John Welsh, Thesis report

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Imagining Arms: Rationality and the Sociotechnical Imaginary of Swedish Defense Requirements Engineering

Abstract

Despite significant efforts at improving requirements engineering in the development of military systems, defense procurement is still plagued by expensive, well-publicized failures. Central to requirements engineering is the concept of rationality – more reason is assumed to eventually 'solve' the problem of defense requirements engineering.

This thesis suggests that rationality, instead of being an objective standard, might be part of a socially constructed framework for action. Leaning on Science and Technology Studies for a theoretical framework, it is suggested that rationality and irrationality is part of a larger sociotechnical imaginary which outlines desirable outcomes, actions, and values in military systems development.

This thesis presents an interview study of requirements analysts in the Swedish defense sector to outline if and how rationality relates to the narrative of this potential imaginary. The results indicate that a Swedish defense requirements engineering imaginary consists of a rationality/irrationality dichotomy which sets the stage for action in a state of chaos, and that the narrative associated with that imaginary enables the creation of certainty for analysts throughout the requirements engineering process.

Keywords: Requirements Engineering; Rationality; Science and Technology Studies; Sociotechnical Imaginaries; Defense Systems

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Sammanfattning

Trots betydande ansträngningar för att förbättra kravhantering i utvecklingen av militära system, plågas försvarsupphandlingar fortfarande av dyra, väl omtalade misslyckanden. Centralt för kravhantering är begreppet rationalitet – applicering av mer förnuft antas så småningom "lösa" problemet med kravhantering I försvarssektorn.

Denna framställning menar att rationalitet, istället för att vara en objektiv standard, kan vara en del av ett socialt konstruerat ramverk för handling. Med ett teoretiskt ramverk hämtat från Science and Technology Studies (SLS) föreslås det att rationalitet och irrationalitet är en del av en större "Sociotechnical Imaginary" som beskriver önskvärda resultat, handlingar och värderingar i utvecklingen av militära system.

Denna framställning presenterar en intervjustudie av kravanalytiker inom den svenska försvarssektorn för att beskriva om och hur rationalitet relaterar till berättelsen om denna potentiella imaginary. Resultaten indikerar att en svensk försvarsteknisk imaginary består av en rationalitet/irrationalitet-dikotomi som sätter scenen för handling i ett tillstånd av kaos, och att narrativet som förknippas med det imaginära möjliggör skapandet av säkerhet för analytiker genom hela kravkonstruktionsprocessen.

Keywords: **Requirements Engineering; Rationality; Science and Technology Studies; Sociotechnical Imaginaries; Defense Systems**

Imagining Arms:

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Contents

1. Introduction

Requirements engineering (RE) is the process of moving from an identified need for a system to a sufficient, actionable list of requirements; it is rarely easy and always important. Owing to the structure of systems development – conducted according to the principles of systems engineering[1] – the greater part of costs sunk into developing a new, marketable system derive from the later stages of a project (Walden, et al., 2015). The identification and correction of mistakes discovered during later project stages can set projects back years, putting a premium on early requirements work. If it is important to assure a successful RE-process in civilian applications, it is essential in defense applications. Adding to issues of cost and delay in the private sector are the increased demands for safety, security, and reliability in military systems, as the competitive dynamic in warfare exposes fielded systems to extreme pressures. Military systems are also subject to great scrutiny from the public, which demands both security and responsibility in exchange for the burden of financing ever more expensive hardware. It can even be argued that an armed force is only as good as the systems that it employs, meaning there is a real possibility that the interests of states could come down to which systems they can develop or field.

Unfortunately, the criticality of military systems development seems to be commensurate with its difficulty. While there have been instances of success, defense development or acquisition (here considered synonymous from an RE perspective) is notoriously prone to cost overruns, delays, and performance shortfalls – frequently due to the challenge of managing requirements appropriately (Pennock, 2015; Lundmark, 2017). The difficulty does not seem to be limited to a domain, weapon system, or nation (Powell, 2023; Lorell, et al., 2015; von Hlatky & Rice, 2018). It is no overstatement to claim that worldwide costs of such programmatic mishaps exceed billions of dollars (Meier, 2010). Again and again, defense acquisition projects seem to fall short of expectations.

[1] While RE has traditionally been conceived as a component of the discipline of software engineering and information systems (Sutcliffe, 2002), it has now been firmly integrated into the Systems Engineering (SE) discipline as well (Walden, et al., 2015; Kossiakoff, et al., 2011; Kossman, et al., 2007; Hull, et al., 2005).

Such shortcomings cannot be written down as incompetence, nor as a dearth of theoretical understanding for the development process. Requirements engineers in the defense sector, like other participants in the systems development process, are both skilled and motivated enough to perform admirably. Moreover, they possess a powerful structuring principle in systems development, namely the concept of *rationality* – the idea of a proportionality between means and ends informed by objective standards. This concept has been understood with reference to an instrumentalist means-ends logic, such that expenditure of time and resources for the development and procurement of a system should not exceed the expected utility of that system (Lundborg, 2022). Deviations from this standard for organizational, ideological, or non-security related protectionist concerns are consequently considered *irrational* – the absence of rationality. Success and failure in defense system development seem to correspond to the dichotomy of the rational and the irrational. Since states desire the greatest military utility per expended unit resource, it follows that their systems should be rationally procured. Any irrational distortions in that process must be purged through the application of more reason. Constant revisions of structured military development standards, such as ISO 15288, point to the continued importance of infusing defense system development with rational routines.

Yet failure still seems to persist in the defense sector, despite the best efforts of all involved. The presumption of a rational process in the defense sector – rendered ever *more* rational through conscious application of more rationality – is hard to square with the observation that systems development in that sector remains extremely difficult. It should be noted that the defense sector is different in ways that are not conducive to the conditions necessary for this sort of rationality. In most countries, procurement in the defense sector takes place in flawed market conditions owing to the remarkably high market powers of both seller and buyer (Hall, et al., 2010; Kundu, 2021). There is the risk of agent-principal problems, as information asymmetries between military and civilian components of the governmental actor might skew development or procurement in various ways (Reykers & Fonck, 2020). There is also the phenomenon of techno-nationalist sentiment: the idea that a state's value and identity depend, to a certain degree, on its capacity for arms production, distorting assessments of military utility (DeVore, 2021).

Put differently, there is a persistent conviction that application of more reason to defense systems development and acquisition will approach a successful, rational process – ultimately banishing irrationality and inefficiency – *despite* the continued prevalence of procurement problems and *despite* the observation that the defense sector context leaves little room for objectivity and the idea of pure rationality. There seem to be strong indications that irrationality is not an eradicable flaw, but a constant feature of defense systems development – yet there is an almost universal conviction within RE practice and theory that application of rational procedures and structures are not merely the only thing that could ‘solve’ systems development, but also the only *right* thing to do.

1.1. Research purpose and research question

While the rationality/irrationality dichotomy could be practical in less contested and controversial sectors, this perspective might be unsuitable for the defense sector. Instead, this thesis suggests that the dichotomy is a component of the social meaning created by those developing defense systems as they navigate a challenging environment. The dichotomy, instead of being a fixed result of a positivist world, is just a part of the ideas which structure and produce values, identities, and behaviors of RE practitioners. This thesis is founded on insights from the science and technology studies (STS) tradition. Specifically, this study takes from that tradition the concept of a sociotechnical imaginary – a productive, shared idea of the role and purpose of future technology – to contribute to the discussion about defense requirements engineering. It is suggested that such an imaginary might serve as a structuring principle of defense RE efforts.

The purpose of this thesis is partly to shift the perspective of traditional defense RE away from the objective positivist ontology suggested by the use of rationality and to reframe RE practice, rationality/irrationality dichotomy included, as a socially constructed and technologically informed imaginary, providing a new theoretical foundation to approach a topic probably less well understood than what is often presumed. The thesis will also analyze this imaginary as a structuring principle or idea of defense RE and decompose it into delineated, constituent themes. It is therefore intended to increase our understanding not just of *what* an important group of professionals – defense requirements engineers – think about important aspects of their field, but also *how* they construct those aspects. Since the imaginary is productive – linking meaning to action, idea to outcome – the thesis is also intended to contribute to the understanding of how the imaginary might enable certain outcomes at the expense of others in defense RE. As such, it also has an empirical purpose. To this author's knowledge, there has been no comparable study on this group. In view of these purposes, the following research question was formulated:

How do requirements analysts in the Swedish defense sector envision and construct a Swedish defense requirements engineering sociotechnical imaginary, and how do the concepts of rationality and irrationality play into this imaginary?

To address this question, this thesis presents an interview study of the Swedish defense sector.

1.2. Definitions:

This study relies on a few principal concepts which must be defined. The Swedish defense sector is defined as the sector (including all organizations and individuals) that develops, procures, and uses systems which are intended or expected to be exposed to military antagonist pressure in Sweden. This definition does not differentiate between the types of systems developed or procured by the different actors: it is the intended, military use of any equipment which unifies individuals and organizations under the term defense sector. In practice, it comprises the Swedish Armed Forces (SwAF), the Swedish Defense Materiel Procurement Administration (FMV) or any private contractor developing defense materiel for the other organizations.

The role of requirements engineer or analyst (henceforth considered synonymous) is defined as anyone who has played a part in the formulation of a requirement for a system in the defense sector. This broad definition is intended to capture the substantial sectoral spread in Swedish defense procurement, reflecting the fact that requirements are generally formulated and refined in close cooperation between different agencies and organizations.

For the purposes of this study, it is sufficient to understand requirements as a genre of text which is intended to provide unambiguous guidance and constraints to designers while representing the desires of a varying set of stakeholders.[2] In this study, the requirements engineering process is considered to include: elicitation of requirements from stakeholders; requirement analysis and refinement to allow wide understanding and formal expression; and negotiation and prioritization of requirements between any relevant stakeholders (Sutcliffe, 2002; Nuseibeh & Easterbrook, 2000; Palomares, et al., 2021; Montgomery, et al., 2022; Young, 2004).

