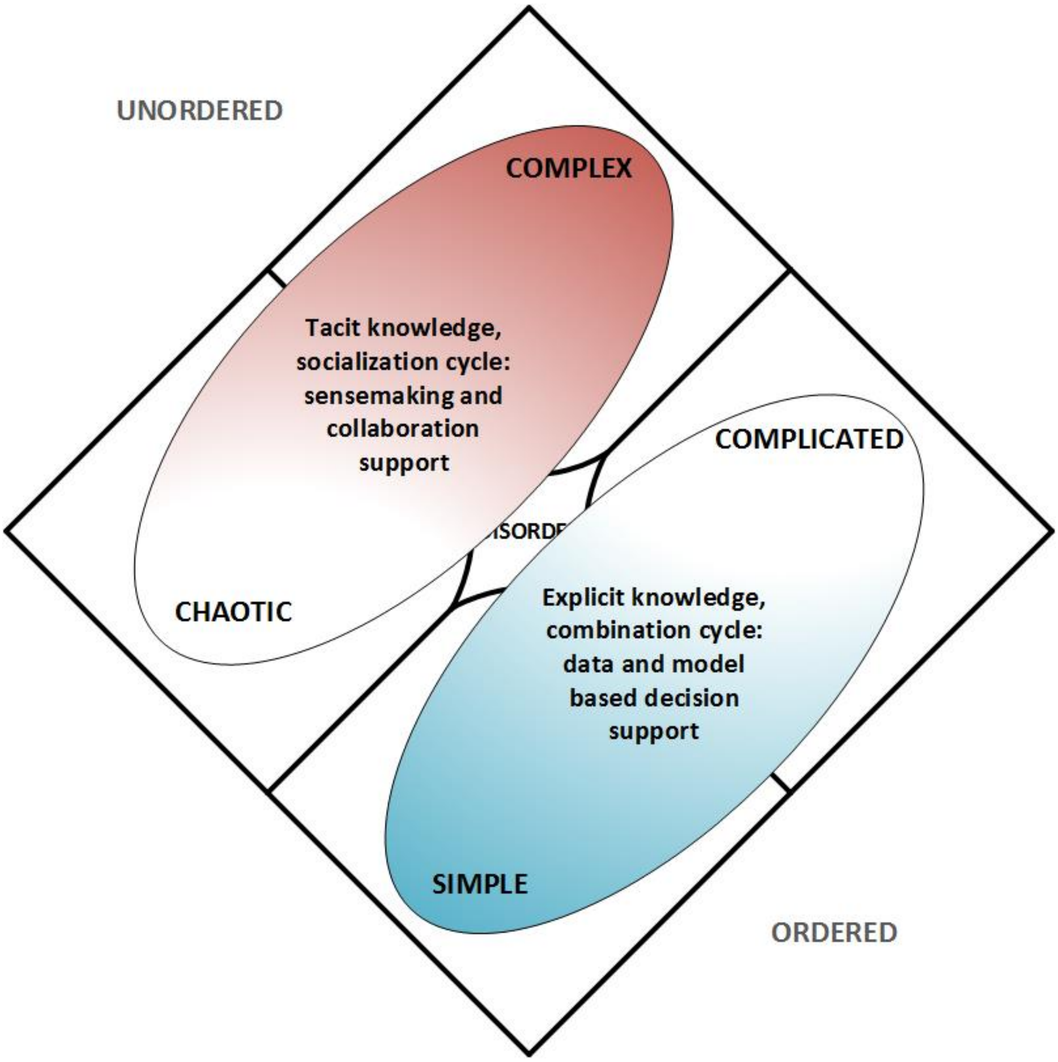

Figure 14. Knowledge and knowledge creation implications to decision making and decision support (adapted from French et al. 2009, p. 109; French 2013)

It is viewed that decision making in the simple and complicated contexts of the Cynefin framework can rely more on explicit knowledge created through the combination process. In these contexts, required knowledge can often be deployed through databases, knowledge bases and models and the decision making processes and decision support can be based more on data and information management, along with information systems that embed knowledge and provide predefined models for acquiring, storing and processing data and information. In the complex and chaotic contexts, on the other hand, decision making is viewed to rely more on decision makers' judgment based on their tacit knowledge created through the socialization process and emphasis in the decision making processes and decision support should be more on supporting sensemaking and collaboration, sharing tacit knowledge and building judgment. (French et al. 2009, pp. 109-110)

5. Organizational decision making

Decision making is a central organizational activity that is necessary for coordinating various activities at different levels of an organization (Simon 1997, pp. 1-2). It is viewed that decision making has an equally important role in coordinating activities within complex service systems and that models of organizational decision making can provide a basis for understanding the characteristics of decision making processes within complex service systems. Besides the characteristics of a particular decision situation and its associated decision making context, the overall organizational context is characterized by a number of factors that influence individual decision makers and organizational decision making processes (Shapira 1997, pp. 4-5). The key contextual factors that are viewed to influence organizational decision making are summarized in Table 4.

Table 4. Contextual factors influencing organizational decision making (adapted from Shapira 1997, pp. 4-5)

Factor	**Influence on organizational decision making**
Ambiguity	Decision makers and organizational decision making processes frequently face ambiguity over information, preferences and interpretations of the present decision situation in relation to past organizational decisions.
Conflict	Decision makers and organizational decision making processes frequently face conflict, and are more often influenced by power considerations and agenda setting, rather than objective evaluation of the present decision situation.
Incentives	Decision makers and organizational decision making processes are influenced by incentives and penalties, which have real and potentially long lasting effects that are intensified due to the longitudinal context of organizational decision making.
Longitudinal context	Decision makers are part of an ongoing organizational decision making process and are influenced by its consequences, event when they do not have an active role during all the phases of the process.
Repeated decisions	Decision makers frequently face decisions on similar issues, are influenced by their past experience and may develop a sense of being in control, which may both potentially be misleading during the organizational decision making process.

The impacts of the different influencing factors present within the organizational decision making context are reflected in different models of organizational decision making. The dominant organizational decision making models include the rational choice model, the political model and the garbage can model (Eisenhardt and Zbaracki 1992; French et al. 2009, p. 353-355).

Rational choice model

The rational choice model assumes that organizational decision makers seek to use information rationally to take decisions on benefit of their organizations (French et al. 2009, p. 353). The underlying assumption in the model is that decision maker behavior has purpose that reflects organizational goals and objectives. According to the model, the decision makers enter decision situations with known objectives that determine their preferences and the value of possible consequences of an action. They then gather appropriate information, develop a set of alternative actions and then select an optimal alternative depending on organizational objectives. In reality the decision makers are rarely capable of purely objective rationality. During the decision making process they rarely engage in comprehensive search of information and development of alternative actions, the analysis of alternatives may also be limited and decisions often reflect the use of standard operating procedures rather than systematic analysis and optimization. Furthermore, the organizational goals and objectives are often unclear and shift over time and are only discovered during the decision making process. (Eisenhardt and Zbaracki 1992)

Political model

The political model focuses on how organizational decision makers develop and apply strategies and tactics to influence organizational decision making processes in such a way to benefit themselves (French et al. 2009, p. 354). The underlying assumption in the model is that organizations are coalitions of people with competing interests and conflicting preferences that influence the organizational decision making process (Eisenhardt and Zbaracki 1992). These conflicting preferences arise from different expectations on the shape of the future, biases induced by position within the organization and clashes in personal ambitions and interests (Allison 1971 in Eisenhardt and Zbaracki 1992). During the decision making process the conflicts are resolved among individual decision makers with competing preferences and often the decisions follow the desires and subsequent choices of the most powerful people involved (March 1962). Furthermore, decision makers often attempt to change the existing power structure by engaging in political tactics such as coalition formation, cooptation, strategic use of information, and the employment of outside experts (Eisenhardt and Zbaracki 1992).

Garbage can model

The garbage can model views organizations as organized anarchies, which are characterized by ambiguity, complexity and instability that influence the organizational decision making process (French et al. 2009, p. 354). According to Cohen et al. (1972) the ambiguity has three main manifestations. First, organized anarchies have problematic preferences. Decision makers often possess inconsistent and ill-defined preferences and they are as likely to discover their preferences through action as they are to understand them prior to choice. Second, organized anarchies have unclear technology. Decision makers only have loose understanding of the organizational processes and the cause and effect relationships that are present in a particular decision situation, its decision making context and the overall organizational context. They often operate on the basis of trial and error and knowledge learned from the past experience, but without clear understanding of the underlying cause and effect relationships. Finally, organized anarchies are characterized by fluid participation. Participants in organizational decision making processes come and go, with their involvement depending upon their energy, interest and other demands on their time. In comparison to the rational choice and political models, the garbage can model focuses attention to the importance of chance (Eisenhardt and Zbaracki 1992). In organized anarchies, events seemingly occur outside the control of decision makers and even small changes in the circumstances can have a major effect on the decision outcome (French et al. 2009, p. 354). Decision situations often have a complex and fuzzy character, decision makers have no clear preferences and they wander in and out of the ongoing decision making process that has no clear beginning and end points. Decisions are therefore not so much the result of rational analysis or power considerations, but rather are a random confluence of events. (Eisenhardt and Zbaracki 1992)

In management and decision support literature (Daft 2006; Cooke and Slack 1984; Power 2002; French et al. 2009; Turban et al. 2011) the rational choice model is commonly viewed as the normative model that defines how decision makers should make decisions within the organizational context. The rational choice model also provides basis for various prescriptive models of organizational decision making process, which seek to guide decision makers towards rationality within the context of real world, often ill-defined problems.

5.2 Rational choice model and bounded rationality in organizational decision making

According to March (1994, pp. 1-3) rational choice models assume that decision making is consequential and preference based. Decision making can be regarded consequential in the sense that decision maker actions depend on the anticipation of future effects of current actions and that alternatives are evaluated in terms of their expected consequences, and preference based in the sense that decision makers compare alternatives in terms of extent to which their expected consequences are thought to serve the preferences of the decision maker. Based on these assumptions, rational decision making can be viewed as based on four aspects (March 1994, pp. 2-3):

1. A knowledge of alternatives; decision makers have a set of alternatives for action.
2. A knowledge of consequences; decision makers know the consequences of alternative actions.
3. A consistent preference ordering; decision makers have consistent values by which alternative consequences of action can be compared in terms of their value.
4. A decision rule; decision makers have rules by which they select a single alternative of action on the basis of its consequences for the preferences.

Although rational choice models are used as a common portrayal of decision making behavior on many different fields (March 1994, p. 3), pure rational choice models are hardly useful in predicting and prescribing decision maker behavior in real world decision situations due to their underlying assumptions. According to Simon (1997, p. 119) following assumptions are made about a rational decision maker in the pure rational choice models:

1. A rational decision maker will always deal with the real world decision situation in all its complexity.
2. A rational decision maker will always maximize value by selecting the best alternative from all the available decision alternatives. This behavior is also called optimization.

These assumptions have two important implications regarding the rational decision maker and the decision making process. First, the decision maker must have perfect knowledge about all the available alternatives and all the possible outcomes and consequences of those alternatives in a particular decision situation. Second, the decision maker must be capable of perfect judgment by maintaining a consistent system of preferences against which the value of alternative courses of action can be judged in order to be able to choose the alternative that will guarantee the maximum value in a particular decision situation. (Cooke and Slack 1984, pp. 55-57)

According to Simon (1955; 1956; 1997, pp. 118-129) human decision makers are not capable of following pure rational choice models in real world decision situations due to their limited cognitive capacity that makes it impossible for them to carry out all mental operations that would be required by these models, but are instead using simpler decision making strategies that involve processing less information, often in a much simpler way. Due to their cognitive limitations human decision makers are only capable of bounded rationality and the actual decision making behavior in real world decision situations can be described as satisficing rather than maximizing (Simon 1997, p. 119):

1. A satisficing decision maker chooses a course of action that is satisfactory or good enough in the given decision situation.
2. A satisficing decision maker recognizes that the perceived world is a drastically simplified model of the real world and treats individual decisions situations as only loosely connected with each other. Therefore, most of the facts of the real world have no great relevance to any single decision situation and the most significant chains of causes and consequences are short and simple. The decision maker can therefore leave out of consideration those aspects of reality that appear irrelevant at a given time and take into account only few of the factors of the decision situation that are regarded as the most relevant and crucial and deal with one of few problems at a time, because the limits of attention do not permit everything to be attended to at once.

Accepting that decision making behavior in real world decision situations is based on bounded rationality and satisficing rather than maximizing, means abandoning the conditions of perfect knowledge and perfect judgment that are required by the pure rational choice strategies (Cooke and Slack 1984, p. 57). Instead of dealing with all the complexity the decision makers construct a personal, limited, approximate simplified model of the real world decision situation that can be called their definition of the situation (March and Simon 1958, p. 139), which represents the perception of the decision maker of the real world decision situation as the decision maker selects the elements of the real world decision situation that are meaningful and significant at that particular point of time (Cooke and Slack 1984, p. 57). The elements of this model are not predetermined, but are themselves outcome of mental and social processes, including decision makers' own activities and the relevant activities of others (March and Simon 1958, p. 139). The model provides the decision makers the basis for understanding the causes and consequences that are present in the real world decision situation and allows them to make judgment about the appropriate course of action. Because the real world decision situations are often characterized by regularities, such that it is not necessary to process all the information, satisficing may often perform quite as well and more formal rational choice strategies in these types of situations. Therefore satisficing does not necessarily mean sacrificing decision quality, given the constraints of limited time and resources to make decisions and the lower demands that this decision making strategy makes on mental and other resources. (French et al. 2009, pp. 28-29)

5.3 Organizational decision making process

The rational choice model, together with the notion of bounded rationality, provides a basis for a number of prescribed models of organizational decision making in the management and decision support literature (Daft 2006; Cooke and Slack 1984; Power 2002; French et al. 2009; Turban et al. 2011). According to Simon (1997, pp. 122-127) the real world context of organizational decision making and bounded rationality of human decision makers together necessitate following a structured approach and structured process in organizational decision making. The prescribed model of organizational decision making process can be divided in three main phases (Simon 1977, pp. 40-41):

1. Intelligence phase; which involves searching the environment for conditions calling for a decision.
2. Design phase; which involves inventing, developing and analyzing possible courses or action.
3. Choice phase; which involves selecting a particular course of action from those available.

Although the phases of decision making process generally proceed in a linear fashion, the intelligence phase generally preceding the design phase, and the design phase generally preceding the choice phase, the overall process can be more complex than this sequence suggests. Each phase in a particular decision situation can itself be a complex decision making process and the overall decision making process can rather be seen as a series of interdependent and nested sub-processes. For example, the design phase may require new intelligence activities and problems at any given level can generate sub-problems that, in turn, have their own intelligence, design and choice phases. The three main phases can nevertheless usually be clearly distinguished as the organizational decision making process unfolds. (Simon 1977, p. 34)

The prescribed organizational decision making process models generally build on the intelligence, design and choice phases, but frequently also a fourth phase of implementation is added in the models (Daft 2006; Cooke and Slack 1984; Power 2002; French et al. 2009; Turban et al. 2011). The implementation phase describes the process of implementing a chosen course of action in the organizational context (Turban et al. 2011, pp. 58-59). An example of a prescribed organizational decision making process model that builds on this model is provided by Turban et al. (2011, pp. 45-59). The decision making process model is represented in Figure 15.

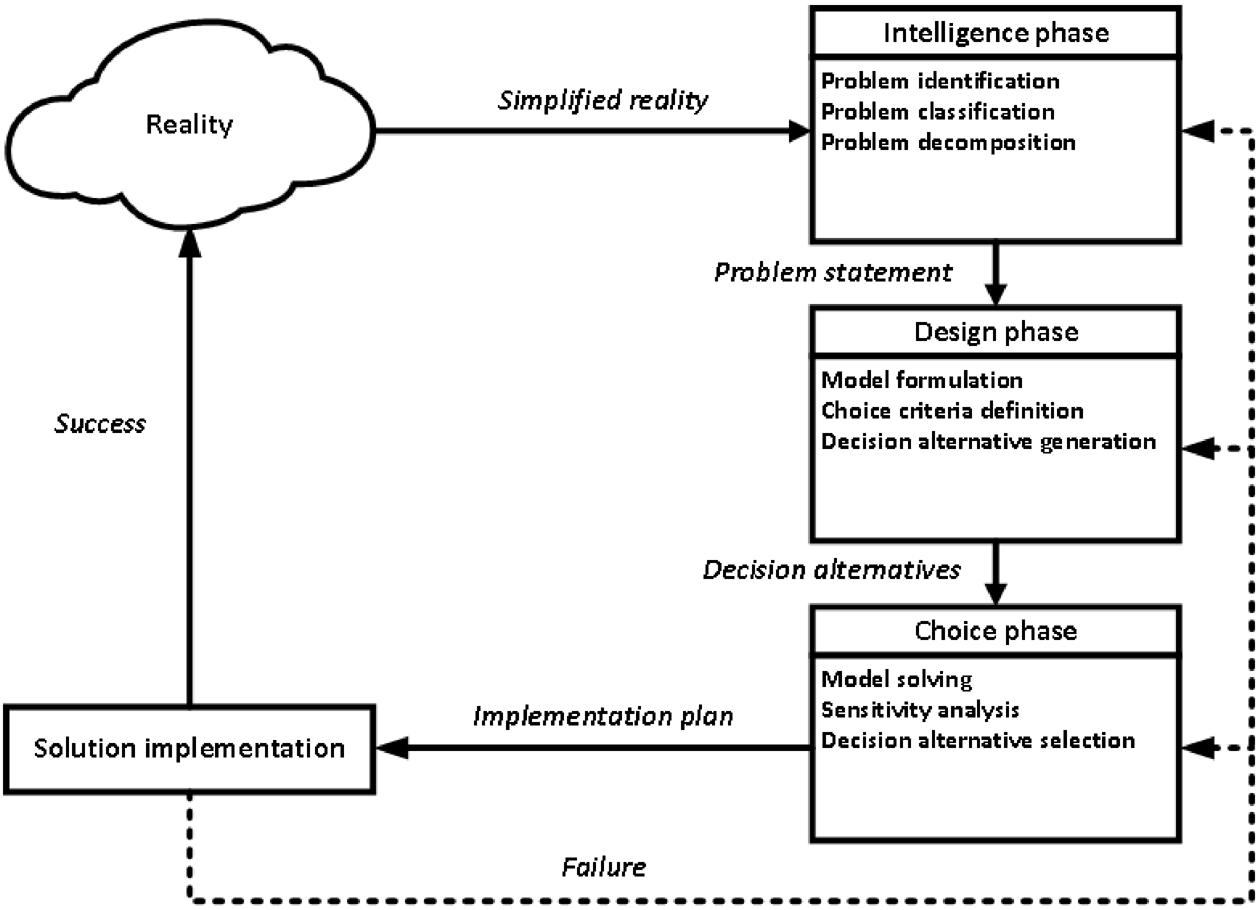

Figure 15. Organizational decision making process model (adapted from Turban et al. 2011, p. 46)

Intelligence phase

The main intelligence phase activities include problem identification, problem classification and problem decomposition. Problem identification focuses on identifying a potential issue of concern and defining its relation to organizational goals and objectives. Problem situations occur because of dissatisfaction with the perceived present situation in relation to organizational goals and objectives. Dissatisfaction is the result of a difference between what is expected and what is perceived to occur in reality. In this phase, decision makers attempt to determine whether a problem requiring a decision exists, identify its symptoms and determine its magnitude, and explicitly define the problem. Problem classification involves conceptualizing the decision problem in an attempt to place it in a definable category, possibly leading to a standard solution approach for familiar decision problems. Decision problems can be generally categorized according to their degree of structuredness, ranging from totally structured to totally unstructured. Problem decomposition involves dividing complex problems into individual sub-problems. Seemingly unstructured decision problems may frequently be composed of many interrelated and structured sub-problems. Successful decomposition may potentially allow focusing on solving an interrelated set of structured sub-problems, may help in incorporating both quantitative and qualitative factors into decision models and may facilitate easier communication between individual decision makers. (Turban et al. 2011, pp. 48-50)

Design phase

During the design phase the main activities include model formulation, choice criteria definition and decision alternative generation. Model formulation has the purpose of conceptualizing the decision problem and abstracting it to an appropriate quantitative or qualitative form or a combination of these. Model describes the relevant part of the system and the decision problem based on the perceived simplified reality. For many standard problems there are standard classes of models available that provide the basis for model formulation. Choice criteria definition establishes the principle of choice among decision alternatives based on their desirability. Selecting the principle of choice is not part of the choice phase, but is part of defining decision objectives and incorporating those objectives in the formulated decision model. Decision alternative generation has the purpose of developing possible courses of action. Generating decision alternatives can be a significant and time consuming part of the design phase that involves searching and creativity, is heavily dependent on the availability and cost of information and requires expertise in the problem domain. (Turban et al. 2011, pp. 50-58)

Choice phase

The choice phase is the one in which the actual decision and the commitment to follow a certain course of action are made. Choice phase activities include the search for, evaluation of and recommendation of an appropriate solution to the model. Solving the model, however, is not the same as solving the decision problem that the model represents. The solution to the model only provides a recommended solution alternative to the decision problem, but the decision problem can be considered solved only if the recommended solution alternative is successfully implemented. (Turban et al. 2011, p. 58)

Implementation phase

The implementation phase activities depend on the characteristics of the decision problem and the selected solution alternative, making the activities difficult to define. The phase may potentially include many activities and may involve many members of an organization and a number of other stakeholders, making it a complex process with vague boundaries. A simplistic definition for these activities can be applying the selected solution alternative in practice. (Turban et al. 2011, pp. 58-59)

6. Naturalistic decision making

Naturalistic Decision Making (NDM) (Klein and Calderwood 1991; Orasanu and Connolly 1993; Zsambok 1997; Lipshitz et al. 2001; Klein 2008) provides another perspective on decision making that focuses on how individual experienced decision makers make decisions in real world decision making contexts that are meaningful and familiar to them. Besides the organizational decision making models, also the NDM model is viewed to have an important role in organizations, especially in domain of operational performance and hands-on activities, and their instinctive decisions (French et al. 2009, pp. 5-6). It is viewed that the NDM model has an equally important role in decision making within complex service systems and that the model can provide a basis for understanding how individual decision makers make decisions within different types of decision making contexts in complex service systems, drawing on their experience and knowledge about the decision situation and the decision making context.

