Safety management theory and the military expeditionary organization:
A critical theoretical reflection

Abstract

Management of safety within organizations has become a key topic within safety science. Theorizing on this subject covers a diverse pallet of concepts such as "resilience" and "safety management systems". Recent studies indicate that safety management theory has deficiencies. Our interpretation of these deficiencies is that much confusion originates from the issue that crucial meta-theoretical assumptions are mostly implicit or applied inconsistently. In particular, we argue that these meta-theoretical assumptions are of a systems theoretical nature. Therefore, we provide a framework that will be able to explicate and reflect on systems theoretical assumptions. With this framework, we analyze the ability of two frequently used safety management theories to tackle the problem of managing safety of Dutch military expeditionary organizations. This paper will show that inconsistent and implicit application of systems theoretical assumptions in these safety management theories results in problems to tackle such a practical problem adequately. We conclude with a reflection on the pros and cons of our framework. Also, we suggest particular meta-theoretical aspects that seem to be essential for applying safety management theory to organizations.

Keywords: safety management theory, general systems theory, military operations, safety management systems, resilience engineering

1. Introduction

Over the past decades, the application of safety management within organizations has increased steadily. Some examples are the ICAO safety management guidelines in aviation (ICAO, 2012), the SEVESO-III directives for working with hazardous materials (European Union, 2012) and the Safety Management System for the Dutch ministry of Defence (VMSdef; ministry of Defence, 2010). Also, theorizing on what safety management is, or should be, has accumulated. At the one hand, a wide array of fairly broad safety management practices and concepts are studied, ranging from safety culture (e.g., Guldenmund, 2000) to accident investigation (e.g., Roed-Larsen & Stoop, 2012), and from Normal Accidents Theory (Perrow, 1999) to high reliability theory (e.g., Roe & Schulman, 2008; Weick & Sutcliffe, 2007). Safety management systems (SMS) theory, on the other hand, seems to be a somewhat more specifically oriented towards the organization's management and control processes (e.g., Hale, Heming, Carthey & Kirwan, 1997).

Recent studies, however, have criticized theorizing on safety management. In their review on occupational health and safety management systems (OHSMS), Robson et al (2007) stated that: "*There is no consensus on what an OHSMS is and its scope is potentially wide. Some definitions are simply too vague* (…)". Also Reiman and Rollenhagen (2011) point to such conceptual confusion and argue that: "*In practice, different definitions of safety that are used explicitly or implicitly, affect safety management priorities and practices*". Moreover, Hale (2003) argued that safety management theory: "(…) *is governed by fashion and not evidence, and it has a one-sided, rationalistic view of what it is trying to do*".

In our interpretation, a contributing factor to these difficulties in safety management theory is that crucial meta-theoretical assumptions are mostly implicit or not explicated consistently. More in particular, we assert that these meta-theoretical assumptions are of a systems theoretical nature. We argue so because within systems theory, dealing with, or reducing, uncertainty is the central topic of concern (e.g., Von Bertalannfy, 1972). Dealing with uncertainty also seems to be of central concern to safety management. Grote (2007, p. 638) points out that: "*Safety is frequently defined as the smallest possible and/or acceptable risk, while risk is the product of possible damages and the probability of their occurrence. Inherent in these definitions is the concept of uncertainty.*". Managing safety within organizations consequently centres on the problem of how organizations can reduce uncertainty in the best possible way (Grote, 2012, p. 1985). Debate between different schools of thought within systems theory, however, has resulted in the development of fundamentally different perspectives on how a system can deal with (environmental) uncertainty in the best possible way (e.g., Blom, 1997; Kramer, 2007; Stacey, 1993). As safety management theory frequently employs systems theoretical concepts such as "control" and "emergence", it may therefore benefit from a reflection on systems theoretical assumptions. Also, such a reflection possibly resolves some of the difficulties that were described above.

The goal of this paper is therefore to show that explicating and reflecting on systems theoretical assumptions is crucial for understanding ways safety management problems are perceived, defined and the way they are tackled. We argue that this becomes particularly relevant when safety management theory is applied to safety problems within organizations. The following steps are followed to achieve the goal of this paper. Firstly, by using Grote's (2012) "minimizing" and "coping" with uncertainty distinction we identify two frequently employed, and contrasting, safety management theories: Safety Management Systems theory and resilience engineering theory. Secondly, based on a categorization of systems theoretical perspectives constructed by Blom (1997), we build a meta-theoretical framework. Thirdly, we introduce an empirical case: managing safety of the Dutch Armed Forces' expeditionary organizations. Fourthly, we will apply the premises of both safety management theories to the case and reflect on solutions by means of our meta-theoretical framework. We conclude with an elaboration on the implications of the reflection for applying safety management theory to organizational settings. Also, we will highlight some advantages and disadvantages of our method.

2. Two frequently used safety management theories

This section will discuss two safety management theories that are frequently applied to improve organizational safety: safety management systems theory and resilience engineering theory. In selecting these theories we employed Grote's distinction between "minimizing uncertainty" and "coping with uncertainty" paradigms in safety management (e.g., Grote, 2012). Although Grote does not define what she conceptualizes as a "paradigm" we will employ her distinction because it is regarded as a practically useful tool to categorize contrasting avenues of theorizing in safety management. To Grote, the minimizing uncertainty approach aims to achieve a high level of predictability, standardization and specialization and is founded on Taylor's scientific management and bureaucratic organizational theory (2012, p. 1985). In contrast to the minimizing approach, the coping with uncertainty approach stresses: "*the need for flexible adaptation* (…) *by providing them with options for action rather than fixed plans and standards*" (Grote, 2012, *ibid*.).

In our interpretation, the Safety Management Systems theory of Hale et al (Hale et al., 1997; Hale, 2003) can be defined as a "minimizing uncertainty" approach because to Hale et al, safety issues are regarded as resulting from deviations that have to be removed in order to ensure predictable, stable and safe organizational behavior. In their 1997 publication, Hale, et al argue that the concept of deviation from a desired standard or ideal situation is well known in safety and that: "*Deviations can be seen as undesired outputs arising from problems with inputs, controls and/or resources*." (1997, p. 128). In his 2003 article, Hale sums up what components should constitute a "good" SMS (Hale, 2003, p. 187-189):

1. A clear understanding of the company's primary production processes and all their ancillaries, with all the scenarios leading to significant harm. […] Task and job safety analysis must be rooted in a functional analysis of the processes so that the deviations in the flow of those processes, which can lead to accidents, can be traced to their origins and linked to barriers.
2. A life cycle approach to safety management, considering how all the system elements are designed, purchased, constructed, installed, used, maintained, modified, and disposed of.
3. A problem-solving cycle identifying, controlling, and monitoring these scenarios at three levels: people in direct control of the risk, procedures and plans and a structure and policy level that at intervals reviews the current operation of the SMS and makes structural improvements to it.

4. Feedback and monitoring loops ensuring assessment against performance indicators at each of the three levels.
5. Systems at the middle level, linked to the staff and line functions of the company, delivering the crucial resources and controls to safety-critical tasks at the lower level.

