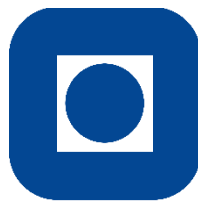# How to make Enterprise Architecture attractive for decision makers by leveraging methods and techniques from the field of Information Visualization

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Abstract

Enterprise Architecture is a relatively young architectural discipline that merges strategic business goals and information technology objectives. It is considered to be a promising instrument to provide management with insight and overview to drive portfolio planning in a holistic context. Despite its promises, architects *discern a reluctance by decision-makers to include and use architectural products* in their business processes.

This master thesis examined underlying causes for that lack of interest by performing a case study in the Norwegian Defense. Interviews, augmented by observation and document inspection were used to collect data. The data analysis revealed *lack of understanding* to be a principal issue. Innate complexity and alienation caused by unfamiliar terms were pointed out as essential sources.

Additionally, this master thesis studied how Information Visualization potentially could increase the attractiveness of architectural products. A thorough literature review was conducted to discover techniques on how to represent complex information, and to identify best practices on how to present such information in novel and inspiring ways.

Findings indicate that a conscious application of methods and techniques from Information Visualization can have a positive impact on presentation of complex architectural information. Guiding principles are pointed out to be clarification, customization and standardization. However, this will require some adjustments in the architects' skillset. Among others, basic knowledge to decide on appropriate encoding and how to do storytelling with visualization.

Further research could be used to verify these indications, by comparing attractiveness of architectural products before and after an implementation of methods and techniques put forward in this study.

Sammendrag

Enterprise Architecture[1] er en forholdsvis ung arkitektonisk disiplin. Den brukes til å beskrive sammenhengen i en virksomhet, fra strategiske forretningsmål til planlegging og bruk av informasjonsteknologi for å oppnå disse. Det anses for å være et lovende instrument for å gi ledelsen innsikt til å kjøre helhetlig porteføljestyring.

Til tross for denne muligheten, oppfatter arkitektene en motvilje blant beslutningstakere til å inkludere og bruke arkitekturprodukter i sine beslutningsprosesser.

Denne masteroppgaven undersøker bakenforliggende årsaker til denne manglende interesse ved å utføre en casestudie i Forsvaret. Datainnsamlingen foregikk hovedsakelig med hjelp av intervjuer, men observasjon og dokumentinspeksjon ble også brukt for å kompletter bildet. Analysen av dataene viste først at mangel på forståelse var hovedproblemet. Iboende kompleksitet og fremmedgjøring forårsaket av ukjente begreper ble pekt ut som viktige årsaker. I tillegg ble det undersøkt hvordan visualisering kan bli brukt for å gjøre det mer fristende å bruke arkitektur. En litteraturstudie ble avholdt for å oppdage representasjonsteknikker for kompleks informasjon, og for å identifisere nye og inspirerende måter å presentere denne på.

Funnene tyder på at en bevist bruk av metoder og teknikker, som forenkling, tilpasning og standardisering kan ha en positiv innvirkning på presentasjonen av komplekse arkitekturprodukter. Det vil imidlertid kreve at arkitektene tilegner seg grunnleggende kunnskap om informasjonsvisualisering.

Hvorvidt de funnene og de beskrevne forslagene til forbedring virker i praksis kan være interessant å forske videre på.

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[1] Forfatter har valgt å beholde Enterprise Architecture som begrep siden en oversettelse til norsk mest naturlig er virksomhetsarkitektur. Virksomhetsarkitektur, derimot er allerede et innarbeidet begrep på norsk og tilsvarer det som på engelsk kalles Business Architecture eller Operational Architecture, avhengig av hvilket rammeverk det refereres til.

Preface

Very special thanks are due to my family, Toril, Tord and Vetle, who supported me even as I stole precious time away from them to complete this work, and to Aurora and Mina, understanding I could not visit them as often as I would have liked to, in this period. I know you have had to live with a somewhat distant husband and father whose thoughts were always on his master thesis.

Some may say choosing a qualitative research design is the easy way out of doing a master thesis. I'll say no – it's not. It's an enduring selection of best options and the way forward where conscious selections have had to be made daily. It is not a lie to say that some days have been though. However, I found a lot of support in books. I like books. In particular, I like good books. Books that provide insights into new knowledge in a comprehensible way. I know when I read books like that, but I don't know how to write them. I have never fancy writing. That's probably why I can't write them. What I do fancy, is to help people safely maneuver in this ever increasing abundance of information. To use new technology and new methods to label, structure and organize information. That's likely the reason why I call myself an information architect.

"Looking at something doesn't mean you see it". The basketball video shown in one of our classes was a *real eye-opener* to me. For those of you that still haven't seen it, visit http://www.theinvisiblegorilla.com/videos.html, and follow the instructions. This and other classes inspired me to learn more about information visualization, and that is why this is a part of this thesis. I have learnt a lot from my some-years-younger classmates, they being young and enthusiastic, I being somewhat more reserved and assessing. Sometimes I saw their optimistic approach wouldn't work, most of the time I kept my mouth shut. It has been inspiring being a part of class filled up of creative designers. Especially for me, coming from a world of technocrats. So thank you all classmates. Thanks to my supervisors, Amalia Kallergi and Kirsi Helkala, who gave me deadlines and thoroughly followed up all my work, always providing good advices during this journey. It wouldn't have been the same without you. Now I look forward to engage with new colleagues and practice some of my newly acquired knowledge.

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1. Introduction

1.1 Topic Covered

This study covers Information Visualization (IV) related to Enterprise Architecture (EA). EA is a relatively young architectural discipline that merges strategic business and information technology objectives in order to drive portfolio planning in a holistic context (Jensen et al., 2011). Visualization, according to McCormick et al. (1987), offers a method for seeing the unseen, that fosters profound and unexpected insights. This corresponds well with the dictionary definition of visualization (Webster, 2015): *visualize: to see or form a mental image of*. Information Visualization (IV), in its simplest terms, can be described as data transformed into pictures, whereas the pictures are interpreted by a human being (Spence, 2007). Hence we can say that a principal task of IV is to allow insights to be derived from data.

EA is considered to be a promising instrument for providing management with insight and overview to harness complexity (Op 't Land et al., 2009). This complexity is a result of a comprehensive set of data of different types, e.g. quantitative data, ordinal data, categorical data. This study investigates how these diverse data types can best be represented and presented, by use of best practice from information visualization in order to enhance sense making and achieve informed decision-making, as depicted in Figure 1.
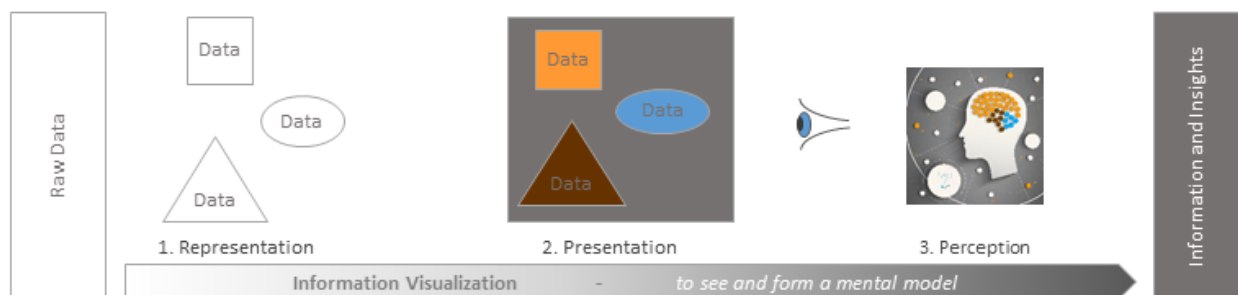
Figure 1: Steps of Information Visualization

1.2 Keywords

Information Visualization, Enterprise Architecture

1.3 Problem Description

The plan for INI 2030 (Cyberforsvaret, 2015c) describes a vision for Networked Operations in the Norwegian armed forces in 2030. The plan includes a roadmap with the necessary steps towards the desired end-state. These steps are directly related to a database called **Nor**wegian **A**rchitecture **R**epository (NORAR), where architectural master data (artifacts) are stored and maintained. The roadmap assures that all developmental activities are consistent and coherent with existing information, so that new solutions are interoperable and sustainable. Complementary to the database tool, the development of solutions is supported by two frameworks. The NATO Architecture Framework (NATO, 2014) is used to guide the meta model, views and models - the *what to,* whereas TOGAF[2] is used to guide the processes and procedures - the *how to.* A national advisory board is governing the execution, to ensure that all developmental activities are directed towards a common goal.

Despite the application of a well-established framework (NATO, 2014) and a recognized tool set (Systems, 2015), *there exist challenges in presenting the stored artifacts*. Today architects extract information from the NORAR database, and produce different figures in self-composed presentations for decision-makers. Checklists exist to help verify and validate the architectural content (Cyberforsvaret, 2015b, Cyberforsvaret, 2015a). This is insufficient to achieve an understanding at the decision-making level. Leading architects in the Norwegian Defense state that there *exists a problem in presenting complex architectural information in a way that provides for an understandable and holistic picture suitable for sound decision-making* (Apalvik, 2015).

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[2] TOGAF: The Open Group Architecture Framework - http://www.opengroup.org/subjectareas/enterprise/togaf

Enterprise architects in NATO recognize similar challenges. Recently, NATO organized an Enterprise Architecture Hackathon (NATO, 2015) to address some of the issues with participants from national governments and industry, such as a *lack of proper visualization and unattractiveness of architecture products*. This lack of appeal may affect the quality of products and services, and hamper progress.

Other studies support the abovementioned findings. An example is the comprehensive study (Roth et al., 2014) about EA Visualization Tools that confirms that EA practitioners' main pain points *includes lack of understanding and stakeholder buy-in*.