According to Lipshitz et al. (2001) NDM research attempts to understand how people make decisions in real world decision making contexts that are meaningful and familiar to them. The NDM can be shortly defined as the way how people use their experience to make decisions in operational settings (Zsambok 1997, p. 4), where the key contextual factors that affect the way real-world decision making occurs often include ill-structured problems in uncertain and dynamic environments, shifting, ill-defined and often competing goals, multiple feedback loops between decision maker actions and the environment, time stress, high stakes, multiple players and organizational goals and norms (Orasanu and Connolly 1993). The main motivation for the NDM research has been provided by observations that traditional models of decision making have lacked explanatory or predictive power in these types of real-world decision making contexts, or there have been problems with their prescriptions (Zsambok 1997, p. 4). Besides the contextual factors, other key factors that characterize NDM research include its focus on experienced decision makers, descriptive approach with focus on discovering how experienced decision makers make decisions in real-world decision making contexts and focus on the entire decision making episode, including the necessary pre-decision processes, such as situation assessment process (Zsambok 1997, pp. 4-5), necessary for making sense and building the necessary understanding about the present decision situation and its decision making context. Taking into account the factors that characterize NDM research, a more comprehensive definition for the NDM is proposed by Zsambok (1997, p. 5):

“The study of NDM asks how experienced people, working as individuals or groups in dynamic, uncertain, and often fast-paced environments, identify and assess their situation, make decisions and take actions whose consequences are meaningful to them and to the larger organization in which they operate.” (Zsambok 1997, p. 5)

Although the comprehensive definition emphasizes decision situations within complex, uncertain and unstable decision making contexts, where decision makers cannot rely on routine action or thinking (Zsambok 1997, p. 6), it is recognized that many real world decision situations involve routine actions (Rouse and Valusek 1993). The resulting differences in decision maker behavior in different decision situations within different types of real world decision making contexts are addressed by various NDM models (Zsambok 1997, p. 6).

6.1 Recognition-primed decision (RPD) model of naturalistic decision making

There are a number of NDM models proposed in the literature (Lipshitz 1993). According to Lipshitz et al. (2001) a prototypical model of NDM is provided by the recognition-primed decision (RPD) model (Klein et al. 1986; Klein 1993; Klein 1997; Klein 1998, pp. 24-28; Klein 2004, pp. 24-33; Klein 2011, pp. 90-93). The RPD model essentially describes how decision makers use their experience and knowledge in real world decision situations in the form of a repertoire of patterns to identify an effective course of action and through mental simulation to make sure that it will work in the decision making context (Klein et al. 1986). The basic principle of the RPD model is illustrated by a simplified version of the model represented in Figure 16.

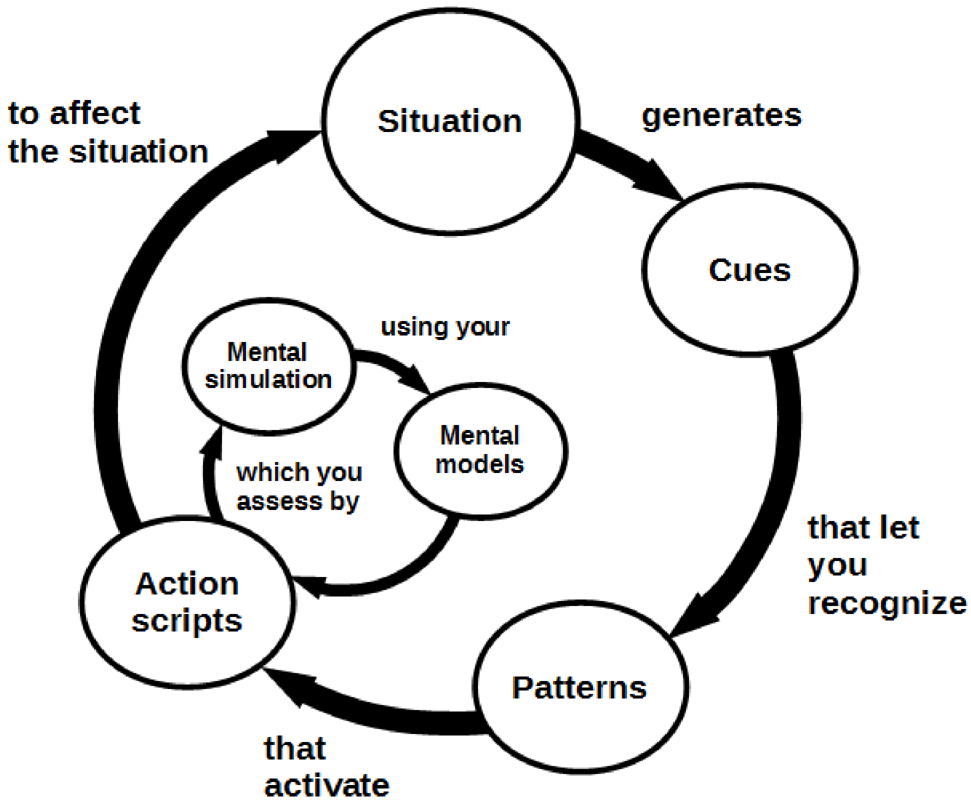

Figure 16. Simplified RPD model (adapted from Klein 2004, p. 26)

The RPD model can be viewed as a blend of intuition and analysis (Klein 2008) that fuses two types of cognitive processes: the way decision makers make situation assessment to generate a plausible course of action and the way they use mental simulation to evaluate that course of action (Klein 1993, pp. 138-143; Klein 1998, p. 24). The situation assessment process relies on pattern matching and is the intuitive part, while the mental simulation process is the conscious, deliberate and analytical part. Decision makers can quickly make the situation assessment and match the decision situation to the patterns they have learned. The perceived patterns describe the primary cause and effect relationships present in the situation and highlight the most relevant cues, provide expectancies, identify plausible goals and suggest typical courses of action in that type of situation. If the decision makers find a clear match, they can carry out the most typical course of action, allowing them to make extremely rapid decisions. However, there may also be need for the decision makers to evaluate a course action using mental simulation to imagine how it would work out in the context of the current situation. If it would work, they could initiate action. If it would almost work, they could try to adapt it or else consider other courses of action that are somewhat less typical, continuing until they find an alternative that they feel comfortable with. (Klein 2008)

The blend of intuitive and analytical processes present in the RPD model corresponds to the System 1 (fast and unconscious) and System 2 (slow and deliberate) account of cognition proposed by Kahneman (2011, pp. 20-24). These two types of cognitive processes can be viewed as complementing and balancing each other in real-world decision situations. In many decision situations a purely intuitive strategy relying only on pattern matching would be too risky because sometimes pattern matching generates flawed options, while a completely deliberative and analytical strategy would be too slow (Klein 2008). The overall decision making process exemplifies the notion of satisficing (Simon 1997, p. 119), looking for the first workable course of action rather than trying to find the best possible course of action (Klein 1993, p. 144).

6.2 Recognition-primed decision (RPD) decision making process

Depending on the decision maker experience and knowledge and the real world decision situation and decision making context characteristics, the overall decision making process may follow different courses that are dominated by different types of cognitive processes. The RPD model has three main variations that illustrate typical decision making process variations (Klein 1993; Klein 1998, pp. 24-28; Klein 2008). The RPD model variations are represented in Figure 17.

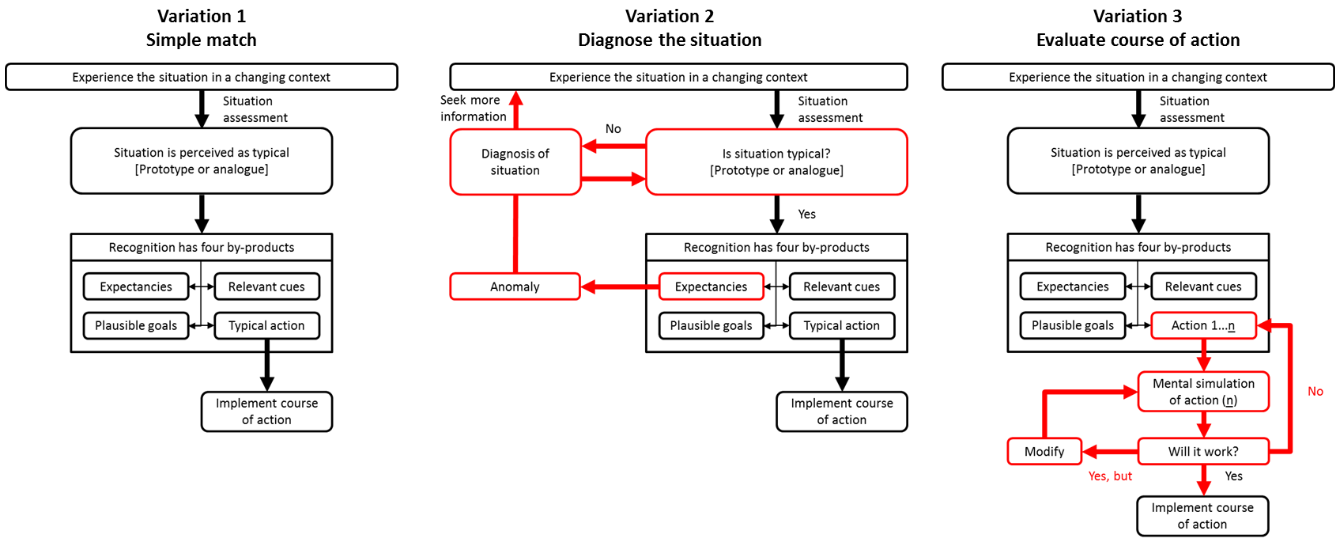

Figure 17. Recognition-primed decision model variations (adapted from Klein 1993, p. 141; Klein 1998, p. 25)

In the simplest variation of the model, decision makers recognize the situation as typical and proceed to take action with the initial course of action identified (Klein 1998, p. 24). The hypothesis is that skilled decision makers can usually generate a feasible course of action as the first one they consider by using their experience and knowledge that provides them with prototypes or analogues of familiar decision situations that suggest certain types of actions that are appropriate and usually successful (Lipshitz 2001). This hypothesis is central to the RPD model and has been supported by a number of studies (Klein 2008). An essential part of recognizing the situation is that the decision makers also relate with the relevant goals, cues, expectancies and actions that together prepare them to take the appropriate action. The decision makers do not start with evaluating their goals and expectancies and use these to assess the nature of the situation, but the recognition of typical situation in a real world decision making context brings them understanding about what types of goals make sense, which cues are important, what to expect next and the typical ways of responding in a given situation. Understanding the relevant goals allows the decision makers to set their priorities, the relevant cues help them to direct their limited attention and avoid information overload, and their expectations together with typical actions prepare them to take action and notice any surprises. (Klein 1998, pp. 24-26)

The second variation describes what happens when the decision situation is not clear, since the situation assessment does not clearly match a typical situation or may map into more than one typical situation. In these types of situations decision makers need to devote more attention to diagnosing the situation and may need to gather more information in order to properly assess the situation. Another potential complication arises when the decision makers have misinterpreted the situation but do not realize it until some of the expectancies are violated. The decision makers will again respond to observed anomalies or ambiguities by diagnosing which interpretation provides the best match with the features of the situation, this type of diagnosis may involve an attempt to build a story to account for the inconsistencies. (Klein 1998, p. 26)

The third variation describes how decision makers can evaluate a course of action without comparing it with others by mentally simulating how the course of action will work in the decision making context. In case that the decision makers anticipate difficulties, there may be need to adjust the course of action, or maybe reject it and look for another alternative. (Klein 1998, p. 26)

According to Klein (2011, p. 45) expert decision maker performance is heavily dependent on their tacit knowledge, which affects their perceptual skills, pattern matching and judging typicality that are necessary for situation assessment to form situation awareness and for identifying workarounds that are necessary for mental simulation. Both situation awareness and mental simulation have an important role in the RPD model. Situation awareness is the result of the situation assessment process and valid situation awareness provides decision makers with necessary understanding about the relevant goals, important cues, expectancies and possible courses of action in a decision situation within the decision making context. Mental simulation is additionally required in less typical decision situations within more complex decision making contexts and can be identified in three places in the RPD model: diagnosing to form situation awareness, generating expectancies to help verify situation awareness and evaluating a course of action (Klein 1998, pp. 89-93).

7. Situation awareness

Situation Awareness (SA) has an important role in Naturalistic Decision Making (NDM) (Zsambok 1997; Endsley 1997, Klein 1998, pp. 89-92). The concept of SA originated in the domain of military aviation (Endsley 1995), but SA has become a key concept in Human Factors (HF) research and applications (Endsley 2006), especially in the areas systems design and evaluation for systems that are aimed to support cognitive work in complex socio-technical systems (Wickens 2008; Salmon et al. 2009, p. 7). It is viewed that SA is required in a wide variety of domains, where input from the environment is necessary for decision making and task performance (Endsley 1995), but the concept of SA is most often associated with operational situations, where SA is needed for a specific reason, and the required information that form SA is defined in terms of the goals and objectives of a specific task or activity (Endsley and Jones 2012, p. 13). Furthermore, it is viewed that acquiring and maintaining SA is an important prerequisite for both individual and team decision making and task performance in complex socio-technical systems, where decision making and task performance often involves cognitively demanding tasks in a dynamic and complex environment (Salmon et al. 2009, p. 31). Similarly to the NDM, it is viewed that SA is associated with decision making in the domain of operational performance and hands-on activities, and their instinctive decisions, and is an important prerequisite for both individual and team decision making and task performance in many activities within different types of decision making contexts in complex service systems that involve cognitively demanding tasks in a dynamic and complex environment.

There are a number of SA models proposed in the literature (Salmon et al. 2009, pp. 7-34), but the dominating SA model in both NDM and HF research and applications is Endsley's (1995) three level model of SA in dynamic decision making (Salmon et al. 2009, p. 10). According to Salmon et al. (2009, pp. 16-17) the model provides a generic and intuitive description of SA, and its utility lies in its simplicity and division of SA into three hierarchical levels, which allows SA to be measured easily and effectively and also supports the abstraction of SA requirements and the development of training programs and systems design guidelines to support the acquisition and maintenance of different SA levels. The model is comprehensive in that it identifies the various different factors that affect an individual decision maker's acquisition and maintenance of SA, including the individual, task and system related factors. Furthermore, the inherent notion that an experienced decision maker's tacit knowledge in the form of mental models facilitates the development of higher levels of SA effectively explains the differences between different levels of SA achieved by novices and experts. The model has been developed in conjunction with the NDM research (Zsambok 1997) and provides an SA framework that is compatible with the Recognition-Primed Decision (RPD) model of NDM (Endsley 1995).

7.1 Model of situation awareness in dynamic decision making

According to Endsley (1995) SA is based on maintaining a constantly evolving picture about the state of the environment and can be described as knowing what is happening around you now and understanding what that information means now and in the future in relation to the present goals and objectives. In dynamic and complex environments many decisions are typically required across a fairly narrow space of time and decision making and task performance are dependent on an ongoing up-to-date understanding of the state of the environment. Increasing complexity and dynamics of the environment, however, make acquiring and maintaining SA increasingly difficult. When the state of the environment is constantly changing, maintaining good SA may therefore become a major challenge for decision makers and may also become one of the major factors determining their performance. SA is defined as "the perception of the elements in the environment within volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley 1988 in Endsley 1995). This definition forms the basis for the three level model of SA in dynamic decision making (Endsley 1995) that is represented in Figure 18.

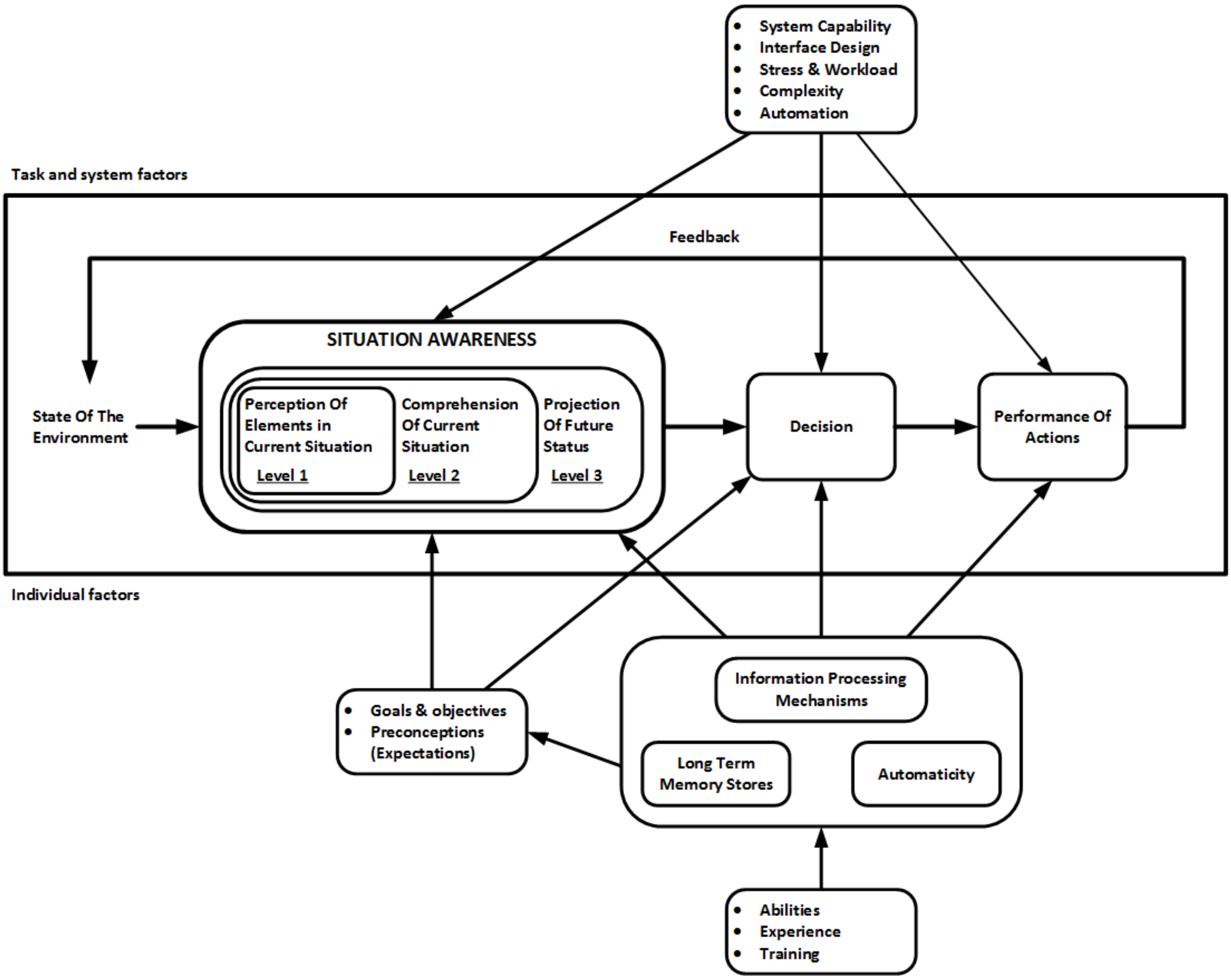

Figure 18. Model of situation awareness in dynamic decision making (adapted from Endsley 1995)

The SA model represents the dynamic interaction between the human decision maker and the constantly evolving environment and provides basis for understanding the role of SA in the overall decision making process in complex and dynamic environments (Endsley 1995). According to the model, individual decision makers form SA based on the perception of relevant elements in the environment that are reflecting the state of the system and its operational environment and are important for performing present activities in light of the present goals and objectives (Endsley and Jones 2012, pp. 13-14). Perception of the elements can come directly through human senses or may be assisted through various technologies, such as information system displays (Endsley 1995). Acquiring and maintaining SA, however, is based on more than simply perceiving information about the environment. SA also includes comprehending the meaning of the perceived information in an integrated form, comparing that with the present goals and objectives, and projecting possible future states of the environment that are valuable for the decision making process. Therefore, SA is viewed as a prerequisite for the decision making process, which aims for selecting the appropriate actions that are necessary for meeting the present goals and objectives. The performed actions are reflected in the state of the environment and provide feedback for the decision makers in the form of perceived changes in the state of the system and its operational environment. (Endsley 1995; Endsley 2000)

According to the model there are several factors related to an individual decision maker, and the system and task domains, that influence the process of acquiring and maintaining SA. Individual decision makers vary in their ability to acquire SA, due to differences in the information processing mechanisms between individuals, which are influenced by their innate abilities, experience and training. In addition, individual expectations, and present goals and objectives may act to filter and interpret the environment in forming SA. System design may affect SA in terms of the degree to which the system provides the needed information and the form in which it provides it. All system designs are not equal in their ability to provide the needed information, or in the degree to which they are compatible with human information processing mechanisms. Finally, task environment features, including work load, stress and complexity may also affect SA. (Endsley 1995)

7.1.1 Levels of situation awareness

According to the definition and the model, SA breaks down into three hierarchical levels (Endsley 1995; Endsley 2000; Endsley and Jones 2012, pp. 14-18):

- Level 1 – perception of the elements in the environment;
- Level 2 – comprehension of the current situation;
- Level 3 – projection of the future status.