To model an organizational Safety Management System (SMS), Hale et al (1997) employ In 't Veld's Structured Analysis and Design Technique (SADT; 2002). The SADT technique is used to visualize every process step in the production cycle of a particular product and study a particular activity with regard to its inputs, outputs, resources and controls. This method enables one to determine where deviations in inputs and resources threaten the safe and stable output of a particular activity so that these deviations can be reduced in order to ensure safety. In the words of Hale et al: "*The logic of the modeling is that the inputs must be necessary and sufficient to produce the outputs, given the resources and the control criteria*" (1997, p. 126). Summing up, the SMS developed by Hale et al aims to control for safety by reducing deviations. It aims to do so by generating safety criteria and scenarios for inputs, outputs and resources. Based on these criteria, the SMS is able to steer the behavior of particular activities back to stable and, presumably, safe behavior by means of the implementation of barriers.

In contrast to the "minimizing uncertainty" approach, we interpret that resilience-engineering theory can be defined as a "coping with uncertainty" safety management theory. Resilience engineering theory aims to account for the problem that quite often work situations seem to be dynamic and that aiming for a stable "steady state" may not be the best way to ensure safety in such dynamic situations. Although Rasmussen (e.g.: 1994; 1997) did not label his own work as "resilience engineering theory", it can be stated that he was one of the first theorists who addressed the influence of operational dynamics on safety as a reaction to the, then, dominant "human error" approach. Moreover, resilience-engineering theory seems to be building on Rasmussen's theoretical premises, such as in the work of one of the main contributors to resilience engineering theory, Erik Hollnagel (e.g.: Hollnagel, 2004; 2012).

In his 1997 article, Rasmussen pointed to the effects of "dynamic" operational conditions on managing safety. He stated that: "*Control of activities and their safety by the classic prescriptive command-and-control approach deriving rules of conduct top-down may be effective in a stable society where instruction and work tools at all levels can be based on task analysis. In the present dynamic situation, this approach is inadequate and a fundamentally different view on system modeling is required*" (1997, p. 185). In the same paper Rasmussen proposes that: "*safety in the direct interaction with the work environment must be based on an identification of the boundary of* *safe performance by analysis of the work system, and the criteria that drive the continuous adaptive modification of behavior*." (1997, p. 206). In line with Rasmussen, Woods (in: Hollnagel, Woods & Leveson, 2006, p. 22) states: "*Resilience then concerns the ability to recognize and adapt to handle unanticipated perturbations that call into question the model of competence, and demand a shift of processes, strategies and coordination*". These quotes highlight that instead of reducing deviations in order to ensure stability, resilience-engineering theory acknowledges that it might be impossible to remove all uncertainty in many organizational settings. Consequently, resilience engineering emphasizes that organizations should cope with this uncertainty in a safe manner and consequently focuses on how an organization might adapt safely.

A recent development within resilience engineering is the concept "functional resonance" and the accompanying Functional Resonance Analysis Method (FRAM; e.g., Hollnagel, 2012; Hollnagel & Goteman 2004). FRAM aims to understand and analyze the influence of organizational dynamics on safe performance and incorporate such an understanding into an organizational safety management method. For understanding "functional resonance" and FRAM, the underlying concepts "intractability" and "emergence" seems to be central. According to Hollnagel, large socio-technical systems are (partly) intractable. This means that: "[…] *the conditions of work are underspecified, in principle as well as in practice. To the latter must be added the fact that resources materials, manpower, information and especially time usually are limited and sometimes insufficient"* (Hollnagel, 2012 p. 24). So while Hale et al aim for a detailed description of the production process of an organization, the concept of intractability points to the issue that such efforts will always come up short. Therefore, according to Hollnagel, understanding the influence of dynamics on safety should start with looking at "emerging" relationships at the operational level that come into existence in doing everyday work (2012, p. 25). To get insight into these emerging relationships, he proposes to define a system on the basis of "functions" instead of "structures". Hollnagel writes: "*Systems are usually defined with reference to their structure, that is, in terms of their parts and how they are connected or put together.* (…). *It is, however, entirely possible to define a system in a different way, namely in terms of how it functions rather than in terms of what the components are and how they are put together. From this perspective, a system is a set of coupled or mutually dependent functions*." (2012, p. 6). According to Hollnagel safety issues may arise as a result of emergence because the performance of functions is subject to variability that originates from the: "*approximate adjustments of people, individually and collectively and of organizations that are the basis of everyday functioning*" (2012, p. 29). Consequently, in a system of interdependent functions "[…] *the functions may interact or combine so that a specific function is incorrectly performed or even missed*" (Hollnagel & Goteman, 2004). This is referred to as “resonance”. To identify potential sources for resonance and prevent safety consequences from emerging, Hollnagel (2012, p. 36) proposes to:

1. Identify functions that are required for everyday work to succeed
2. Characterize the variability of these functions
3. Look at a specific state and determine how functions may become coupled
4. Propose ways to manage the possible occurrences of performance variability

To describe functions and visualize their interaction, Hollnagel proposes a hexagonal representation in which the performance of each function is specified in six characteristics (2012, p. 46). In addition to the inputs, outputs, controls and resources that Hale et al (1997) specified for analyzing a particular activity, Hollnagel proposes to add the notion of “time” and “necessary preconditions” to the analysis of functions because any function is in some sense governed by time and almost all functions need “something that has to exist” before the function can be carried out (2012, p. 46). Although Hollnagel deliberately omits SADT’s use of arrows because it would refer to something “prescribed”, the hexagonal representation has some resemblance to the SADT method Hale et al (1997) employed to model their SMS. Hollnagel explicitly points to the notion that the hexagonal model is to be used to both visualize the functions themselves and the interaction between functions as the organization adjusts to a particular situation.

Summing up, resilience engineering aims to manage, i.e. control for, safety by accounting for the constantly changing nature of dynamic operational conditions. Managing safety, from the perspective of resilience engineering, is not about removing deviations on the basis of pre-defined safety criteria. Instead resilience engineering theory intents to get insight into the organization’s adaptation process to dynamic operational situations and ensure safe adaptation. FRAM aims to do so by highlighting the concepts of “intractability” and “emergence”, defining the organization in terms of “functions” instead of “structures” and consequently identifying resonating functions in order to propose ways to manage performance variability of these functions.

3. Meta-theoretical framework

The theories outlined in the previous paragraph explicitly employ systems theoretical concepts. However, safety management systems theory and resilience engineering theory employ such concepts in an entirely different manner. Such a difference can be found in their use of the concept “control”. At the one hand, for Hale controlling for safety within an organization refers to creating stability and restraining behavior within the organization between predetermined boundaries. On the other hand, Rasmussen and Hollnagel seem to define controlling for safety as creating sufficient room for variation and adaptation.