1.4 Justification, motivation and benefits

Both research and experience indicate that Enterprise Architecture has the potential to bring added value to organizations. Tamm et al. (2011) conducted a systematic review of books and academic journals in the EA space in order to get a trustworthy picture of benefit claims. An EA Benefit Model was developed during the study and found amongst others following possibilities: reduced IT-cost, better alignment between IT and strategic goals, more responsiveness to changes, and improved business processes. The study finds that the quality of the Enterprise Architecture is vital to realize the abovementioned possibilities*, where one of the measurements of quality is the effectiveness of presentations*. A more recent study (Langeland, 2015) into how to successfully implement Enterprise Architecture underscores the importance of *making architecture communicable to stakeholders*. Consequently, this study is based upon *a tenet that enhanced presentations (visualizations) can improve the definition and representation* of a high-level view of an enterprise's business processes and IT systems. Bygstad and Pedersen (2012) state that there is a lack of research regarding practical implementation. This study is meant to fill a void regarding practical implementation of Enterprise Architecture, with focus on how visualization can be used to make it more inviting and intelligible to a broader audience.

1.5 Research Question

This led to the following research question.

To what extent is it possible to take advantage of methods and techniques from the field of Information Visualization to increase attractiveness of Enterprise Architecture? This includes

- a) to examine underlying causes for the lack of interest in architectural products by decision-makers,
- b) to discover ways to represent information used for strategic decision-making, and
- c) to investigate novel and inspiring ways of presenting that information.

1.6 Contributions

As the core of this master thesis was to study issues regarding inclusion of Enterprise Architecture in existing decision-making processes, *a key contribution was to document underlying causes* for *lack of interest in architectural products*. These findings were used as a basis to investigate if and how information visualization could benefit its attractiveness. Therefore, a*n equally important contribution was a set of advices* (best practices) on how to encode (represent) and visualize (present) architectural information. Findings are intended for larger governmental organizations, however it may be applicable also for other, smaller organizations that need to get some traction in the implementation and use of Enterprise Architecture.

An important delineation made for this study is level of details related to where it is applied. As remarked by Jensen et al. (2008), it would be impractical to analyze all projects in a roadmap at solution level detail. Consequently, the effort will be pointed at enterprise planning level.

This is an essential delineation to focus on those aspects of the research problem that address the issues regarding the architecture's suitability for decision-making. Related to this, Harishankar and Daley (2011) points out that historically there is a lack of strong and formal representation of the business aspects in Enterprise Architecture. Another important delineation is considering the organizational scope of the study. Wherever terms are used like Norwegian Defense, Norwegian Armed Forces or similar, these are restricted to the authority delegated to what is called Cyber military affairs. The author recognizes that other communities of interest related to architecture exist, notwithstanding those are not covered by this study.

1.7 Definitions

Enterprise Architecture (1): A set of artifacts representing the design of an enterprise's business and IT, that alongside a set of principles, roles and processes, direct that enterprise towards a desired future state (Gunther, 2014).

Enterprise Architecture[3] (2): The description of the business as a system of components, the relationships between these components, and the principles and guidelines that govern the enterprise's design and development. The purpose of an Enterprise Architecture is to support the effective implementation of a business strategy (Cyberforsvaret, 2016).

Information Visualization (1): Tool and techniques, including representation, presentation and interaction that aids the formation of a mental model (Spence, 2007)

Information Visualization (2): The use of computer-supported, interactive, visual representation of abstract data to amplify cognition (Card et al., 1999).

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[3] Translated from Norwegian: Beskrivelsen av virksomheten som et system bestående av komponenter, relasjonene mellom disse komponentene, og de prinsipper og retningslinjer som styrer virksomhetens design og utvikling. Formålet med en virksomhetsarkitektur er å understøtte effektiv gjennomføring av virksomhetens strategi.

1.8 Structure of this report
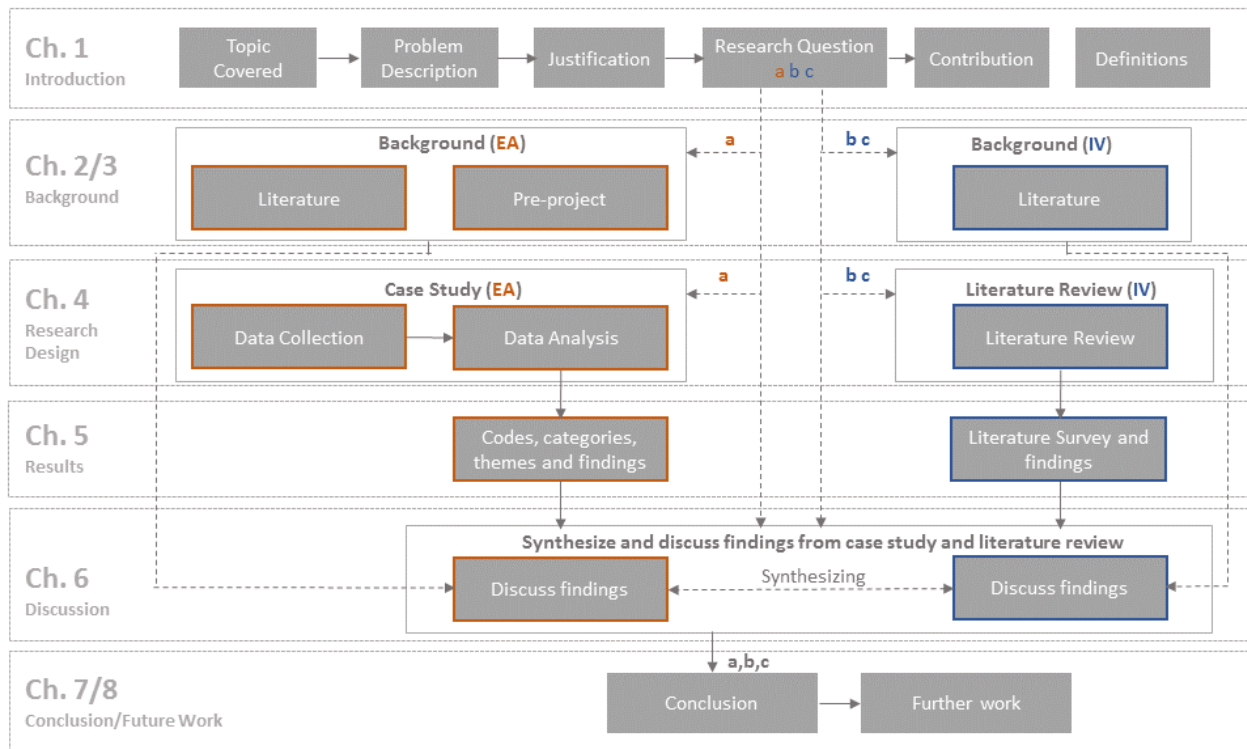
Figure 2: Provides an overview over the study and the structure of the report

An overview over the study is offered in Figure 2. **Chapter two and three** provide a theoretical foundation for the thesis. Chapter two establishes a common view on what Enterprise Architecture is and what it means for an enterprise. Chapter three describes fundamental properties of Information Visualization and how it is interpreted in this study. **Chapter four** describes the research design and methods used in the study. A case study was selected as method for acquiring more knowledge about the current situation to answer part a) of the research question. To answer part b) and c), a comprehensive literature review on Information Visualization was conducted. In **chapter five**, results and findings from the EA case study and the literature review are made available. Following in **chapter six,** these findings are discussed in relation to existing literature and research, and each other in an attempt to answer the research questions. Advices are given for the exploitation of visualization to increase attractiveness of architectural products. In the conclusion chapter, **chapter seven**, the outcome of the research is evaluated towards the research questions, and finally, some proposals for future work are listed in **chapter eight**.

2 Enterprise Architecture

2.1 Enterprise Architecture in this study

One of the most important topics on today's enterprises' agenda is the harmonic alignment of business with supporting technology in order to support agility and transformation (Jensen et al., 2011). Enterprise Architecture (EA) is one way to foster this alignment through an enterprise wide focus, including both strategy and planning. Strategy includes knowledge about business opportunities and technological possibilities, whereas planning covers transition planning and architecture governance.

As this is a young discipline, several definitions of EA exist. IBM defines EA to be an architectural discipline that merges strategic business and IT objectives with opportunities for change and governs the resulting change initiatives (Jensen et al., 2008). This is also supported by Gartner who provides following definition (Gartner, 2013); Enterprise architecture (EA) is a discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analyzing the execution of change toward desired business vision and outcomes. In a later paper IBM revised the definition where they distinguish between EA as a discipline and EA as a construct (Jensen et al., 2011).

That brings us closer to how EA is interpreted and used in this study. This definition is also closer to the definition from Op 't Land et al. (2009), where EA is looked upon as a coherent set of descriptions, covering a regulations-oriented, design-oriented and patterns-oriented perspective on an enterprise. These perspectives provide indicators and controls that enable the informed governance of the enterprises evolution and success. This is in particular true for the first two perspectives, described to be complementary to each other, where the first perspective "*accommodates for the needs to steer and direct developments*", whereas the second perspective

is about *"gaining insight into the enterprise's design while also providing guidance to the designers of enterprise systems"*.

It seems clear that an appropriate definition for this study should cover both dimensions; a description of artifacts representing an enterprise's design and the policies and principles used to govern the enterprise's further development of their Enterprise Architecture. This is well synthesized in a recent paper *Measuring EA effectiveness* (Gunther, 2014), and is the same definition as will be used in this study.

Enterprise architecture (EA): A set of artifacts representing the design of an enterprise's business and IT, that alongside a set of principles, roles and processes, direct that enterprise towards a desired future state (p.3)*.*

2.2 Enterprise Architecture in Norwegian Defense

The purpose for use of Enterprise Architecture in the Norwegian Defense is stated in *Bestemmelse om bruk av arkitektur i Forsvaret[4]* (Cyberforsvaret, 2016). This document is a draft version and despite anticipated changes in scope and authorization levels, it is clear that the intent for the use of Enterprise Architecture in the Norwegian Defense organization will stay unchanged. As described earlier under Chapter 1.6, this study is limited to use of architecture for Cyber Military affairs only. The directive defines roles and responsibilities regarding use of Enterprise Architecture, and provides directions on processes and tools. For instance, the mandate for the Architecture Board is given here.