Level 1 SA

Level 1 SA concerns the perception and awareness of relevant elements in the environment, including the status, attributes and dynamics of the relevant elements in the environment (Endsley 1995). The perceived cues and data from the environment are the fundamental basis for SA (Endsley 2000). In different domains and tasks the Level 1 SA requirements and the required information are typically different and also the way how the cues and data are perceived can be quite different. Perception of cues and data can come through different senses and they can be available from different information sources. An important source of Level 1 SA information in many domains and tasks is by directly perceiving the environment. In many complex systems it is, however, not possible to directly perceive all the relevant elements in the environment due to human cognitive limitations or limitations of the system, in these types of systems it is often necessary to augment Level 1 SA information through various technologies, such as information systems that provide displays with information about the relevant elements and state of the system. Finally, verbal and non-verbal communications with others can be an important source of Level 1 SA information. Regardless of the information source, confidence in the information, as well as the information itself forms a critical part of Level 1 SA in most domains. (Endsley and Jones 2012, pp. 14-15)

Level 2 SA

Level 2 SA concerns the comprehension of the current situation based on a synthesis of the perceived individual Level 1 SA elements (Endsley 1995). Achieving Level 2 SA requires that decision makers form an understanding about what the cues and data perceived mean in relation to their present goals and objectives and involves integrating many pieces of data to form information and prioritizing that information combined with its importance and meaning in relation to achieving present goals and objectives (Endsley and Jones 2012, pp. 16-17). Based on their understanding of integrated Level 1 elements, particularly the patterns that they form with other elements, decision makers form a holistic picture of the environment, allowing them to comprehend the significance of the perceived objects and events in the environment (Endsley 1995). With Level 2 SA decision makers have comprehension of the situation through understanding the importance and relations of individual pieces of data and have associated a specific goal-related meaning and significance to the information at hand (Endsley and Jones 2012, p. 17). Forming Level 2 SA comprehension requires expertise and knowledge of the domain in the form of sufficient mental models. Less experienced decision makers might be capable of achieving the same Level 1 SA as more experienced decision makers, but may fall short of also being able to integrate various data and cues along with present goals and objectives in order to comprehend the situation (Endsley 1995).

Level 3 SA

Level 3 SA concerns the ability to project the future status of the elements in the environment, at least in the short term (Endsley 1995). Achieving Level 3 SA requires that decision makers have knowledge about the status and dynamics of the relevant elements and comprehension of the situation (both Level 1 and Level 2 SA) (Endsley 1995) and also sufficient knowledge about the functioning and dynamics of the system in which they are working (Endsley and Jones 2012, p. 18). With Level 3 SA projections decision makers have the necessary understanding and time to decide on the most favorable course of action to meet one’s goals objectives in complex and dynamic environment (Endsley 1995). Forming Level 3 SA projections, however, can be quite mentally demanding and requires a very good knowledge of the domain in the form of highly developed mental models. In many domains experts may devote a significant amount of time to forming Level 3 SA. By constantly projecting ahead, they are able to develop a set of strategies and responses to events, which allow them to be proactive, avoiding many undesirable situations and responding very fast when various events occur. (Endsley and Jones 2012, p. 18)

Temporal and spatial aspects of SA

The SA model highlights the importance of the perception and comprehension of the relevant elements present in the environment, but SA also has a temporal and spatial nature. Temporality implies that SA is not necessarily acquired instantaneously, but develops gradually over time. This reflects taking into account the dynamics of the situation that are acquired over time and that are used to project the state of the environment in the near future. In other words, although SA consists of information and knowledge about the state of the environment at any given point of time, this information and knowledge also includes temporal aspects of the environment, relating to both past and future. Spatiality concerns information and knowledge about relationships between the elements in the environment, or functional relationships between system components. Different types of spatial information and knowledge may be relevant in different domains and tasks and understanding spatial relationships may also provide means for determining which elements in the environment are important for the SA. (Endsley 1995)

7.1.2 Supporting situation awareness

The process of acquiring and maintaining SA is influenced by a number of individual and system and task related factors (Endsley 1995). Taking into account the different influencing factors, different approaches can be taken to support the process. SA oriented training (Endsley and Jones 2012, p. 235) focuses on the individual factors and can support the development of sufficient domain and task related knowledge and mental models that are necessary for acquiring SA. Although training can have an important role, it is fundamental to ensure that sufficient SA information sources are available for decision makers. This requires focus on the system and task related factors and can be addressed through SA oriented systems design methods (Endsley and Jones 2012, pp. 43-59).

According to the SA model, SA information in the form of perceived cues and data from the environment is the fundamental basis for the SA (Endsley 1995). In different domains and tasks the relevant SA information may be acquired from different information sources with potentially different importance that all contribute in acquiring and maintaining SA (Endsley 2000). Depending on the task and system characteristics, relevant SA information may be available through the combination of direct observation of the environment, various technologies, such as information system displays, and verbal and non-verbal communication with others (Endsley 1995; Endsley 2000). The different SA information sources are represented in Figure 19.

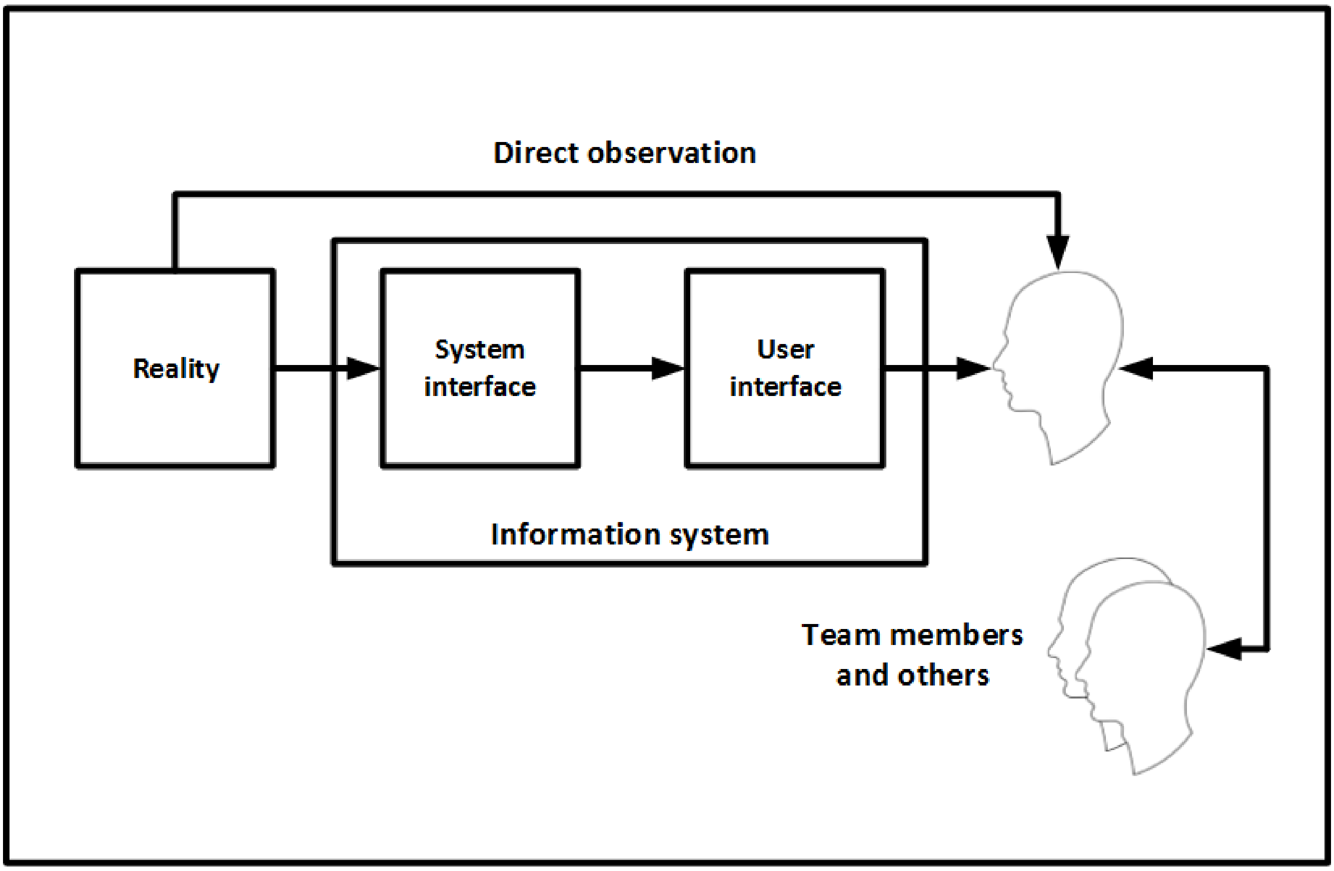

Figure 19. Situation awareness information sources (adapted from Endsley 1995; Endsley 2000)

Direct observation of the environment and verbal and non-verbal communication with others are important information sources in many domains and tasks (Endsley 1995). In many complex systems it is, however, not possible to directly perceive all the relevant elements in the environment and form comprehensions and projections about the state of the system due to human cognitive limitations or inherent limitations of the system. In these types of systems it is often necessary to augment SA information through various technologies, such as information systems that provide displays with information about the relevant elements in the environment and the state of the system. (Endsley 1995; Endsley 2000) This is especially important in non-collocated working environments where it can be a major challenge to provide sufficient information to compensate for the cues and data that would otherwise be available through direct observation and collaboration with others (Endsley 2000).

Information systems can support SA by collecting relevant subsets of all available information from the environment and about the state of the system and displaying the portion of the information that is relevant for decision makers in achieving their present goals and objectives through their user interface (Endsley 1995). Some portion of this information is perceived and interpreted by the decision makers, allowing them to acquire and maintain SA (Endsley 2000). The key issues that influence acquiring and maintaining SA through an information system include the degree to which the information system acquires the needed information from the environment through its system interface and the degree to which relevant information is provided to decision makers through its user interface. There are a number of potential systems design related challenges and sources of errors that may influence acquiring and maintaining SA. First, the information system may not acquire all the needed information, depending on system designers' understanding of what information is required and technological limitations in acquiring certain types of information from the environment. Second, all the relevant information acquired by the information system may not be displayed to the decision makers due to system internal and user interface limitations. Finally, the information displayed by the information system may be incomplete or inaccurately transmitted to the decision makers because of their cognitive limitations or limitations in the user interface design. The user interface design determines how the information is presented to decision makers and will largely influence SA by determining how much information can be acquired, how accurately it can be acquired and to what degree it is compatible with the decision makers' SA needs. (Endsley 1995)

Designing information systems to support SA requires that the necessary information is obtained by the information system and presented in a way that makes it easy for decision makers to process the relevant information in an environment where there are potentially many pieces of information competing for their attention (Endsley and Jones 2012, pp. 3-11). Information system design should also take into account the information that decision makers derive by other means, that is, through direct observation or communications with others. This requires considering the value added or subtracted by the information that is provided by a given information system in comparison to the information that is available from other sources and the potential costs in terms of interference to that information. Therefore, the systems design process needs to consider not only the SA information provided by the new information system, but also the SA information already available in the local environment that the system may be interfering with. (Endsley 2000)

7.2 Shared situation awareness

Situation awareness (SA) is not only concerned with individual decision makers, but is also necessary for effective team work and collaboration. In many complex systems, people do not just work as individuals, but as members of teams that have common objectives and work towards achieving a common goal. In these types of systems, it is not sufficient to support only the SA of the individual team members, but supporting SA of the team as a whole is necessary (Endsley and Jones 2012, p. 193).

A team is not just a group of individuals who are working together, but teams have a number of defining characteristics. According to Salas et al. (1992 in Endsley and Jones 2012, p. 193) team can be defined as “a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership”. This definition highlights several important characteristics of teams and the nature of team work that are important for supporting SA in teams. Teams have a common goal and individual team members are assigned specific roles in the team. These roles define individual goals for each team member. This is important for the SA, because the individual goals also determine the SA requirements for each individual team member. It is therefore possible to identify SA requirements for each individual team member of a particular team through the examination of the different roles within a team. It is also pointed out in the definition that roles of the different team members are interdependent and that the individual team members are together working toward a common goal. In team work, the success of each individual team member is therefore dependent on the success of the other team members. (Endsley and Jones 2012, pp. 193-194)

7.2.1 Team situation awareness model

Team SA is a prerequisite for team work and collaboration in many complex systems. According to Endsley and Jones (2012, p. 194) the interdependence between the roles and goals of different team members is a key in defining what constitutes team SA. The interdependence between the goals of each individual team member also implies a certain degree of overlap between the SA requirements of each team member. Within teams, team members share the load in performing tasks. In some cases, each individual team member may perform very similar tasks, but in other cases, team operations may be divided up so that individual team members have very different responsibilities and tasks. In case that there is a lot of overlap between the goals of the team members, there will also be a considerable overlap in the SA requirements they have in common. Conversely, if there is less overlap between their goals, there will be a more limited set of SA requirements that they have in common. Team SA is defined as “the degree to which every team member possesses the SA required for his or her responsibilities” (Endsley 1995). Team SA model building on the definition is represented in Figure 20.

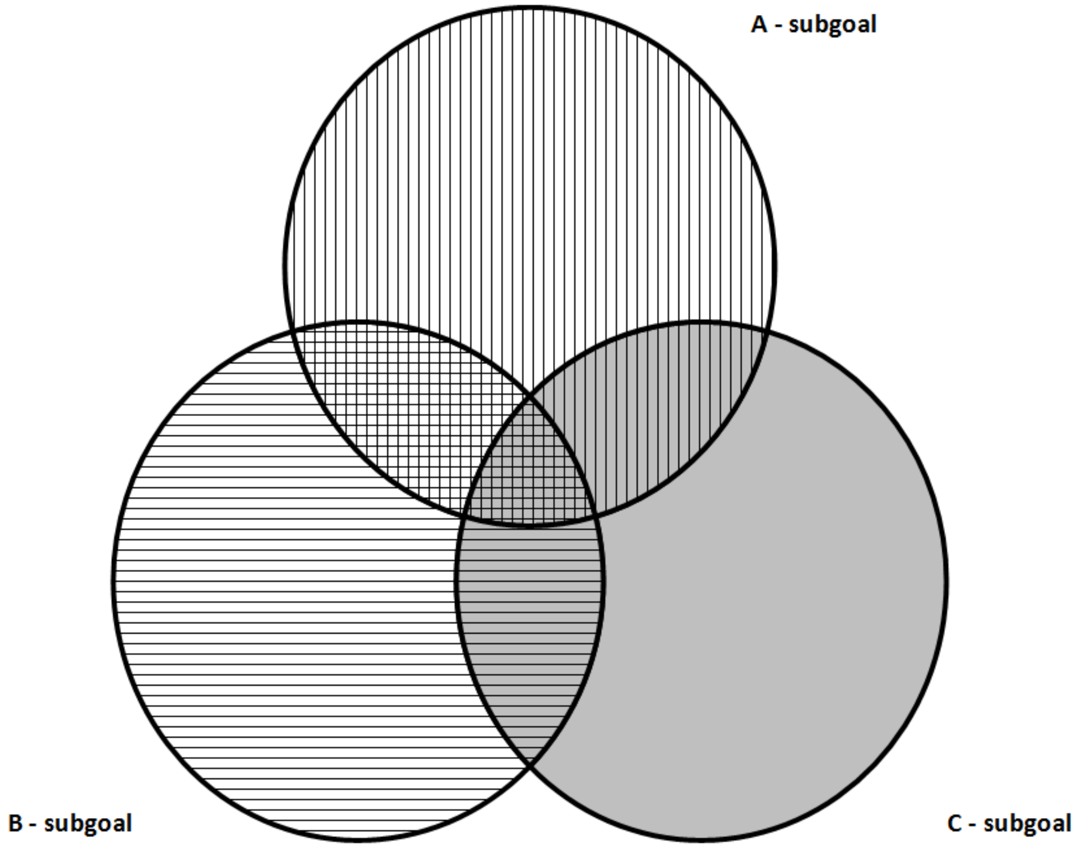

Figure 20. Team SA model (adapted from Endsley and Jones 2012, p. 197)

The team SA model represents the SA and the distinct sets of SA requirements for each individual team member, which depend on their role within the team and their individual goals. The model also identifies the presence of shared SA and sets of shared SA requirements between the individual team members, which depend on the overlap between their roles and goals. According to Endsley and Jones (2012, pp. 195-196) sufficient team SA is necessary for ensuring overall team performance due to the interdependent nature of team work. It is, however, important to note that SA is a cognitive construct and as such is not something that a team can possess as a whole, but only the individual team members can have SA. It is therefore necessary that team SA is embodied in the SA of each individual team member, and each individual team member has a sufficient level of SA on those factors that are relevant for their tasks. As a significant component of team SA, it is necessary to ensure that there is a sufficient level of shared SA between the team members (Endsley and Jones 2012, pp. 196-198).

7.2.2 Shared situation awareness model

Shared SA is a prerequisite for the development of team SA. According to Endsley and Jones (2012, p. 196) shared SA is not dependent on complete sharing of information between team members, but only on a shared understanding of that subset of information that is necessary for each of their individual roles and their overlapping goals. Depending on the overlap between the goals of the individual team members, only subsets of their SA requirements are common and are shared between the team members. Therefore, shared SA does not mean that the understanding of the present situation by different team members is entirely the same, as this would potentially lead to cognitive overload, but shared SA requirements between the individual team members are determined by their tasks. Shared SA is defined as "the degree to which team members have the same SA on shared SA requirements" (Endsley and Jones 2001 in Endsley and Jones 2012, p. 196). Shared SA model building on this definition is represented in Figure 21.