2. Previous Research

This section briefly illustrates how previous research in defense system procurement has conceived of a rational process for acquiring such systems and how a traditional, positivist perspective on RE has provided the ontological foundation for such procurement. This section will then show how these foundational presumptions in RE become questionable or even indefensible in the context of war and defense. Finally, this section will briefly present some attempts that have been made to question the ontology of RE in response to these challenges.

2.1. The rational model

According to the means-ends logic inherent to ideas of a rational process of systems development, expenditure on military systems must be justified by a commensurate and proportional final output – national security (Markowski, et al., 2010). Military utility

[2] For interesting discussions regarding the nature of requirements, see Salado (2021) and Zave & Jackson (1997).

is considered the relevant intermediary output. For an entirely rational and efficient military systems development project, every taxpayer dollar spent should translate into a dollar’s worth of military utility and consequently a dollar of national security. National security is argued to provide its value to the procurer in terms of the avoidance of undesirable outcomes such as territorial breaches, invasions, or terrorist attacks. Military utility reflects this fact by integrating components of both effectiveness (compliance to desired objective) and affordability in its measure (Andersson, et al., 2015).

This understanding of rational defense system procurement entails two crucial presumptions. The first is that desired objectives can be identified *a priori* and with certainty. Those objectives are selected early during the systems development and engineering process and before major efforts are initiated at scale. They do not change throughout the process. Second, the objectives corresponding to the requested capabilities exist independently of the personnel entrusted to realize the system: they are not created by the individuals involved. In positivist RE literature, these two presumptions correlate to two essential – and amply discussed – features of a functional RE process, namely stable needs and what might here be called analyst objectivity.

Stable needs

If the envisioned purpose of a system shifts during development, requirements no longer correspond to needs, and must either change, often at great cost, or, in the case of military systems, become irrelevant and harmful to the operators of the finalized system owning to the nature of their intended use (Demir, 2015; Hull, et al., 2005). The accepted term for this problem is requirements volatility (Peña & Valerdi, 2015, p. 59; McGee & Greer, 2012). A more specific case of changing needs or requirement volatility is that of requirement creep: the slow, inexorable addition of requirements over time as the development project nears completion (Kulk & Verhoef, 2008; GAO, 2015).

Volatility is recognized as a major driver of cost and delay (Kulk & Verhoef, 2008; Bolten, et al., 2008; Méndez Fernàndez, et al., 2017). Consequently, previous research has focused on generating management methods for requirements change, such as requirement re-use, intensified requirement analysis and modeling, and structured interviewing to reveal possible misunderstandings in the requirements list (Ferreira, et al., 2011). Academic engagement with requirements change brought on by changing needs from the stakeholders and not merely program mismanagement has often been limited to prediction and projection (Kulk & Verhoef, 2008).

Analyst objectivity

Due to their role as technical agents to the stakeholders, positivist RE literature requires analysts to never make decisions about requirements which impact the design of the final system without consulting the stakeholders first. Firm legal and contractual limitations are drawn between stakeholders in the interests of efficiency, due process, and legitimacy. To provide value despite this constraint, analysts are required to take on an objective and informed mediator role.

In RE research, it has been stressed that the analyst ought to be the project's "translator", entrusted with becoming "as familiar as possible with the domain and to understand it as well as possible" (Pohl & Rupp, 2015, p. 6). Likewise, the requirements engineer is advised to study the domain of the system, for if the analyst does not understand "the user domain almost as well as the users do, he risks limiting his role to that of an order taker" (Young, 2004). The concept of domain knowledge – quality of having subject-matter expertise in an area, distinct from the expertise associated with the craft of requirements – has been stressed as a way for the objective analyst to provide added utility while playing a mediating role in the process (Khatri, et al., 2006; Sutcliffe & Maiden, 1998; Khatri & Vessey, 2016). It has been argued that what is normally termed system development is actually application domain problem-solving using technical system solutions (Hadar, et al., 2014; Rossman, et al., 2007). Consequently, from a narrow, positivist RE perspective, domain knowledge has often been considered a major strength in a requirements analyst (Prasarnphanich, et al., 2016; Ferrari, et al., 2016; Vitharana, et al., 2012).

Another exhortation to the analyst has been to help stakeholders understand the important trade-offs they make when choosing requirements and priorities. This advice has apparently not been seen as constituting decision-making in a sense that upsets demands of objectivity (Young, 2004). Neither, apparently, has the setting of stopping rules – the cognitive heuristics used by requirements analyst to determine when requirements elicitation is sufficient for moving on to systems design – despite them being examples of decisions incumbent on the requirements analyst which could have an impact on final system design and which cannot feasibly be anchored with the stakeholders (Pitts & Browne, 2004).

2.2. Two challenges to positivist RE in the defense sector

Unfortunately for defense planners, the defense sector is marked by extreme uncertainty of many different kinds. The presumptions for the rational conduct of defense systems procurement – stable needs and analyst objectivity – are arguably cast into doubt by the conditions associated with defense and defense establishments.

Stable needs

Requirements engineering pertains to formalizing firm, predictable needs in actionable text: it "assumes a strong reality" (Ramos, et al., 2002). When needs are neither obvious nor constant, requirements may change wildly as needs fluctuate. Needs are exceedingly hard to specify precisely or objectively for combat conditions. Battle often renders the exact position and performance of friendly and adversary forces unknowable in the field, not yet dispelled by improved command and control systems (York, 2011; Rosen, 1991). The enemy will also try to exploit limitations or weaknesses in the most well-designed technical system brought to the battlefield, rendering any needs specified before action null (Angstrom & Widen, 2015). Determining future needs is even more complicated. Systems might stay in service for upwards of half a century, long after initial needs formulations (Rosen, 1991). While it has been argued that studies and operational analysis can provide some valuable insight, understanding, and justification for decisions in the defense sector (Modig & Andersson, 2022), such studies are the most accurate when based on already mature technology amenable to historical data extrapolation as opposed to technological innovations or novel doctrinal applications of new materiel (Kott & Perconti, 2018; Guha, 2018). Militaries are also large, expansive organizations, subject to political bargaining and often designed to be resistant to change, potentially stifling warranted innovation (Rosen, 1991). Additionally, military needs are also formulated by individuals, subject to the same cultural biases as the rest of society: awe and prestige can bias efforts to objectively select military needs for systems under development (Zilincik, 2022; DeVore, 2021).

Analyst Objectivity

The presumption of the desirability of high domain knowledge in RE literature seems to assume the analyst can uphold a distance between him- or herself and the stakeholders – which is not easy in the defense sector where requirements analysts come close to playing the role of the user: almost as if that analyst *was* the user, complete with his or her worldview and language. In non-defense related RE research, it has been noted that developers with high domain knowledge sometimes proceed to create what they assumed was needed based on their own experience and creativity (McAllister, 2006). Developers might be led to create systems akin to those they are used to creating, or want to create, on the basis that "developers know better" (Ferrari, et al., 2016, p. 146). This is important because the defense sector is highly insular: military personnel (who often form the backbone of defense procurement) generally stays in the same business or cluster of organizations from juniority to seniority (Rosen, 1991). System complexity and secrecy pose substantial barriers to entry for private sector businesses and employees (Hall, et al., 2010). Finally, in some systems, such as the Swedish one, officers are also expected to formulate the needs in a first draft of requirements prior to further analysis – in which case those officers act as users, procurers, and requirements engineers at the same time (Lundmark, 2020).

2.3. Attempts to address challenges in positivist RE

Overall, the deep-seated ontological issues presented by assumptions of rationality in RE have received precious little attention. A strand in RE research which here could be termed political requirements has delved deeper into the implications of attempting to create supposedly objective requirements in highly politicized environments such as larger organizations. There have been attempts both to model this essential dimension of requirements elicitation and negotiation for program-management gains, and to understand the co-creative process of coming to a common understanding of a set of requirements (Milne & Maiden, 2012; Bergman, et al., 2002; Ovaska, et al., 2005; Ferrari, et al., 2022; Chakraborty, et al., 2010). This foundation is promising but has not yet fully embraced constructivist views on the inherently social process of creating requirements. Calls to recognize the socially constructed nature of both needs and analyst have been made, but largely left unheeded (Ramos, et al., 2002).

3. Theory

The section above shows that the conditions inherent in the defense sector necessitate theory with a different ontological background. The following section will begin with an overview of an alternative, constructivist approach to society and technology, Science and Technology Studies, centering on its military strands of research. This section will conclude with a review of the theoretical framework for a structuring principle beyond pure rationality – a so-called sociotechnical imaginary.

3.1. Constructivism and Science and Technology Studies

Constructivist thought is based on the original ontological position that the world is populated both by material and ideational objects, and that the former lack inherent meaning until constructed in terms of the latter (Lynch, 2016; McCarthy, 2018).

Objects and meanings are partly made in a context, negotiated in the continuous interactions between individuals and groups. Through such negotiations, meaning is fixed to identities and symbols of various kinds. By associating select concepts to already available cultural and rhetorical resources, social actors create representations of various aspects of the world whose interconnections motivate some action over other. Such discursive actions make some goals more “reasonable”, “justifiable”, or “appropriate” than others, regardless of objective rationality (Weldes, 1996, pp. 281-282). This dynamic has been vigorously employed to show how constructed frames of meaning interact with actor identities to enable certain action, or even make such action necessary or inevitable. There is a wealth of research exemplifying this dynamic in defense related applications (Wasinski, 2011; Weldes, 1996; Eslami & Vysotskaya Guedes Vieria, 2021; Coetzee, 2017).

A field that has thoroughly embraced constructivist ontology to explain sociotechnical outcomes is Science and Technology Studies (STS), which can be seen as the study of the creation of knowledge and artifacts in their social context (Lynch, 2016; Edge, 1995; Bijker, 2010). Central to this discipline is a fundamental skepticism towards technological determinism – the idea that technology can be treated as an uncomplicated fact and that the appearance and design of technological artifacts is objective and independent of the contexts of its creation (McCarthy, 2018).

STS theory instead emphasizes the social construction of technology. Objects and artifacts fundamentally reflect both the intentions and possible biases of the designers, and the social and political structure of the context in which the artifacts were made (McCarthy, 2018; Manjikian, 2018). Once technological objects are stabilized and in widespread use, they exercise a deterministic influence on society, as systems become too expensive to modify or otherwise become considered the normative standard (Hughes, 1987).