In general, the acquisition process in the Norwegian Defense is initialized by the Ministry of Defense (MoD) tasking the Armed Forces to launch a project responsible for establishing project documentation necessary for further decision-making (Forsvaret, 2014). Fundamental to this is the creation of a document called Fremskaffelsesløsning[5]. A Project Coordinator will be appointed and made responsible for bringing this forward. In guidelines given to the Project Coordinator,

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[4] Translated from Norwegian: Directive for use of Architecture in the Norwegian Defense
[5] A comprehensive description of the solution to be acquired, including goals and objectives, demands and requirements, alternative and proposed solution, time, investments, scope and life cycle costs. Current template is available at https://forsvaret.no/prinsix/Prosjektfaser/Definisjonsfase.

the following expectation is stated – «*nettverkskoblinger og komplekse sammenhenger knyttet til informasjonsinfrastrukturen skal dokumenteres ved hjelp av arkitektur …[6]*» (Forsvaret, 2014). It is expected that these architectural descriptions include both business models and technical infrastructure, and states their mutual importance. Furthermore, it states that these architectural products will help locating this project in the bigger picture, both current and future. The responsibility for different parts of the Enterprise Architecture is divided between organizational units. The draft document of *Project Architecture -Diagrams* (IKT, 2015) is consulted whenever it is required to deliver architectural products as part of at the project documentation. This document will be subject to analysis as part of the document inspection included in the case study (see 5.1.3). The same is case for a document called *Sjekkliste for arkitekturgjennomgang av FL i Forsvarets arkitekturråd*[7] (Cyberforsvaret, 2015a). These two documents are used to guide both the development and the inspection process of architectural products supporting the acquisition process. It is recommended (not: required) to include a total of eight architectural products in the checklist that is expected for the Architecture Board's review. It is furthermore stated in these documents, that a project may be endorsed even if some models are insufficient or lacking. In the end, a comprehensive evaluation is done based on the totally, and based on the Board members' collective assessment and a decision based on consensus. An overview over those eight products are listed in Table 1, and examples are offered in Appendix H. The names of the architectural products are taken from NATO Architecture Framework (NATO, 2014). Use of some of these products are evaluated as part of the observation under the case study (see 5.1.2).

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[6] It is mandatory to use architecture to document links and complex relations in the information infrastructure.
[7] Check list for scrutinizing architectural products in FL in The Architecture Board.

Table 1: Architecture Products used in FL production

Architecture Product	Description
NAV-1	Stakeholders' concerns
NPV-2	How project and deliveries underpin goals and capabilities
NPV-2 (detailed)	How project and deliveries are depended of other project(s)
NSOV-3	Mapping of deliveries towards NATO C3 Classification Taxonomy
NSO-1	Operational Concept
NOV-2	Operational Cooperation, information flow and collaboration
NSV-1	System roles (technical solution)
NSV-12	Service(s) delivered by system(s)

2.3 Enterprise Architecture related work

As the first study mentioned in the next paragraph points out, there is not much related work and only a limited amount of research available. This chapter is therefore somewhat limited in extent. Langeland conducted a research on how to successfully implement Enterprise Architecture (Langeland, 2015). He noticed it *to be difficult to find studies directly related to visualization* of architectural products and its effect on attractiveness. However, one recent comprehensive study about Enterprise Architecture Visualization Tools was completed by Sebis[8] (Roth et al., 2014).

2.3.1 Enterprise Architecture – successful implementation

The study *Virksomhetsarkitektur – Hva er de viktigste faktorene for å lykkes med innføringen?*[9] (Langeland, 2015) was performed in 2014 – 2015 and investigated how to successfully implement Enterprise Architecture. Norwegian Defense was used as a case and the research design was based on the Delphi method. This method requires a group of experts who

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[8] Sebis: Software Engineering for Business Information Systems, Technische Universitat Munchen, Germany.
[9] Translated from Norwegian: Enterprise Architecture – What are the most important aspects for successful implementation.

anonymously reply to questionnaires. The group response is analyzed and the process repeated until an expert consensus is obtained (RAND, 2016). The relevance of the study discussed is based on the fact that the same organization was involved in both that study and this thesis. One finding is in particular interesting and of relevance. Among the prioritized factors, was the importance of making Enterprise Architecture communicable. This entailed both to make it readable and usable, and to make it adaptable to different audiences. Moreover, it included making it less "technical" in order to fit in to more general decision processes.

2.3.2 Enterprise Architecture Visualization Tool Survey 2014

Enterprise Architecture Visualization Tool Survey (Roth et al., 2014) is probably the paper most relevant for this study. As the authors state in their paper, this is a comprehensive study about EA tools and their support of visualization. The paper has extensive information about visualization techniques and examples of their practical use. Unfortunately, there is little evidence that points to what makes one type of visualization more appropriate than another, or why certain elements need to be represented to achieve the intended communication purposes. At least not directly. Indirectly, this can be derived in a way based on the knowledge acquired during their study, i.e. every type of visualization presented is connected to a particular usage and stakeholder in a certain way. In their research design they used a two-folded approach. In step one, an online survey was conducted among 18 EA tool vendors to get an overview of the current state-of-the-art in EA Visualization. All together they received over 1000 visualizations, and after a careful consideration they ended up with 26 distinct visualization types they found succinct. These visualizations instituted the basis for step two, a second online survey. This time, EA practitioners were targeted. The aim was to find out which visualizations were currently used and typical usage scenarios. An example of such visualization is provided in Figure 3.

A flow diagram depicts the flow of data or control between different entities. Typically, flows are represented by arrows and structural entities are represented by boxes or symbols. In EA, for instance, flow diagrams are used to visualize business process steps or data flow between different applications.

Usage

According to our survey, 74 out of 109 practitioners use some kind of flow diagram. They provided 74 examples to illustrate how they use this visualization type. Flow diagrams are mainly used to display information about business aspects and, to a lesser extent, the application landscape.

Strategy	3%
Business	59%
Applications	59%
Infrastructure	7%
Cross-Cutting Aspects	4%
n = 74	

Usage Domain

Strategy (3%)
Business (59%)
Cross-Cutting Aspects (4%)
Applications (27%)
Infrastructure (7%)

Figure 3: Example from EA Study - Flow Diagram explanation and usage (Roth et al., 2014)

Flow Diagrams were one of the frequently most used diagrams. Figure 4 displays the findings from the study. It is worth to notice that on the top of the list visualizations either show relational or time information, thus these types could be considered as typical.

Visualization Type	Value
Matrix	82
Cluster Map	82
Timeline	77
Flow Diagram	74
List	73
Graph/Tree	64
ER Diagram	63
Bar Chart	54
BPMN Diagram	51
UML Diagram	50
Bubble Chart	50
Treeview	48
Pie Chart	42
Dashboard	41
Kiviat/Spider	39
EPC Diagram	29
ArchiMate	28
Line Chart	27
Scatter Chart	24
Geographical Map	21
Business Model Canvas	18
Gauges	12
Treemap	11
Tag Cloud	8
Sunburst	8
3D	3

Figure 4: Usage of visualization types (Roth et al., 2014)

Another interesting finding from the study is the 75 out of 109 participants replied that they customize visualizations, and that most customization is done internally. Even more interesting, and maybe surprising, is the fact that most of the customization is done manually, although both scripting and wizards are offered in many tools. Figure 5 gives an overview over which visual attributes are modified in the customization process.
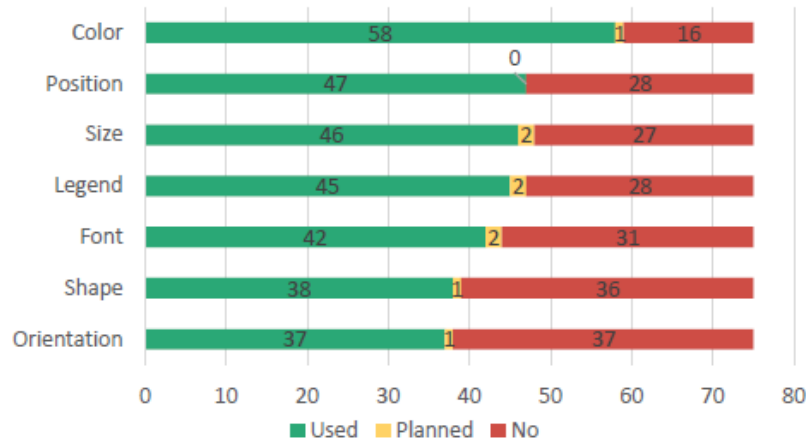
Figure 5: Which visual attributes do EA practitioners customize? (Roth et al., 2014)

Yet another unanticipated finding from the study was about the software tool used for creating the EA visualizations. As depicted in Figure 6 the three most used tools are not EA tools at all, but ordinary Microsoft Office software.
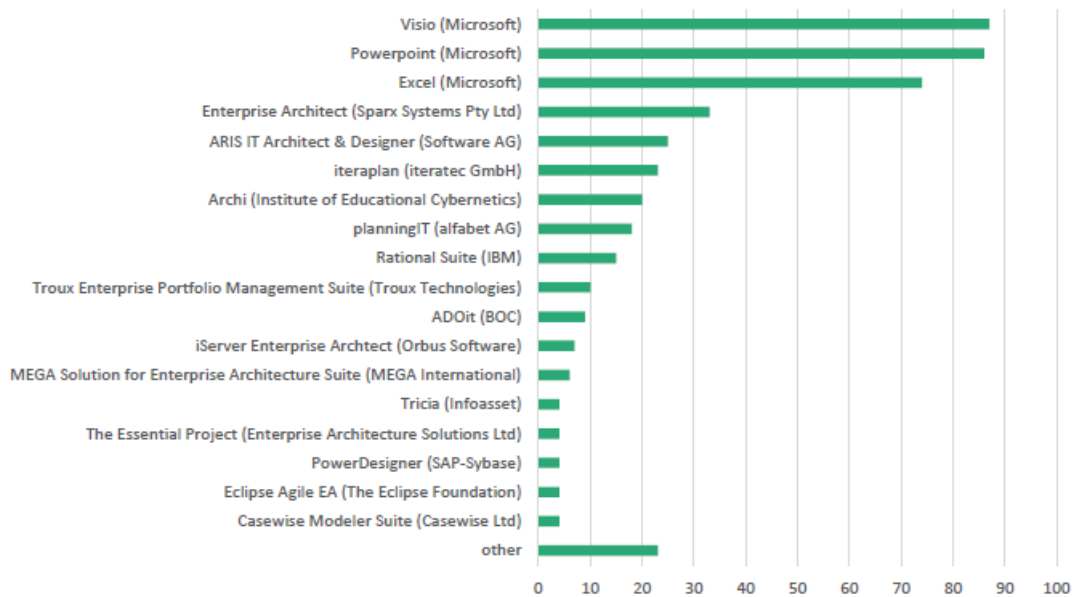
Figure 6: Tools used to create EA visualizations (Roth et al., 2014)