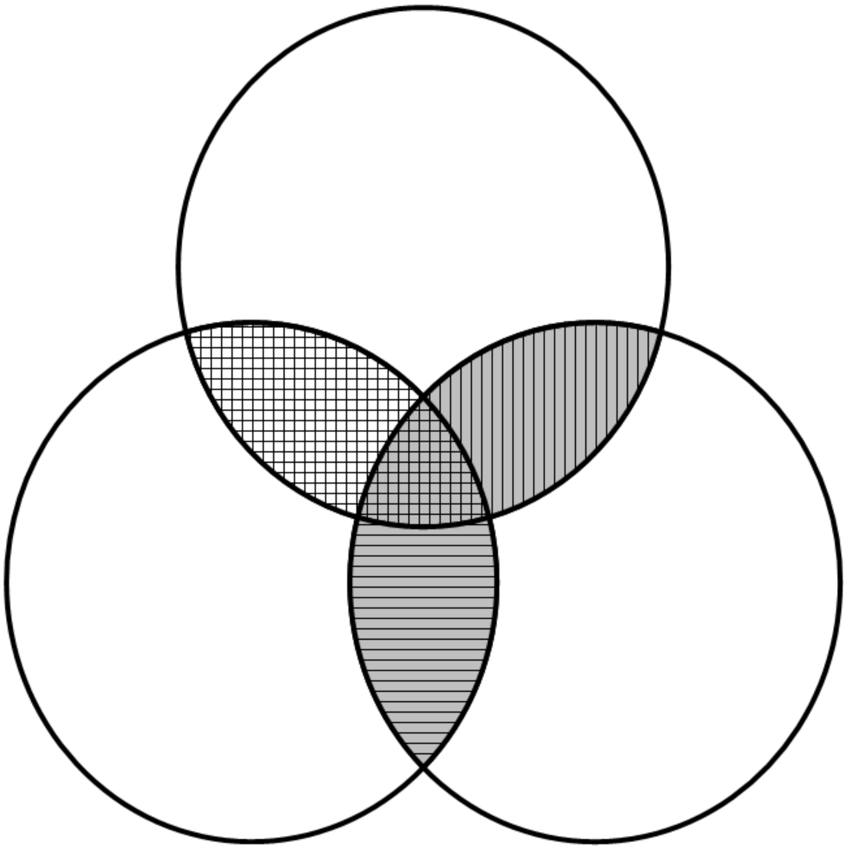

Figure 21. Shared SA model (adapted from Endsley and Jones 2012, p. 197)

The shared SA model represents the SA and the sets of shared SA requirements that are common between the individual team members, and are necessary for the development of team SA. Because the shared SA provides the basis for the development of team SA, it is viewed that addressing the shared SA requirements between individual team members is an important prerequisite for supporting team work and collaboration in many complex systems.

7.2.3 Supporting shared situation awareness

Acquiring and maintaining appropriate and accurate team SA is critical for ensuring effective team operations and performance. Without it, team coordination may be poor and individual SA that is needed for decision making may be lacking. In team operations, effective actions by individual team members often depend on developing a shared understanding of the present situation, that is, development of shared SA is required. There are various ways in which the development of shared SA can be supported. Because the individual team members and their actions are interdependent, the SA of each team member often influences the others, therefore the devices, processes and mechanisms that support the development and transference of SA between individual team members according to shared SA requirements are a significant concern in supporting shared SA. (Endsley and Jones 2012, pp. 198-202)

Shared SA requirements

Shared SA builds on sharing of the SA elements that are common between individual team members, the overlap between those elements determining the shared SA requirements in teams. Sharing of the SA elements may be necessary on all three levels of SA, including Level 1 SA data, Level 2 SA comprehensions and Level 3 SA projections. Therefore supporting shared SA requires accurate and timely sharing of the data about the environment and the system, but may also involve active sharing of information about the comprehensions and projections of individual team members regarding their common and overlapping tasks and individual goals. When needed SA is not transferred successfully, it is possible that significant team failures occur. (Endsley and Jones 2012, pp. 199-200)

Shared SA also encompasses considerations about the status and tasks of individual team members. In many teams SA requirements of a particular team member involve understanding the status of other team members and their tasks, and how their progress in those tasks will affect one's own goals and tasks. Similarly, in well-functioning teams, team members often project how the status and progress of their own tasks will affect other team members. It may also be often necessary to project what impact potential changes to the common plan are likely to have on other team members and the overall team goal. If there are is no sufficient time and no technological capabilities available to communicate verbally or by some other means with other team members, the projections must be made alone, which can potentially significantly affect the functioning and performance of the entire team. (Endsley and Jones 2012, p. 201)

In teams that are operating at the highest levels of team SA, team members also project what fellow team members are likely to do. Effective team functioning and performance in many time-critical team operations may depend on this type of projections. (Endsley and Jones 2012, p. 201)

There are a number of potential challenges in developing a common understanding of shared SA requirements in teams. In many teams, team members may not be aware about which information needs to be shared with other team members (Endsley and Robertson 2000). In other cases, shared information may not get passed between team members either because they assume that other team members already know or because they do not realize that it needs to be passed on (Endsley and Jones 2012, p. 201). This may often be a problem especially for Level 2 and Level 3 SA, when team members assume that others will arrive in the same situation assessment as they do based on the same Level 1 data (Endsley and Robertson 2000).

Shared SA devices

Shared SA in team operations can be supported through shared SA devices that facilitate sharing SA information and enable collaboration and communication between teams and individual team members (Endsley and Jones 2012, pp. 202-204). Different types of shared SA devices and their combinations may be appropriate in different types of systems and team operations.

In collocated team operations shared SA development can be supported at the most elementary level through direct verbal and non-verbal communications between team members. A potential benefit of direct communications is that people can also get a great deal of information about the emotional state of another team member and use that information for assessing how well a team member can be expected to perform in the present situation. Direct verbal and non-verbal communications, however, may not always be possible or practical and may not therefore provide the necessary means for conveying all the required SA information. (Endsley and Jones 2012, p. 202)

Shared information systems and displays provide a potential technology for sharing SA information and enabling collaboration and communication between team members. In many complex systems shared information systems and displays may have a critical role in supporting shared SA. With shared displays, different team members can be provided with the necessary Level 1 SA data concerning the environment and the system state, and also the development of common Level 2 SA comprehension and Level 3 SA projections can be supported directly on the displays. (Endsley and Jones 2012, pp. 202-203)

Shared environments may also facilitate SA information sharing between team members. When team members are performing their tasks in the shared environment, they may not need to pass information to each other through any other means, except direct observation. Working in a shared environment can therefore provide team members with high levels of shared SA without requiring any other means to facilitate SA information sharing. (Endsley and Jones 2012, p. 203)

Distributed team operations, where teams and team members are working towards a common goal in a non-collocated working environment are increasingly common and even mandatory in many complex systems. In many cases teams and team members are not just spatially distributed in different locations, but also temporally distributed, with work taking place in shifts to provide around-the-clock operations. Distributed team operations create a number of additional issues in supporting shared SA development and enabling collaboration and communication in distributed teams. (Endsley and Jones 2012, pp. 208-210)

According to Endsley and Jones (2012, pp. 209-210) the SA requirements for distributed team operations are the same as in collocated team operations, but the SA devices that are available to support the transmission of SA information are more restricted. In distributed team operations, teams and team members will not have available the advantages of direct verbal and non-verbal communications and shared environments. Traditionally, this has placed the burden on information transmission through verbal communications technologies, such as telephone calls, or on dedicated electronic communications and collaboration technologies, including shared information systems and displays. Nowadays, there is a wide variety of general purpose electronic communications and collaboration technologies, such as chat, email, file sharing and web-based video conferencing that can be used to facilitate SA information transfer. While each of these communications and collaboration technologies have advantages in supporting distributed team operations, they also have limitations in terms of the types of team processes and information flows that they can support in distributed team operations (Bolstad and Endsley 2003). The SA information that is lost by not sharing a common environment and due to having more restricted communications channels must be compensated for by a greater load on the available SA devices (Endsley and Jones 2012, p. 210).

There are a number of potential challenges in designing shared SA devices to support team operations. When different combinations of shared SA devices are available team members may freely trade-off between different available sources of SA information. In any shared SA device development efforts, it is important that the effects of the changes on the level and type of information communicated are carefully assessed. Any changes to the types of shared SA devices available may also cause a trade-off between different SA information sources. It is therefore important that care is taken to ensure that all information that is required for shared SA in team operations in provided through some means and that the changes do not accidentally decrease shared SA in some unanticipated way. (Endsley and Jones 2012, p. 210)

Shared SA mechanisms

Shared SA mechanisms are team internal mechanisms that support the development of shared SA in team operations in conjunction with shared SA devices and shared SA processes. The presence of shared mental models is particularly important in supporting the ability of teams to develop Level 2 SA comprehension and Level 3 SA projections based on Level 1 SA data. Without shared mental models, individual team members are likely to process information differently, arriving at different interpretations of the present situation. With shared mental models, individual team members are more likely to arrive at the same understanding of the situation and the workload associated with doing so can be significantly decreased. Compensating for the lack of shared mental models will potentially require considerable amount of communications between individual team members to arrive at a common understanding of the situation and to form accurate expectations of what other team members are doing and what they will do in the future. (Endsley and Jones 2012, pp. 204-206)

Shared mental models can be developed through a number of ways. First, development of shared mental models can be supported through common training experiences, such as joint training exercises that incorporate the entire team and cross-training in each other’s tasks (Endsley and Jones 2012, pp. 204-205). Cross-training has been shown to specifically enhance the SA of team members (Bolstad et al. 2005). Second, common experiences from working together are helpful for building shared mental models. Teams that have worked together in the past are able to develop a sufficient understanding of each other as individuals and of the roles and functions of other team members, which helps them to communicate effectively, anticipate each other’s actions and perform well as a team. Finally, teams can use direct communications to help build shared mental models in advance of working together. Information that supports building shared mental models can be provided to team members through databases or verbal communications to help them build shared mental models when team members are new to one another. (Endsley and Jones 2012, pp. 205-206)

Shared SA processes

Shared SA processes are team internal processes that support the development of shared SA in team operations. It is critical for shared SA development that team processes support sharing relevant information and developing common comprehension and projections, even when high quality SA devices and mechanisms exist. (Endsley and Jones 2012, pp. 206-208)

8. Conceptual model of decision making and decision support in service systems

A conceptual model of decision making and decision support in service systems is proposed based on a synthesis of the literature. The proposed conceptual model builds on the proposed integrated model of complex service systems, and addresses characteristics of decision making contexts and decision making processes in complex service systems, and typical requirements for decision support in different work systems within complex service systems, based on the characteristics of their associated decision making context and their decision making processes.

8.1 Decision making contexts in service systems

It is viewed that the service ecosystem provides an overall context for decision making for individual service system entities, but it is possible to identify further levels of different types of decision making contexts within complex service systems. It is proposed that different types of work systems within complex service systems are associated with different types of decision making contexts whose inherent characteristics are influenced by their associated value creating processes and activities and the characteristics of their shared context of value creation within the production system and the service ecosystem. The inherent characteristics of the decision making context are viewed to influence the types and characteristics of decision situations that are typically occurring within a work system and to be a source of influences on the nature of decision making processes and requirements for decision support within a work system. Traditionally the inherent characteristics of different types of decision making contexts and the types and characteristics of their typical decision situations are associated with hierarchical levels of organizational activities, but it is viewed that while the traditional characterization may be fit for the traditional manufacturing organizations, it fails to take into account the influences that the different types of value creating processes and activities and the characteristics of the shared context of value creation have on the characteristics of decision making contexts and their typical decision situations within work systems at different levels within complex service systems. Furthermore, it is viewed that the nature of decision making processes and requirements for decision support within individual work systems are not just influenced by the inherent characteristics of their decision making context and their typical decision situations, but also by the decision makers' information and knowledge that influence their perception and understanding of the decision making context and an individual decision situation characteristics. Another perspective on the characteristics of decision making contexts within organizations is provided by the Cynefin framework, which views that the different types of decision making contexts are associated with different knowledge spaces, and that the inherent characteristics of the decision making context and the decision makers' information and knowledge together determine the perceived characteristics of the decision making context and are a source of influences on the nature of decision making processes and requirements for decision support in a specific decision situation within a specific decision making context. It is therefore proposed that the Cynefin framework can provide the basis for characterizing the different types of decision making contexts within complex service systems. The proposed relationship between different types of decision making contexts within complex service systems and the Cynefin framework decision making contexts is represented in Figure 22.

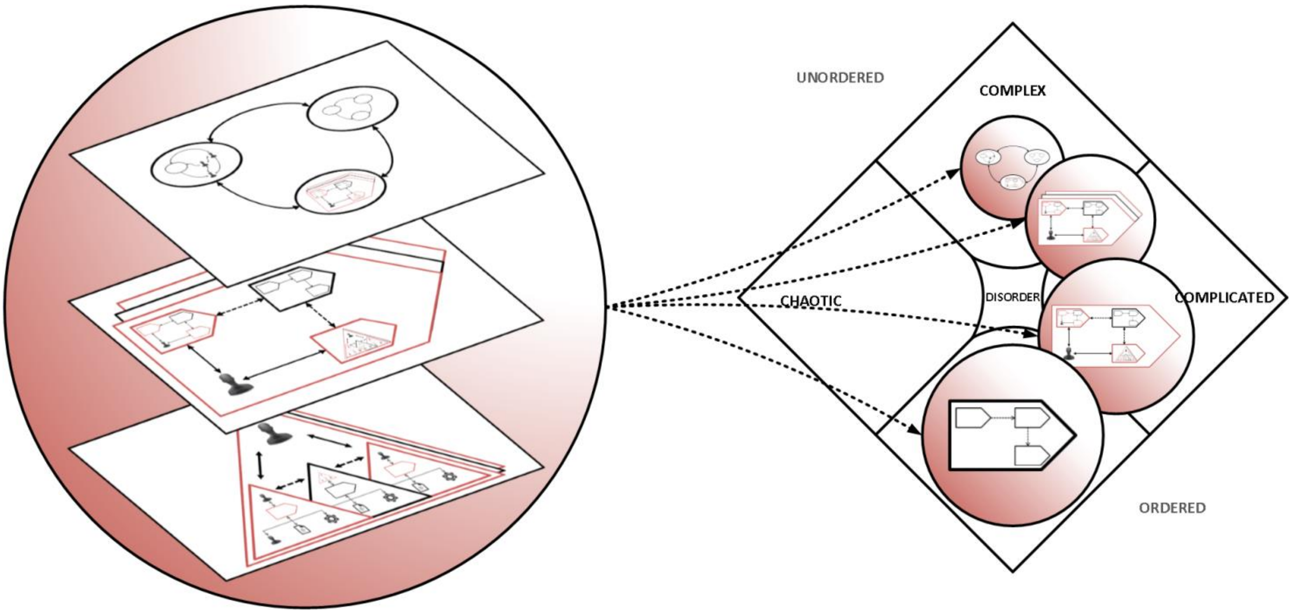

Figure 22. Decision making contexts in service systems

Simple decision making contexts

Simple decision making contexts are viewed to be associated with work systems that enact value creating processes and activities that are mostly related to the performance of relatively independent individual non-service processes and standard service processes and their tasks, which have inherently rigid characteristics and only a minimal degree of variation between the individual input cases. It is viewed that these types of processes and their tasks have a well-defined role in various value creation processes, and, because they are performed relatively independently from other processes, the information and knowledge required for service provision is mostly focused on the individual process and its individual tasks. These types of decision situations and their decision making contexts are traditionally associated with instinctive decisions that are related to operational performance. It is viewed that in service processes, only a relatively rudimentary understanding about the customer's value creation process beyond the context of the service process and its tasks is required, implying that only a relatively low level of information exchange and information processing is required to determine the customer's requirements for service provision in a particular input case, and that little or no knowledge about the other processes and their tasks that are linked with the customer's value creation process within and outside the boundaries of the service system during the customer episode is required to make a decision about the mobilization of service system resources in a particular input case. Decision situations within simple contexts are viewed to be mostly structured, and are viewed to mostly include individual programmed decision problems that are frequently recurring and are therefore familiar to the individual decision makers, who can rely on their existing knowledge and follow an established procedure for handling them. Decision making model in simple contexts is to sense, categorize and respond to the situation. It is viewed that decision making processes and decision support within simple contexts should therefore focus on supporting decision makers' capability to perceive and understand the facts in the decision situation, facilitating their effective use of information and existing knowledge to categorize various decision situations, and enabling them to take effective actions based on the established best practice.

Complicated decision making contexts

Complicated decision making contexts are viewed to be associated with value creating processes and activities that are mostly related to planning, control and coordination of value creating activities within constellations of different types of interdependent and interacting processes at different levels within the production system, but complicated contexts may also be associated with decision situations that are related to the performance of routine and non-routine service processes, which have inherently fluid characteristics and a higher degree of variation between the individual input cases. It is viewed that although the individual processes and their tasks may have a well-defined role in various value creation processes, the interdependencies and interactions between the individual processes and their tasks may be a source of decision situations, in which information and knowledge about a single process or its tasks is not sufficient, but further understanding about the system and the relationships between its interdependent and interacting parts is also required. This implies that the information and knowledge required for planning, control and coordination of value creating activities is not limited to the context of an individual process and its tasks, but there are frequently decision situations, in which further information and knowledge is required about other processes and their tasks that are associated with the overall value creation process and are contributing to its overall outcome. These types of decision situations and their decision making contexts are traditionally associated with operational and tactical level decisions, but it is viewed that in complex service systems similar decision situations may also be associated with instinctive decisions that are related to operational performance. It is viewed that in routine and non-routine service processes, higher level of understanding about the customer's value creation process beyond the context of the service process and its tasks is required, implying that higher level of information exchange and information processing is necessary to determine the customer's requirements for service provision in a particular input case, and that further information and knowledge about the other processes and their tasks that are linked with the customer's value creation process within and outside the boundaries of the service system during the customer episode and its service events is required to make a decision about the mobilization of service system resources in a particular input case. Decision situations within complicated contexts are viewed to be frequently semi-structured, and are viewed to often include a number of interdependent programmed decision problems in various combinations that are less frequently recurring and are therefore less familiar to the individual decision makers, potentially being beyond their existing knowledge and requiring that the decision makers have capability for analyzing the decision situation, identifying alternative courses of action and evaluating their consequences in order to determine an appropriate procedure for handling them. Decision making model in complicated contexts is to sense, analyze and respond to the situation. It is viewed that decision making processes and decision support within complicated contexts should therefore focus on supporting decision makers' capability to discover and understand the facts in the decision situation, facilitating their effective use of information and existing knowledge to analyze various decision situations, and enabling them to take effective actions based on the results of the analysis, following an established good practice.

Complex decision making contexts

Complex decision making contexts are viewed to be associated with value creating processes and activities that are mostly related to planning, control and coordination of value creating activities within the overall production system that includes interdependencies and interactions between constellations of different types of processes and within the overall service ecosystem that includes interdependencies and interactions between different types of service system entities, but complex contexts may also be associated with decision situations that are related to individual service processes and their tasks, whose performance is influenced by interdependencies and interactions between individual instances of multiple simultaneously performed value creation processes. It is viewed that the interdependencies and interactions between different types of service system entities and their value creation processes within a shared context of value creation may be a source of decision situations, in which information and knowledge about individual instances of value creation processes and the associated production system processes and their tasks that are contributing to their overall outcome is not sufficient, but further understanding about the behavior of the system, that emerges from the interactions between different types of entities and their individual instances of value creation processes at different levels of aggregation within the production system and the service ecosystem, and is never fully predictable, is also required. This implies that the information and knowledge required for planning, control and coordination of value creating activities is not limited to the context of individual instances of value creation processes, but there may frequently be decision situations, in which further information and knowledge is required about the present state of the system, including information and knowledge about the characteristics and state of the individual instances of value creation processes and the associated production system processes and their tasks that are contributing to their overall outcome, and their change and evolution over time. These types of decision situations and their decision making contexts are traditionally associated with strategic level decisions that are concerned with the relationship of the service system and its environment within the service ecosystem, but it is viewed that in complex service systems similar decision situations may also occur at the levels of tactical and operational decisions, and instinctive decisions that are related to operational performance. It is viewed that in service processes that are involved with multiple simultaneous instances of service provision related to different customers' value creation processes and their associated customer episodes and service events, not only understanding about an individual customer's value creation process is sufficient, but also understanding about the interdependencies and interactions between the different simultaneous instances of value creation processes and their influences on service provision is required, implying that further information and knowledge about the state of the system and the characteristics and state of the different individual instances of value creation processes within and outside the boundaries of the service system may be required to make decisions about the mobilization of service system resources in different input cases and to monitor and modify the mobilization of service system resources according to the perceived present state of the system and its processes and their tasks, and their change and evolution over time. Decision situations within complex contexts are viewed to be frequently unstructured, and are viewed to often include non-programmed decision problems that are either rarely recurring or whose exact nature and structure are difficult to perceive and understand, making them unfamiliar to the decision makers, and potentially being beyond the existing knowledge about the system and its behavior and requiring that the decision makers have capacity for learning and adaptive behavior in order to develop a procedure for handling them. Decision making model in complex contexts is to probe, sense and respond to the situation. It is viewed that decision making processes and decision support within complex contexts should therefore focus on creating conditions that make the existing and emerging patterns of behavior within the system and their change and evolution over time more visible to the decision makers, supporting decision makers' capability to perceive and understand the existing and emerging patterns and their change and evolution over time, and enabling them to take effective actions to manage the emergence.