In this paragraph we will outline a meta-theoretical framework that will be able to explicate the origins of such differences. We build this framework mainly on a categorization by Blom (1996; 1997) who identifies three systems theoretical perspectives: classic systems theory, open systems theory and self-referential systems theory. We employ his categorization in particular because, as we also highlighted in the introduction, safety management theory and systems theory have a common central focus: how to reduce, or control, uncertainty in the best possible way. Grote highlights that the uncertainties an organization has to deal with originate from two main sources: the organization's transformation process and the operational environment (2007, p. 638). As contemporary operating environments are increasingly characterized by environmental uncertainty and complexity (Trist, 1980), which means that tasks and goals that organizations have to conduct change rapidly and continuously, we argue that reducing environmental uncertainty is of particular relevance for managing safety.

In categorizing systems theoretical perspectives, Blom takes the distinction between the system and its environment as his *leitdifferenz* (cf. Luhmann, 1995 p. 176), his starting point. This enables him to formulate three fundamentally different perspectives on the interaction between the "inside" of the system and its environment, the "outside". These three systems theoretical perspectives Blom identifies, therefore theorize fundamentally different on the issue of how a system reduces environmental uncertainty in the best possible way in order to survive. It should be noted that to Blom, systems theory refers to General Systems Theory (GST) as defined by Boulding (1956) and Von Bertalanffy (1972). GST provides an alternative to the classic "reductionist" paradigm because it aims to explain behavior of particular "wholes", such as organisms, social groups and organizations, by means of studying *relationships* between elements, instead of studying the elements themselves. According to Rapoport (in: Kramer, 2007 p. 63) crucial to understanding GST is that a "system" is:

1. Something consisting of a set of elements
2. Among which relationships are specified so that
3. Deductions are possible from such relations to others or from the relations among the elements to the behavior or history of the system.

One of the main advantages of studying relationships between elements instead of the elements themselves is that it gives one the ability to get insight into the way characteristics of these relationships influence system behavior. Blom's categorization consequently enables us to present three fundamentally different perspectives on how characteristics of these relationships, the "inside" of a system, enable the system to reduce, or control, environmental uncertainty, its "outside" in the best way. We emphasize that employing systems theory does not mean that an organization "is" a system. Instead, we employ systems theory because it is regarded useful to understand an organization as a system in order to get more insight into its problems (cf. Kramer, 2004 p. 69).

Within organizations, dealing with and reducing environmental uncertainty in order to attain safety is regarded as normal everyday work of operators (e.g., Dekker, 2005). Therefore, we employ systems theory to perceive organizations in terms of social relationships. In addition, we define the organization as having a social and technical *aspect* system and stress the relevance of the organization's social aspect system with regard to the organization's capability in dealing with environmental uncertainty. This is somewhat in contrast to "mainstream" safety management literature, which mostly divides the organization into a social and technical sub-system (e.g., Reason, 1997). Focusing on the social aspect system within organizations is, however, in line with contemporary developments in organization science (e.g., De Sitter, Den Hertog & Dankbaar, 1997; Kuipers, Van Amelsvoort & Kramer, 2010). Social relationships within organizations are largely influenced by the organization's structural design, or the way *activities are grouped and coupled to workstations* (Kuipers et al., 2010). By employing Blom's categorization we are consequently able to formulate three, fundamentally different, perspectives on how social relationships within organizations are to be influenced, i.e. managed, by means of the organization's structural design in order to reduce environmental uncertainty, as an organization, successfully. In the following section of this paragraph we will outline Blom's rather abstract categorization and we will point out how it enables us to think about social interactions, organizational design and controlling environmental uncertainty.

A classic systems perspective acknowledges an environment, however, the relationship between the environment and the system is considered as static. That is, interaction between elements is to be determined from inside the system following a top-down "normative order", an idea on what is relevant to the system and what is not. This implicates that the system is oriented towards internal stability, predictability and compliance to a prescribed "code" (Blom, 1997 p. 14). Consequently, the system is inflexible and to any *change* in the operational environment. Reducing, or controlling, environmental uncertainty in classic systems theory can be interpreted as making sure that the "normative order" within the system is maintained. This means that deviations due to environmental variation have to be removed so that the criteria for stable interaction between the elements within the system can be upheld. These premises of classic systems theory can be found in traditional bureaucratic organizational designs, in which interactions at the operational level are controlled by "top-down" procedures (Morgan, 1986 p. 11-32). Controlling environmental uncertainty is in such organizations achieved by designing and improving control loops in order to keep behavior within these "top down" defined criteria.

In contrast to the classic systems perspective, the open systems approach, developed by Von Bertalanffy, Ashby and many others, defines a system as a set of elements that interact with each other and with the environment. In other words, the relationship between system and environment is theorized as dynamic and interactive. Within open systems theory the central issue is adaptation of the system to a *changing* environment. Blom and Haas (1996) point out that open systems theory assumes that sensing changes in an environment and making subsequent changes within the system is not regarded as being problematic. This means that open systems theory assumes that every change can be sensed and recorded successfully, so that the system can execute the necessary adaptations accordingly. The system is expected to change along with environmental cues. Consequently, controlling environmental uncertainty in open systems theory can be interpreted as attaining absolute flexibility and variation. Open systems perspectives on organizations are characterized by concepts such as "contingency" and "best fit" (Morgan, 1986 p. 39-65). This means that, in contrast to the classic perspective, (social) interactions are not restricted or kept within predetermined boundaries. However, as Morgan argues, aiming for continuous adaptation might be practically impossible in an environment that changes constantly and quickly. He states (1986, p. 74): "*it can be misleading to suggest that organizations need to "adapt"* (…) *this tends to make organizations and their members dependent on forces operating in an external world*". It can therefore be argued that reducing environmental uncertainty is somewhat more problematic than hypothesized by an open system perspective. Aiming for unrestricted adaptation may eventually lead to dissolving of the system in its environment. Furthermore, operators who try to deal with environmental change may be bound by existing procedures, rules and structures. Blom's (1997) third systems theoretical perspective addresses this issue.

The self-referential systems perspective (see for example: Luhmann, 1990; Maturana, 1980) advocates that the relationship between system and environment is not as straightforward as is assumed by "open" systems theory. Blom (1997) emphasizes that self-referential systems theory does not assume openness. Instead, it reintroduces the idea of a system's "closedness". This closedness within self-referential systems theory points to the realization of "circularity": the system's characteristics influence its adaptive capacities and survivable qualities. In this sense, systems adapt *in reference* to themself. Heyligen and Joslyn argue that self-referential systems thinking is one of the cornerstones of "second order cybernetics" because it discovered that: "*circularity*, (…), *can help us to understand fundamental phenomena, such as self-organization, goal-directedness, identity, and life, in a way that had escaped Newtonian science*" (2001, p. 9). This circular relationship between the system's characteristics and its adaptive capacities is highlighted by the concept *emergence*. Emergence acknowledges how specific survivable patterns of relationships can emerge out of indeterminate relationships ("chaos") (e.g., Waldrop, 1992).