3 Information Visualization

3.1 Information Visualization in this study

Visualization, according to McCormick et al. (1987), offers a method for seeing the unseen, foster profound and unexpected insights. Furthermore, the authors state it is to study those mechanics in humans and computers which allow them in concert to perceive, use and communicate visual information. Pickover and Tewksbury (1994) state that people mainly perceive information through vision, as this is the most developed part of the human perception system. The perception system does not only receive information, but it also understands it. Colin Ware introduces in (Ware, 2004) a three-stage model for human perception. The first stage is rapid parallel processed detection of edges' orientation and color of a patch. The second and third stages are slower, as it involves both working and long-term memory. Therefore, it is important that the visual information is presented in a way that facilitates the human cognitive process. Design which conflicts with preferences imposes an unnecessary cognitive workload (Zhang, 2007). A too demanding cognitive workload may also cause inattentional blindness, resulting in failure to notice an unexpected object when attention is focused elsewhere (Bredemeier and Simons, 2012).

So how do we facilitate the human's perception and cognition? In the field of Information Visualization (IV), representation – together with presentation and interaction, constitute important building blocks that can help stakeholders acquire insight and understanding (Spence, 2007). Figure 7, borrowed from Spence (2007) and modified to fit topic for research can be used to better understand how information visualization is implemented as part of this study.
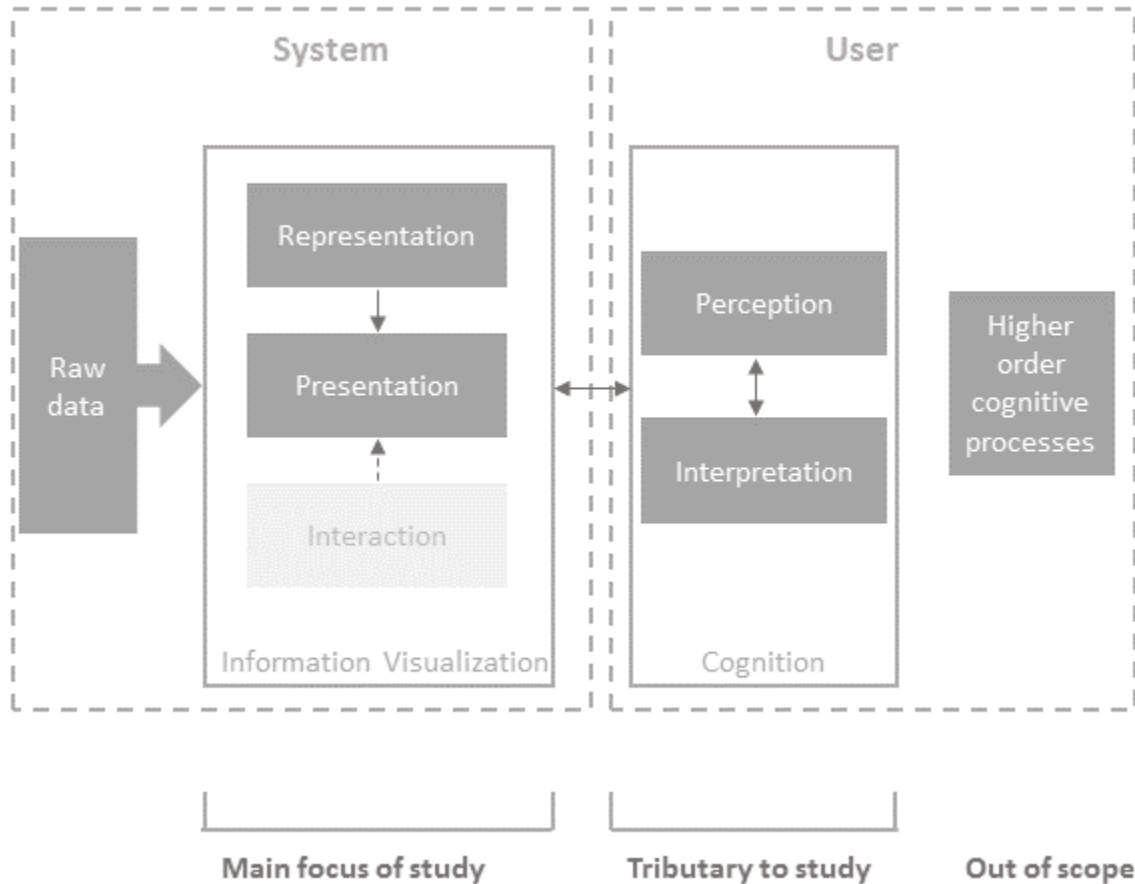
Figure 7: Focus area related to Information Visualization part of the study. Model modified from Spence (2007)

Representation includes the understanding of the data structure, and subsequently the relations between two or more data items. In addition, it is necessary to represent values. Encoding of values and relations are central to this, and several well-established techniques are available (Spence, 2007). Further research on *representation* is performed as part of the Literature Review on Information Visualization. This is addressing part b) of the research question. Results are offered in 5.3.2 and findings are summarized in 5.4.

Presentation then, is about how to display the representation, dealing with limitations in space, a diverse audience, limitation in both tools support and an originators skill set. It is also to ensure that elements of representations fit together – that it tells the story. It is about striking the right balance between decoration and functionality, between familiarity and originality, and other mutually exclusive parameters. Further research on *presentation* is performed as part of the

Literature Review on Information Visualization. This is seeking to answer part c) of the research question part. Results are offered in 5.3.2 and findings are summarized in 5.4.

If applied correctly, *interaction* will be vital to information visualization. Although this is outside the scope for this study, due to resource constraints, a short description is provided for completeness, owing to the fact it is a part of the model of information visualization set out by Spence (2007) used in this study. Interaction is not an easy task, as variables exist and many considerations have to be taken. We have to know what it is with a data set that makes one type of interaction more appropriate than another, and when to apply which technique. Among known methods are scrolling, zooming and panning. Several others exist, such as distortion and suppression, or a combination of these.

In the same Figure 7, visual perception and cognition is defined as tributary to the study. Before looking into more details about representation and presentation in Chapter 5.3.2, it seems fair to offer some facts on how the human visual perception and cognition systems work.

3.2 Information Visualization related knowledge

An appropriate departure could be to echo Spence's definition, asserting Information Visualization, in its simplest terms, can be described as data transformed into pictures, whereas the pictures are interpreted by a human being (Spence, 2007). Alberto Cairo is more particular about this; he proclaims we are visual species. More in details he says we understand because we see. Cairo claims that deep inside our minds, seeing and understanding are two sides of the same coin (Cairo, 2013). What he means, is that *we see* in the meaning of *we understand based on previous experiences*. This *see* is what is called a mental model. Sometimes this is called an internal model or a cognitive map (Spence, 2007). The important takeaway is that visualization relies on the formation of a mental model. It is therefore key to understand more about this forming process.

According to Terrence W. Deacon we are not only visual species, we are symbolic species. He once expressed it like this

"everything our senses gather is transformed, deep inside our minds, into simple manageable representation, or symbols." (Deacon, 1997).

The formation of this mental model takes place in a combination of bottom-up and top-down processes as depicted in Figure 8. The bottom-up process is triggered when light reflected by an object activates photosensitive cells in the hindmost part of the eye, the retina. The impulses from retina is stored and processed in a very short-term storage in the brain known as the iconic memory, where pre-attentive perception and cognition takes place. It functions as a buffer for visual information and stores the "image' for about 200ms, which is the time between saccadic eye movements. The pre-attentive processing is used to extract plain properties such as orientation, size, and basic shapes. Pre-attentive processing is important for information that pops-out, and number of properties applied in a visualization.
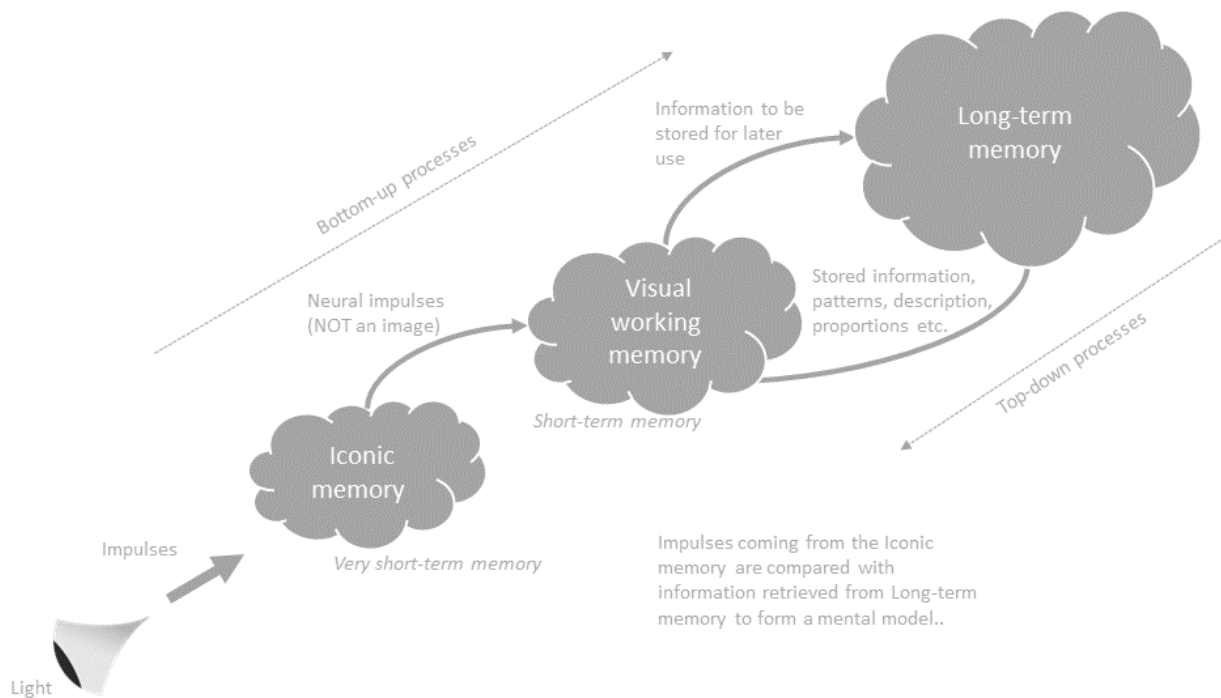
Figure 8: Forming a mental model