3.2. Imaginaries

This study turns to the subset of STS literature concerning *imaginaries* for its theoretical framework. Drawing on classic studies on nationalism as the creation of a collective sense of belonging to the social construct of the 'nation', Taylor (2004), in his landmark study of the modern political order, describes the social imaginary as "the ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows" (Taylor, 2004, p. 23). Taylor employs a social imaginary as the "background" context in which collective norms and ideals make sense.

Scholars in defense and military matters have applied this concept to security in the shape of a security imaginary. Such an imaginary has been used to explain the emulation of the modes of military organization of strong states by weaker ones as the latter are socialized into accepting the former's ideals and forms (Pretorius, 2008). Addressing the relationship between constituent groups and states, military imaginaries have also been used to analyze state expectations of military service and its links to norms of violence and masculinity (Bickford, 2011). Similarly, an imaginary of the "perfectibility of warfare through technical means" has been credited with providing the impetus for development of new weapons systems in spite of ethical concerns (Sherman, 2022, p. 440). Notably, many military imaginaries outlined in theory pertain to a future, often one informed by a sense of an approaching revolution in military affairs (Lawson, 2011; Bollman, 2021).

3.2.1. Sociotechnical Imaginaries

In combining (i) STS' emphasis on technology as a determinant, as a mediator, and as a result of social meaning and practice; (ii) the view of a social imaginary as a collective definition of desirability; and (iii) the forward-looking temporal dimension associated with application of (security) imaginaries, STS scholars have developed the analytical tool of a *sociotechnical imaginary*.

Perhaps the most prolific proponents of the sociotechnical imaginary are Jasanoff & Kim (2009). In their study on the parallel trajectories of nuclear power in the US and South Korea, the authors introduced the sociotechnical imaginary concept to address the issue of how one state's nuclear industry decayed to relative insignificance while that of another's reached technological ascendence (Jasanoff & Kim, 2009). In her later work, Jasanoff (2015) has presented the now ubiquitous definition of sociotechnical imaginaries as "collectively-held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order, attainable through, and supportive of, advances in science and technology" (Jasanoff, 2015). Unpacking this definition, one finds a set of important qualities or traits relevant to defense requirements engineering. A sociotechnical imaginary is a *belief* held by *many individuals*, united by a *social and institutional context*. This belief pertains to *technology*. The technological belief has a 'double-edged' temporal dimension, insofar as it concerns *future* advances in technology while also consisting of understandings of desirability in the *present*, informed by the *past.* It is *performative* in the sense that it prescribes action for individuals, who also reproduce it as they act.[3]

Perhaps owing to the prevalence of ideas and models as crucial for the efficient development and employment of military systems (Modig & Andersson, 2022; Jensen, 2018; Zilincik, 2022), defense research has embraced the use of a sociotechnical imaginary as a conceptual framework. Within various defense-related fields, the use of such imaginaries to understand the relation between groups and individuals, ideas about technology, and outcomes have become quite prominent (Bollman, 2021; Oliveria Martins & Mawdsley, 2021; Lawson, 2011; Öberg, 2018).

3.2.1.1. On the study of sociotechnical imaginaries

While there has been great interest in the use of sociotechnical imaginaries in defense applications, it has not always been clear how such imaginaries ought to be studied. A partial solution to this shortcoming can be found in a recent article by Skumsrud Andersen & Reichborn-Kjennerud (2022), who have provided a clear and convincing account of a complementary approach to studying sociotechnical imaginaries in the defense sector. In their study, the authors attempt to explain the substantial investment made to develop the indigenous Norwegian anti-ship missile known as the "Terne". They note that no-one in the Norwegian defense establishment had asked for the missile, undermining the assumptions of rationality that underpin normal military systems development. The authors make the argument that the Terne was developed thanks to a Norwegian sociotechnical imaginary which enabled the weapon program to secure sufficient funding for construction and adoption, despite the disinterest of the military establishment. The scholars' study breaks the sociotechnical imaginary supporting the Terne down into three component parts: the *narrative* supporting a technology, the

[3] For a deeper discussion on the suitability of the sociotechnical imaginary as a concept see Jasanoff (2015) and Sherman (2022). For a discussion on the relation between an imaginary created and propagated by a subgroup, see (Hilgartner, 2015)

coalitions that attempt to propagate that technology, and the *competition* between coalitions which makes appeals to imaginaries necessary.

The inclusion of coalitions and competitions in Skumsrud Andersens & Reichborn-Kjennerud’s understanding of a sociotechnical imaginary clearly reflects their interest in the relative success of a given imaginary in competition with others and is thus of limited interest in the present thesis. The authors’ breakdown of the narrative component (which in Terne’s case consisted of a vision of the post-WWII military domain as dominated by developments in rocketry and sensors) of a sociotechnical imaginary, however, is highly relevant. According to the authors, the narrative of imaginaries consists of “stories about cause and effect that include the past, present, and visions of the future” (Skumsrud Andersen & Reichborn-Kjennerud, 2022, p. 7). The implication is that sociotechnical imaginaries can be studied in terms of (i) the desirable future or the “cause” (“features and uses of [technology that] are seen as crucial”) and (ii) the effort to be undertaken to achieve that future or the “effect” (“[impacting] how technology is developed, diffused, and used”). Arguing that “narratives, and who tells them, thus affect how individuals and groups respond to technology”, the authors also include actors as crucial parts of the overall narrative. Consequently, the breakdown must also include (iii) the social orders (or roles) of the actors which are to expend the effort identified as necessary. This breakdown both conforms well to Jasanoff’s foundational definition of a sociotechnical imaginary, and provides a tri-partite, deductive framework for studying such imaginaries. It will inform the method employed in this thesis.

4. Method

To outline the features of the defense requirements engineering sociotechnical imaginary, including the rationality/irrationality dichotomy, and to understand what actions and outcomes might be enabled by this imaginary, this thesis presents an interview study of Swedish defense sector requirements analysts.

4.1. Analytic framework

An analytical framework adapted from Skumsrud Andersen's & Reichborn-Kjennerud's narrative was developed in order to structure the collected material in the form of testimonies from the requirements engineers in a way that properly outlined the features of a sociotechnical imaginary. First, however, testimony pertaining to the rationality/irrationality dichotomy was considered *per se*, and therefore presented separately from the other aspects of the imaginary. This is because divergence from perfect rationality, here understood as adherence to an ideal, perfectly structured process, is what theoretically provides space for the imaginary's narrative. The presentation of the rationality/irrationality dichotomy as separate from the 'rest' of the sociotechnical imaginary narrative is, it must be stressed, an editorial decision, not a theoretical one: the dichotomy is a vital part of the imaginary. The discourse about rationality and its limits sets the boundaries for other values: that which is seen as worthwhile when the context does not allow for performance of a perfect ideal.

The 'rest' of the collected material pertaining to the imaginary was analyzed separately, in accordance with Skumsrud Andersen & Reichborn-Kjennerud's narrative approach for studying sociotechnical imaginaries in the defense sector as presented above. As such, the sociotechnical imaginary is made researchable in terms of the *narrative* connecting a future technological cause to present effort which obliges the actors in the story to expend that effort. However, in contrast with Skumsrud Andersen & Reichborn-Kjennerud, who relied upon the narrative as a key component of an imaginary without clearly structuring their material according to the narrative's components, this thesis uses the narrative to categorize material collected in the interviews. Thus, the narrative here serves as an analytic framework, allowing for a deductive categorization of meanings and themes expressed during the course of the interviews.

To enable categorization of meanings discovered in collected material, the narrative-structure implicitly used by Skumsrud Andersen & Reichborn-Kjennerud was developed into three analytical categories prior to the interviews. These were requirement analyst *ideal system values*, *processes*, *and roles and behaviors*. The categories correspond to the logical components used by the authors in their application of narrative in their study as was described in section 3.2.1.1. above. That is, (i) a cause or desirable technological future was mapped to the category *ideal system values*, (ii) the effect or the effort to achieve that future was mapped to the category *ideal processes*, and (iii) roles of the actors who are to expand that effort was mapped to *ideal roles and behaviors.* Table 1 summarizes how the sociotechnical imaginary was studied in terms of these three aspects as suggested by theory.

Table 1: Aspects of the narrative of the sociotechnical imaginary broken down into Skumsrud Andersen & Reichborn-Kjennerud component, equivalent in the definition of a sociotechnical imaginary, and description. Source: The author.

Aspect	Skumsrud Andersen & Reichborn-Kjennerud Narrative component	Defense RE Sociotechnical Imaginary Component Equivalent	Description
Ideal system values	The *cause* of a narrative; “features and uses of [technology that] are seen as crucial	The desirable technological future	The qualities that are always, inherently, or predominantly seen as important to a system in the defense sector
Ideal processes	The *effect* of a narrative; “how technology is developed, diffused, and used”	The effort to be undertaken to achieve that future	The dynamics, incentives, structures, procedures, or rules which are necessary to create a system which comprises the ideal system values
Ideal roles and behaviors	The *social orders* proscribed by a narrative; “how individuals and groups respond to technology”; ”[limits on] available courses of action.”	The actions required by the actors in the narrative in expending that effort	The acts, attitudes, knowledge, codes of conduct, or authorities which are incumbent on the individual analyst as a participant in the ideal processes

These analytic frameworks are deductive. However, this deductive aspect of the thesis’ method only extends to the categorization of material, and not to its later analysis and interpretation. These later aspects, in keeping with the interpretivist approach necessary for fine-grained understanding of meaning expressed by the respondents, were inductive.

Finally, while Skumsrud Andersen & Reichborn-Kjennerud investigated a specific artifact (the Terne), this thesis considers the particular features of the artefact under development largely irrelevant: it is concerned with finding the imaginary for Swedish defense requirements engineering overall (which by its nature and definition pertains to technological futures), not for a specific system or technology. As such, the categorization of themes does not take any specific technology into account.