Also, emergence accentuates that such survivable properties cannot be reduced to the components from which they are constituted. Instead, these properties are defined as characteristics at the system's level. Within organization science several contributions can be interpreted as self-referential. These contributions explicitly theorize on the problem of "circularity" in adapting to environmental change. Weick (1979), for example, points to the notion that the ability of operators to tackle environmental complexity is bound by interaction repertoires retained within the organization. This means, for example, that interactions are influenced by training and written procedures. A self-referential perspective consequently aims to question, or doubt (cf. Kramer, 2007), such retained interaction repertoires in order to provide for successful adaptation to complex environments. From the self-referential perspective, an organization's structural design provides a crucial source for such retained interaction repertoires. Consequently, a self-referential perspective aims to provide social actors with a structural design that is suited to deal with environmental uncertainty and complexity. For example, Morgan (1986, p. 95-105) points to holographic structural organizational design. Similar self-referential ideas can be found in the De Sitter's (1994) sociotechnical organizational redesign theory that proposes an alternative for traditional bureaucratic organizational designs. Both Morgan's and De Sitter's ideas are specifically oriented towards shaping the best possible conditions for self-organization for operators at the "sharp end" of the organization. Consequently, from a self-referential systems perspective, reducing environmental uncertainty can be interpreted as "selective adaptation". That is, in a complex operating environment the organization is at the one hand restricted by its own structural characteristics in its options to adapt. On the other hand, self-referential systems thinking opens up the possibilities to reflect on, and develop, specific organizational designs that promote the organization's survivability in a complex environment.

4. Managing safety of the Dutch military expeditionary organization

Although reflecting on theoretical premises for the sake of theory may be useful, the implications of the systems theoretical assumptions presented above for safety management is possibly best demonstrated by means of sketching its consequences for safety management practice. Therefore this section will present the case of the Dutch military and the problem of managing safety for its expeditionary missions. This case will serve as object for both the application of safety management theory and the reflection by means of the meta-theoretical framework in section five and six of this paper.

The nature of military operations has changed dramatically since the cold war came to an end. Instead of preparing for large-scale war scenarios close to home, the Dutch military nowadays mostly conducts operations with reconstruction, humanitarian, peace keeping and peace enforcing tasks abroad. Some recent examples are operations in Afghanistan, Iraq, Former-Yugoslavia and Cambodia. To conduct such diversity of expeditionary operations, the Dutch defence organization employs a "mixing and matching" organizational design strategy to build expeditionary organizations (De Waard & Kramer, 2008). This means that expeditionary organizations are assembled from "building blocks" from the four military "parent" organizations at home: the Army, Navy, Air Force and Military Police. A recent example of such an expeditionary organization is Task Force Uruzgan (TFU). TFU was responsible for reconstruction and combat duties in Afghanistan's Uruzgan province and was mainly built up from elements originating from the Dutch Army and the Air Force. In particular within the Army, the way in which the parent organization is designed did not match the requirements of the Uruzgan mission. This means that the Army needed to "handpick" several elements from the parent organization and "glue" them together to form TFU. The units that were selected from the Army and assembled into TFU-1 are shown between the dotted lines in Figure 1. The blue dotted lines in Figure 1 reflect that TFU staff had limited command and control over the Air Task Force, the military police and the Special Forces. Within TFU, the infantry battalions and the artillery platoon were grouped in the so-called "Battle Group". Provincial reconstruction teams (PRTs) are units that do not exist within the Army parent organization. During the deployment of TFU, PRT tasks were conducted by several different units of the Army combined with specialists from the Army's reserve forces, which are organized under to the Army's support command in the parent organization. The psychological support element of TFU is part of the intelligence battalion within the Army parent organization.

[INSERT FIGURE 1 HERE]

Initially, the Dutch government depicted the operation in Uruzgan as a reconstruction operation. However, over the four years of its deployment TFU has engaged in numerous combat activities with opposing parties in the Uruzgan province. Along the way, TFU developed a rather bottom up assembly process to create operational units that could match the tasks of these missions. These units were called Smallest Units of Action (SUAs). Because assignments practically varied per mission, the SUAs within TFU differed substantially from each other in composition (Kramer, De Waard & De Graaff, 2012). The design process of SUAs within TFU is schematically presented in Figure 2.

[INSERT FIGURE 2 HERE]

During its operations in the Uruzgan province, TFU was confronted with safety problems. For example, in 2008 a friendly-fire incident occurred in which one Dutch Army unit accidently shot another Dutch Army unit, which resulted in two fatalities (ministry of Defense, 2008). Also, research on the operations of the Army's unmanned aerial vehicle (UAV) unit within TFU (see: Moorkamp, Kramer, Van Gulijk & Ale, 2014) shows that interaction between the UAV unit and other members of TFU was rather problematic, which resulted in near misses between UAVs and other flying members of TFU such as Dutch Apache helicopters and a transport helicopter. Recent research points out that due to the mixing and matching organizational design strategy of the Dutch military organization, units within TFU had to cooperate with other units in an organizational configuration that was not extensively trained or simulated within the parent organizations (see: De Waard & Kramer, 2008; Kramer et al, 2012). As a result, units within TFU had to work together with other units with which they were unfamiliar. Consequently, it can be hypothesized that a mixing and matching organizational design strategy influenced social interactions in such a way that it had consequences for safe interaction between units of TFU.

Our case, therefore, presents a particular safety management problem. The problem brought forward in the case questions the relationship between a particular organizational design strategy and safety. This maybe somewhat different than the safety issues of, for example, a process industry factory or nuclear power plant because organizational designs of such factories mostly remain static. Nevertheless, the ad-hoc formation of temporary organizations from building blocks that originate from multiple "parent" organizations is not a rare organizational phenomenon. For example, Modig (2007) and Flyvbjerg, Bruzelius and Rothengatter (2003) mention that the formation of ad-hoc temporary organizations from rather stable parent organizations is a popular organizational design strategy in project management and construction.

Also, the safety issues of the Dutch defense organization are of a particular nature because the expeditionary organization is deliberately engaging in risky, military, operations that are unsafe by nature. Clearly, safety management of the expeditionary organization should not be oriented towards the inherent unsafe characteristics of the military job, such as fighting the Taliban in Afghanistan. This seems to be more a "security" issue that might be relevant for military sciences. Instead, we point to unnecessary dysfunctional and unsafe interactions between friendly units during military operations, which are possibly influenced by the way the expeditionary organization was designed. Because the expeditionary organization needs to operate without dangerous internal interactions in order to be able to provide security in the mission area successfully, safety seems to be a necessary precondition for establishing security.

In the next two sections we will apply both Safety Management Systems theory and resilience engineering theory to the case and reflect on this application by means of our meta-theoretical framework. It should be noted, however, that the application is not to be interpreted as an in-depth analysis. Instead of applying the fine-grained and specific safety management strategies of Safety Management Systems theory and resilience-engineering theory, we aim to apply their basic theoretical premises.