There have been many experiments conducted with regards to what features are pre-attentive processed. In accordance with Ware (2004) these features can be organized into the following categories: form, color, motion, and spatial position. Table 2 provides a more detailed overview over features that are pre-attentive processed.

Table 2: Feature that are pre-attentive processed (Ware, 2004)

Form	Color	Motion	Spatial position
Line orientation	Hue	Flicker	2D position
Line length	Intensity	Direction	Stereoscopic depth
Line width			Convex shape from shading
Line collinearity			Concave shape from shading
Size			
Curvature			
Spatial grouping			
Blur			
Added marks			
Numerosity			

Experiments show that most people can only store three to seven features in the iconic memory. This in important to know when applying different features as those displayed in Table 2. For instance, use of many different colors in a graphics put unnecessary strain on the visual cognition. The information extracted in the iconic memory is transferred to the visual memory sitting in the cortex. This area in cortex has allocated plenty of neural processing power, and has fine-tuned cells for each of the features mentioned above (form, color, motion, and spatial position), making it possible to massively parallel process incoming information. Finally, this processed information is stored in the long-term memory for later use (Cairo, 2013).

The visual working memory serves other functions as well. It can be used to create a mental image of something stored in the long term memory, it can even make a mental image based on a description earlier received, for instance as a verbal message. This is what known as the top-down process. The top-down process is also used for comparing visual impressions with stored information for the sake of recognition (Cairo, 2013).

4 Research Design and methodology

The research design consists of two parts, as shown in Figure 9. For the first part, a case study comprising a set of adequate research methods was selected to learn more about the purported reluctance to architectural products and to answer part a) of the research question. For the second part, and to answer part b) and c) of the research question, a literature review was carefully chosen to learn more about information visualization. More in particular, how its methods and techniques could benefit to the area of Enterprise Architecture. Both methods belong to the family of qualitative research. A qualitative approach is recommended when a study seeks to reveal knowledge and understanding about a phenomenon, and where no hypothesis is formed in advance (Leedy and Ormrod, 2010).
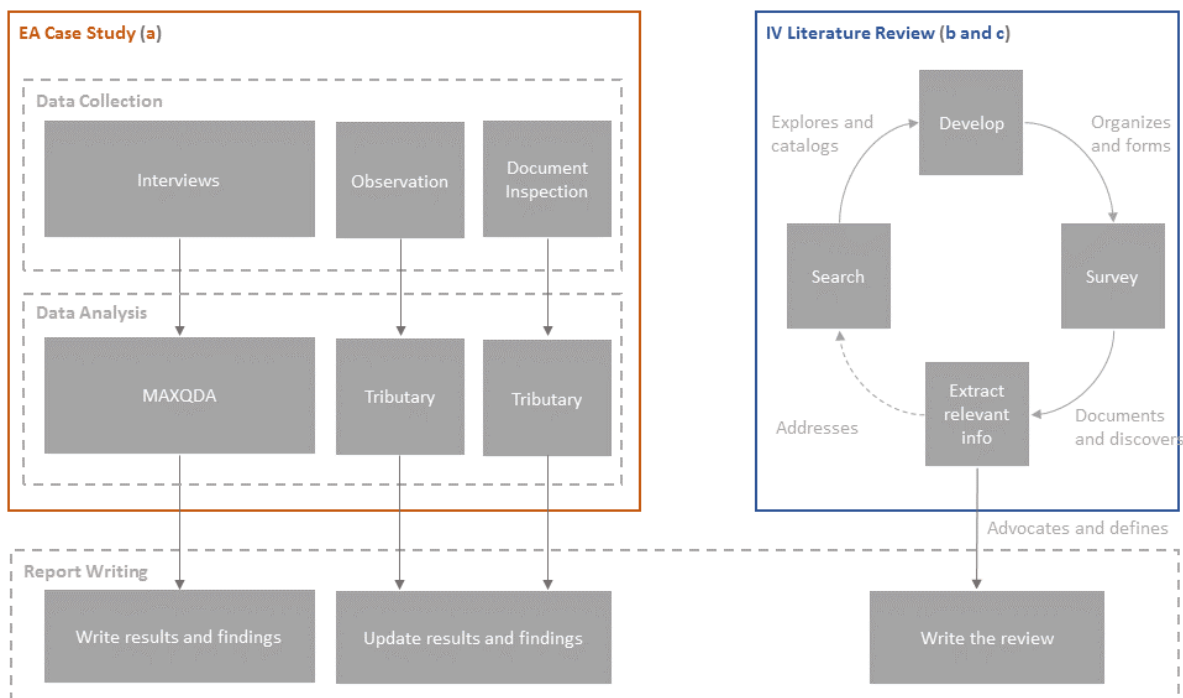
Figure 9: Study's research design.

4.1 EA Case Study - Overview

The case evaluated was about use of architectural products as support to the procurement process in the Norwegian Armed Forces. The main purpose was to interpret the phenomenon studied, including to gain new insights and discover any existing problems as advised by Peshkin (1993). Within the broad category of qualitative research, *case study* was selected as the specific method. That is especially suitable for learning more about a poorly understood situation (Leedy and Ormrod, 2010), and to provide for an in-depth study to elicit as many nuances and details as possible (Jacobsen, 2005). Since only a limited number of units were available for the study, it was designed to facilitate so, by use of a *Small N Design*. In addition, it is a recommended approach when the phenomenon itself is given more attention than the context in where it takes place (Jacobsen, 2005). However, the main purpose of choosing *Small N Design* was the possibility to study the phenomenon from different perspectives. Although data collection, data analysis and report writing seems to be very distinct steps in the process (Figure 10), in reality these were executed fairly simultaneously – and in spirals. It therefore makes sense when Dey (1993) advocates that qualitative researchers learn by doing. This will be further elaborated on later, when describing the data analysis process.
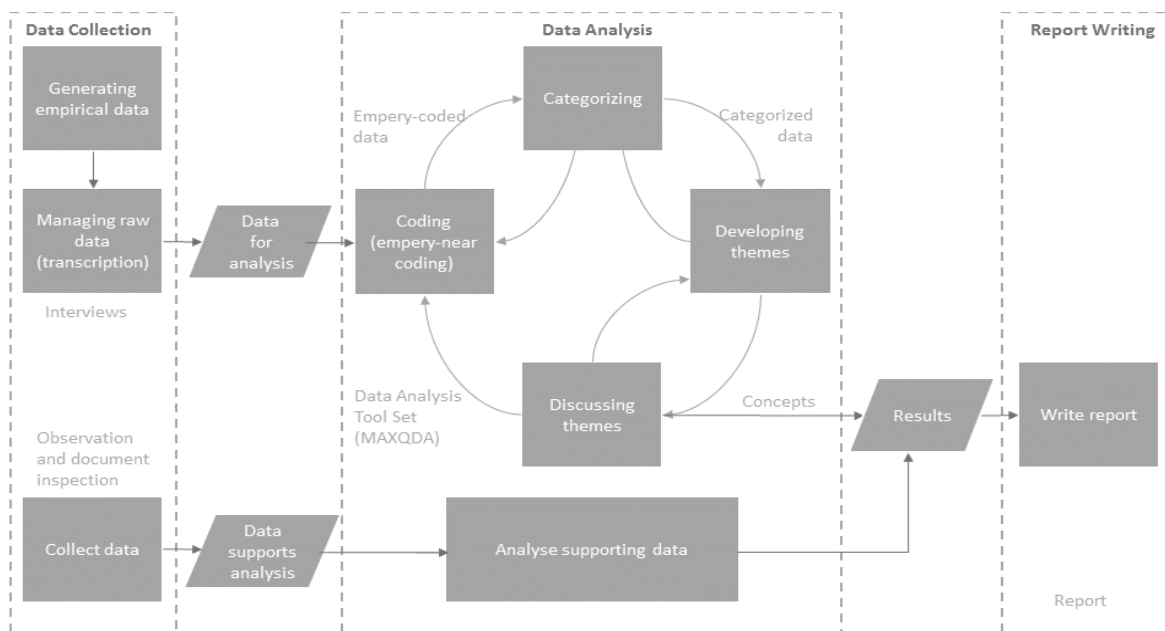
Figure 10: Data Collection and Analysis Process used in this study

4.2 EA Case Study - Data Collection

A diverse set of data collection techniques were employed to collect as relevant data as possible, where interviews were chosen as the primary means of collection. In addition, observation and document inspections were performed to augment the understanding.