4.2. Case Selection

The interview study presented in this paper is intended to contribute to the wider literature on defense requirements engineering, meaning selection logic and generalizability must be addressed. This generalizability should not be understood in positivist, quantitative, or statistical terms, but – in keeping with the study’s inductive and interpretative design – should rather refer to “generalization toward a theory rather than toward the population” (Carminati, 2018, p. 2097). Because this theoretical, or analytical, generalization pertains to augmenting any extant theory to be applied to cases beyond the population of the study, the logic of selection of the object of study or “case” becomes crucial (Hays & McKibben, 2021). This paper’s area of interest – a sociotechnical imaginary as a structuring principle for defense requirements engineering – is too temporally and spatially diffuse to provide a clearly definable case sufficient to render it a case study in the traditional sense (Yin, 2014). Instead, this study will use the word case to denote “an instance of a class of events”, with the class referred to being modern defense sectors (Bennet & Checkel, 2014). Specifically, the chosen case must exhibit features which pertain directly to or have implications on theory (Yin, 2014).

This study aims to contribute to the theory of defense requirements engineering by suggesting an imaginary as a structuring principle instead of the pure rationality inherent in standard views of systems and requirements engineering. Therefore, the case of the Swedish defense sector was chosen because it provides an *extreme* case. An extreme case is characterized by its deviation "from theoretical norms" (Yin, 2014, p. 52). It is argued that the Swedish defense sector stands apart from the larger class of defense sectors in that conditions are *extremely* favorable to the conduct of requirements engineering based on rationality alone. This follows from several facts: Sweden is consistently in the top 5 among the least corrupt nations on Earth, meaning odds of encountering illegal distortions to the rational systems development process could barely be lower (Transparency International, 2022); the Swedish defense sector is very well-established and broad, and is consciously structured according to the values of rational (systems engineering-based) procurement (Lundmark, 2020; FMV, 2023); and while the details of Swedish security policy has changed with the tensions in its immediate environments, the country has been remarkably consistent in the sense that it has developed systems to counter the same aggressive neighbor, Russia, for more than a hundred years. As such, the Swedish defense sector is expected to be remarkably unsusceptible to the uncertainty and instability which might undermine the application of a rationality/irrationality dichotomy. If the structuring principle for defense requirements engineering diverges from pure rationality/irrationality in the Swedish case, therefore, other cases in the same class ought to diverge as well, if not more.

While Sweden represents the extreme case of a defense sector that should be amenable to fruitful application of the rationality/irrationality dichotomy, it should also be noted that this extremity only pertains to the presence of factors which could enable a truly rational process. Thus, there is nothing to suggest that Sweden's defense RE imaginary is not unique in terms of its makeup and characteristics. This point is addressed at greater length in the discussion section below.

4.3. Research design

A qualitative, interpretive interview study was conducted with experienced requirements engineers in the Swedish defense sector. The data was collected from 10 interviews. The interviews were conducted using a semi-structured interview format, the Biographical-Narrative-Interpretive Method, modified according to the limitations of the study (Wengraf, 2001). For instance, during scheduling for interviews it became clear that no potential respondent had time for 2-3 temporally separate interview sessions, meaning each interview was conducted in one session.

All interviews were conducted in Swedish – direct quotations below have been translated into English by the author. Each respondent was informed about the general structure of the interview before it took place. 9 out of the 10 interviews spanned from 45 to 75 minutes. The remaining interview was conducted over roughly 150 minutes. Respondents were interviewed one-on-one. Respondents were offered the choice of whether to be interviewed face-to-face or online over their choice of video-communication platform. 4 chose the former option and 6 chose the latter. Out of those who chose the latter, 3 enabled video input. Respondents were asked, after a short introduction of their background, to give a recount, as thorough and detailed as possible, of a requirement engineering process in a defense setting that they had experienced *and* which they thought stood out in a particularly positive or negative way. Respondents were informed that they could take as long as they wished to recount their experience, and that the interviewer would only take notes to be able to ask follow-up questions when they were done. When respondents unambiguously signaled that their biographical-narrative account was done, they were first asked clarifying follow-up questions grounded in their account. When there were no such clarifying questions left, the respondents were asked one or more general follow-up questions written before the interview. The selection and number of such follow-up questions depended on the account which had just been given. Some respondents were very open and talkative, others more reserved: those more reserved were asked questions about topics which they might only have touched upon briefly. These pre-written follow-up questions were divided according to which aspect they were intended to address: the imaginary’s system values, process, or roles and behaviors.

All respondents were asked for permission to record the interviews for later transcription. Recording was performed using a private recording device. Transcriptions of the interviews were produced using audio-to-text software. The resultant text was thereafter manually corrected. Each respondent was provided with the transcription of their interview and encouraged to object should they have detected errors in the final transcription. Save for minor clarifications and editorial corrections, no objections were raised.

4.3.1. Sample selection

The criterion for respondents was substantial experience with requirements engineering in the Swedish defense sector. The respondents were chosen based on a snowball sample selection. The initial sample of respondents were found using personal contacts at a Swedish consultancy firm with substantial experience of the Swedish defense requirements engineering process. At the time of writing, the author of this thesis was working at the consultancy and used his connections there to establish an initial sample. That initial sample was supplanted by other contacts, not affiliated to that firm, made during preparation for the study. The initial sample was supplanted by asking each respondent at the end of the interview whether he was comfortable with recommending any of his acquaintances for an ensuing interview. The search for more interviews stopped when the method of recruiting participants ceased to yield more willing respondents. At this time, the sample of respondents had grown to the extent that the majority of combat domains (air, land, naval, cyber, C2 systems) were represented in the resultant set of the respondents' previous systems development experience. The resultant set of respondents was therefore considered sufficient.

Due to availability, all 10 participants were men.[4] Respondents either held senior positions in their fields or had previously held such positions before retiring or changing careers. All three actors in the Swedish defense sector (as defined above) were represented in the set of respondents: the SwAF, FMV and the private sector. A respondent was considered affiliated with the private sector if he was either employed by a company delivering a service or product to the SwAF or FMV, or if he was hired as a consultant at either of these two actors. Half of the respondents had worked at more than one of the actors over the span of their respective careers.

4.3.2. Analysis of material

Collected material was subjected to thematic analysis inspired by the methodological process suggested by Braun & Clarke (2006) and further elucidated by Nowell, et al. (2017). After transcription and familiarization with the basic material, each segment of the collected data

[4] To this author's knowledge, there are no available statistics on the gender distribution among Swedish defense requirements engineers.

was coded into one of three organizing aspects of a defense requirements engineering narrative. These aspects were (i) the ideal values of systems developed for the defense domain, (ii) the ideal process in the defense sector which might result in the development or procurement of systems which live up to those values, and (iii) the ideal role and behaviors of the analysts tasked with developing such systems in this process. The codes were chosen *a priori* in accordance with the reasoning presented in section 4.1. After coding, segments that had been coded together were subjected to interpretive, inductive analysis to distinguish themes within the organizing aspects. Identified themes were further processed and defined. The thematic analysis was focused on latent meaning, in the sense that it aimed to "identify […] the underlying ideas, assumptions, and conceptualizations" which provide the semantic level with its meaning (Braun & Clarke, 2006, p. 84).

5. Results

In this section, the defense requirements engineering sociotechnical imaginary is presented as it appeared in the form of a narrative in the course of the interview study. The way respondents described the perfect, structured process is presented, followed by a recount of how respondents saw the limits and obstructions to that perfect ideal. Finally, the narrative of the sociotechnical is described.

5.1. The Rationality/Irrationality Dichotomy of the Imaginary

The results reveal that analysts constructed rationality as the ideal framework for their activities and its obverse, irrationality, as the unfortunate reality to which they had to conform. The construction of these two parts of the dichotomy, which provides the space for the narrative of the sociotechnical imaginary, is presented in this section.

5.1.1. Rationality

Without exception, all respondents clearly expressed their genuine desire and ambition to adhere to the principles of rational, formal requirements engineering as stipulated by the systems engineering processes employed in the Swedish defense sector. This desire to adhere to the ideals of the rational process took many forms.

Analysts consistently emphasized the primacy of the customer (the SwAF) for defining 'their own' combat and defense needs (I4, I5, I6, I7). Some expressed a clear and unambiguous customer needs formulation in terms of a necessary condition for successful requirements engineering process – that unclear needs or goals made requirements engineering fundamentally unviable, on par with poorly informed guesswork (I7). Even those who did not go as far as to claim that deviation from clearly defined needs made requirements engineering impossible tended to repeatedly emphasize the importance of understanding the need and context of the customer to avoid costly misunderstandings (I1, I6, I9, I10). Many also emphasized analyst domain knowledge as a way to understand the customer's needs when such needs were ambiguous. Virtually all analysts implicitly expressed a view of escalating costs of development and acquisition projects as a potential drawback of faulty requirements engineering and therefore as a limit to the utility of such projects from a rational ends-means logical perspective. Where defense needs were expressed unambiguously, analysts perceived them as a natural fact and did not consider questioning their rationale: some overarching defense needs were considered "completely logical" and an expression of military tasks "constant since the beginning of time" (I2).

Tying into the perception of the primacy of the customer as the fount of needs is the rational view of the analyst. Some analysts expressed a very clear ambition to separate between requirements analysts and other participants in the development project. These analysts explicitly rejected the idea that requirements analysts ought to consider the correctness of the needs as presented to them. Stressing that "those who work in the defense sector are incredibly ambitious and conscientious, and are endowed with an acute desire to strengthen the defense of Sweden", one analyst still insisted that the individual could not "take responsibility that the needs are correctly formulated", and that doing so is to "take on a greater role than what is expected of you" (I5). Another analyst, working at FMV, stressed the collective responsibility of the agency instead of that of the individual analyst. While he recognized that there was a personal desire "to do a great job, the best job possible" and that "it would be embarrassing to deliver poor results", he nonetheless emphasized that it is the agency as a whole, as part of the procurement process, that has ultimate responsibility to deliver requirements in accordance with customer needs (I4). Another analyst, working for a private supplier, echoed this sentiment. While recognizing that he personally had more than a decade of relevant experience with military systems and needs, the analyst preferred to construe that personal competence as merely an expression of the collected knowledge of the company for which he worked (I9).