5. Applying and reflecting on Safety Management Systems theory

The main goal of the Hale et al SMS is to improve safety by developing a detailed description of the organization's primary process, determining safety boundaries/ criteria for activities and adjusting deviations in such a way that behavior of the activity remains within pre-determined safety criteria. Hale et al (1997) referred to mapping "product life cycles" within the primary production process and the development of scenarios that may lead to harm. Applying these principles of Hale's Safety Management System to improve safety of the military expeditionary organizations would be a challenging enterprise. For example, the process of mapping the primary process of TFU in detail would be hard because the composition SUAs changed frequently. Furthermore, because every expeditionary mission requires a different set of "mixed and matched" building blocks, mapping the primary process would have to start over again with every new expeditionary mission. Also, creating predetermined harm scenarios for such constantly changing organizational configurations may have to start from scratch every time the layout of the organization's primary process changes, both within and between expeditionary organizations. In addition, the SUA-idea within TFU was developed along the way and the configuration of units within these SUAs changed during the mission because of constantly changing tasks that had to be carried out in the mission area. Weick (1979) points out that organizations that operate in complex environments can only develop an understanding of their environment along the way by acting. He calls this "enactment". Because of enactment, required configurations of units to carry out tasks in the mission area are not predictable beforehand. Developing predetermined harm scenarios and safety criteria is therefore simply impossible. Consequently, a SMS designed along the premises of Hale et al is likely to lag behind constantly, when applied to the expeditionary organization.

One potential strategy to apply the Hale et al SMS successfully to the expeditionary organization is to stabilize interactions by fixing its organizational structure so that the layout of the primary process remains stable. That might mean that instead of assembling all sorts of different expeditionary organizations and SUAs, one particular fixed organizational structure remains. However, the observation that there is an apparent operational need to assemble varying expeditionary organizations and SUAs implies that fixing the organizational structure to one particular layout would lead to a diminished ability of both the Dutch defense organization and TFU to conduct all sorts of missions that are needed. In other words, the demands of the Hale et al SMS would make the defense organization too rigid to deal with the demands of a dynamic mission environment.

We are now able to conclude that the Hale et al SMS seems to apply assumptions from classic systems theory. More in particular it seems to do so both implicitly and explicitly. Implicit traces of classic systems theory are found in the choice to focus on mapping activities by means of an adoption of In 't Veld's SADT technique. The SADT technique is aimed at controlling the inputs and outputs of an organization's production process, in which the particular layout of that primary process is regarded as a given fact (see: In 't Veld, 2002, p. 239). It can be argued that the Hale et al SMS therefore assumes stability of a particular, given, organizational structure. Consequently Hale et al do not theorize on the influence of characteristics of organizational design on the ability of the organization reduce, or control, (environmental) uncertainty. This also renders SMS theory insensitive to the potential safety consequences of organizational design such as brought forward in our case. These mostly implicit assumptions can be regarded as originating from classic systems theory. Classic systems theory aims to reduce uncertainty by imposing an internally formulated normative idea about how elements should interact, onto the relationships within the system in order to maintain internal stability. Furthermore a definition of risks as "deviations" can be regarded as an explicit application of classic systems theory. The Hale et al SMS aimed for removing these deviations to comply with prescribed internal safety criteria. This highlights that the Hale et al SMS intents to achieve safety within the organization by ensuring internal predictability, which can be interpreted as a straightforward application of classic ideas about reducing environmental uncertainty.

We may now conclude that our attempt to apply the Hale et al SMS to our case is problematic because of both implicit and explicit classic assumptions present in their theory. Although Hale et al seem to be very consistent in their application of classic systems assumptions, applying SMS theory to an organization with a variable organizational structure that operates under dynamic conditions is likely to fail. It either results in a SMS that lags behind constantly, or an organization that is too rigid to deal with its dynamic operating environment. Explicating systems theoretical assumptions in the Hale et al SMS consequently enables us to conclude that a successful application of the Hale et al SMS, therefore, may only be possible in organizations that can rely on stable organizational structural designs and operate in stable operating environments, which seems to be the case in process industry plants and factories.

6. Applying and reflecting on resilience-engineering theory

In this section we turn to resilience engineering theory and aim to apply its premises to the case of the expeditionary organization and reflect on its systems theoretical assumptions.

Rasmussen (1997) pointed out that safety management of organizations with "dynamic" operations should be based on: "*an identification of the boundary of safe performance by analysis of the work system, and the criteria that drive the continuous adaptive modification of behavior*". In our case, such an analysis of the "criteria that drive continuous adaptive modification" may lead to the recognition that in order to discover what has to be done in the mission environment, behavior had to be continuously changed. The varying character of SUA compositions highlights this. Because of these continuous adaptations, the boundary of safe performance within the SUA was clearly constantly under pressure. We highlighted this by stressing that units within TFU had to familiarize themselves with other units with which they had never worked before. This included getting to know each other's ways of working, but also each other's capabilities and safety limitations (Moorkamp et al, 2014). To cope with, or manage, such dynamics safely and "become resilient", Woods argued that the organization needs to: "*adapt to handle unanticipated perturbations that call into question the model of competence, and demand a shift of processes, strategies and coordination*" (2012, p. 22). Within TFU processes were changing continuously and also strategies and coordination were continuously altered. The formation of SUAs can consequently be seen as a bottom up attempt to anticipate on "environmental perturbations". Along the way TFUs processes, procedures and coordination were altered in such as way that interaction between units gradually improved and a workable organization was achieved.

Consequently, it might be argued that the invention of SUAs is perfectly in line with resilience engineering's ideas regarding adaptation in a dynamic operating area. In this sense, resilience-engineering theory shows explicit assumptions from open systems theory. That is, open systems theory emphasized that in order to adapt to a changing environment, and reduce uncertainty successfully, the relationships between elements within the system have to vary along with environmental change. However, our case showed that while operating and adapting to the dynamic mission environment dysfunctional interactions occur that threatened safety within the expeditionary organization. This was highlighted by the friendly-fire incident and the problems that units within TFU had with operating together with UAVs. In our case, the "mixing and matching" organizational design strategy seemed to influence social interactions within the expeditionary organization in such a way that it may hinder organizational adaptation and safety. Resilience engineering theory, however, does not seem to be able to account for the issue that existing organizational design might influence adaptation efforts. Consequently, resilience engineering seems to disregard that there may be better and worse organizational adaptation strategies in dealing with a particular operating environment. An open systems theoretical perspective on adaptation by being “flexible” and simply vary along with environmental variation, as seems to be proposed by resilience engineering theory, might to be too simple and, as our case shows, may eventually even lead to safety issues instead of preventing them.