Chaotic decision making contexts

Chaotic decision making contexts are viewed to be associated with unexpected and abnormal decision situations that the service system is not prepared to handle, and that influence its ability to efficiently and effectively provision service, therefore requiring an immediate action to recover from the situation and to restore the normal operation of the system. It is viewed that these types of decision situations may occur at different levels within complex service systems, including both unexpected exceptions in the established value creating processes and activities related to the planning, control and coordination of value creating activities and to the performance of service processes, and unexpected abnormal situations that are not associated with any of the established value creating processes and activities within the system. Decision situations within chaotic contexts are viewed to be unfamiliar to the decision makers and beyond the existing knowledge about the system and its behavior, requiring that the decision makers have both capacity for problem oriented action in order to work to recover from the exceptions and abnormal situations, and learning and adaptive behavior in order to perceive and understand their exact nature and structure and to develop a procedure for handling them. Decision making model in chaotic contexts is to act, sense and respond. It is viewed that decision making processes and decision support within chaotic contexts should therefore focus on enabling the decision makers to take effective actions to manage the situation and supporting their capability to perceive and understand the effects of their actions to the existing and emerging patterns of behavior within the system, allowing them to work to gradually recover from the situation.

8.2 Decision making processes in service systems

It is proposed that both rational decision making processes and naturalistic decision making processes have an important role in decision making within complex service systems. Traditionally rational decision making processes are viewed to dominate organizational decision making at the levels of strategic, tactical and operational decisions associated with complicated, complex and even chaotic Cynefin framework decision making contexts, while naturalistic decision making processes are viewed to be mostly limited to the instinctive decisions that are related to operational performance and associated with the simple Cynefin framework decision making context. It is, however, viewed that the different types of decision making processes are not mutually exclusive, nor limited to particular types of value creating processes and activities and Cynefin framework decision making contexts, but rather complementary, and that different types of decision making processes may have a dominating role in different work systems within complex service systems, depending on the characteristics of their decision making context and typical decision situations. It is therefore proposed that both rational decision making processes and naturalistic decision making processes may exist in different work systems within complex service systems, and that either type of decision making process may dominate decision making within a work system depending on the characteristics of its decision making context and typical decision situations. The proposed relationship between the different types of decision making processes and the Cynefin framework decision making contexts is represented in Figure 23.

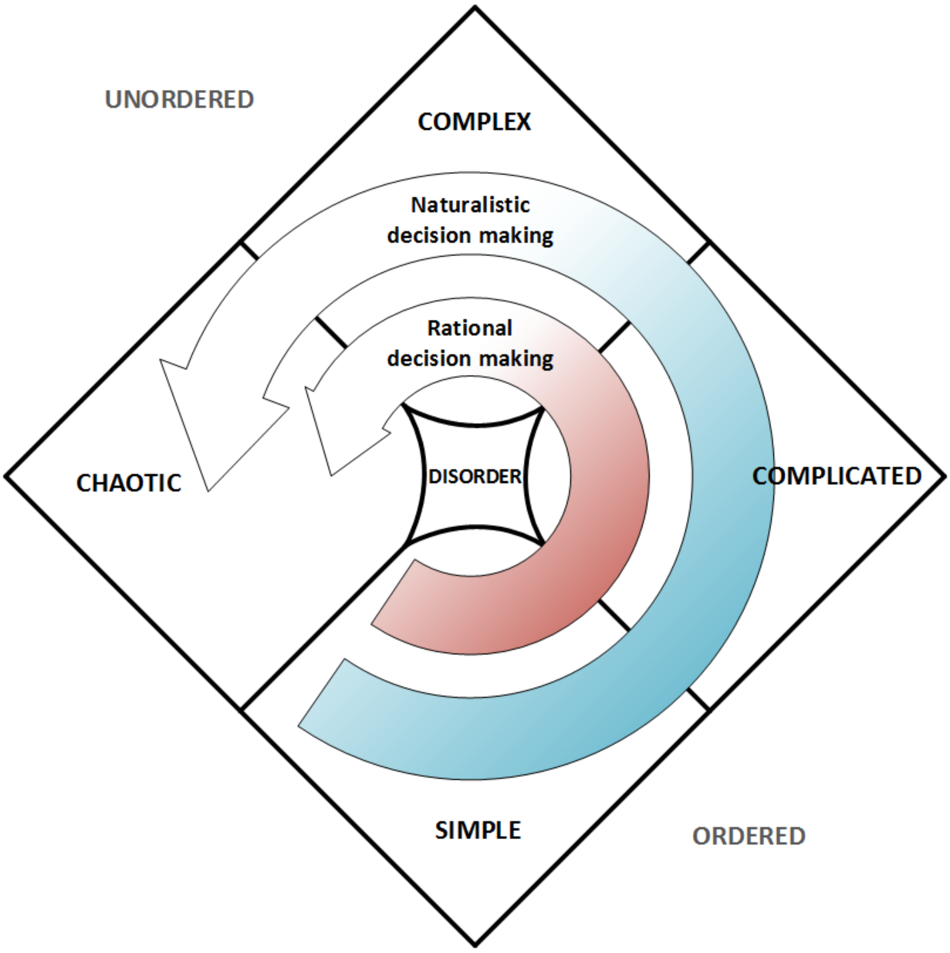

Figure 23. Decision making processes in service systems

According to Klein (1998, pp. 92-96) it is possible to identify a number of boundary conditions, which have influence on whether the decision makers are more likely to follow either comparative decision strategies, corresponding to rational decision making processes, or singular decision strategies, corresponding to naturalistic decision making processes. The different boundary conditions present in the decision making context and its decision situations have different influences on the choice of the decision strategy that the decision makers typically follow and on their decision making processes. The proposed boundary conditions for different decision strategies and their influences are presented in Table 5.

Table 5. Boundary conditions for different decision strategies (adapted from Klein 1998, pp. 95-96)

Task conditions	**Singular decision strategy**	**Comparative decision strategy**
Greater time pressure	More likely, there is typically lack of time that may prevent performing an analysis of different alternatives	
Dynamic conditions	More likely, there are typically rapid changes in the context that may render a performed analysis of different alternatives useless	
Ill-defined goals	More likely, there is typically ambiguity that may prevent establishing common evaluation	

	criteria for different alternatives	
Higher experience level	More likely, decision makers' experience with the domain typically allows them to recognize plausible courses of action	
Need for justification		More likely, there is typically need to establish evidence that different alternatives have been considered
Conflict resolution		More likely, there is typically need to establish common priorities and common evaluation criteria for different alternatives
Optimization		More likely, there is typically need to perform an analysis of different alternatives to determine the optimal course of action
Greater computational complexity		More likely, decision maker's limited cognitive capacity typically makes it necessary for them to perform an analysis of different alternatives to determine plausible courses of action

It is viewed that the presence of different boundary conditions within different decision making contexts and their decision situations influences the decision maker's choice of decision strategies and therefore the dominating types of decision making processes in different work systems within complex service systems. However, actual decision making processes in real world decision making contexts and their decision situations may often include elements of both comparative and singular decision strategies, and correspondingly rational and naturalistic decision making processes (Klein 1998, p. 96). It is therefore viewed that although different types of decision making processes may dominate in different work systems within complex service systems, their actual decision making processes may combine various elements of both rational decision making processes, which are drawing on known facts about the decision making context and its decision situations and explicit knowledge, and naturalistic decision making processes, which are drawing on decision makers' perception and understanding about the decision making context and its decision situations and their tacit knowledge.

8.3 Decision support in service systems

It is proposed that typical requirements for decision support in different work systems within complex service systems depend on the types of their decision making processes and the characteristics of their associated decision making context and its typical decision situations. Both rational decision making processes and naturalistic decision making processes are viewed to have an important and complementary role in the real world decision making processes in different work systems, and it is viewed that decision support is therefore typically required for the aspects of the work systems' real world decision making processes that are related to both rational decision making and naturalistic decision making. Traditional organizational decision support concepts are viewed to provide the basis for supporting rational decision making processes, but it is viewed that the appropriate types Decision Support Systems (DSSs) (Power 2002), and types and levels of decision support technologies (French et al. 2009, pp. 82-85; French 2013), depend on the characteristics of the decision making context and its typical decision situations. Supporting naturalistic decision making processes can be based on supporting the decision makers' Situation Awareness (SA) (Endsley 1995), and facilitating the development of their tacit knowledge through learning and development of mental models of the system and its tasks. Together the different approaches for decision support have a potential to provide holistic decision support in different work systems within complex service systems, addressing both the aspects of their real world decision making processes that are related to rational decision making and to naturalistic decision making.

8.3.1 Decision support for rational decision making processes in service systems

It is proposed that the decision makers' typical requirements for decision support for the rational decision making processes in different work systems within complex service systems are influenced by the characteristics of their associated decision making context and its typical decision situations. It is viewed that decision support for the rational decision making processes in different types of Cynefin framework decision making contexts should focus on providing support for different aspects of the decision making process and can be based on different types decision support technologies. The proposed relationship between different types of decision support technologies and the Cynefin framework decision making contexts is represented in Figure 24.

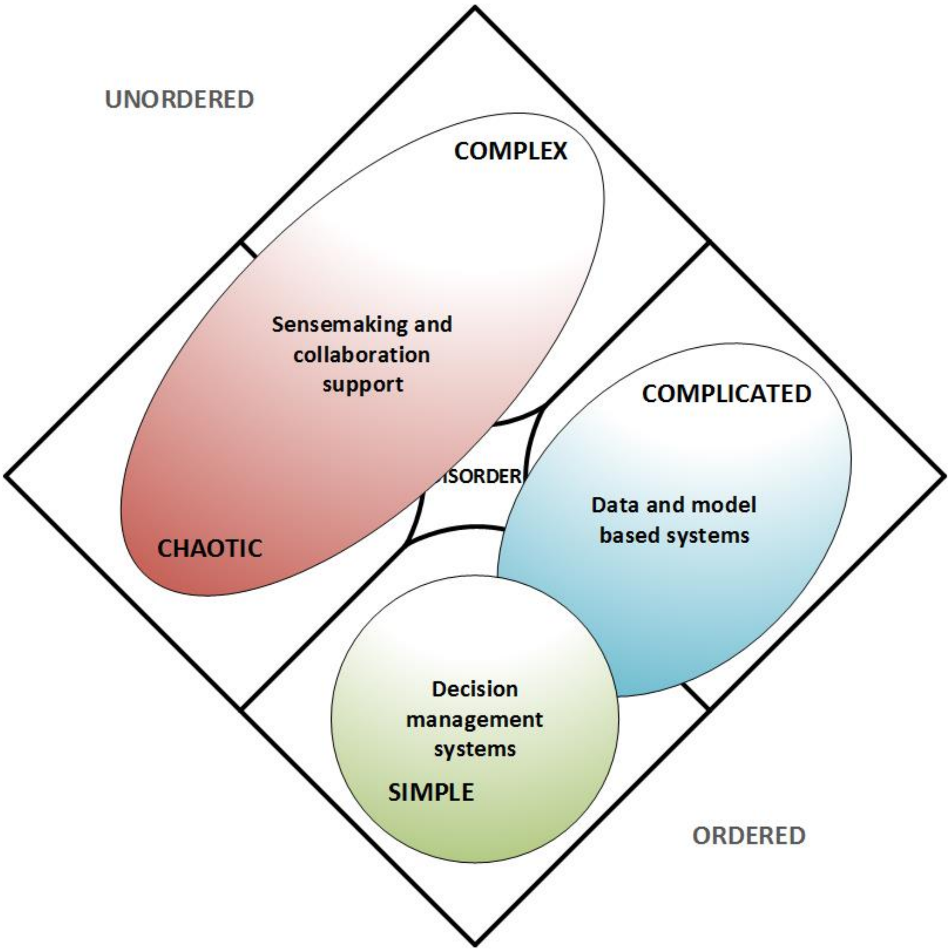

Figure 24. Decision support for rational decision making processes

The simple and complicated Cynefin framework decision making contexts represent an ordered world and the domain of fact based management, where rational decision making processes are drawing on known facts about the decision making context and its decision situations and build on the exploitation of explicit knowledge that is created through the combination cycle of organizational knowledge creation (Nonaka et al. 2000). It is viewed that effective decision support within these decision making contexts can typically be based on data, representing the facts about the decision making context and its decision situations, and various models that embed the necessary explicit knowledge needed for processing the data into useful information that supports the decision makers' perception and understanding of the decision making context and its decision situations and provides the basis for their judgment. Typical types of DSSs in the simple and complicated decision making contexts are therefore viewed to include various Data-, Model- and Knowledge-Driven DSSs (Power 2002, p. 13). Furthermore, it may be possible to automate decision making in the highly structured and repetitive decision situations within the simple decision making context with various Decision Management Systems (DMS) (Taylor 2012) that are able to emulate the decision making capability of a human decision maker.

In the complex and chaotic decision making contexts, that represent an unordered world and the domain of pattern based management, the decision making processes are drawing more on the decision makers' perception and understanding of the decision making context and its decision situations and build on the sharing and exploration of tacit knowledge that is created through the socialization cycle of organizational knowledge creation (Nonaka et al. 2000). It is viewed that effective decision support within these decision making contexts needs to focus on facilitating sense making and collaboration to allow the decision makers to increase their perception and understanding of the decision making context and its decision situations, and develop their tacit knowledge through sharing and exploration to provide the basis for their judgment. Typical types of DSSs in the complicated and complex decision making contexts are therefore viewed to include various Communications-Driven and Group DSSs (GDSS) (Power 2002, p. 14) that may be based on different decision support technologies, and other collaboration and communications technologies.

According to French (French et al. 2009, pp. 82-85; French 2013) different types of DSSs and decision support technologies can be further categorized based on the level of decision support provided to the decision makers, ranging from minimal analytical support through acquisition and presentation of data to full judgmental support through evaluation and ranking of alternative courses of action. The proposed levels of decision support are presented in Table 6.

Table 6. Levels of decision support (adapted from French et al. 2009, pp. 83-84; French 2013)

Level	**Decision support provided**
Level 0	Acquisition, checking and presentation of data, directly or with minimal analysis, to decision makers; supporting their perception and understanding of the external environment.
Level 1	Analysis and forecasting of the current and future environment; supporting their perception and understanding of the evolution of the external environment.
Level 2	Simulation and analysis of the consequences of alternative courses of action; determination of their feasibility and quantification of their benefits and disadvantages; supporting their capability to identify and analyze alternative courses of action.
Level 3	Evaluation and ranking of alternative courses of action in the face of uncertainty by balancing their respective benefits and disadvantages; supporting their capability to reach judgment under conflicting preferences and uncertainty.

It is characteristic for level 0 to level 2 DSSs that they mainly relate to supporting the evolution of decision makers' perception and understanding of the external environment, including the relevant aspects of the decision making context and its typical decision situations (French 2013), but do not necessarily themselves recognize that the decision makers are facing a decision situation (French et al. 2009, p. 84). It is only at level 3 that DSSs fully relate to the decision makers' understanding of their preferences and evaluation and ranking of alternative course of action in a decision situation in order to reach a judgment (French 2013).

Different levels of decision support can be provided by different types of DSSs and decision support technologies, but besides the level of decision support provided also the characteristics of the decision making context and its typical decision situations influence the types and characteristics of DSSs and decision support technologies (French et al. 2009, pp. 82-85; French 2013). Different types of DSSs and decision support technologies can therefore be associated with different Cynefin framework decision making contexts, according to the level of support provided (French 2013). The proposed relationship between the different types of DSS and decision support technologies and the Cynefin framework decision making contexts, according to the level of decision support provided, is represented in Figure 25.

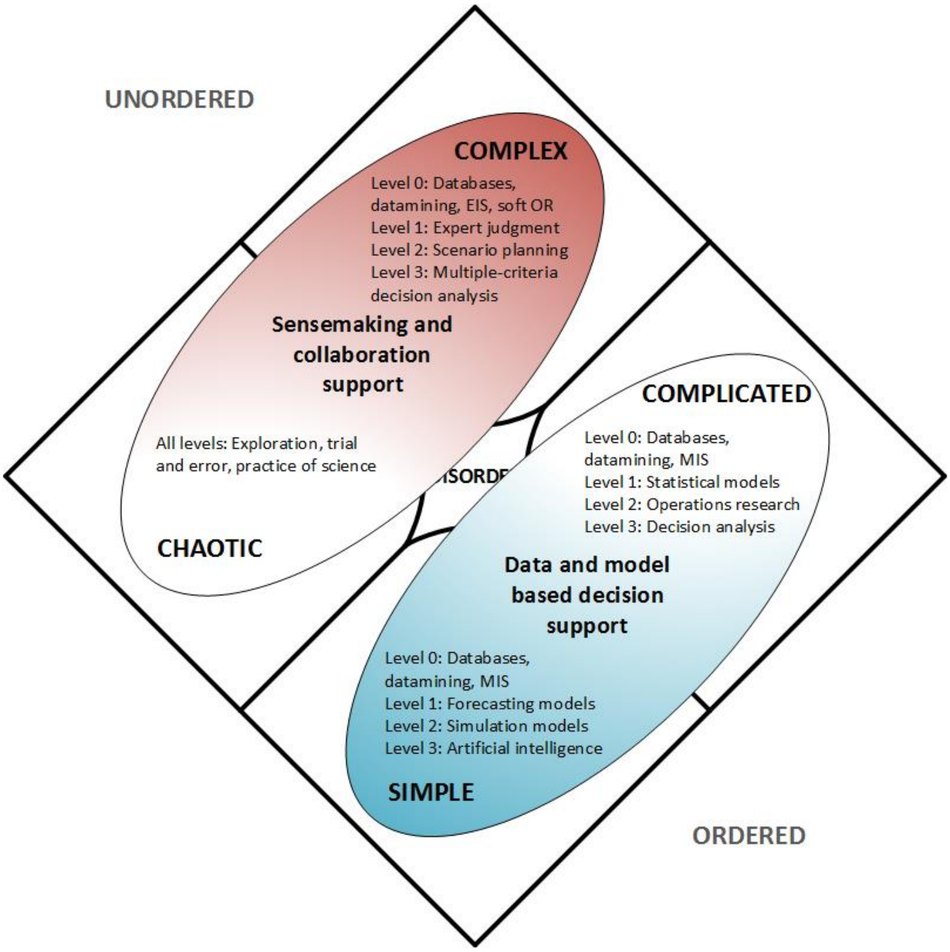

Figure 25. Decision support technologies according to level of support and decision making context characteristics (adapted from French 2013)

Decision support at level 0 focuses on the presentation of data, or according to the distinction between data and information, on the presentation of information that is relevant to the decision makers to help them perceive and understand the decision making context and its typical decision situations. At this level various DSSs typically extract the relevant data from databases and other information sources and present them to the decision makers with minimal analysis. Different types of DSSs based on databases and data mining techniques and representational models of data can typically provide level 0 decision support in all the Cynefin framework decision making contexts, although their characteristics and capabilities may differ depending on the characteristics of the decision making context and its typical decision situations. These types of DSSs traditionally include Management Information Systems (MIS) and Executive Information Systems (EIS), which provide graphical and tabular summaries of information, and Geographic Information Systems (GIS) related to the presentation of spatial, temporal and factual data. In the complex decision making context, various Problem Structuring Methods (PSM), or soft Operations Research (OR) methods (Mingers 2011), can help the decision makers in exploring and structuring the decision making context and its decision situations in order to better perceive and understand them. (French et al. 2009, pp. 84-85; French 2013)