Recognition of the primacy of customer needs and the delineation of the role of the analyst was also seen in the light of appreciation for a larger, rational structure as expressed by the respondents. Adherence to a rational process and structure was generally lauded. Several respondents expressed a desire for even more structure and overall command exercised by the procuring agency, FMV (I1, I9). Likewise, several analysts emphasized adherence to structured standards in systems engineering, such as ISO 15288, as a desirable method in systems development and requirements engineering (I1, I7, I2, I10). One analyst considered work in the defense sector as arguably more structured than equivalent requirements engineering work in other civilian domains (I5). Similarly, respondents were keen to point out that their work is always structured by laws and regulations, and that such regulations provide crucial, mandatory constraints on resultant requirements.

5.1.2. Irrationality

While there was a strong principal commitment to the ideals of rationality among the requirements engineers' interviews, the results also revealed an almost universal recognition of the difficulties inherent in executing systems development in accordance with these ideals in practice. As mentioned in the description of the method selected for the study, the respondents were asked to decide themselves whether they wanted to describe a very negative or very positive experience they had had in defense requirements engineering. It is perhaps indicative that every single respondent chose to either describe a negative experience in detail or discuss the many substantial problems involved in defense requirements engineering in general: while some positive experiences were mentioned, no respondent chose to exclusively recount a purely positive experience. There was widespread recognition among the respondents that defense requirements engineering provides such distinct difficulties (I1, I3, I4, I6). One analyst said that he would have to recount a negative experience, seeing as "[he] unfortunately [hadn't] participated in very many particularly positive [projects]" (I4). Another respondent was more vocal: "if you want to find a project which was handled well," he argued, "you would have to go back a fair few number of years" (I7). Later in the interview, the same respondent seems to have realized that that was not the whole truth and partly corrected himself: upon being asked what a truly successful defense requirements process would be like, he claimed to not know for the simple reason that he “had never experienced that”.

A very prominent circumstance mentioned as an explanation for the problems experienced in defense requirements engineering was a lack of certainty about the future. Many respondents expressed a degree of frustration with the limits imposed on their work by the remarkably long service lives and lead times common in the defense sector (I1, I4, I9). A commonly cited example by respondents pertains to computer hardware *vis à vis* operating systems: analysts noted that they could make much less concrete and much less specific requirements on operating systems in military hardware than for comparable systems and subsystems seeing as an operating system is likely to be obsolete within a decade (I1, I4, I6). One respondent noted that the lead times for rare components in military systems sometimes necessitates that suppliers make an order for such components on the same day that that supplier signs a contract for defense materiel. In those cases, requirements might still be largely up in the air, forcing suppliers to “guess where the wind is blowing” (I9). Another analyst expressed the perennial concern that the combination of the uncertainty of future war and an impulse to make requirements too specific carries with it the risk of locking the armed forces into dated, obsolete systems and infrastructure (I2). One analyst laconically noted, on the topic of predicting future requirements for systems that will be in service in 15-20 years, that “the only thing one can be sure of is that no matter what one includes in the requirements, it will still end up wrong. Those requirements can be very wrong or just somewhat wrong. One must be humble about requirements: they are not the truth.” (S10).

Moreover, it was noted that the political context in which defense requirements engineering operates provides substantial difficulty to the process. Respondents regretted what they saw as inevitable requirements changes originating in the political level (I1, I4). It was noted that long lead times and sudden changes in the environment naturally create what is otherwise considered undesirable requirements volatility, exemplified by the recent outbreak of full-scale war in Ukraine (I1, I2, I7, I9). Some analysts were more specific. One analyst raised the issue that decisions regarding allocation of budgetary resources not based on purely rational military utility considerations created substantial requirements engineering problems. He described how, in one of his projects, the requirements engineering process had been forced into an unprepared and immature ‘kick-start’ by an unexpected decision to launch a project when funds suddenly became available (I4). Similarly, another analyst recounted his experience of how a then-prevailing urgency at the time of a procurement decision contributed to acceptance of an otherwise insufficient list of requirements (I10).

Some also pointed to the organizational issues of requirements engineering in the defense sector. One respondent claimed that institutional distrust between actors tended to lead to a distinct rigidity in requirements formulation unwarranted by the specification of needs (I3). The prestige and military discipline inherent in defense sector requirements engineering was also commonly seen as a major detriment to a rational process: respondents reported that individuals involved in the requirements engineering process occasionally stuck to manifestly unproductive or incorrect views when their reputations, or the reputations of their organizations, seemed threatened (I2, I3, I7, I10). Many respondents noted that one or more of the main organizational actors here included in the defense sector had substantial problems with the requirements engineering process, especially in relation to each other. For instance, some respondents associated with SwAF felt that FMV was too rigid when interpreting initial needs and requirements, while some associated with FMV instead felt that analysts at SwAF tended to steer the design process instead of formulating solution-neutral requirements (I3, I10). Some felt that understanding of the systems engineering process was insufficient and flawed (I7, I10). Respondents also expressed an impression that the SwAF and FMV had underestimated both the difficulty and desirability of capability-based requirements engineering (I2, I3, I10).

The results presented above illustrate two points. First, requirements engineers in the Swedish defense sector clearly understand what rational systems development entails and consider it a desirable ideal. Consequently, they attempt to act in accordance with an ideal, rational requirements engineering process to the best of their abilities. Second, they portray this ideal process as severely constrained by various issues inherent in the defense sector. There is a remarkable unanimity among the respondents that this ideal is worth striving for but that it is compromised in contact with reality by factors beyond their control.

5.2. The Narrative of the Imaginary

The results above seem to indicate that the construction of the dichotomy provides a context for meaning beyond the strictly rational but above the completely irrational, to be filled by a narrative. In this section, the narrative of the defense RE imaginary is presented, broken down into aspects in accordance with the method used by Skumsrud Andersen & Reichborn-Kjennerud (2022): the ideal system values, the ideal processes, and the ideal roles and behaviors.

5.2.1. Ideal System Values of the Defense RE Imaginary

The narrative of an imaginary includes a firm conviction of desirability, of values worth striving for. Aside from some inevitable variation in personal opinion, which is to be expected in a set of requirements engineers working at different agencies and with developing systems for different domains, the study revealed that some prominent system values, properties, or qualities of systems, which were always, generally, or particularly desirable in defense systems.

5.2.1.1. Effect

The premier system value or quality which emerged during the study was that of capability or *effect*. Effect is seemingly closely related to and clearly derived from the theoretical concept of military capability. Respondents often explicitly stated that they found a focus on capability (*förmåga*) or effect on target (*verkan*) desirable. However, they spoke of such capability less in terms of an integrated collection of material and immaterial components in service of the achievement of a military sub-objective, and more in terms of the physical effect such achievement might have in context. The word here pertains to a variable set of system attributes which together allows the system – or adjacent systems – to partake in the act of 'fighting' an adversary, having the 'right capability' (I2, I3, I4, I6). It should be noted that these attributes are also often discursively lumped together on the basis of perceived failures or shortcomings of earlier systems development. Effect can in this context be understood as the desired, physical outcome resulting from a system's intended use: the explosion of an artillery system's grenade, the impact of a machine gun's bullet. However, the concept of effect, as constructed in the defense requirements engineering imaginary, has a few different important traits.

Most importantly, it is seemingly less understood in terms of what it is than what it is not. For instance, one respondent expressed the view that Swedish defense procurement has long been focused on relatively inconsequential qualities – "[Swedish defense procurement] is inordinately focused on ensuring that the flight technician is not under any circumstances allowed to drop his wrench on his foot, [resulting in] solutions which end up being unusable. We develop arms which we provide to the Armed Forces. Consequently, [those arms] should be dangerous for the adversary" (I10). Echoing this sentiment, another analyst felt that requirements for Swedish defense materiel had prioritized systems and functions intended for training or other peacetime uses at the expense of effect. "I think one ought to focus on what is required to achieve a certain effect. That is what's going to be needed if things go hot." The same analyst also expressed the highly relatable view regarding military IT-systems that "it is after all more important to have the capability to fight the enemy than it is to order pizza" (I7).

Interestingly, another respondent characterized effect as a necessary constraint in his requirements engineering work. He felt that effect "is so critical that I have to make an exception to [implementing preferred requirements] and I might have to solve it another way" (I5, p. 8). When asked to explain how he would make an exception or trade-off in favor of effect, the analyst clarified that "workplace safety – the well-being of personnel – is of such immense importance that the framework which surrounds it comes to dominate the issue". He also added that "system security – that is, the risk of harm to personnel – becomes of greater importance than [a threat to military information security]". The analyst here makes an implicit connection between effect and workplace safety.

While it seems unintuitive to equate the concept of effect to workplace safety (especially given that concern for dropped wrenches was placed firmly outside the boundaries of effect by another analyst), the results suggest that effect is to be understood as the achievement of a physical outcome undesirable to an adversary *at very specific costs*. A different respondent's testimony illustrates how effect is constructed along these lines. In discussing how requirements differ between ordinary system operation and critical operations (i.e., combat), the analyst ascribed the desirability of capability or effect to the operations of the latter kind. He explained that critical operations, characterized by the imperative to achieve effect, can be understood with reference to the suspension of otherwise important system qualities: in a critical scenario, "if the people who normally [manage various IT-security related functions such as access control] die, and if there is no-one else who could assume those responsibilities, who's going to be assigned the relevant authorizations? In those cases, we want to be able to bypass all of that and just act" (I6). As another example, a respondent favorably contrasted achieving effect or 'basic capability in the field' with the less important value of stakeholders retaining control over systems design to the extent that they could decide which side of a driver's seat the cupholders were to be located (I3).

Requirements analysts therefore seem to imbue the concept of effect with meaning by reference to sacrifices made to other system qualities. This is not surprising, as systems development programs do not have infinite budgets and must therefore always accept tradeoffs between system values. Military systems that enable users to order pizza or prevent dropping wrenches do not have effect in this sense. Systems that protect personnel in operations at the expense of certain information security-related functions or systems that allow bypassing otherwise crucial security functions should that personnel perish, on the other hand, can have effect. In a sense, effect as a concept has a normative dimension: it derives its meaning from the extent to which analysts feel it is appropriate or possible to sacrifice more peripheral system attributes.