4.2.1 Interviews

In particular, interviews are useful in situations where the researcher tries to get an understanding of the phenomenon from the informants' point of view (Dalen, 2011). A generic interview guide (Appendix D) was developed to assist the interview situation. This guide was slightly adapted and tailored to fit each specific interview i.e. the written guide was not changed, but some questions were left out and some given more emphasis during the interview sessions. As it is important to build good rapport between the interviewer and the interviewee, the interviews were prepared to contain three phases (Tjora, 2012). A total of eight interviews were conducted in the period between February 12 and March 16 2016. All interviews started with some innocuous warm-up questions. Thereafter, questions were directed towards the core of the researched phenomenon. In the end, the interviewees were always given the opportunity to talk about anything they might have left out during the interview. All interviews were audio-recorded and thereafter transcribed. Audio-recording helps focusing on the interview situation and is recommended for in-depth interviews (Tjora, 2012). Immediately after transcription, the audio-files were deleted, since anonymized transcriptions are easier to manage with regards to privacy protection (Tjora, 2012).

4.2.2 Observation

In addition to interviews, one observation was conducted on February 23 2016. The observation screened a meeting called Architectural Board whom roles and responsibilities are described in 2.2. The fourteen participants represented all stakeholders as later illustrated in Figure 11, except Program Owner and Program Manager. They all received a written report from the meeting.

Observation differs noticeably from interviews, as it records what people say or do, not what they say they do (Jacobsen, 2005). Open observation was assumed as the best option due to the fact that the Architectural Board is a relatively small group where it would be challenging to perform a closed observation. Furthermore, it was considered unlikely that the behavior would change significantly as a result of the participants being observed. The reason is that this is a meeting held regularly, most participants know each other and it follows a well-known agenda. As the observer had limited insight in the subject observed, a non-participant form of observation was selected. In addition, it was chosen to limit the impact the observation could have on the outcome, and consequently the reliability of the research, as advised by Jacobsen (2005). The observation was gravitating towards the use of artifacts – the architectural products. More specifically, the focus was to observe how artifacts were used and reviewed. This encompassed an attempt to capture, by note-taking, how well the participants found the quality of the artifacts to be and how well they served the intended purpose.

4.2.3 Document Inspection

Document Inspection was used to improve the understanding of the phenomenon achieved through interviews and the supporting observation session. Document Inspection is often used to collect data extending what is possible through own data generation (Tjora, 2012). This study looked for case-relevant documents which could provide more information about how the business is meant to be performed, e.g. process descriptions, architecture guidelines, policies and directives. Table 3 provides an overview over documents used in document inspection.

Table 3: Overview over documents included in the document inspection

Title	Description	Audience
Mandat arkitekturråd	Mandate is given in *"Bestemmelse om bruk av arkitektur i utviklingen av Forsvarets informasjonsinfrastruktur (INI)"*[10](Cyberforsvaret, 2016)	Stakeholders involved in projects
Prosjektarkitektur – diagrammer (IKT, 2015)	A document that specifies what architectural products that should be developed under each phase of an acquisition project.	Stakeholders involved in projects
Begrepsapparat (Materiellavdeling, 2015)	A common terminology for use at development, procurement and management related to security accreditation of ICT-systems.	Stakeholders involved in projects
Sjekkliste FL (Cyberforsvaret, 2015a)	A document used to guide the development process of a FL-document and the assessment process in the Architecture Board.	Stakeholders involved in projects

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[10] This document is still in a draft version due to unresolved issues related to scope and level of authority. A revised version is expected to be released.

4.2.4 Participants

Interview participants were recruited from the group of EA practitioners relevant for the topic of research, i.e. knowledge workers that in one way or another contribute to or use Enterprise Architecture as part of their job. A stakeholder analysis was conducted early in the study, and the result informed the selection process. Figure 11 shows the different stakeholders identified as involved in making or use of Enterprise Architecture.
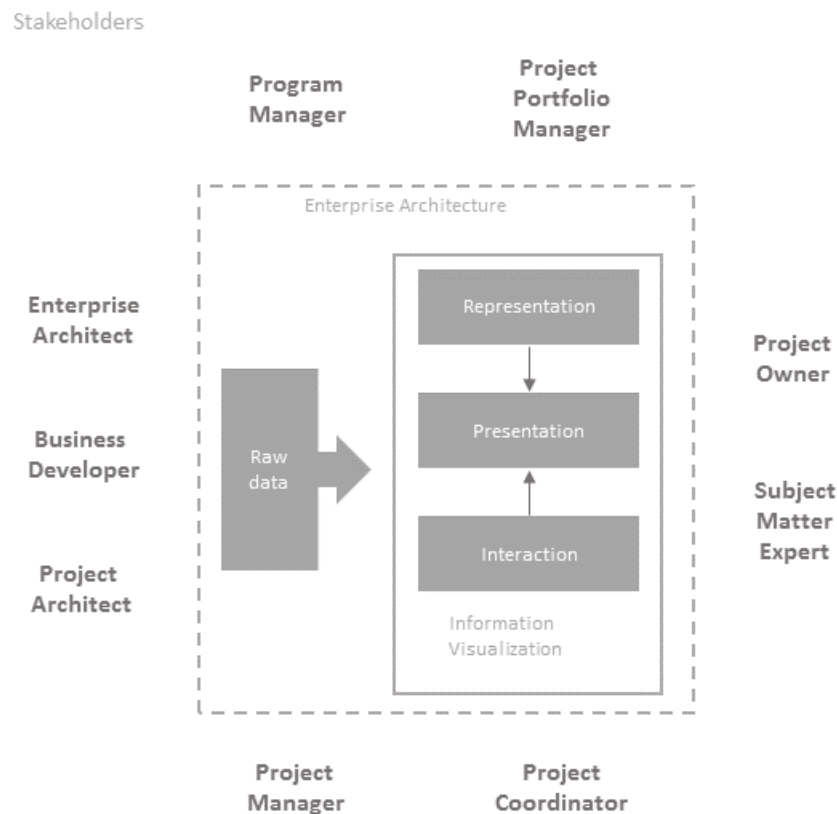
Figure 11: Stakeholders involved in use of EA

Participants were subject to different methods, depending on level of involvement and proximity to the core architectural work. As small N-studies were used, it was important to recruit participants from different parts of the organization contributing to reflect the entirety of the development process. The purpose was to draw a complete picture as possible of the situation. Table 4 provides an overview over roles involved in either interviews or observation, or both.

Table 4: Roles participated in case study

Method	Roles involved in method
Interview	Enterprise Architect, Project Manager, Project Coordinator, Subject Matter Expert, Project Architect, Project Owner
Observation	Enterprise Architect, Project Manager, Project Coordinator, Subject Matter Expert, Project Portfolio Manager, Business Developer, Project Architect

4.3 Case Study (EA) - Data Analysis

As the main part of this case study was centered around the interviews, an extensive data set was collected. In order to manage this information-rich collection, a structural approach was selected and the following steps performed: organization of details about the case – reading and memoing – coding and categorizing – identification of patterns – synthesis and generalization. As mentioned in Chapter 4.1, data collection, data analysis and report writing happen more or less simultaneously. Above all, this is true for the data analysis process, which has a distinct iterative characteristic. Creswell (2007) refers to this as the data analysis spiral, where researchers engage in the process of moving in analytical circles. In addition, Miles and Huberman (1994) talk about data analysis as a custom-built, revised and choreographed process. Below is a detailed description of how the data analysis process was tailored to fit this specific project. Figure 12 provides a graphical overview of the process used to analyze the data collected from the interview sessions. In addition, the results from both observation and document inspection were used to enrich, align and sometimes modify the end results.
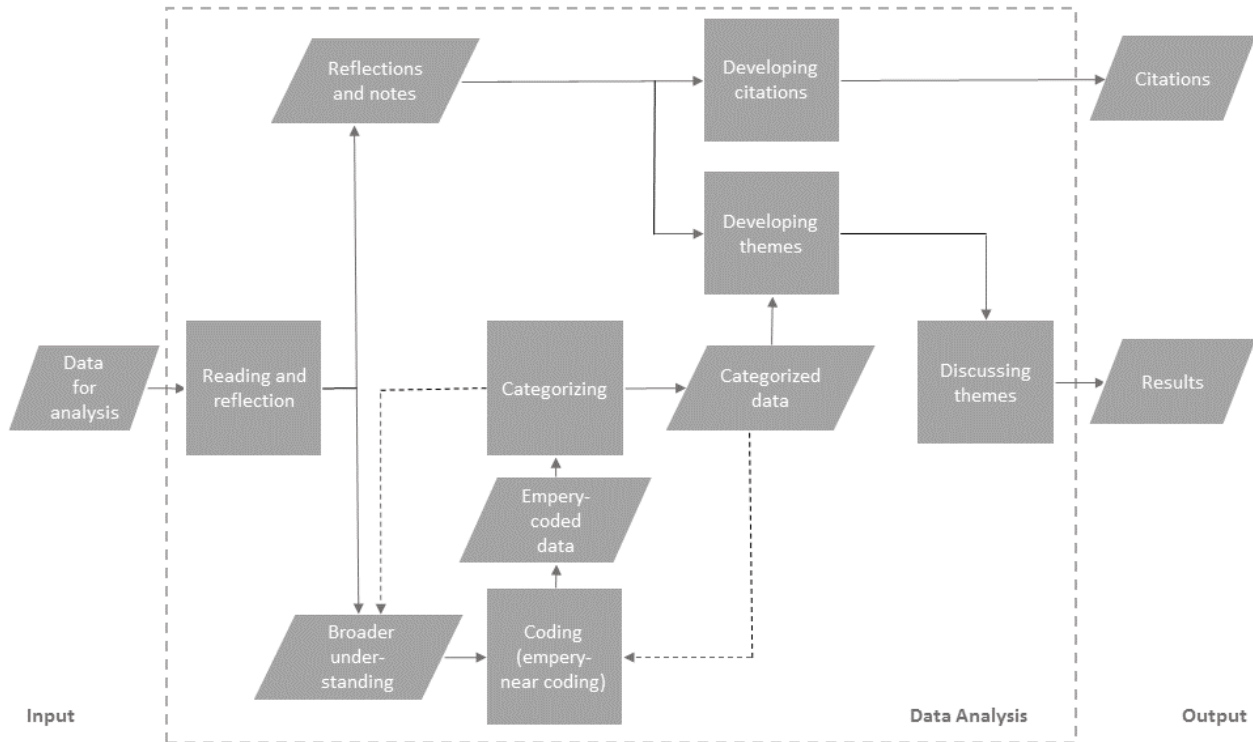
Figure 12: Data analysis process in detail (only used for the interview)

Organization of details

- Interviews were transcribed and stored in text documents.
- An interpreted understanding of the observation in a chronological order was stored as a text document.
- All documents inspected were stored in text documents.