Level 1 decision support provides the decision makers with forecasts that help them perceive and understand how the decision making context and its typical decision situations are likely to evolve in the future. At this level various DSSs typically combine the relevant data with expert knowledge, which may be either expressed directly or through the use of one or more models. Different types of DSSs based on time series of data and various quantitative forecasting and statistical models can typically provide level 1 decision support in the simple and complicated contexts, and include, for example, economic forecasting systems and market share predictions. In the complex decision making context, various qualitative forecasting methods that rely on expert knowledge, such as the Delphi method (Linstone and Turoff 1975) can help the decision makers gain different perspectives and reach a consensus on the likely evolution of the decision making context and its decision situations. (French et al. 2009, pp. 84-85; French 2013)

Level 2 decision support provides the decision makers predictions about consequences of alternative courses of action in a decision situation, but does not support the process of judgment that the decision makers must undergo to reach a decision. DSSs providing level 2 decision support in the simple and complicated decision making contexts can be typically based on data and various quantitative techniques and models, including simulation models (Law 2014), and different Operations Research (OR) (Taha 2007) and Operations Management (OM) (Slack et al. 2010; Krajewski et al. 2010) techniques and models for standard categories of decision problems, such as linear programming, inventory models and maintenance models. Most of these techniques and models, however, assume too much structure and repeatability to be practical in the complex decision making context, where various qualitative techniques, such as scenario planning in the domain of strategic decisions (Schoemaker 1995) are instead more appropriate to help the decision makers identify potential contingencies and make predictions about the consequences of alternative courses of action. (French et al. 2009, pp. 84-85; French 2013)

Level 3 decision support provides the decision makers support with evaluating the consequences of and ranking alternative courses of action in a decision situation, and helps them to explore their preferences and evolve their judgment to reach a decision. DSSs providing level 3 decision support in the simple decision making context can potentially be based on Artificial Intelligence (AI) techniques (Russell and Norvig 2009) and include, for example, Expert Systems (ES) that emulate the decision making capability of a human expert, but are typically only suited to highly structured and repetitive decision situations that are characteristic for the simple decision making context. In the complicated and complex decision making contexts various Decision Analysis (DA) and Multiple-Criteria Decision Analysis (MCDA) techniques (Clemen 1996), such as, for example, decision trees and influence diagrams at different levels of detail, and the Analytic Hierarchy Process (AHP) (Saaty 1988) can instead help the decision makers in structuring and modeling the decision situation, evaluating and ranking alternative courses of action based on a number of evaluation criteria and weighing together the decision makers' conflicting preferences and balancing potential benefits and costs with key uncertainties, and evolving their judgment to reach a decision. (French et al. 2009, pp. 84-85; French 2013)

Different types of DSSs and decision support technologies can provide support for the aspects of different work systems' real world decision making processes that are related to rational decision making in their characteristically different types of associated decision making contexts and their typical decision situations. It is viewed that they often structure the decision making processes according to the phases of the prescribed intelligence, choice and design model of organizational decision making (Simon 1977, pp. 40-41), and are often focused on finding solutions on individual typical decision situations, or decision problems, existing within the decision making context. It is therefore viewed that individual DSS and decision support technologies cannot by themselves holistically support all the aspects of the different work systems' real world decision making processes, but providing holistic decision support just for the aspects of their decision making processes related to rational decision making may require combining a variety of different types of DSS and decision support technologies to address different types of individual typical decision situations, or decision problems, either separately or together.

8.3.2 Decision support for naturalistic decision making processes in service systems

The naturalistic decision making processes in different work systems within complex service systems are viewed to be drawing on decision makers' perception and understanding about the decision making context and its decision situations in the form of their Situation Awareness (SA) (Endsley 1995) and their tacit knowledge in the form of their mental models of the system and its tasks. It is proposed that effective decision support for the naturalistic decision making processes should therefore focus on supporting the decision makers' SA requirements to allow them to increase their perception and understanding of the decision making context and its decision situations and to develop their tacit knowledge through learning and development of mental models of the system and its tasks. There are viewed to be different needs and typical requirements for decision support in different work systems within complex service systems, depending on both the decision makers' perception of the characteristics of the decision making context and its decision situations, and the inherent characteristics of the decision making context and its decision situations. The proposed typical requirements for decision support in different types of Cynefin framework decision making contexts are represented in Figure 26.

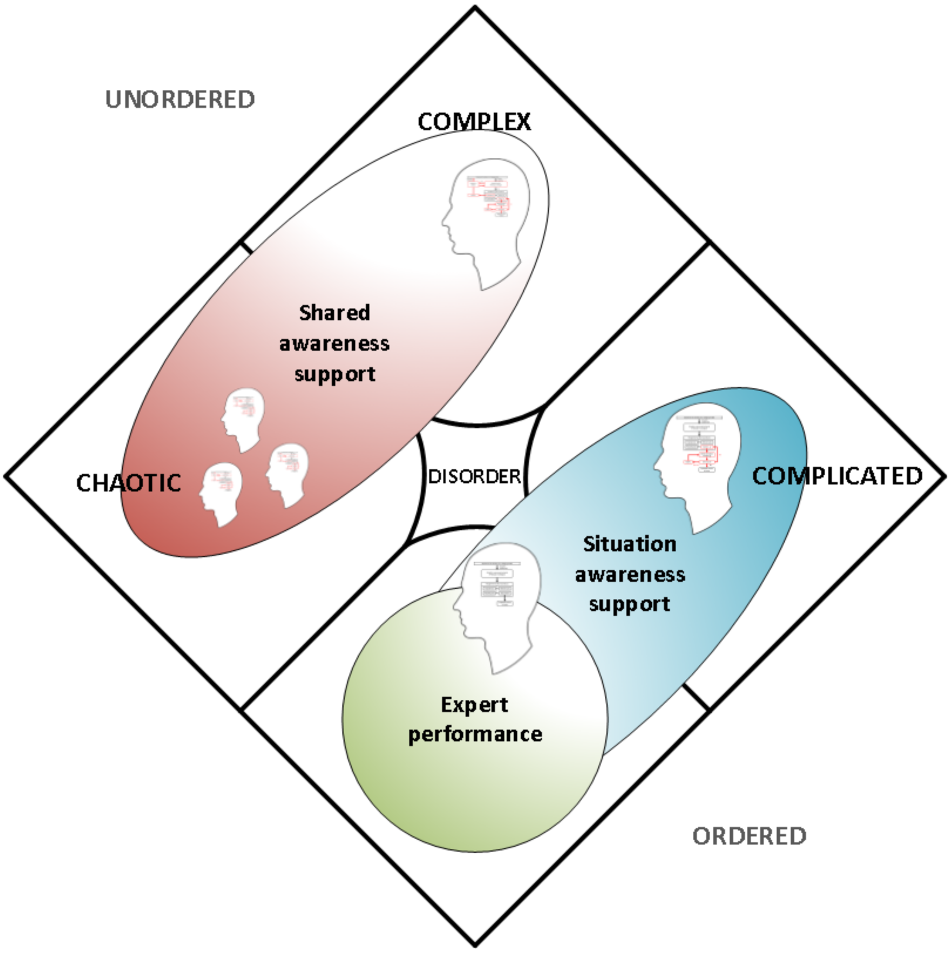

Figure 26. Decision support for naturalistic decision making processes

Perceived decision making context characteristics influence on need for decision support

It is proposed that the decision makers' need for decision support in different work systems within complex service systems is determined by their perception of the characteristics of the decision making context and its typical decision situations. In decision making contexts that are perceived to be characteristically simple, the decision makers are viewed to be familiar with the decision making context and its decision situations, and have both the necessary tacit knowledge in the form of well-developed mental models of the system and its tasks and the necessary level of SA to provide them sufficient perception and understanding of the decision making context and its decision situations to allow them to perform efficiently and effectively in typical decision situations. The work systems that are associated with these types of decision making contexts are viewed to represent the domain of expert performance, and it is viewed that their decision makers typically have little or no additional requirements for decision support. In decision making contexts that are perceived to be characteristically complicated, complex or chaotic, the decision makers are viewed to be increasingly unfamiliar with the decision making context and its decision situations and may lack both the necessary tacit knowledge in the form of sufficiently well-developed mental models of the system and its tasks and the necessary SA to provide them sufficient perception and understanding of the decision making context and its decision situations. It is viewed that the work systems that are associated with these types of decision making contexts are subject for decision support, but their decision makers' typical requirements for decision support depend on the inherent characteristics of the decision making context and its decision situations, and their specific requirements for decision support are determined by the system and task characteristics.

Inherent decision making context characteristics influence on typical requirements for decision support

It is proposed that the type of the decision makers' typical SA requirements in different work systems within complex service systems depend on the inherent characteristics of their associated decision making context and its typical decision situations, and that either individual SA requirements or shared SA requirements may dominate in different types of Cynefin framework decision making contexts. It is viewed that the decision makers' individual SA requirements related to the performance or planning, control and coordination of individual tasks typically dominate in the inherently simple and complicated decision making contexts. Decision support in these types of decision making contexts can typically focus on increasing the decision makers' perception and understanding of the decision making context and its decision situations in relation to individual tasks, and facilitating the development of their tacit knowledge through learning and development of mental models of the system and its individual tasks. In the inherently complex and chaotic decision making contexts decision makers' shared SA requirements related to the performance or planning, control and coordination of interdependent and interacting tasks are viewed to dominate. In these types of decision making contexts decision support can typically focus on increasing the decision makers' perception and understanding of the decision making context and its decision situations in relation to the interdependent and interacting tasks, enabling the necessary collaboration and communications between the decision makers, and facilitating the development of their tacit knowledge through learning and development of shared mental models of the system and its interdependent and interacting tasks. Although different types of decision makers' SA requirements may dominate in different work systems, depending on the inherent characteristics of the decision making context, it is viewed that both individual SA requirements and shared SA requirements may have an important role in different work systems, and therefore decision support for both decision makers' individual SA requirements and shared SA requirements may be required within a work system.

The decision makers' typical requirements for decision support in different work systems within complex service systems are proposed to further depend on the level of their SA requirements. According to the three level model of SA in dynamic decision making (Endsley 1995), decision makers' SA requirements can be broken down on three levels, with Level 1 SA concerning their perception and awareness of the environment, Level 2 SA requirements their comprehension and understanding of the present situation, and Level 3 SA requirements their projection of the future status of the environment. Depending on the level of the decision makers' SA requirements, decision support should therefore focus on supporting different aspects of the decision makers' limited cognitive capacity and their knowledge about the system and its tasks.

Level 1 SA requirements in different work systems within complex service systems are viewed to mostly concern the decision makers' perception and awareness of the system and its tasks, based on the state and attributes of the relevant individual elements within the decision making context that are related to its decision situations, and their interdependencies and interactions. In many systems and tasks direct perception of the environment and communications with others can be important information sources for the decision makers (Endsley 1995), but it is viewed that in complex service systems there are frequently lines of visibility that may hide the relevant elements within the decision making context from the decision makers and make them difficult to perceive without appropriate decision support to support and facilitate the decision makers' capability to acquire the necessary data about the relevant elements and process it into useful information that forms the basis for their SA. It is viewed that decision support at this level can mostly focus on augmenting the decision makers' limited cognitive capacity, by providing them real time data and information about the status and attributes of the relevant individual elements within the decision making context, and their interdependencies and interactions.

Level 2 SA requirements are viewed to mostly concern the decision makers' ability to comprehend and understand the present state of the system and its tasks, based on a synthesis of the state and attributes of the relevant individual elements within the decision making context that are related to its decision situations, and their interdependencies and interactions. Achieving Level 2 SA requires that the decision makers have sufficient level 1 SA, and the necessary knowledge in the form of sufficiently well-developed mental models of the system and its tasks that allow them to comprehend and understand their meaning in relation to their present goals and objectives (Endsley 1995). It is viewed that decision support at this level should augment both the decision makers' limited cognitive capacity and knowledge about the system and its tasks, by providing them relevant real time information about the present state of the system and its tasks based on data concerning the present state and attributes of the relevant individual elements within the decision making context, and their interdependencies and interactions, and models that embed knowledge about the system and its tasks.

Level 3 SA requirements are viewed to mostly concern the decision makers' understanding of the dynamic behavior of the system, including changes in the present state of the system and its tasks and their evolution over time, based on the changes and evolution of the state and attributes of the relevant individual elements within the decision making context that are related to its decision situations, and their interdependencies and interactions. Achieving Level 3 SA requires that the decision makers have both sufficient Level 1 and Level 2 SA, and the necessary knowledge in the form of well-developed mental models about the system and its tasks that allow them to understand the dynamic behavior of the system and its tasks and make projections about the likely changes in their state and their evolution over time (Endsley 1995). It is viewed that similarly to Level 2 SA, decision support at this level should augment both the decision makers' limited cognitive capacity and knowledge about the system and its tasks, by providing them relevant real time information about the changes in the present state of the system and its tasks and their evolution over time, and projections about the likely future state of the system and its tasks, either as a result of changes and evolution of the state and attributes of the relevant individual elements within the decision making context that are related to its decision situations or as a result of consequences of their actions, based on various data and models that embed knowledge about the system and its tasks.

Decision support technologies

It is proposed that a potential technology for supporting different types and levels of decision makers' SA requirements in different work systems can be provided by information system displays that are based on representational models and real time visualization of the decision making context and the relevant elements that are related to its decision situations, and provide the decision makers different types and levels of SA information according to their SA requirements. It is viewed that the representational models and real time visualization of the decision making context according to the decision makers' SA requirements can support them in acquiring and maintaining SA, and also expose them to the system and its tasks and their dynamic behavior and facilitate the development of the decision makers' tacit knowledge through learning and development of mental models of the system and its tasks. Furthermore, it is proposed that different types and levels of decision makers SA requirements in different work systems can often be supported by combining, or embedding, different types DSS functionalities based on different decision support technologies that are commonly associated with the support for rational decision making processes in organizations, in the representational models. Depending on the type of the DSS functionalities and their underlying decision support technologies, their role may not be limited to only supporting the decision makers' SA requirements, to support the aspects of their decision making processes that are related to naturalistic decision making, but the representational models in combination with different DSS functionalities may be able to provide a more holistic support for their decision requirements, and address both the aspects of their decision making processes that are associated with naturalistic decision making processes and with rational decision making processes.

It is viewed that different Data-, Model- and Knowledge-Driven DSS (Power 2002, p. 13) functionalities and decision support technologies (French et al. 2009, pp. 82-85; French 2013) in combination with the representational models are capable of providing support for different levels of decision makers' individual SA and shared SA requirements, but their usefulness may be limited to specific types of decision making contexts. Decision support technologies providing level 0 decision support (French et al. 2009, pp. 83-84; French 2013), such as databases and data mining techniques, can be combined with the representational models to support the decision makers' Level 1 SA requirements in all types of Cynefin framework decision making contexts. It is viewed that these types of decision support technologies are mainly capable of augmenting the decision makers' limited cognitive capacity by providing them real time data and information based on a combination of data acquired from different information sources that is proposed and presented in a form that supports their Level 1 SA requirements. Decision support for the decision makers' Level 2 and Level 3 SA requirements should be capable of augmenting both the decision makers' limited cognitive capacity and their knowledge about the system and its tasks, and their dynamic behavior, and it is viewed that decision support technologies providing level 1 and level 2 decision support (French et al. 2009, pp. 83-84; French 2013), such as forecasting and statistical models, and operations research and operations management models, can be combined with the representational models to support their SA requirements at these levels, but their usefulness may be limited to the simple and complicated Cynefin framework decision making contexts. Different Communications-Driven and Group DSS (Power 2002, p. 14) functionalities, and other collaboration and communications technologies, in combination with the representational models can additionally provide the decision makers the necessary collaboration and communications tools that may be required to support their shared SA requirements.

Specific requirements for decision support

It is viewed that understanding the specific requirements for decision support in different work systems within complex service systems not only requires understanding the perceived and inherent characteristics of their associated decision making contexts and their typical decision situations, but also requires understanding about the characteristics of the system and its value creating processes, and their tasks and activities, and identifying the factors that influence the decision makers' performance and decision making processes. Therefore, it is viewed that the proposed conceptual model, together with an appropriate Cognitive Systems Engineering (CSE) (Hollnagel and Woods 1983; Rasmussen et al. 1994; Hoffman et al. 2002) methodologies, such as the Decision-Centered Design (DCD) process (Crandall et al. 173-181) and the User-Centered Design (UCD) process (Endsley and Jones 2012, pp. 43-59) can provide the basis for building the required understanding, identifying and describing specific requirements for decision support in different work systems within complex service systems, and for the DSS systems development and evaluation.

9. Discussion and conclusions

A conceptual model of decision making and decision support in service systems is proposed based on literature. The proposed conceptual model builds on a proposed integrated model of complex service systems, and addresses characteristics of decision making context and decision making processes in complex service systems, and typical requirements for decision support in different work systems within complex service systems, based on the characteristics of their associated decision making context and their decision making processes. The model can potentially provide the basis for further research and development based the Ä-Logi, Intelligent Service Logic for Welfare Sector Services research project (Tekes 2013a) results and material, and provides a number of implications for service research and practice.

9.1 Proposed conceptual model of decision making and decision support in service systems

Characteristics of complex service systems and their implications for decision making and decision support

It is viewed that understanding the characteristics of complex service systems and their implications on the nature of decision making processes and requirements for decision support in complex service systems is necessary to provide the basis for the development of the conceptual model of decision making and decision support in complex service systems. There are a number of models of complex service systems proposed in the literature that build on different theoretical backgrounds and offer different perspectives on their characteristics, but it is viewed that none of the individual perspectives alone provides a sufficient basis for understanding their characteristics, and therefore integration of a number of perspectives is necessary. An integrated model of complex service systems is therefore proposed that views complex service systems as hierarchical complex systems (Simon 1962) that can be analyzed through multiple complementary perspectives, at different levels of abstraction, that focus on different aspects of the system and view the individual components and subsystems of the system and their interactions through different concepts. The proposed integrated model views complex service systems through the service ecosystem, production system and work system perspectives, each perspective building on different theoretical backgrounds, but proposed to be interrelated and offering different, but complementary implications on their characteristics and on the nature of decision making processes and typical requirements for decision support in complex service systems.

Service ecosystem perspective

The service ecosystem perspective provides a systemic view (Ng et al. 2011, pp. 19-20) on the characteristics of complex service systems and describes the system as a value network of different types of service system entities, where value is created through interactions between individual service system entities, that are facilitated by different types of information, knowledge and technologies, and produce value creating outcomes through service provision. According to this perspective the nature of service ecosystems as complex adaptive systems (Plsek and Greenhalg 2001), whose behavior is inherently unpredictable and self-organizing, is viewed to be the main source of implications on the nature of decision making and requirements for decision support in complex service systems. As complex adaptive systems service ecosystems are viewed as collections of different types of service system entities that all exist within a shared context of value creation and act in ways that are not always fully predictable, and whose actions are interconnected so that actions of one service system entity change the context of others. The overall behavior of the service ecosystem as a whole emerges from the interactions among individual service system entities and therefore the detailed behavior of the service ecosystem and its individual service system entities is fundamentally unpredictable over time and the only way to know how the system will behave in a particular situation, and how its behavior will evolve over time, is to observe the patterns of behavior of the system. The behavior of the service ecosystem and its individual service system entities is also self-organizing and therefore there is often no need for centralized planning, control and coordination of every aspect of the system, but the individual service system entities themselves are able to behave adaptively in varying situations and perform value creating activities associated with their different roles in different shared contexts of value creation at different levels of aggregation within the service ecosystem.

Production system perspective

The production system perspective provides a reductionist view (Ng et al. 2011, pp. 17-19) on the characteristics of complex service systems and describes the system as a system of production processes, including service processes and non-service processes, that conceptualize the various patterns of interaction, and tasks and activities necessary for service provision between different types of service system entities within the service ecosystem, and link them together into value creating systems, providing a structure that enables the necessary planning, control and coordination of value creating activities within the system. According to this perspective the nature of complex service systems as open systems (Fitzsimmons and Fitzsimmons 2006, pp. 29-32), whose processes, and their tasks and activities at different levels of aggregation are exposed to varying degrees of uncertainty that is caused by the inherently unpredictable nature of the behavior of the individual service system entities and the service ecosystem as a whole, is viewed to be the main source of implications on the nature of decision making processes and requirements for decision support in complex service systems. As open systems the complex service systems interact with other service system entities within the service ecosystem within a shared context of value creation and are subject to varying customer inputs through customer interactions with their service processes that can impact the process in different degrees, causing variations in the process and requiring that the service processes have the necessary capacity to adapt to the variations and changes in the customer inputs. The customer interactions with a complex service system are not necessarily limited to a single service process, but customer's value creation processes may include a number of interactions with the system and its service processes that may also exert indirect influences on the associated non-service processes. Different types of customer interactions with complex service systems and their processes involve different requirements for service provision that require different mobilizations of service system resources, and imply different requirements for the information and knowledge and differences in the decision making processes that are involved in making the mobilization decision.