5.2.1.2. Integration

The second system value that was particularly emphasized was that of *integration*. Like effect, part of its conceptual background is found in the process of integration of components and subsystems so common to rational systems and requirements engineering thinking. Moreover, the concept of integration also has a distinct meaning inside the boundaries of the defense requirements engineering imaginary. Integration in this context ought to be understood as a crucial, subordinate condition for the premier value: effect. The value of integration as expressed by respondents is found both in combining systems of different types into one system and in integrating one given sub-system uniformly across all applicable systems or platforms. It describes the linkages and reductions of systems which would enable the user to achieve disproportionate effect.

Respondents identified the quality of integration differently, but also tended to describe it in negative terms – as a quality imperiled by failures of the requirements engineering process (I1, I2, I7, I9). One analyst felt that flawed defense procurement could result in "straggly solutions" and a tendency to "reinvent the wheel" (I1). He advocated for increased use of government furnished equipment, GFE, in systems development to integrate systems more efficiently, reducing the number of unique sub-systems. While the analyst in question suspected the main issue with such un-integrated solutions would ultimately come down to cost, the use of the word 'straggly' and the wheel-metaphor is indicative, as it implies both redundancy of effort and lack of direction. His sentiment was echoed by other analysts, who felt that specially tailored defense system solutions posed a problem in defense procurement, noting that they did not care from where a system or a particular component of a system was sourced (I3, I10). Contrary to the previously mentioned analysts, however, another respondent was of the view that insistence on the use of GFE in the development of new defense materiel posed an issue when it came to system integration. By insisting on the use of national GFE as sub-systems in procurement of defense materiel from a supplier, governments might hinder the developing supplier from using the most efficient solution in its product (I9).

This apparent disagreement between analysts on the role of GFE in system integration partly reflects a difference in perspective, but it is also indicative of the normative and negative role integration plays in the narrative of the imaginary. Analysts use the concept of integration to denote the potential for disproportionate gain or loss, using system components *already available to them*. GFE is important to the concept of integration because the former is per definition already available for use. Consequently, GFE can both hinder and promote integration, since integration seemingly denotes efficient (or most commonly, seeing as the concept is used negatively, wasteful) use of a set of components. Another respondent's testimony shows how the same understanding of integration is applied in a slightly different context. In describing a sub-par systems development process, the analyst argued that while the resultant system turned out very well, the distinct lack of concern for integration was argued to have substantially delayed its initial deployment (I10). By discursively associating lack of integration to project delay, rather than as an attribute of the technical system itself, the concept of integration is reinforced as a qualification of the project's use of available resources – in this case time rather than GFE.

The value or quality of integration is also intimately connected to the other crucial system value, effect. Integration here plays a clearly subordinate role. In an unusually clear example, a respondent, elucidating his view on desirable qualities for defense systems, explicitly related the imperative to achieve integration to Sweden's national security needs as a small country. "To become more efficient with the resources available to us, we need to collaborate: we need to be able to put together the systems we already have to achieve a greater system effect. That is the most important thing a small nation can do against a larger, more well-resourced adversary" (I2, p. 6). Integration – the combination of available systems – is conducted in the service of system effect rather than as a goal unto itself. Again, the superior goal is the application of undesirable physical outcomes on the enemy. This construction of integration in relation to effect is logically coherent: analysts construct effect such that it provides the goal and the necessary sacrifice which poor integration could waste.

5.2.2. Ideal Processes of the Defense Requirements Engineering Imaginary

The narrative of an imaginary also features a story of how ideal values come to be achieved. Naturally, being practitioners of requirements engineering, respondents were well-accustomed with the process of achieving system values through elicitation and formulation of requirements. Despite a wider spread in central themes for this aspect compared to that of system values, the study revealed some prominent characteristics of an ideal requirements engineering process in absence of fertile conditions for rationality.

5.2.2.1. Suitable resolution of uncertainty

A central theme regarding an ideal defense requirements engineering process which recurred in different interviews was that which might appropriately be termed a *suitable resolution of uncertainty* (henceforth *uncertainty resolution*). The phrase was here chosen to encompass various practices in a hypothetical requirements process that are together intended to ensure that the information deficit and uncertainty in a systems development project is managed appropriately through execution of a set of practices. In other words, an ideal process – short of a completely rational process, where near-certainty is a realistic option – was prominently described as one in which satisfactory steps had been taken to resolve uncertainty.

One such practice was that of the establishment of close contacts and relationships between participants. There is of course the perennial desire expressed by all requirements engineers (not least defense requirements engineers – many respondents in the present study expressed a desire to achieve a better understanding between SwAF and FMV) to sit down with the prospective user of the system so as to understand his or her needs. Additionally, however, many analysts noted that the uncertainty of long lead-times inherent in the defense sector was best managed through constant and multilateral communication between users, procurers, and developers (I3, I4, I9).

The desirability of creating close contacts was expressed differently by different respondents but it was consistently conceived as a way to foster mutual understanding and manage uncertainty (I1, I2, I3, I4, I6, I9). One analyst expressed his conviction that a requirements engineering process he took part in would have been improved if FMV and the supplier in that case had conducted a mutual pre-study prior to the requirements process. Having previously noted that an issue had been the lack of harmonization between supplier and procurer requirements, the analyst felt that a cooperative approach might have resulted in a common view (I4). Another respondent, who then worked for a supplier in the private sector, noted that "the customer might not always know what they [i.e., the armed forces] want at the time of project launch. When dealing with new capabilities, it isn't always easy to see all the consequences [of one's capability decisions]" (I9). He consequently strongly advocated for the establishment of working groups or integrated product teams (IPTs) to manage the resultant uncertainty. Another analyst also felt that close contact was a prerequisite for a successful project, but noted that such contacts might not be enough if they centered on individuals whose military ranks were so low that they had no understanding of the system's larger picture, or, alternatively, if those contacts centered on older personnel not open to improvements (I7).

Some analysts, in advocating for better understanding between the parties involved, seemed to question traditional divisions of labor in requirements engineering. One respondent, who had worked with requirements in both the private and public sector, suggested that, in order to conduct the requirements engineering process satisfactorily, the individual engineer "should really be able to act like a supplier, because one should be on that level. One must have that kind of knowledge. One must be a subject matter expert or comparable to be able to do this" (I8). While the analyst did not intend to endorse relinquishing any formal responsibilities associated to requirements engineers in the systems development process, his reasoning is nonetheless indicative of a clear theme, namely the resolution of uncertainty by means of a partial dissolution of boundaries between actors in the process. The underlying reasoning can quite easily be gleaned: a process in which each party could easily step into the shoes of any other is one in which there is great understanding concerning the motivations, needs, and constraints among all participants. Others shared a similar sentiment. One respondent, who had worked in the SwAF at the time, ascribed the success of one of the projects he had participated in to a 'user organization' assigned to the supplier during development of a defense system (I2). The user organization, of which he had been part, had been integrated with the supplier, working alongside its employees to solve requirements-related problems as they arose. While he noted that it was occasionally difficult to separate his roles as a customer and as a problem-solver, he nonetheless felt the arrangement contributed to the successful conclusion of the project. One analyst claimed that true expertise in defense requirements engineering presumed previous experience: "if you want to write a more thorough requirements list of a tank, you have to be a Tank Man. [You have to know] what made the old tank good. What is it that makes the old tank obsolete?" (I3).

On a similar note, another analyst criticized what he felt was undue distrust between the private and the public sector. The analyst, then working in the public sector, felt that one of the issues with a requirements process in which he had taken part was a sense among the public leadership that the defense industry "is just going to try to scam you either way". Instead, he felt that they should "be seen as a good partner": systems ought to be developed "together with the defense industry" (I3). Others shared this conviction (I6, I9).

5.2.2.2. Level of specification of requirements

Related to the concern of resolving uncertainty in the requirements process was the sub-theme of the *degree* to which requirements should be specifically or generally formulated. The remarkable prominence of this topic among the respondents merits its distinct mention in the results, despite it being conceptually related to the previous theme, the resolution of uncertainty. A very common topic of discussion for respondents was the difficulty of choosing the appropriate level of specificity of requirements once needs were understood. Many respondents noted that by designing the requirements, one also directly took part in the design of the final system and a resultant concern was the risk that by being *too* specific while constructing requirements, the requirements process might unnecessarily infringe on the space for creative solutions by the engineers tasked with system design (I1, I2, I4, I10). By being overly specific the analyst might unnecessarily hamper the designer's "freedom of movement" (I1).

Analysts who discussed this problem implicitly associated it with the correct allocation of uncertainty. For instance, by stressing that the suppliers "know their product best" (I6), an analyst suggested that overly-specified requirements might infringe on that supplier's "creative freedom". In ascribing the supplier both superior knowledge and creative license, it is implied that the supplier is better suited to resolve the uncertainty as to the design of the system. In a similar vein, other respondents discussed the common desire by the SwAF to start formulating higher-system level requirements based on requirements rather than design to avoid the risk of over-specification (I2, I10). While acknowledging that the ambition is laudable, it was simultaneously felt by the respondents that the SwAF had underestimated the difficulty of using this method of setting requirements. Specifically, the respondents noted that capability requirements did not absolve the analysts responsible from understanding potential consequences on a lower system level. Implicit in this argument is the reasoning that the SwAF is better suited to resolve uncertainty of true needs when it comes to military capability, and that requirements that are too 'loose' would be undesirable for the reason that suppliers are less well-suited to shouldering the responsibility for managing that uncertainty. One analyst, mirroring the sentiment of dissolution of boundaries between actors, noted that a consequence of the desirability to allow for faster and more flexible solutions could be greater reliance on this type of loose requirements in defense procurement. However, he also added, somewhat apprehensively, that increased use of capability-based requirements might necessitate a much larger degree of trust in suppliers, who would also need to be much more knowledgeable: "the very relationship between supplier and procurer will be subject to new requirements" (I2)

5.2.3. Ideal Roles and Behaviors of the Defense RE Imaginary

The final component of a narrative in a sociotechnical imaginary is that of the roles assigned to the actors in the story – the behaviors which bring about the fulfillment of the desirable future, or, as Jasanoff put it, the forms of social order supportive of the technological advance in question.