Reading and reflection

The entire data source of text documents was imported into MAXQDA[11], and made ready for analysis. All documents were read several times in order to get a sense of the whole collection of data. Agar (1980) suggests that researchers should do so before breaking it into parts. Reflections took place and key concepts were formed, everything captured as notes for later use in the report.

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[11] MAXQDA is a professional software for qualitative and mixed methods data analysis. (http://www.maxqda.com/products/maxqda)

Coding and categorizing

Codes and categories were developed based on the content in the data sources. This is recommended approach to ensure terms and expressions existing in the collected material are captured (Tjora, 2012). A code register materialized as the text documents were analyzed, one after another. In parallel, a conscious categorization took place, in order to form meaningful units for further analysis. Codes were merged, split, collapsed or expanded during this phase to represent the data collection in a best possible way. Categories were also adjusted as patterns or themes occurred. Creswell (2007) suggests keeping the number of categories or themes to five or six. An invaluable technique used in this part of the process was *affinity maps*. Gray et al. (2010) advise use of affinity maps to find categories or meta-categories. Furthermore, the authors suggest affinity maps can give a sense of where most people's thinking is focused.

4.4 IV Literature Review

The second part of the research design is a literature review. The purpose was to acquire sufficient knowledge to later discuss application of Information Visualization in the field of Enterprise Architecture. The literature review process followed, was mainly inspired from *The Literature Review – six steps to success* (Machi and McEvoy, 2009), but to some extent modified and adapted to fit the overall research process. The actual process used in this study is depicted in Figure 13. Machi and McEvoy (2009) defines a literature review to be: *a written document that presents a logically argued case founded on a comprehensive understanding of the current state of knowledge of a topic*.
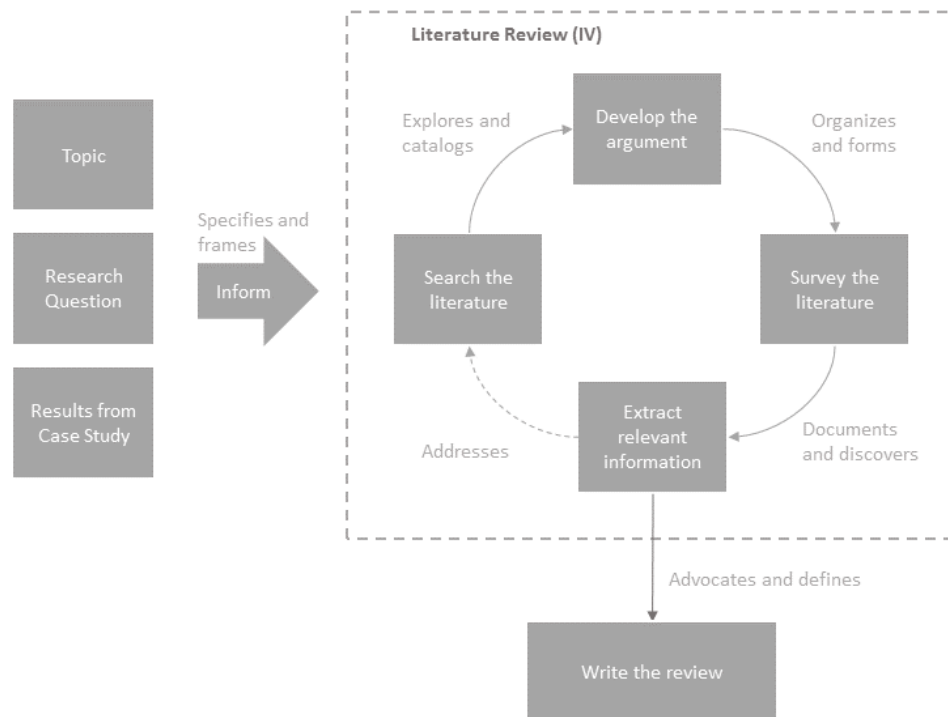
Figure 13: Overview over the literature review process used in this study. Inspired by Machi and McEvoy (2009)

Their six step model promotes a decomposition of the research question prior to the literature search. For this study, an important adaption was instituted, in order to provide appropriate guidance. Rather than embarking on a vague journey of decomposition, concepts and elements obtained through the case study were allocated at best effort to the building blocks instituted in

the Chapter 3.1. as depicted in Figure 14. In this way, a more focused approach to the literature review should be achieved, reacting more directly to the intermediate findings from the case study. To be clear, it is not a decomposition, it is more a set of attributes used for inspiration, or hints or clues, what to look for during the survey of the literature.
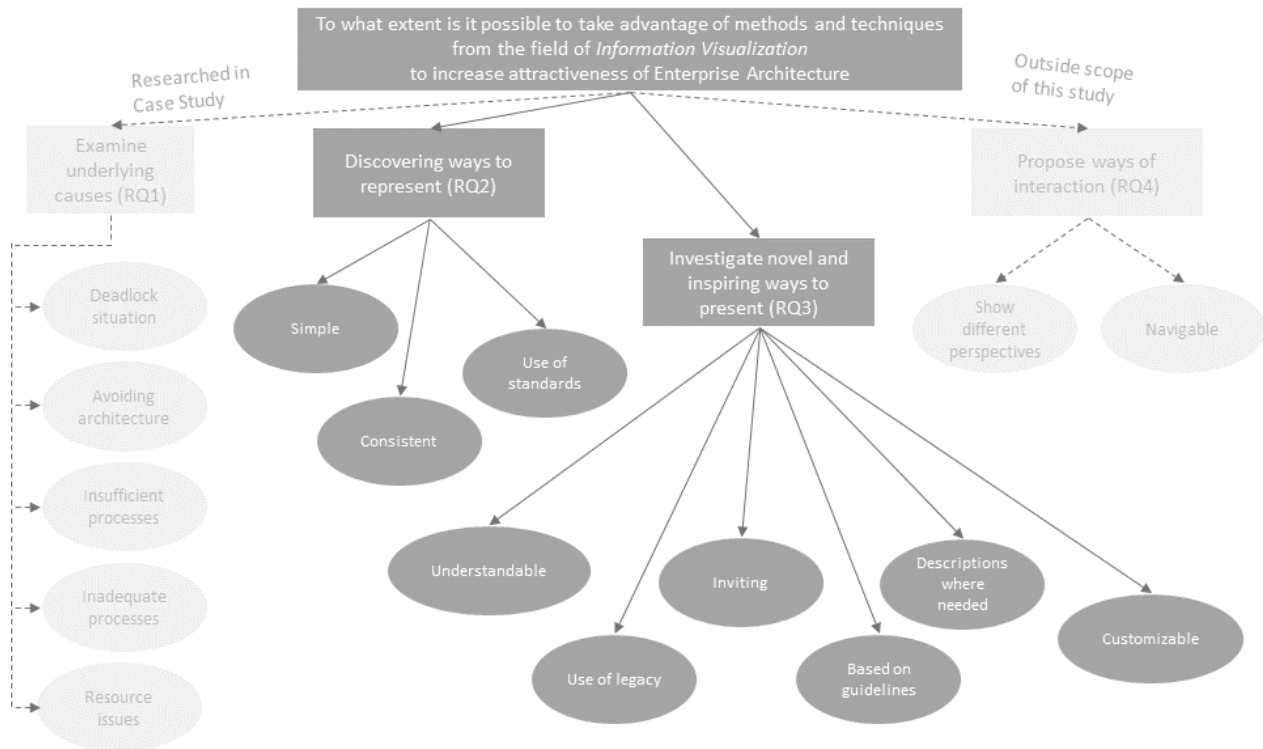
Figure 14: Hints or clues from case study used to guide the literature survey

Search the literature

Prior to the search process, a decomposition of the topic of research should already have been made. In this way, fairly complex topics can be more easily solved (Leedy and Ormrod, 2010). This decomposition then becomes the guideline while searching the literature. Machi and McEvoy (2009) are more explicit as they have specified the search process to contain both skimming, scanning and mapping of data. They suggest to log all relevant data, such as author, title, place of publication, key idea, and descriptor of the source to capture how this is contributing to the review.

Develop the argument

Central to developing the argument is what Machi and McEvoy (2009) call building the case. Meaning to compile and arrange sets of facts or reasons in a logical fashion. These facts or reasons should make up a convincing argument leading to a sound conclusion.
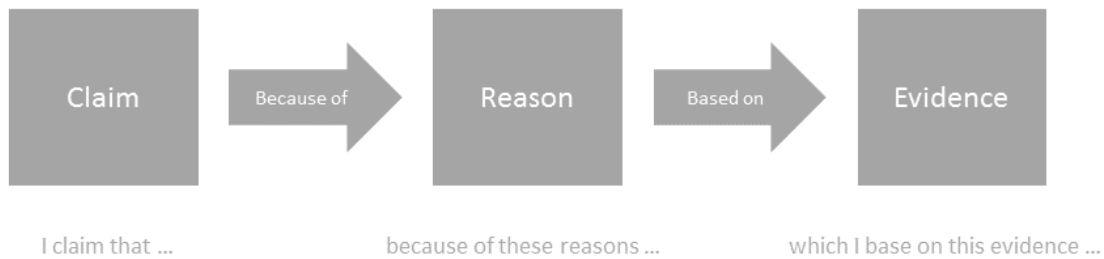
Figure 15: Making an argument, the claim - evidence chain (Booth et al., 2008)

This gives the structure, the bare bones. Facts can be thought of as claims, and in accordance with Booth et al. (2008) claim statements should be specific in language and logic and significant acceptable, i.e. how much the readers must change how they think. Figure 15 illustrates the claim – evidence chain, and how this is used in the literature study.