Also, from the perspective of FRAM, the bottom-up formation of SUAs can be seen as an exemplary case of the solutions of a rather intractable system that gradually adapts. That is, within TFU things changed quickly and work was clearly underspecified. As a reaction to environmental change, particular functions were grouped within a SUA. Furthermore, the concept of functional resonance seems to be able to account for the dysfunctional interactions within the Task Force. In terms of Hollnagel, the interacting functions hinder each other in their outcome, they “resonate”. In our case, this was highlighted by dysfunctional interactions between the reconnaissance function, which was carried out by the UAV unit, and the fire support function that was conducted by the Dutch Apaches. Consequently, FRAM indeed seems to be sensitive to finding self-organizing local interaction patterns that are aimed at reducing uncertainty, and recognize the dangers of variability between interdependent functions. However, according to In ‘t Veld (2002 p. 287) studying functions is only one part of an organizational analysis. People (with or without the help of machines), who are located at particular workstations, carry out these functions (sometimes also referred to as activities; De Sitter, 1994). An organizational analysis by only studying functions, therefore, shows only one part of the medal. It is only capable of showing the particular functions an organization conducts at a certain point in time while being blind to the configuration, or *coupling*, of workstations that is needed to conduct these particular functions. Although FRAM mentions the word “coupling” in its method, it refers to the “coupling of functions” instead of addressing the way workstations interact. This, however, may only be suitable for bureaucratic organizations, because bureaucracies are generally characterized by workstations that are functionally specialized (cf. Mintzberg, 1993), which means that specific functions are carried out by specific workstations.

In any other organizational context, omitting the coupling of workstations from the analysis misses out on the (social) interactions between workstations and the possible relevance for improving safety. Also, in our case, focusing only on functions disregards the organizational design process of “mixing and matching” workstations to form the expeditionary organization, the assembly process of SUAs and its possible safety implications. In order to study what an organization “does”, it is therefore essential to study functions and relate these to the way they are divided over workstations. Consequently, FRAM seems to be partly insensitive to the possible influence of organizational design on safety. To our interpretation, this is mainly due to an inconsistent systems theoretical foundation that guides Hollnagel's deliberate choice to turn away from structure in favor of functions. We argue so for two reasons.

Firstly, Hollnagel justifies his choice for functions over structure by arguing that a focus on functions enables one to study what the system "does", instead of what it "is". In a 2004 case study on the operation of a navigation instrument for flight operations, Hollnagel and Goteman write: "[…] *structure, however, represents the normative organization of functions, when everything goes according to plan. Since it is unrealistic to assume that this will always be the case, it is preferable to use a representation that makes it possible to account for how events may develop in reality*.". Later on, they point out that an assumption in this particular case study is that: "*the steady-sate performance of the underlying air navigation infrastructure and operational structure is assumed to be acceptable as it is*". These quotes reveal that FRAM has rather implicit classic assumptions on the concept organizational structure. That is, in classic systems theory, interactions between elements within the system were subject to an internal "normative order" in order to ensure internal predictability and stability. Our case showed, however, that both configurations of functions and workstations change when operators try to anticipate on and reduce environmental change. An organization's structure is therefore not fixed or static per definition. It can be quite variable, which was highlighted by the fact that the composition of expeditionary organizations and SUAs changed continuously.

Secondly, Hollnagel specifically turns to "functions" instead of "structure" because to his interpretation, interactions between functions have "emergent" properties. His application of the concept "emergence" and his reference to "second (order) cybernetics", points to explicit traces of the self-referential systems perspective. However, as we have argued, reducing environmental uncertainty takes predominantly place at the sharp end of the organization where interacting operators try to anticipate on constantly changing demands. Hollnagel seems to have a limited account for such social interactions in his application of the concept emergence. Studying functions, and omitting interactions between workstations, may not fully reveal these interaction patterns. Also, his theorizing seems to have no account for the central aspect of "circularity" within self-referential systems theory. That is, we argued that the central premise of self-referential thinking is that interactions between elements within the system are influenced by retained interaction repertoires, and that an organization's structural design provides an important source for such retained repertoires within organizations. Interactions between functions in FRAM, however, are not described in reference to any structural characteristics because Hollnagel deliberately disregards "structure" from the safety management equation. As such, Hollnagel fails to theorize on the relationship between an organization's "closure" and its influence on safety. Yet, as we already highlighted in section three of this paper, the concept of "circularity" is the cornerstone of self-referential systems thinking and second order cybernetics (see: Heylighen & Joslyn, 2001). As a consequence, FRAM is unable to tap into the consequences of organizational design and come up with an idea to structurally improve an organization's ability to reduce environmental uncertainty successfully and safely. FRAM may therefore run the risk of addressing resonance between functions that may originate from a problematic organizational design strategy. Furthermore, Hollnagel's concept of "emergence" does not seem to refer to the emergence of "order" out of "chaos", as it is defined within complexity science (e.g., Kelly, 1994; Waldrop, 1992). In Hollnagel's terms, the process of emergence can co either way, resulting in either a good functioning and flexible organization or an accident. In terms of self-referential systems theory however, an accident cannot be defined as "emerging" because it does not refer to any survivable, i.e. controllable, state of the system. A safety issue, such as an accident or near miss, is therefore to be interpreted as a failure to reduce environmental uncertainty successfully and a symptom of a system with characteristics of problematic survivability.

Summing up, we have shown that at the one hand, resilience engineering and FRAM have explicit open systems theoretical assumptions that advocate organizational adaptation by varying along with environmental variation. On the other hand, FRAM seems to have a combination of implicit traces of both classic and self-referential systems theory. Due to this inconsistent application of systems theoretical concepts and assumptions, resilience-engineering theory and FRAM are unlikely to be able to propose safety management solutions that structurally improve an organization's ability to reduce environmental uncertainty successfully and safely, which renders it unsuitable for managing safety of the expeditionary organization.

7. Conclusion

The main goal of this paper was to show that inconsistent and implicit use of meta-theoretical assumptions in safety management theory has consequences for the applicability of safety management theory to organizations. Based on our reflection in the previous paragraph we are able to draw conclusions on the applicability of Safety Management Systems theory and resilience engineering theory to organizations. We will conclude this paragraph with some observations regarding the pros and cons of our research strategy and the meta-theoretical frame that we employed in this study. Also we will address the relevance of our reflection for application of safety management theory to organizational settings.

We found that Safety Management Systems theory employed explicit and implicit assumptions from classic systems theory. This resulted in a failure to apply the premises of Safety Management Systems theory to our case because it seemed to be oriented towards stability and predictability. We pointed out that applying SMS theory to our case might lead to either a SMS that lags behind constantly or diminished ability of the Dutch defense organization to deal with the complexity of its operating environment. Also we argued that SMS theory might only be suitable for organizations that encounter minimal environmental variance and that therefore are able to rely on stability of the organizational structure. In such organizations, safety management by means of organizational control instruments that keep interactions within the organization between predetermined boundaries might be a suitable strategy. Hale seems to recognize this potential limitation of Safety Management Systems theory by stating that the present models of "good safety" tend to be bureaucratic in nature (2003, p. 187). That is, Hale seems to indicate that because of the fact that within bureaucracies the classic principles of aiming for predictability and stability are applied to a great extent, SMS theory may only fit such organizations.