5.2.3.1. Educational and advisory role

The most prominent theme among ideal analyst roles and behaviors was that of the educator or advisor. Respondents often described themselves in terms reminiscent of teachers or mentors.

Despite the relatively prominent recognition for the fact that the formulation of requirements plays a decisive part in the design of the final system, the respondents did not identify themselves with decision-making roles or tasks (I1, I5, I6, I7). As was exemplified by the testimony presented and referred to in section 5.1., respondents were generally clear-sighted and unambiguous about the limits to which they could take on personal responsibility for the appropriateness of the requirements they were tasked with processing (I5). Discussing proper codes of conduct regarding defense requirements engineering, many respondents seemed skeptical of the idea that decisions could or should be taken by individual requirements engineers. Indeed, some expressed views that important decisions were always better anchored in the responsible groups or organizations, as individual decision-makers risked oscillating in a way harmful to the continuity necessary for defense system development (I10). The prominence of referral to decision-makers as the proper response to the identification of ambiguity or incompatibility among stakeholder requirements testifies to a clear rejection of any potential self-image as a 'judge' or 'owner' of requirements.

Instead, respondents saw themselves as educators. In this capacity, many felt their role was defined by a need to explain and facilitate (I5, I6, I7, I8). One analyst described his defining task – after having interpreted and understood the intention behind a given requirement – as that of a conveyer, helping those later in the design process to understand what was being asked of them (I5). Another analyst, more explicit about his perceived role as a sort of 'teacher', claimed that his educational tasks extended far beyond merely teaching stakeholders about the technical principles at work in the system under development. He also felt it was incumbent on him to teach stakeholders about possible alternatives, other technical solutions available in context, how the system should be used once developed, or even why the developed system should be used at all (I6). The sentiment of teaching the users about why and how a system should be used was mirrored by another respondent, who was at the time working with secure IT-systems. He held that this "educational effort" was akin to that of a sales pitch: he felt that the ultimate success of the system for which he was developing requirements often depended on whether the users understood why the system was needed (I8). Notably, one respondent who at the time worked at a supplier emphasized the essential role of the IPT as a forum for information sharing between stakeholders, not just in terms of priorities and intentions but also the hard limits system functionality set on project timeframes and resource costs, all the while explicitly rejecting the term 'education' and its connotations (I9).

In some (albeit very particular) cases, this educational dimension of the role of the requirements analyst was seemingly not too far removed from that of the commonly rejected 'judge' or 'decision-maker'. Specifically, some respondents seemed to feel responsible for the contents of requirements (i.e., not just their formulation) in the odd cases when the analysts could swiftly identify that these contents obviously clashed with reality. For instance, one analyst remembers being tasked with refining a requirement, the fulfillment of which he, on closer mathematical inspection, found to be statistically impossible. While the discovery provided some minor contractual inconveniences between supplier and procurer in this particular case, the analyst was praised for his efforts and, in retrospect, considered bringing such issues to light an appropriate thing to do. In a similar vein, another respondent simply noted that he had had experiences of reworking lists of requirements on the basis that first drafts included requirements "breaking the laws of physics" (I10).

Most of the respondents, however, did not recount experiences with impossible or near-impossible requirements. Many respondents explained that, if they encountered requirements which they felt were questionable in context but not entirely implausible to execute, they would instead attempt to advise their counterparts rather than attempt to decide on an outcome (I6, I8). Mirroring their often-educational tasks, the respondents commonly offered advice when they felt that their positions provided them with an essential perspective for the solution of a problem (I9). The previously mentioned respondent who had rejected the label of education, for instance, later emphasized that it was appropriate for the requirements engineers of a supplier of a platform – owing to the rather unique insight such a position offers – to let "the procuring organizations and the user of the system know that it probably isn't too smart to bet on [a requested sub-system] because it will affect other capabilities" (S9). Another respondent recounted his experiences of disagreements between user and developers when it came to human-machine interfaces. The respondent noted that developers' understandings of the limits of human cognition and perception often clashed with user groups who tended to prefer total control of the functions of the system. He felt that requirements engineers' advice in the matter was often ignored, to the detriment of a satisfying solution to human-machine interface problems (I10).

It should finally be noted that a supporting construct to that of the educational or advisory role was that of risk management. Many respondents, independently of each other, compared their craft to that of risk management. One analyst, who at the time worked at FMV, leaned heavily on risk management concepts when describing his work to harmonize supplier and procurer sets of requirements for a system under development: the analyst constructed discrepancies between requirements lists in terms of risks of non-compliance with real needs (I4). Similarly, another respondent expressed deletion or removal of contradictory requirements in terms of risk. If one requirement was incompatible with that of another, the omission of the less desirable requirement would have to be described as a remaining risk – the risk that the value which the deleted requirement aimed to secure would be compromised by that requirement's omission (I5). To some, the metaphors used to describe requirements engineering invoked risk. In a vivid explanation of the nature of requirements, one respondent, using his index finger to draw a wide, irregular shape in the air, described a requirement as simply a tiny "pinprick" in a much wider, more diffuse need. The need as defined by this wide, irregular shape, he implied, could or should never fully be captured by a great number of small pinpricks: instead, he argued, the requirements should be selected so that they could represent this diffuse area. His analogy, invoking images of scatter-shot patterns or survivorship bias, suggests a view of managing the relationship between requirements and true needs based on mental models of probability, chance, and risk (I2).

6. Discussion

The results paint a picture of the Swedish defense requirements engineering sociotechnical imaginary in its constituent parts, consistent with theory. These constituent parts (the themes identified by reading of Skumsrud Andersens & Reichborn-Kjennerud), however, form a coherent whole, which through examination provides a larger framework of meaning. Therefore, this section first presents a discussion on how the themes are to be understood in unison, i.e., how the imaginary is constructed as a narrative composed of the identified themes – strictly speaking, this is the answer to the research question underlying this thesis.

Moreover, the implications of a sociotechnical narrative with these features are also discussed, pertaining both to RE theory and methodology, but also to the understanding of the Swedish defense sector *per se* and possible practical implications for RE practitioners of that sector. Finally, the potential limitations of the research design and execution are presented and discussed.

6.1. The narrative of the defense RE imaginary – a search for certainty

The results suggest that requirements analysts prefer to think of the Swedish defense sector as one ideally structured according to the principle of rationality. The respondents also clearly express the view that this ideal is spoiled by irrational distortions to a rational RE process. These distortions are very common – so common, in fact, that the exception to a purely rational process almost comes across as the rule. Taken to its *logical extreme,* this constellation of beliefs creates a somewhat contradictory image: one in which there is a clear principle which ought to be striven for, yet with no realistic option to do so. By outlining rationality as adherence to positivist RE processes in an environment wherein such processes are severely constrained, this imaginary may severely constrain the prospects of claiming any sort of traditional success in systems development. This paradoxical situation creates a constant state of exception: as the pervasive "irrational" disruptions become something akin to a norm, the requirements analysts' space for action can become a milieu filled with incomprehensible, undesirable randomness – a distorted, irrational mess. As such, merely the harsh delineation between successful and rational on the one hand and the failed and irrational on the other can act to produce an environment of emergency or abnormality.

The rational/irrational dichotomy part of the imaginary, then, is what provides the *foundation* for the remaining narrative: the meaning-providing story of systems development in the seemingly meaningless, irrational world.

This narrative ties into the milieu of randomness created by the dichotomy: the narrative's values, processes, and roles provide a measure of certainty in an environment where there is otherwise none. By constructing effect and integration as the prime values for future technological systems, the imaginary puts an onus on selection and sacrifice. Prioritizing effect, which per definition necessitates sacrifice of other system traits, limits the set of concerns or rival system values, enabling the imaginary analyst to gain a clear understanding of what, exactly, should be ignored. By restructuring effect as 'effect *at the expense of…'*, a potentially unlimited opportunity cost is avoided. Consequently, integration becomes important as a guarantee that such deprioritized system values were not sacrificed in vain: a sacrifice lacks meaning if it is unnecessary or if it does not achieve the desired goal.

Similarly, the processes which stood out in the results suggest an ideal of resolving uncertainty, or suitably allocating such uncertainty. By collaborating with all stakeholders, and by attempting to find a consensus in this milieu of randomness, an imaginary process creates a separate space of clarity where certitude can realistically be achieved in a broader chaotic environment. Inside this space there is shared meaning and understanding, and perhaps there is also some room for the rational systems engineering activities impossible on the 'outside'. Naturally, there is no better way to achieve a common understanding with others in these uncertainty-resolving contexts than to immerse oneself completely in the needs of other actors involved. Finally, the role of advisor or teacher follows logically on the views of ideal values and processes. These roles seem to suggest a lack of complete control – which is entirely consistent with the aforementioned "state of emergency"-worldview and the management of uncertainty inherent in the systems development in the sector. By conceiving requirements analysts as akin to advisors or teachers, the imaginary is consistent with the very real limits of requirement analyst power. The uncertainty is minimized, but not eliminated in the imaginary, and it would be objectionable to expect more from analysts than advice or wisdom in such a chaotic environment.

The sociotechnical imaginary thereby constructed by Swedish defense requirements engineers is internally consistent and coherent. The rationality/irrationality dichotomy by which these engineers operate creates the space in which they act. The narrative's themes are what fills that space with meaning and purpose. That meaning centers on selection and sacrifice, collegial reduction and allocation of uncertainty, and playing a role akin to that of a teacher. This is the sociotechnical imaginary of Swedish defense requirements engineers.

6.2. Implications of the imaginary

Some theoretical implications of this sociotechnical imaginary merit further discussion. First, the results of the study imply that there is reason to investigate the process of RE *as is,* not as it ought to be. The existence of a sociotechnical imaginary among defense requirements analysts suggests that there is a rich body of meaning created in context, between individual analysts. This meaning does not reveal itself deductively, through ever more rigorous game-theoretical studies and simulations. Such socially created meaning must be investigated at the source, by examining not only *what* analysts say, but also *how.* This point is largely in line with – but is more radical than – the view and methodology of the strands of RE research that has called for more attention to the political nature of requirements (Bergman, et al., 2002).