Work system perspective

The work system perspective views complex service systems as socio-technical systems (Trist 1981; Mumford 2000; Mumford 2006; Baxter and Somerville 2011) that are composed of a number of interdependent and interacting work systems (Alter 2008; Alter 2010; Alter 2011) that build around the production systems' processes and enact the tasks and activities necessary for value creation within different shared contexts of value creation within the service ecosystem. According to the work system perspective, different types of knowledge, information exchange and information processing, and supporting and facilitating technologies are required in different work systems for making decisions about the mobilization of service system resources and for the performance of their value creating tasks and activities necessary for service provision, implying that there are differences in the nature of decision making processes and requirements for decision support in different work systems, depending on the characteristics of their associated processes, and their tasks and activities, and the characteristics of their associated shared context of value creation within the service ecosystem.

Based on the proposed integrated model of complex service systems, it is proposed that different work systems, associated with different types of production systems' processes and enacting value creating tasks and activities within different types of shared contexts of value creation within the service ecosystem, are associated with different types of decision making contexts that may be dominated by different types of decision making processes and where different types of decision support may be required, depending on the characteristics of the decision making context and decision making processes.

Characteristics of decision making contexts in complex service systems and their implications for decision making and decision support

It is proposed that different work systems within complex service systems are associated with different types of decision making contexts whose inherent characteristics are influenced by their associated value creating processes, and their tasks and activities, and the characteristics of their shared context of value creation within the production system and the service ecosystem. Traditionally the inherent characteristics of different types of decision making contexts and the types and characteristics of their decision situations are associated with hierarchical levels of organizational activities, but it is viewed that the traditional characterization fails to take into account the influences that the different types of value creating processes and activities and the characteristics of the shared context of value creation have on the characteristics of decision making contexts and their typical decision situations within work systems at different levels within complex service systems. Furthermore, it is viewed that the nature of decision making processes and requirements for decision support within individual work systems are not just influenced by the inherent characteristics of their decision making context and their typical decision situations, but also by the decision makers' information and knowledge that influence their perception and understanding of the decision making context and an individual decision situation characteristics. Another perspective on the characteristics of decision making contexts within organizations is provided by the Cynefin framework (Snowden 2002; Kurtz and Snowden 2003; Snowden and Boone 2007), which views that different types of decision making contexts are associated with different knowledge spaces, and that the inherent characteristics of the decision making context and the decision makers' information and knowledge together determine the perceived characteristics of the decision making context and are a source of influences on the nature of decision making processes and typical requirements for decision support in specific decision situations within a specific decision making context. Instead of the traditional view, it is proposed that the Cynefin framework can provide the basis for characterizing different types of decision making contexts within complex service systems.

The Cynefin framework identifies five distinct types of decision making contexts whose inherent characteristics are primarily defined by the nature of cause and effect relationships in each context. The simple, complicated, complex and chaotic contexts represent distinct domains for decision making that require diagnosing the prevailing context characteristics and acting in contextually appropriate ways. In the simple and complicated contexts an ordered world is assumed where cause and effect relationships are perceptible and right answers can be determined based on the known facts. These contexts represent the domain of fact based management, which is viewed to correspond to the reductionist view of the characteristics of complex service systems. The complex and chaotic contexts assume an unordered world where there is no immediately apparent relationship between cause and effect and the way forward needs to be determined based on emerging patterns. These contexts represent the domain of pattern based management, which is viewed to correspond to the systemic view of the characteristics of complex service systems. The fifth context, disorder, applies when it is unclear which of the four other contexts is predominant.

A characterization of different types of decision making contexts within complex service systems is proposed that addresses the typical characteristics of different types of decision making contexts within complex service systems and their typical requirements for decision support. The proposed characteristics of different types of decision making contexts within complex service systems are summarized in Table 7.

Table 7. Proposed characteristics of decision making contexts in complex service systems

Context	**Context characteristics within complex service systems**	**Decision support focus within complex service systems**
Simple	Structured decision situations related to performance of relatively independent non-service processes, and performance of service processes with minimal degree of variation between instances of service provision	Support perception and understanding of facts in a decision situation; facilitate effective use of information and existing knowledge to categorize decision situations; enable taking effective actions based on best practice
Complicated	Semi-structured decision situations related to planning, control and coordination of value creating activities between interdependent processes, and performance of service processes with higher degree of variation between instances of service provision	Support discovery and understanding of facts in a decision situation; facilitate effective use of information and existing knowledge to analyze decision situations; enable taking effective actions based on good practice
Complex	Unstructured decision situations related to planning, control and coordination of value creating activities between constellations of interdependent and interacting	Create conditions that make existing and emerging patterns of behavior and their change and evolution more visible; support perception and

	processes, and performance of service processes with multiple interdependent and interacting simultaneous instances of service provision	understanding of existing and emerging patterns; enable taking effective actions to manage emergence
Chaotic	Unexpected and abnormal situations that require immediate action to recover from the situation	Enable taking effective actions to manage situation; support perception and understanding of the effects of the actions to existing and emerging patterns of behavior

Simple decision making contexts

Simple decision making contexts within complex service systems are proposed to be associated with work systems that enact value creating processes, and their tasks and activities, that are mostly related to the performance of relatively independent individual non-service processes and service processes that have only a minimal degree of variation between the individual instances of service provision. It is viewed that these types of processes and their tasks have a well-defined role in various value creation processes, and, because they are performed relatively independently from other processes, the information and knowledge required for service provision is mostly focused on the individual process and its individual tasks and activities. The Cynefin framework decision making model in the simple context is to sense, categorize and respond to the situation. Therefore it is viewed that decision support within the simple context should focus on supporting the decision makers' capability to perceive and understand the facts in the decision situation, facilitating their effective use of information and existing knowledge to categorize various decision situations, and enabling them to take effective actions based on the established best practice.

Complicated decision making contexts

Complicated decision making contexts are proposed to be associated with value creating processes, and their tasks and activities, that are mostly related to planning, control and coordination of value creating activities within the production system, but complicated contexts may also be associated with decision situations that are related to the performance of service processes that have a higher degree of variation between the individual instances of service provision. It is viewed that although the individual processes and their tasks may have a well-defined role in various value creation processes, the interdependencies and interactions between individual processes and their tasks may be a source of decision situations, in which information and knowledge about a single process or its tasks is not sufficient, but further understanding about the system and the relationships between its interdependent and interacting parts is also required. It is viewed that in service processes, higher level of understanding about the customer's value creation process beyond the context of the service process and its tasks is required, implying that higher level of information exchange and information processing is necessary to determine the customer's requirements for service provision in a particular instance of service provision, and that further information and knowledge about the other processes and their tasks that are linked with the customer's value creation process within and outside the boundaries of the service system is required to make a decision about the mobilization of service system resources in a particular instance of service provision. The Cynefin framework decision making model in the complicated context is to sense, analyze and respond to the situation. Therefore it is viewed that decision support within the complicated context should focus on supporting the decision makers' capability to discover and understand the facts in the decision situation, facilitating their effective use of information and existing knowledge to analyze various decision situations, and enabling them to take effective actions based on the results of the analysis, following an established good practice.

Complex decision making contexts

Complex decision making contexts are proposed to be associated with value creating processes, and their tasks and activities, that are mostly related to planning, control and coordination of value creating activities within the overall production system that includes interdependencies and interactions between constellations of different types of processes and within the overall service ecosystem that includes interdependencies and interactions between different types of service system entities, but complex contexts may also be associated with decision situations that are related to individual service processes and their tasks, whose performance is influenced by interdependencies and interactions between individual instances of multiple simultaneously performed value creation processes and their simultaneous instances of service provision. It is viewed that the interdependencies and interactions between different types of service system entities and their value creation processes within a shared context of value creation may be a source of decision situations, in which information and knowledge about individual instances of value creation processes and the associated production system processes and their tasks that are contributing to their overall outcome is not sufficient, but further understanding about the behavior of the system, that emerges from the interactions between different types of entities and their individual instances of value creation processes at different levels of aggregation within the production system and the service ecosystem, and is never fully predictable, is also required. It is viewed that in service processes that are involved with multiple simultaneous instances of service provision related to different customers' value creation processes, not only understanding about an individual customer's value creation process is sufficient, but also understanding about the interdependencies and interactions between the different simultaneous instances of value creation processes and their influences on service provision is required, implying that further information and knowledge about the state of the system and the characteristics and state of the different individual instances of value creation processes within and outside the boundaries of the service system may be required to make decisions about the mobilization of service system resources in different input cases and to monitor and modify the mobilization of service system resources according to the perceived present state of the system and its processes and their tasks, and their change and evolution over time. The Cynefin framework decision making model in complex contexts is to probe, sense and respond to the situation. Therefore it is viewed that decision support within complex contexts should focus on creating conditions that make the existing and emerging patterns of behavior within the system and their change and evolution over time more visible to the decision makers, supporting decision makers' capability to perceive and understand the existing and emerging patterns and their change and evolution over time, and enabling them to take effective actions to manage the emergence.

Chaotic decision making contexts

Chaotic decision making contexts are proposed to be associated with unexpected and abnormal decision situations that the service system is not prepared to handle, and that influence its ability to efficiently and effectively provision service, therefore requiring an immediate action to recover from the situation and to restore the normal operation of the system. It is viewed that these types of decision situations may occur at different levels within complex service systems, including both unexpected exceptions in the established value creating processes and activities related to the planning, control and coordination of value creating activities and to the performance of service processes, and unexpected abnormal situations that are not associated with any of the established value creating processes and activities within the system. The Cynefin framework decision making model in chaotic contexts is to act, sense and respond. Therefore it is viewed that decision support within chaotic contexts should focus on enabling the decision makers to take effective actions to manage the situation and supporting their capability to perceive and understand the effects of their actions to the existing and emerging patterns of behavior within the system, allowing them to work to gradually recover from the situation.

Characteristics of decision making processes in complex service systems and their typical requirements for decision support in different types of decision making contexts

Characteristics of decision making processes in complex service systems

It is proposed that decision making in different work systems within complex service systems is based on both rational decision making processes (French et al. 2009, p. 353) and naturalistic decision making processes (Klein and Calderwood 1991; Orasanu and Connolly 1993; Zsambok 1997; Lipshitz et al. 2001; Klein 2008), both types of decision making processes having an important and complementary role in decision making within complex service systems. Traditionally, rational decision making processes are viewed to dominate organizational decision making at the levels of strategic, tactical and operational decisions associated with complicated, complex and even chaotic Cynefin framework decision making contexts, while naturalistic decision making processes are viewed to be mostly limited to the instinctive decisions that are related to operational performance and are mostly associated with the simple Cynefin framework decision making context. It is, however, viewed that the different types of decision making processes are not mutually exclusive, nor limited to particular types of value creating processes and activities and Cynefin framework decision making contexts, but rather complementary, and that different types of decision making processes may have a dominating role in different work systems within complex service systems, depending on the characteristics of their decision making context and its typical decision situations. A number of boundary conditions are identified (Klein 1998, pp. 92-96) that influence the decision makers' choice of a decision strategy, and the dominating type of a decision making process. Rational decision making processes are viewed to be more likely to dominate in decision making contexts and their decision situations that involve need for justification, conflict resolution, optimization or greater computational complexity, while naturalistic decision making processes are more likely to dominate, when greater time pressure, dynamic conditions, ill-defined goals or higher experience levels are involved. It is viewed that the presence of different boundary conditions within different decision making contexts and their decision situations influences the decision makers' choice of decision strategies and therefore the dominating types of decision making processes in different work systems within complex service systems. However, although different types of decision making processes may dominate in different work systems within complex service systems, their real world decision making processes may combine various elements of both rational decision making processes, which are typically drawing on known facts about the decision making context and its decision situations and explicit knowledge, and naturalistic decision making processes, which are typically drawing on decision makers' perception and understanding about the decision making context and its decision situations and their tacit knowledge. Therefore decision support for the real world decision making processes in different work systems within complex service systems may require support for both requirements related to rational decision making processes and requirements related to naturalistic decision making processes.

Typical requirements for decision support in complex service systems

It is proposed that typical requirements for decision support in different work systems within complex service systems depend on the types of their decision making processes and the characteristics of their associated decision making context and its typical decision situations. Perceived characteristics of the decision making context and its decision situations are viewed to mostly determine the need for decision support in different work systems within complex service systems, while the types of decision making processes and inherent characteristics of the decision making context and its typical decision situations determine the typical requirements for decision support, and suggest contextually appropriate types of decision support technologies.

Traditionally, decision support within organizations is viewed to be mostly associated with supporting rational decision making processes with different types of Decision Support Systems (DSSs) (Power pp. 12-16) and decision support technologies capable of providing different types and levels of decision support (French et al. 2009, pp. 82-85; French 2013), that are often focused on supporting the decision makers in specific types of decision situations, or decision problems, that are typically associated with different levels of organizational activities. It is instead viewed that typical requirements for decision support for neither rational decision making processes nor rational decision making processes in different work systems within complex service systems can be taken for granted based on the level of their organizational activities, but are determined by the types of their decision making processes and the inherent characteristics of their associated decision making context and its typical decision situations. The proposed typical requirements for decision support in complex service systems are summarized in Table 8.

Table 8. Proposed typical requirements for decision support in complex service systems

Decision making context characteristics	**Decision support requirements for rational decision making processes**	**Decision support requirements for naturalistic decision making processes**
Simple and complicated decision making contexts	Data-, model- and knowledge based decision support focused on specific decision situations within the decision making context; providing information that supports the decision makers' perception and understanding of the decision making context and its decision situations; facilitating the exploitation of explicit knowledge through models to support the decision making process.	Situation awareness support focused on holistic perception and understanding of the decision making context and its typical decision situations, in relation to individual value creating processes, and their individual tasks and activities; facilitating the development of tacit knowledge in the form of mental models of the system and its individual value creating processes, and their individual tasks and activities to provide the basis for the decision making process.

Complex and chaotic decision making contexts	Sense making and collaboration support focused on specific decision situations within the decision making context; providing information that supports the decision makers' perception and understanding of the decision making context and its decision situations; facilitating the development of tacit knowledge through exploration and sharing to support the decision making process.	Shared situation awareness support focused on holistic perception and understanding of the decision making context and its typical decision situations, in relation to interdependent and interacting value creating processes, and their interdependent and interacting tasks and activities; facilitating the development of tacit knowledge in the form of shared mental models of the system and its interdependent and interacting value creating processes, and their interdependent and interacting tasks and activities to provide the basis for the decision making process.

Rational decision making processes in the inherently simple and complicated Cynefin framework decision making contexts, that represent and ordered world and the domain of fact based management, are viewed to be mostly drawing on known facts about the decision making context and its decision situations, and building on the exploitation of explicit knowledge that is created through the combination cycle of organizational knowledge creation (Nonaka et al. 2000). It is viewed that effective decision support in the work systems that are associated with these types of decision making contexts can typically be based on data, representing the facts about the decision making context and its decision situations, and various models that embed the necessary explicit knowledge needed for processing the data into useful information that supports the decision makers' perception and understanding of the decision making context and its decision situations and provides the basis for their judgment. Typical types of DSSs in the inherently simple and complicated Cynefin framework decision making contexts are viewed to include various Data-, Model- and Knowledge-Driven DSSs (Power 2002, p. 13), and it may also be possible to automate decision making in the highly structured and repetitive decision situations within the inherently simple Cynefin framework decision making context with various Decision Management Systems (DMSs) (Taylor 2012) that are able to emulate the decision making capability of a human decision maker. In the inherently complex and chaotic Cynefin framework decision making contexts, that represent an unordered world and the domain of pattern based management, the decision making processes are viewed to be drawing more on the decision makers' perception and understanding of the decision making context and its decision situations and building on the exploration and sharing of tacit knowledge that is created through the socialization cycle of organizational knowledge creation (Nonaka et al. 2000). It is viewed that effective decision support in the work systems that are associated with these types of decision making contexts needs to focus on facilitating sense making and collaboration to allow the decision makers to increase their perception and understanding of the decision making context and its typical decision situations, and develop their tacit knowledge through exploration and sharing to provide the basis for their judgment. Decision making processes in these types of decision making contexts are viewed to deviate from the normative ideal of pure rationality, and to resemble more satisficing (Simon 1997, p. 119), potentially having more common elements with naturalistic decision making processes. Typical types of DSSs in the inherently complicated and complex Cynefin framework decision making contexts are viewed to include various Communications-Driven and Group DSSs (GDSSs) (Power 2002, p. 14), and other collaboration and communications technologies.

Naturalistic decision making processes are viewed to be always drawing on the decision makers' perception and understanding of the decision making context and its typical decision situations in the form of Situation Awareness (SA) (Endsley 1995) and their tacit knowledge in the form of their mental models of the system and its value creating processes, and their tasks and activities. It is viewed that effective decision support for the naturalistic decision making processes should therefore focus on supporting the decision makers' SA requirements to allow them to increase their perception and understanding of the decision making context and its decision situations and develop their tacit knowledge through learning and development of mental models of the system and its value creating processes, and their tasks and activities. It is viewed that the decision makers' SA requirements related to the performance or planning, control and coordination of individual value creating processes, and their individual tasks and activities, typically dominate in the inherently simple and complicated Cynefin framework decision making contexts. Decision support for naturalistic decision making processes in the work systems that are associated with these types of decision making contexts should therefore typically focus on increasing the decision makers' perception and understanding of the decision making context and its decision situations in relation to individual value creating processes, and their individual tasks and activities, and facilitating the development of their tacit knowledge through learning and development of mental models of the system and its individual value creating processes, and their individual tasks and activities. In the inherently complex and chaotic Cynefin framework decision making contexts decision makers' shared SA requirements related to the performance or planning, control and coordination of interdependent and interacting value creating processes, and their interdependent and interacting tasks and activities, are viewed to typically dominate. In the work systems that are associated with these types of decision making contexts decision support for naturalistic decision making processes should therefore typically focus on increasing the decision makers' perception and understanding of the decision making context and its decision situations in relation to the interdependent and interacting value creating processes, and their interdependent and interacting tasks and activities, enabling the necessary collaboration and communications between the decision makers, and facilitating the development of their tacit knowledge through learning and development of shared mental models of the system and its interdependent and interacting value creating processes, and their interdependent and interacting tasks and activities, that enable them to perceive and understand the dynamic behavior of the system.

9.2 Proposed further research and development process

The proposed further research and development process builds on the Ä-Logi, Intelligent Service Logic for Welfare Sector Services research project (Tekes 2013a) results and material. The Ä-Logi Decision Support System (DSS) design concept can potentially provide the basis for the development and evaluation of a DSS prototype system, and further research in the case organizations, but an appropriate research and development process is required, that addresses the perceived limitations of the Ä-Logi research project, and provides continuation for the research project. An outline for a further research and development process is proposed that is based on the proposed conceptual model of decision making and decision support in service systems, together with Cognitive Systems Engineering (CSE) (Hollnagel and Woods 1983; Rasmussen et al. 1994; Hoffman et al. 2002) methodologies, such as Decision-Centered Design (DCD) process (Crandall et al. 173-181) and the User-Centered Design (UCD) process (Endsley and Jones 2012, pp. 43-59).

Ä-Logi research project decision support system concept

A central part of the Ä-Logi research project was the development of a new type of Decision Support System (DSS) design concept that is especially aimed for supporting decision making and collaboration related to the operational level activities in the case organization focal units, and their focal work systems, and can potentially provide the basis for further research and development. The purpose of the developed DSS design concept is viewed to be dual. First, to provide holistic decision support in different case organization focal units, and their focal work systems, by combining decision support for the aspects of their real world decision making processes that are related to naturalistic decision making and rational decision making in their characteristically different types of associated decision making contexts. Second, to facilitate the development of the decision makers' tacit knowledge through learning and development of mental models of the system and its value creating processes, their tasks and activities, and their dynamic behavior, to provide the basis for their decision making processes.