Resilience engineering theory made explicit use of assumptions from open systems theory and our analysis of FRAM showed traces of implicit and explicit assumptions from both classic and self-referential systems theory. Our attempts to apply the premises of both resilience engineering and FRAM to our case failed. Although the premises of both resilience engineering and FRAM seemed to acknowledge the dynamics of the case, they seemed to be unable to address the influence of organizational design on the ability of organizations to reduce environmental uncertainty successfully. This rendered both resilience engineering and FRAM insensitive to such structural characteristics on safety of the expeditionary organization. Consequently, we inferred that resilience-engineering theory and FRAM are likely to come up with safety management strategies that do not structurally improve the ability of the Dutch military expeditionary organization to reduce environmental uncertainty successfully and safely.

As a result, our reflection on meta-theoretical assumptions showed that both SMS theory and resilience engineering theory are not universally applicable to all organizational settings. First of all, both theories were deemed as unsuitable for managing safety of a Dutch military expeditionary organization, such as TFU. Secondly, we pointed out that SMS theory might only be suitable for specific organizational contexts. Resilience engineering theory, and FRAM in particular, have shown a number of theoretical difficulties that, to our interpretation, make it problematic to apply their theoretical premises to organizations one-on-one. Reflecting on systems theoretical assumptions by means of the meta-theoretical framework that we constructed in section three of this paper, enabled us to detect limitations of two frequently used safety management theories that have implications for the applicability of these theories to organizations.

We therefore argue that successful application of safety management theory to organizations may benefit from an explicit reflection on systems theoretical assumptions, such as how a particular theory aims to reduce environmental uncertainty. As we have shown, however, these assumptions may be implicitly and inconsistently present in safety management theory and therefore hard to detect. Also, our reflection showed that adaptation of safety management theory to organizational setting benefits from an analysis of organizational characteristics such as the variability of the organization's operating environment and the (in-) stability of the organization's structure. Applying safety management theory to organizations by means of our meta-theoretical framework can therefore be interpreted as a two way "matching" process. At the one hand, researchers and practitioners need to be aware of the systems theoretical assumptions present in safety management theory, which may limit the applicability of those theories. On the other hand, they also need to develop an understanding of organizational characteristics that may influence the ability of particular theories to solve safety issues they encounter. The meta-theoretical framework brought forward in this paper may be employed to sensitize researchers and practitioners to these subjects in reviewing, developing and applying safety management theory. By means of Figure 3 we propose a 3x3 matrix to visualize the relationships between, meta-level, systems theoretical assumptions on reducing environmental uncertainty, safety management strategy and organizational characteristics. In this matrix, we intentionally described that applying an open systems perspective to safety management theory is "not applicable" (N.A.), because self-referential systems thinking can be regarded as a substantial development of open systems thinking (Kramer, 2007). The matrix can be employed to identify and analyze safety management theories and organizations in order to improve ways these theories are applied to improve organizational safety.

[INSERT FIGURE 3 HERE]

We consequently recommend extending our reflection to other theories in the field of safety management, especially when such theories are employed to solve a variety of organizational safety issues. To our interpretation, an explicit reflection on systems theoretical assumptions may improve the ability of safety management theory to tackle practical safety issues within organizations, while at the same time it may strengthen the foundations on which safety management theory is built.

Also, our reflection clearly stressed the relevance of an organization's structural design for managing safety. By employing (general) systems theory as a tool to perceive organizations as systems, we have described three fundamentally different ways to manage organizational interactions and reduce environmental uncertainty by means of the organization's structural design. Based on our reflection, we may conclude that safety management theory cannot disregard the role organizational design plays in managing safety. Furthermore, we propose that this relevance stretches beyond the military context that we addressed in this paper. Trist (1980) argues that characteristics of the military operational environment resembles some those of the contemporary business environment. Forces of competition and rapidly changing markets result in a business environment that changes quickly and constantly. Also, the military operating environment and the contemporary business environment are both characterized by "reactiveness". This means that parties present in the environment actively respond to organizational actions and may manipulate with their responses. The contemporary business environment and the military operating environment therefore share similar *dynamic complex* characteristics (cf. Kramer, 2007). Based on the premises of self-referential systems theory we therefore argue that safety management for organizations that operate under dynamic complex conditions has to rely on a definition of reducing (i.e. controlling) environmental uncertainty that involves creating structural conditions aimed at facilitating self-organization at the "sharp end" of the organization. Such a perspective can be found in Morgan's principle of holographic organizational design and sociotechnical design theory (e.g., De Sitter, 1994). Especially sociotechnical design theory explicitly relies on self-referential assumptions to improve the organization's self-organizing capabilities at the operational level by integrally redesigning the organizational structure. This does not mean however, that these self-referential organizational design theories provide a panacea for managing safety of organizations that are confronted with a dynamic complex operating environment. At most, it provides a starting point for including organizational (re-) design into the safety management equation.

Finally, our method has some limitations that need to be considered. As we already highlighted in section three of this paper, we employed (general) systems theory because we argued that it was useful to understand an organization as a system in order to get more insight into its safety problems and the applicability of particular theoretical solutions. Also we employed systems theory because it opened up the road to study structural properties of organizations and helps to get insight into the possible influence of an organization's structural design on safety issues. However, this does not mean that a (general) systems perspective on the organization and safety is the only "right" perspective. Other perspectives on safety such as psychological and technical perspectives may be interpreted as equally relevant because such perspectives have unquestionably proven to result in safety benefits. Moreover, we deliberately chose to focus on the organization's social aspect system, which is in line with contemporary organizational theory. This does not mean that safety management theories that define the organization as having a social and technical sub-system are "wrong". Such a different perspective on the organization has proven to yield safety benefits as well. That being said, the relevance of organizational design for safety is often overlooked (e.g., Bourrier, 2005) and focussing on the organization as a social aspect system opened up the road to highlighting the relevance of organizational design on safety. Furthermore, by choosing two distinctive safety management theories we, quite obviously, did not incorporate the majority of theorizing in in the field of safety management. For example, we deliberately omitted Normal Accidents Theory (Perrow, 1999) and High Reliability Theory (e.g., Weick & Sutcliffe, 2007) that can also be regarded as eminent safety management theories that address systems theoretical concepts in our reflection. However, our decision to incorporate only Safety Management System theory and resilience engineering theory was made because, to our interpretation, they are representative for both ends of Grote's minimizing and coping with uncertainty continuum. Hence providing a rough intersection of theorizing on safety management. Also, we addressed only some contributions to resilience engineering theory. For example, we did not address Sydney Dekker's substantial contributions. These choices were made because, due to the diversity of theorizing in safety management and resilience engineering in particular, aiming to address all contributions might lead to a reflection that comes up short in addressing any detail and depth. At the one hand this would be unjust to the richness of theoretical contributions upon which we reflect. On the other, addressing theory without detail makes drawing specific conclusions on the basis of a reflection rather impossible. Moreover, the main aim of our paper was not to give a detailed literature review. Instead, our aim was to show that explicitly reflecting on meta-theoretical assumptions is of importance in the application of safety management theory to organizations.