Second, the results suggest that the corps of analysts have a large collective impact on the outcome of the development process, not only as professionals, but also as social individuals. The values, delineations, and perceived purposes of requirements analysts could potentially impact the definition or criteria of success, states of normalcy, or even the inclusion or removal of requirements in a system specification, drafted in a context of uncertainty. It is the individual analysts who, according to their understanding of their own roles, the appropriate processes to be followed, and the desirable features of the intended machine, create the system by setting the legitimate parameters of the requirements that will ultimately govern its design. This study reconfirms, much like the writing on requirements engineering stopping rules and common understandings of requirements, that analysts are powerful social actors, whose sense of appropriateness provides a mechanism for enablement (Ovaska, et al., 2005; Pitts & Browne, 2004).

Finally, while previous research has already applied the sociotechnical imaginary concept to the military, the results of this study suggest that it is meaningful and important to investigate the presence and characteristics of military imaginaries on a 'lower' level than has been done before. While it is obvious that the values and imaginations of higher-level decisionmakers impact large organizations, this study shows that it is also important to consider the imaginaries of subordinates or technical specialists in matters of national importance. Those drafting military doctrines and strategies obviously matter, but so could those entrusted to design fuses, fill out Excel spreadsheets, drive trucks. While there is nothing to suggest a split between the imaginaries of higher-echelon defense planning decisionmaker and requirements analyst in the results of this study, it could emerge as an issue in other matters of defense systems development or in defense planning overall, especially in areas where sub-groups vie to have their visions accepted by the community overall (Hilgartner, 2015).

It is also necessary to address some empirical implications of the thesis. Sweden might be uniquely likely to not rely on a defense RE sociotechnical imaginary as a structuring principle in its defense sector. Given that it does, however, the results (especially pertaining to the features of that imaginary) are empirically important for understanding outcomes in Sweden. The observation that the imaginary might enable the construction of systems which prioritize effect and integration is immediately noteworthy. Moreover, the results suggest that despite the organizational decision to separate the user organization from the procurer organization, and despite the decision of the Swedish government and state not to have controlling ownership over defense firms, there seems to be a significant desire among requirements analysts to create communities of consensus extending across organizational limits and an appreciation for the ability to step into the shoes of other stakeholders in the set of stakeholders. This, of course, is neither good nor bad *per se*, but it is potentially an important feature of the Swedish defense sector worth studying further.

Another important empirical observation is the fact that, regardless of whether it is true or not, there is a strong sense among Swedish requirements analysts, that RE is not only challenging, but also underappreciated and most often not given the attention it deserves. There is a pervasive sense that defense RE is often mishandled. This thesis is not intended to answer whether this is the case, but a core feature of the ontology and methodology used here is that social perceptions matter. A sense of failure or neglect matters because it impacts the foundational delineation between rationality and irrationality – which, as this thesis has indicated, provides the basis for application of the defense requirements engineering imaginary.

Finally, while this thesis has not directly been intended to improve the practice of RE, there is one notable practical observation discernable in the results. It has become apparent over the course of the interview study that the corps of Swedish defense requirements analysts is professional, principled, conscientious, and highly focused on the task of providing a crucial service to society. Yet despite these manifest virtues, the respondents collectively described a practice stained by a multitude of irrational problems, beyond the power of analysts to control. One important implication of this thesis is that the manner of a problem’s social construction proscribes and potentially limits its potential solutions. By connecting success to an extremely narrow and uncommon set of constructed social criteria – that which is rational – the imaginary constrains the language surrounding (and therefore the understanding of) the norm: the chaotic, irrational world. There is a risk that, by treating the norm as the illegitimate exception, RE literature and practice become blind to the true structure of the field – the risk that the communities of defense RE mistakenly come to believe a feature to be a bug. The results therefore suggest that such requirements analysts might be better served by a recognition of the inescapable political and social nature of their highly technical craft, as well as their own crucial role in creating not only solutions, but also problems, in social contexts.

6.3. Limitations and suggestions for further research

While imaginaries and similar social constructs have been shown in a great number of cases to enable structured behaviors, it is important to note that this study has not shown that there is a direct causal relationship between, for instance, the ideal system behaviors in the imaginary on the one hand, and how systems turn out in practice on the other. Therefore, this study should not be interpreted as evidence that the Swedish defense sector only churns out systems tailored for effect and integration. The thesis instead shows that the production of such systems might be *enabled* or perhaps incentivized by the way that the defense RE imaginary has been constructed. The thesis has attempted to contribute to RE understanding by identifying that which is constructed as reasonable, justifiable or appropriate, which falls short of causality while still being a powerful enabler of outcomes (Weldes, 1996). Further research – perhaps in the shape of more specific case studies using process tracing methodology – could show if or how this imaginary could play into a concrete defense RE process.

The imaginary here presented strictly only pertains to requirements analysts in the Swedish defense sector. As was noted in this thesis's method section, Sweden presents an extreme case in terms of conditions suitable for *rational* defense RE. Thus, it could be argued that the presence of a defense RE imaginary in this case would suggest that other RE communities, where conditions might be even *less rational*, would also host such imaginaries. However, it should be noted that this generalizability cannot be taken too far. Specifically, one should not expect to be able to extrapolate the individual features or structure of the Swedish defense RE imaginary to other defense sectors. While this thesis suggests that we should expect to find defense RE imaginaries in other defense sectors, we should not assume those imaginaries to look or behave the same. Whether this is considered a virtue or weakness of the present thesis is an open question: a weaker geographical generalizability here also means a clearer empirical contribution regarding Sweden *per se*. Understanding of the Swedish defense sector's imaginary can of course be a goal unto itself.

The interview study presented above was based on a selection of 10 expert requirements analysts in the Swedish defense sector. While a snowball sample selection technique was used to broaden the sample, the initial set of respondents were identified through contacts at a private firm the author made when he briefly worked there. This arrangement might ordinarily present risks of bias, as the interviewer's relationship with the respondents could unduly influence results. In the present case, this appears unlikely for two reasons. First, while contacts were used to identify the set of initial respondents working at the same company as the author of this thesis, the latter had had no extensive personal contacts with any of them and had not participated in any projects with them prior to the interview. Secondly, it should be noted that respondents were asked to speak (albeit candidly and informally) about a highly technical and professional craft. In contrast to the more typical subjects elucidated through biographical-narrative interview techniques, RE practice is usually not seen as traumatic, sensitive, or shameful. Far from appearing ashamed, regretful, or constrained, respondents seemed pleased to get the opportunity to speak about their craft. It therefore seems unlikely that the respondents' and the interviewer's professional relationship introduced any major bias.

The snowball technique used, however, presents further potential issues which merit discussion. The fact that respondents were primarily identified in the same context could potentially suggest that initial sampling was too narrow to fairly represent the broad Swedish defense sector. Notably, most of the respondents were engaged with information and cyber security systems at the time of the interview. If a substantial share of the respondents had only had experience with one type of defense system, it could be argued that the imaginary identified above might more fairly be described as an imaginary pertaining *only* to a subset of requirements analysts, and not to the Swedish defense sector overall. Yet, there is some reason to believe the results are thematically representative of the defense sector in its entirety. While most of the respondents were at the time working with defense information systems specifically, the respondents overall possessed a suitably widespread in terms of scope of experience: together, the respondents had had experience with working on major platforms in three different domains, combat and combat support systems, and with all three major actors in the sector. Most importantly, the argument could be made that for larger contemporary defense systems, information sub-systems are not only the norm, but might also be one of the most crucial components and enablers of capability. Thus, a majority of requirements analyst respondents focusing on information systems might actually be indicative of the Swedish defense sector.

Finally, the gendered dimension of the sample is noteworthy. The fact that respondents were exclusively men undeniably invites criticism that the imaginary presented in the results are merely the *male* Swedish defense RE imaginary. While only availability limited the sample to males, and while it is this author's personal impression that males make up a very large proportion of the relevant population, this thesis' ambition for theoretic generalizability would ideally have necessitated a larger, if not equal, share of women in the sample. Further research should address this limitation by improving the share of females in the sample.

7. Conclusion

The interview study presented in this thesis was inspired by the seeming incongruence between factors identified as crucial for the successful conduct of such RE and the conditions which seemed to characterize the peculiar domain of defense systems development. Moreover, substantial effort is manifestly vested in getting defense RE right, as a sizeable cadre of highly educated, skilled, and conscientious officials and professionals are always involved in such development efforts. Yet, judging by well-publicized procurement difficulties and the testimonies of requirements engineers themselves, a flawless defense RE process seems remote, despite application of ever more sophisticated systems engineering rationality.

To reconcile these observations, it was here suggested, it is necessary to examine this rationality in the defense sector not as an objective given truth, but rather as part of a socially constructed structuring principle. Rejecting a strictly positivist ontology as a basis for defense RE, the purpose of this thesis was to understand and outline the construction of this structuring principle by those most crucial to its operation: the requirements engineers themselves. Leaning on STS theory, the sociotechnical imaginary concept was applied as a framework for understanding the workings of that principle and the role rationality might play in it. Consequently, the structure and meaning of this sociotechnical imaginary, and how rationality plays into it, is the answer to the research question which was posed to direct this thesis.

The results of the interview study of Swedish requirements engineers presented in this thesis indicates that rationality figures as part of a dichotomy which dictates the normal and – more commonly – the exceptional states of being in defense RE. Rationality and irrationality, then, figure as that which defines the state of exception. In this chaotic environment, there is the sociotechnical imaginary’s narrative component: the set of values, processes and behaviors which provides guidance in a seemingly incomprehensible, irrational space. It was found that in the space of irrationality, effect and integration is redefined and enabled, empathic cooperation is crucial, and analysts must be teachers. Suffice to say, this socially constructed, inductive view of RE is not simple or convenient, nor might it be necessary for all requirements related problems. However, it could hopefully play a part in understanding – and coming to terms with – the frustrations and difficulties of a crucial aspect of defense and defense systems.

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