The Ä-Logi DSS design concept is based on information system displays that provide representational models and real time visualization of the relevant aspects of the decision making context and the relevant elements that are related to its decision situations, and support the decision makers' Situation Awareness (SA) (Endsley 1995) by providing the decision makers different types and levels of SA information according to their SA requirements, providing support for the aspects of the focal work systems' decision making processes that are related to naturalistic decision making. Different types of DSS functionalities, based on different decision support technologies and providing different levels of decision support related to specific decision situations, or decision problems, are additionally embedded in the representational models, providing support for the aspects of the focal work systems' decision making processes that are related to rational decision making. The DSS design concept also provides different types of collaboration and communications tools to the decision makers, according to their collaboration and communications requirements. It is viewed that the DSS design concept facilitates the development of the decision makers' tacit knowledge by exposing the decision makers, through the representational models and real time visualization of the decision making context, to the system and its value creating processes, their tasks and activities, and dynamic behavior, that would otherwise be hidden from the decision makers by various lines of visibility. An example of a Ä-Logi DSS design concept user interface prototype is provided in Figure 27.

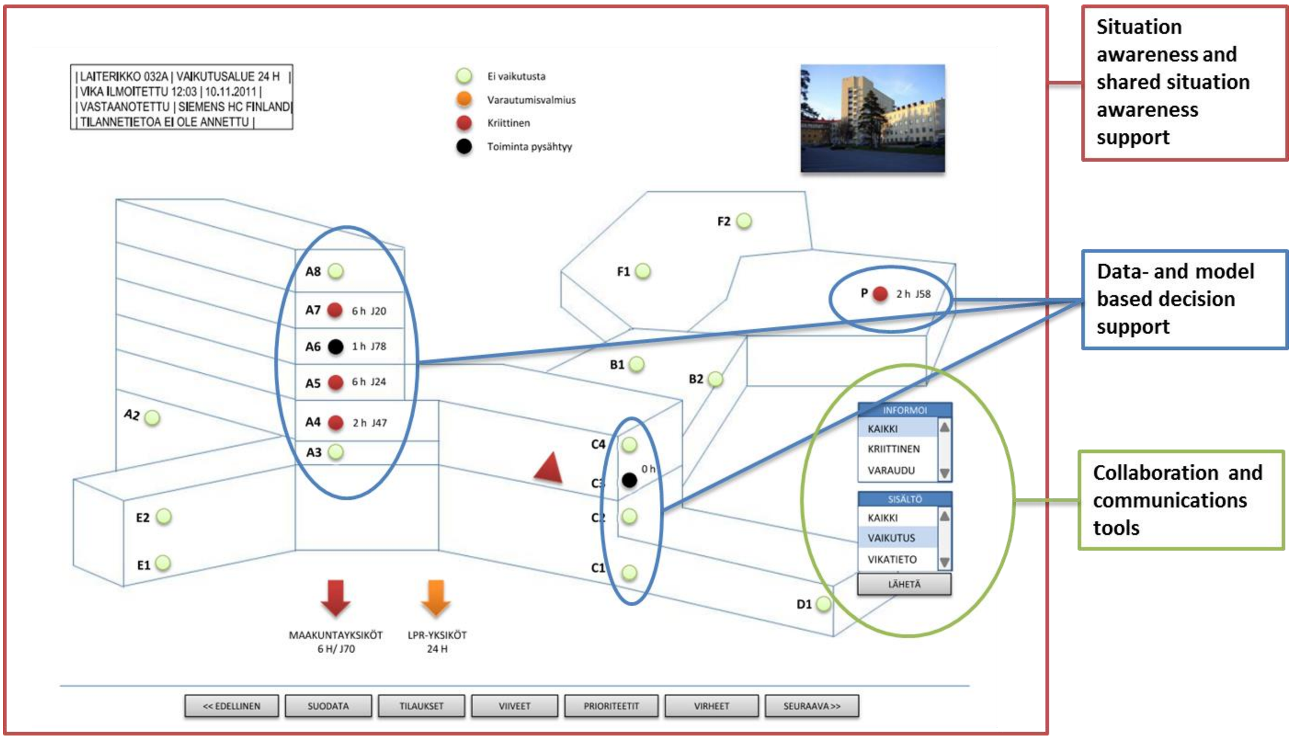

Figure 27. Ä-Logi decision support system design concept example

The presented Ä-Logi DSS design concept user interface prototype depicts the effects of the medical imaging support unit production equipment break down in the South Carelia Social and Health Care District (Eksote) central hospital. The production equipment break down influences different clinical units in the central hospital, and potentially requires changes in the mobilization of the support unit resources to prevent or minimize disturbances in the clinical units' capability to provision service, and additionally collaboration and communications between the support unit and different clinical units is required to manage the situation and recover from the effects of the break down. The presented DSS design concept is based on visualization model of different clinical units that provides the decision makers real time information about the current and projected status of the clinical units, supporting their SA and shared SA about the current and projected effects of the break down to the clinical units' capability to provision service. Information about the current and projected status of the clinical units is provided by combining elements of data- and model-based decision support technologies with the visualization model, that are capable of providing the required information based on current and time series of data and models. Additionally, the necessary collaboration and communications tools required to manage the situation and recover from the effects of the break down are provided.

Further research and development process

It is viewed that the proposed conceptual model of decision making and decision support in service systems, together with an appropriate Cognitive Systems Engineering (CSE) (Hollnagel and Woods 1983; Rasmussen et al. 1994; Hoffman et al. 2002) methodologies, such as Decision-Centered Design (DCD) process (Crandall et al. 173-181) and the User-Centered Design (UCD) process (Endsley and Jones 2012, pp.

43-59), can provide the basis for further research and systems development based on the Ä-Logi research project results and material. While the CSE methodologies are viewed to focus on understanding the present decision making context and process characteristics in the case organization focal work systems that provide the basis for the identification and description of their decision support requirements, and the following systems development and evaluation, the conceptual model suggests a different approach that allows the researchers and systems developers to first build an understanding of the present decision making context and process characteristics, define the target decision making context and process characteristics, and then identify the decision support requirements that are necessary for the transformation of the focal work system decision making context and process characteristics from their present state to the desired target state. Furthermore, the conceptual model provides a tool for the classification and presentation of the present and target decision making context and process characteristics, supports identifying and defining contextually appropriate decision support requirements and decision support technologies, and identifying the achieved decision making context and process characteristics and assessing further decision support development needs. An outline of the proposed further research and development process is represented in Figure 28.

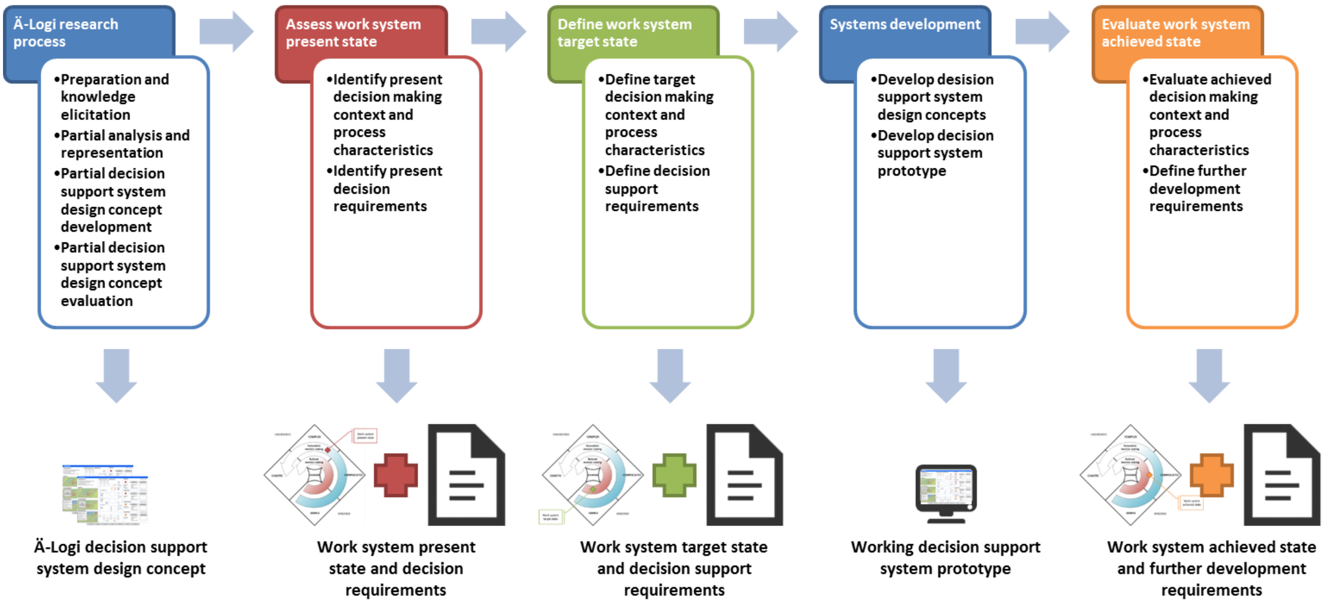

Figure 28. Proposed further research and development process

The proposed further research and development process builds on the Ä-Logi research process results and material. The Ä-Logi research process is viewed to have similarities to the CSE approach to systems design, and the phases of the process are viewed to correspond to various DCD and UCD process phases, but the process is viewed to have a number of limitations that the proposed further research and development process addresses. The Ä-Logi research phase activities are viewed to correspond to performing a Cognitive Tasks Analysis (CTA) (Crandall et al. 2006, pp. 9-26) in the case organizations, and are viewed to include identifying case organization focal work systems, understanding their value creating processes, and their tasks and activities, understanding the present characteristics of their associated decision making context and its decision making processes, and identifying the user decision making and collaboration requirements and the related decision support needs in the case organization focal work systems. The main limitation during this phase is viewed to be that no formal representation of the identified decision making and collaboration requirements and the related decision support needs was performed, but the identified requirements were instead directly applied during the following design phase, which was conducted partially concurrently with the requirements analysis. Furthermore, the identified decision making and collaboration requirements and the related decision support needs are viewed to be mostly associated with the present characteristics of the different case organization focal work systems' associated decision making contexts and decision making processes, and there appears to have been little consideration on how the characteristics of their decision making contexts and decision making processes could be transformed with appropriate decision support. The Ä-Logi design phase activities included developing a prototype DSS design concept based on the identified decision making and collaboration requirements and the related decision support needs within the different case organization focal work systems, which consists of a set of static DSS user interface prototypes. The Ä-Logi testing phase activities included evaluating whether the developed DSS design concept supports user decision making and collaboration requirements and fulfills their decision support needs within the different case organization focal work systems. The phase was also intended to provide feedback for possible further research and development of a working DSS prototype. The main limitation during the Ä-Logi development and testing phases is viewed to be that the available resources and time frame of the project did not allow the development of a working DSS prototype, and it was therefore only possible to perform a subjective evaluation of the developed DSS design concept, based on the developed static DSS user interface prototypes, making it difficult to establish the effectiveness of the developed solutions in supporting user cognitive requirements, and evaluating their impacts on the existing working practices within the different case organization focal work systems.

It is proposed that basis for the further research and development process can be provided by the proposed conceptual model, together with appropriate CSE methodologies, such as DCD and UCD processes. The following provides an outline of the proposed process phases and their main activities, focusing on the role of the proposed conceptual model during the process.

The purpose of assessing work system present state is to identify the present decision making context and process characteristics in the case organization focal work systems, based on an understanding of the perceived characteristics of their associated decision making context and its decision situations, and identify and describe the decision requirements that are related to their value creating processes, and their tasks and activities. The proposed conceptual model can support the identification of the present decision making context and process characteristics by suggesting typical characteristics of different types of decision making contexts and processes in complex service systems that, together with appropriate evaluation criteria and measures, can provide the basis for the classification of the present characteristics of the decision making contexts associated with different case organization work systems and their decision making processes.

The purpose of defining work system target state is to define the target decision making context and process characteristics in the case organization focal work systems, based on an understanding of the inherent characteristics of their associated decision making context and its decision situations, and identify and describe the decision support requirements that are necessary for the transformation of the focal work system decision making context and process characteristics from the present state to the desired target state. The proposed conceptual model can similarly support the definition of the target decision making context and process characteristics, and can additionally suggest typical requirements for decision support depending on the target decision making context and process characteristics. Furthermore, the conceptual model can provide an intuitive tool for identifying and presenting the gap between the present and the desired target states of the focal work system decision making context and process characteristics, providing support in identifying the case organization focal work systems that are the most potential development targets, and prioritizing the DSS development efforts.

The systems development phase has an objective to translate the decision support requirements into DSS design concepts and develop a working DSS prototype. During this phase the proposed conceptual model can suggest appropriate decision support technologies depending on the decision support requirements, and the desired target decision making context and process characteristics.

The purpose of evaluating work system achieved state is to evaluate the achieved decision making context and process characteristics in the case organization focal work systems, and to identify and describe possible DSS further development requirements that are necessary to complete the transformation of the focal work system decision making context and process characteristics from their achieved state to their desired target state. The proposed conceptual model can, similarly to the earlier phases, provide the basis for the classification of the achieved characteristics of the focal work system decision making context and processes, provide a tool for identifying and presenting the gap between the achieved and desired target states of the focal work system decision making context and process characteristics, and support assessing further development needs and identifying further development requirements in the developed DSS.

The systems development and evaluation phases can be iterative in their nature. The process may therefore consist of a number of successive systems development and evaluation iterations following each other, until the desired target state of the focal work system decision making context and processes has been achieved.

9.3 Conclusions

A conceptual model of decision making and decision support in service systems has been proposed based on literature. The proposed conceptual model provides a basis for further research and development based on the Ä-Logi research project results and material, but also offers a number of implications for service research and practice.

Characteristics of complex service systems has been a subject of discussion in the service science literature, and a number of models of complex service systems are proposed in the literature that build on different theoretical backgrounds and offer different perspectives on their characteristics. It appears that the discussion has been more focused on contrasting different models than attempting to find common ground and identify and describe the complementary implications of different perspectives. It is viewed that none of the individual perspectives alone provides a sufficient basis for fully understanding the characteristics of complex service systems, and therefore integration of a number of perspectives is necessary to further develop the understanding of the characteristics of complex service systems and provide a basis for further research and practice. Therefore, an integrated model of complex service systems is proposed that views complex service systems through multiple complementary perspectives, including the service ecosystem perspective, the production system perspective, and the work system perspective. The service ecosystem perspective represents a systemic view on the characteristics of complex service systems and describes the system as a value network of different types of service system entities, where value is created through interactions between individual service system entities that are facilitated by different types of information, knowledge and technologies, and produce value creating outcomes through service provision. The production system perspective provides a reductionist view on the characteristics of complex service systems and describes the system as a system of production processes, including service processes and non-service processes, that conceptualize the various patterns of interaction, and tasks and activities necessary for service provision between different types of service system entities within the service ecosystem, and link them together into value creating systems, providing a structure that enables the necessary planning, control and coordination of value creating activities within the system. The work system perspective views complex service systems as socio-technical systems that are composed of a number of interdependent and interacting work systems that build around the production systems' processes and enact the tasks and activities necessary for value creation within different shared contexts of value creation within the service ecosystem, drawing on different types of information, knowledge and technologies to facilitate service provision. The proposed integrated model not only provides the basis for the proposed conceptual model of decision making and decision support in service systems, but can also provide a basis for further discussion and development of a more holistic view on the characteristics of complex service systems that integrates a number of complementary and interrelated perspectives and can provide a useful framework for service research and practice alike.

The proposed conceptual model of decision making and decision support in service systems provides a new perspective on the nature of decision making and requirements for decision support in complex service systems. The traditional models of organizational decision making acknowledge the contextual nature of decision making and decision support in organizations, and are viewed to be applicable in complex service systems, but their underlying assumptions are viewed to be largely based on the manufacturing logic view on organizations, and are not viewed to be entirely valid in complex service systems. Traditionally, the characteristics of different types of decision making contexts and the types and characteristics of their typical decision situations are viewed to be associated with hierarchical levels of organizational activities, but it is viewed that the traditional characterization fails to take into account the influences that the different types of value creating processes, their tasks and activities, and the characteristics of the shared context of value creation have on the characteristics of decision making contexts and their typical decision situations within work systems at different levels within complex service systems. Instead of the traditional view, it is proposed that different work systems, associated with different types of production systems' processes and enacting value creating tasks and activities within different types of shared contexts of value creation within the service ecosystem, are associated with different types of decision making contexts whose characteristics are not determined by their level within complex service systems, but by the characteristics of their value creating processes, their tasks and activities, and the characteristics of their shared context of value creation within the service ecosystem. A characterization of different types of decision making contexts within complex service systems is proposed that addresses the typical characteristics of different types of decision making contexts within complex service systems and the typical focus areas of decision support within different types of decision making contexts. Traditionally, rational decision making processes are viewed to dominate decision making in organizations. Instead of the traditional view, it is proposed that the nature of decision making processes in complex service systems is dual, both rational decision making processes and naturalistic decision making processes existing in complex service systems, and having an important and complementary role in decision making. A number of boundary conditions are identified that influence the decision makers' choice of a decision strategy, and the dominating type of a decision making process in characteristically different types of decision making contexts and their typical decision situations. It is viewed that the presence of different boundary conditions within different decision making contexts and their decision situations influences the decision makers' choice of decision strategies and therefore the dominating types of decision making processes in different work systems within complex service systems. However, although different types of decision making processes may dominate in different work systems within complex service systems, their real world decision making processes may combine various elements of both rational decision making processes, which are typically drawing on known facts about the decision making context and its decision situations and explicit knowledge, and naturalistic decision making processes, which are typically drawing on the decision makers' perception and understanding of the decision making context and its decision situations and their tacit knowledge. Therefore, decision support for the real world decision making processes within complex service systems may require supporting both requirements related to rational decision making processes and requirements related to naturalistic decision making processes. Traditionally, decision support within organizations is viewed to be mostly associated supporting rational decision making processes with different types of Decision Support Systems (DSSs) and decision support technologies capable of providing different types and levels of decision support, that are often focused on supporting the decision makers in specific types of decision situations, or decision problems, that are typically associated with different levels of organizational activities. Instead of the traditional view, it is proposed that typical requirements for decision support for neither rational decision making processes nor naturalistic decision making processes in different work systems within complex service systems can be taken for granted based on based on their level within complex service systems, but are determined by the types of their decision making processes and the characteristics of their associated decision making context and its typical decision situations. A characterization of typical requirements for decision support within complex service systems is proposed that addresses the typical requirements for decision support that are associated with different types of decision making processes in characteristically different types of decision making contexts. The proposed conceptual model of decision making and decision support in complex service systems not only provides the basis for further research and development based on the Ä-Logi research project results and material, but also provides a new perspective on the nature of decision making and requirements for decision support in complex service systems, that is free from the rigid assumptions of manufacturing logic, complements and extends the traditional perspective that is based on the models of organizational decision making, and offers a framework that can be useful for service research and practice alike.

The proposed conceptual model of decision making and decision support in service systems, together with appropriate Cognitive Systems Engineering (CSE) methodologies, can provide the basis for further research and development based on the Ä-Logi research project results and material. The CSE methodologies are viewed to focus on understanding the present decision making context and process characteristics in the case organization focal work systems that provide the basis for the identification and description of their decision support requirements, and the following systems development and evaluation, but the conceptual model suggests a different approach that allows the researchers and systems developers to first build an understanding of the present decision making and process characteristics, then define the target decision making context and process characteristics, and identify the decision support requirements that are necessary for the transformation of the focal work system decision making context and process characteristics from the present state to the desired target state. Furthermore, the conceptual model can provide a tool for the classification and presentation of the present and target decision making context and process characteristics, support identifying defining contextually appropriate decision support requirements and decision support technologies, support identifying the achieved decision making context and process characteristics with decision support provided, and assessing further decision support development needs. It is viewed that the proposed conceptual model of decision making and decision support, together with appropriate CSE methodologies, not only provides the basis for further research and development based on the Ä-Logi research project results and material, but can also provide a useful framework for the development of decision support in a variety of different types of service systems.

The proposed integrated model of complex service systems and the proposed conceptual model of decision making and decision support in service systems are both viewed to provide valuable new perspectives on complex service systems that can potentially provide the basis for further discussion and development of further understanding of complex service systems. However, the proposed models have been developed based on literature and are conceptual in their nature, their propositions remaining to be validated and their value to be proven in practice. It is, however, believed that with empirical work and further refinement they can both provide useful frameworks for both service research and practice.

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