8. References

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FIGURE 1: Army units and TFU-1

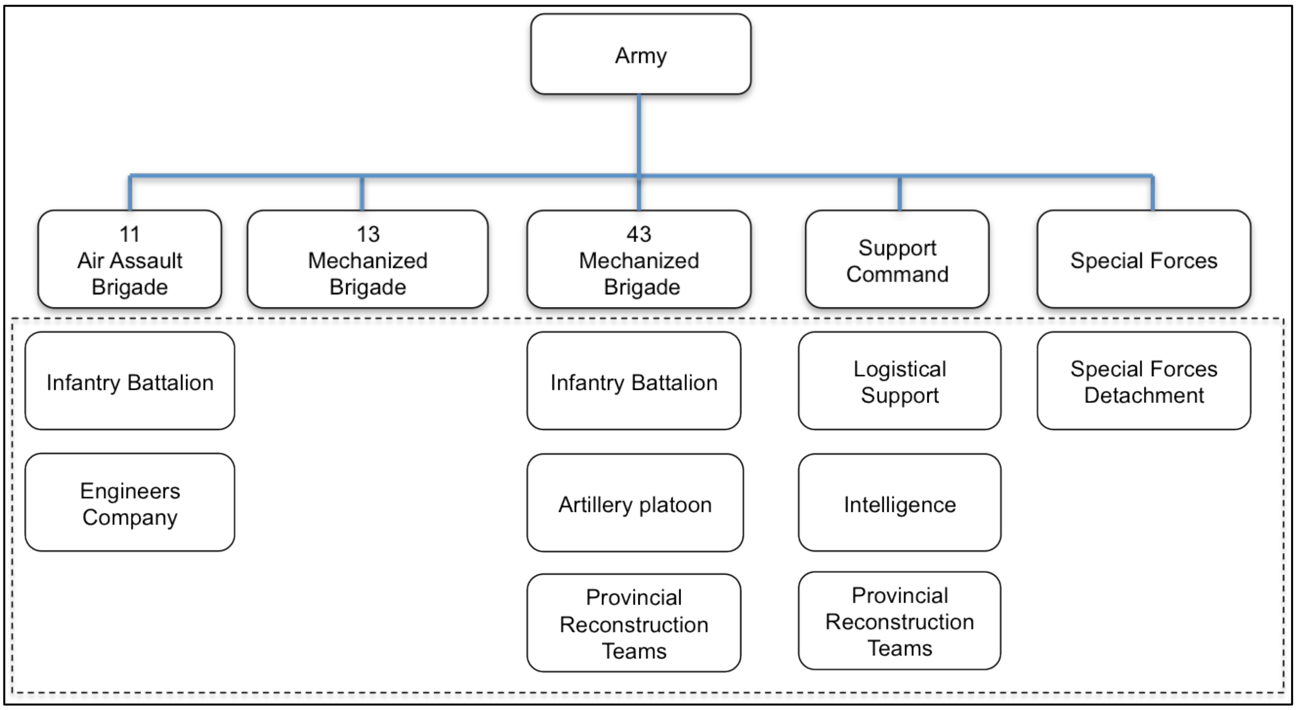

FIGURE 2: The assembly process of SUAs within TFU

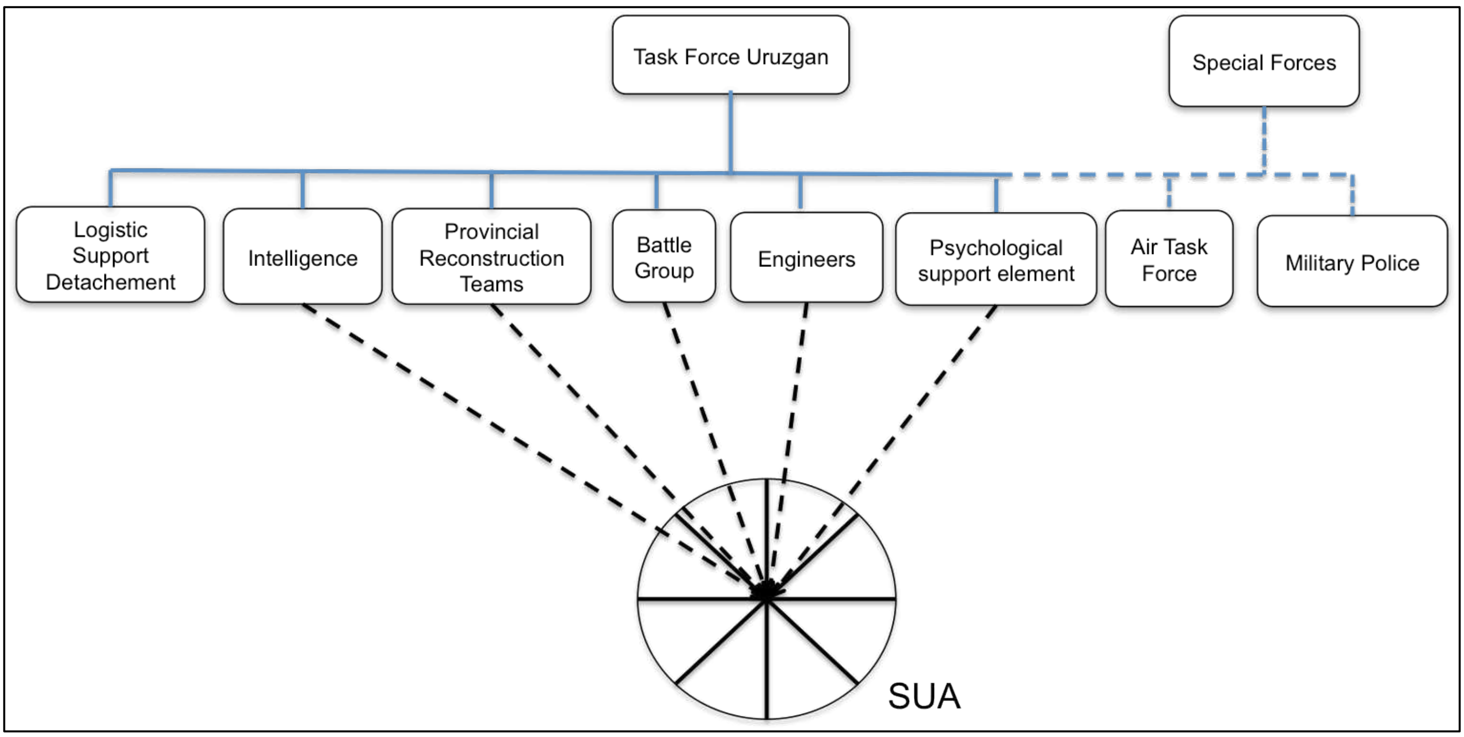

FIGURE 3: 3x3 Matrix

Systems theoretical assumptions		**Controlling environmental uncertainty by means of**	**Safety management strategy**	**Solution suitable for organizations**
	Classic	Creating and maintaining stability and predictability	Improve safety by removing deviations along predefined safety criteria	With stable environment and stable primary process
	Open	Absolute variation	Improve safety by promoting maximum variation and adaptability	N.A.
	Self Referential	Selective variation	Improve safety by acknowledging the influence of organizational design on safety	That are confronted with dynamic complex operating environment