Survey the literature

Survey of the literature is the phase for discovery of what is known about a subject, or to put some flesh on the bones, to say it more figuratively. This part is for this study fairly similar to what was done for the coding process in the case study. However, instead of using codes to form categories and themes, this survey uses the themes established in the introduction chapter and further elaborated upon in the background chapter, namely: representation and presentation. The purpose of this phase is to establish what Machi and McEvoy (2009) refers to as the first argument or the front end of the research case. In the final step, described in the next section, the analysis will show what that means for this particular subject.

Extract Relevant Information

The final step of this literature review was to extract relevant information. In this study the information was used to form a set of best practices.

5 Results

In qualitative studies the writing process can be thought of as continuum of the analysis process. It means that the analysis process does not merely consist of coding, categorizing and classifying data, but it continuous with the write up of the results. In *Making sense of qualitative data*, Coffey and Atkinson (1996) argue that writing is a vital way of thinking about one's data, that writing makes us think about our data in new and different ways. This chapter aims to reflect that argument. Therefore, this chapter will present, not only the end results (findings), but also early results from the analysis process, with the intent to guide the reader through the findings and to provide for better comprehension of the end result.

5.1 Result from EA Case Study

This chapter contains results from interviews, observation and document inspection, in that order. Results from interviews amounts for the majority, where the two others take more of a supporting role.

5.1.1 Results from Interviews

As explained in the method chapter, before commencing the more mechanical process of coding and categorizing, it is important to get an overview over the data collected by reading the text files a number of times. In addition to the benefit of reaching a more comprehensive state of understanding, comments were made about captivating topics and possible citations were identified. Those, in turn, made up the backbone of the end results and will be introduced and used later in this chapter, as well as in the discussion chapter. Before going there, codes and categories will be presented.

Codes after first iteration

In this context, first iteration of coding means the completion of coding of all interviews. The reader should be informed that this process made codes expand or extend, merge or collapse during the journey of coding. At the end of first iteration the total number of different codes ended at 149, whereas the total number of labels ended at 490. Figure 16 presents the ten most used codes during the first iteration, and provides clues for possible areas of interest for further investigation.
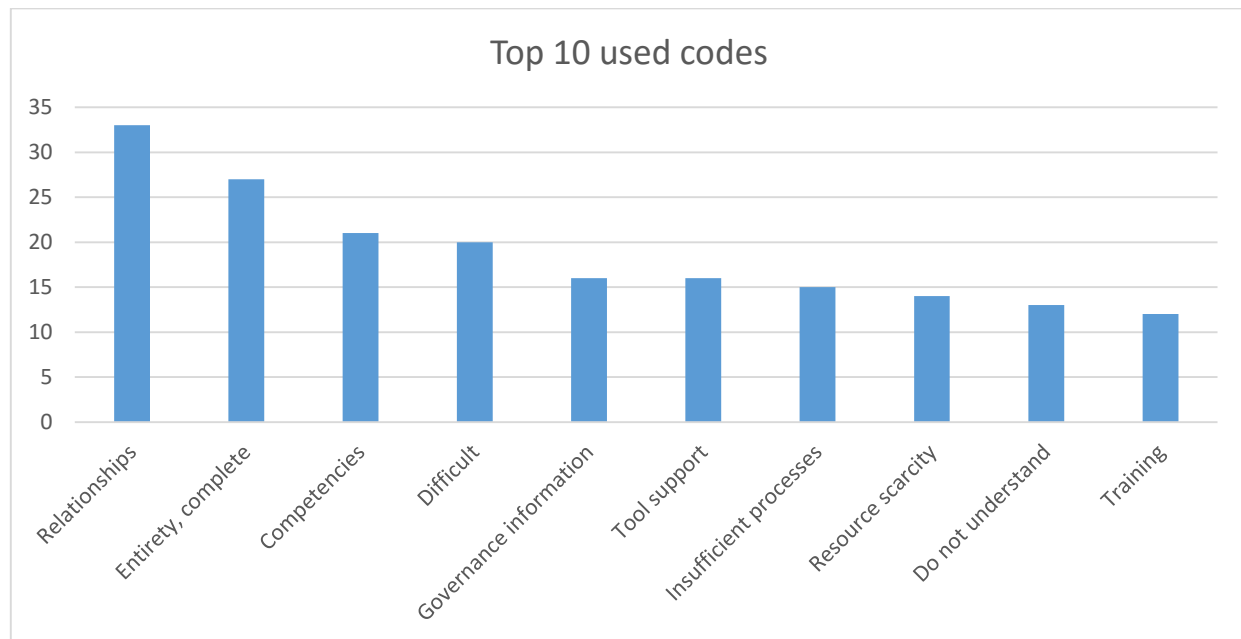
Figure 16: Shows top ten most used codes in all documents (from MAXQDA)

To bring some more factors on board, Table 5 provides an overview over the 35 most used codes, percentage representation and number of interviews where they occurred.

The latter number indicates if this is a commonly understood situation or more single source oriented. Since interviews were conducted in Norwegian, the original terms (codes) are kept in the table, and the translated English terms added.

Table 5: Most used codes in first iteration (from MaxQDA)

Kode	Code	Coded segments	% Coded segments	Documents
Sammenhenger	Relationships	33	6.73	8
Helhet	Entirety, complete	27	5.51	8
Kompetanse	Competencies	21	4.29	6
Vanskelig	Difficult	20	4.08	5
Styringsinformasjon	Governance information	16	3.27	4
Verktøystøtte	Tool support	16	3.27	7
Mangelfulle prosesser	Insufficient processes	15	3.06	6
Ressursknapphet	Resource scarcity	14	2.86	6
Forstår ikke	Do not understand	13	2.65	5
Opplæring	Training	12	2.45	4
Virksomhetsarkitektur	Enterprise Architecture	12	2.45	5
Høringer	Rehearsals, consultations, scrutiny	11	2.24	4
Mangler	Deficiencies	9	1.84	2
Helheten mangelfull	Lack in entirety, incompleteness	7	1.43	5
Hjelp av arkitekter	Support from architects	7	1.43	4
Detaljeringsnivå	Level of details	7	1.43	4
Ressurskrevende	Resource demanding	7	1.43	5
Uferdig	Incomplete, unfinished, raw	6	1.22	4
Virksomhet	Enterprise	6	1.22	2
Arkitekturressurser	Architecture resources	6	1.22	3
Alminneliggjøre	Generalize, normalize	5	1.02	3
beslutningsgrunnlag	basis for decision- making	5	1.02	1
Integrerte team	Integrated Teams	5	1.02	5
Uklart	Nebulous	5	1.02	3
Begreper	Terms	5	1.02	2
Tilpasset mottaker	Customized	4	0.82	3
Standardiserte views løsningen	Standardized views	4	0.82	2
Metamodell	Meta model	4	0.82	2
Prosesser og informasjon	Processes and information	4	0.82	4
Vanskelig å endre arbeidsmåte	Hard to change ways of working	4	0.82	2
Manglende forståelse	Lack in comprehension	4	0.82	1
Behov for forskjellige views	Need for different views	4	0.82	3
Mangel på konsistens	Lack of consistency	4	0.82	2
Koordinere	Coordinate	4	0.82	4

Themes after first iteration

More important than the codes themselves, were the themes evolved during the journey of coding, forming logical groups of codes. In addition to providing foundation for later analysis, the themes were used to manage the complexity inflicted by the extensive number of codes. Figure 17 shows an overview over the situation after first iteration. Not all developed codes fit naturally in a theme, and as shown in the figure some codes were left unspecified. All themes had a fairly even distribution of codes, except architecture, which might be too broad to serve its purpose.
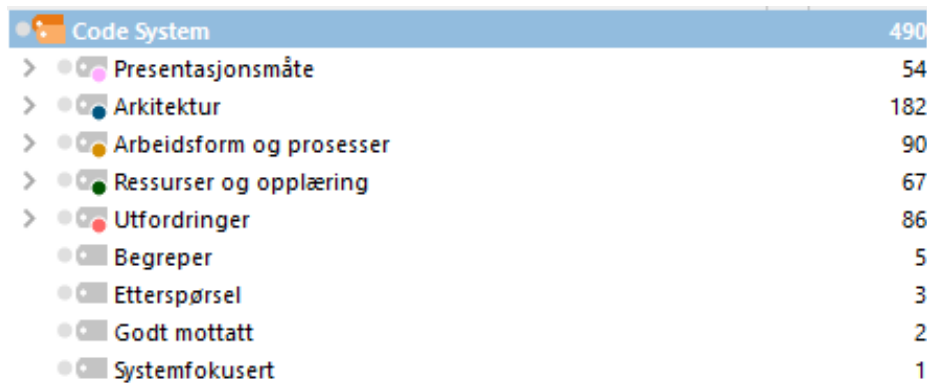
Figure 17: Overview over the code system, showing themes and numbers for each (from MaxQDA)

Codes after second iteration

The entire data collection of transcribed interviews was re-visited and re-coded based on both the broader and deeper understanding of the assortment acquired during the first iteration. New patterns arrived by sorting and clustering these empery-near codes by leveraging the specialty of affinity maps. Merging and generalization of codes took place to simplify the data set at hand. For instance, the theme *Form of presentation* that encompassed 29 distinctive codes after first iteration was reduced to 20 codes. In addition, they were grouped into four categories to help manage complexity. Some codes were moved from one theme into another, for instance the code *Lack of guidelines*[12] moved from *Ways of working* into *Architecture* and changed code to *Imbalance operational/technical*[13]. At the end of second iteration the total number of different

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[12] Lack of guidelines translated from mangelfulle retningslinjer
[13] Imbalance operational/technical translated from ubalanse operativ/teknisk

codes was reduced from 149 to 74, whereas the total number of labels now ended at 492. Figure 18 presents the ten most used codes during the second iteration.
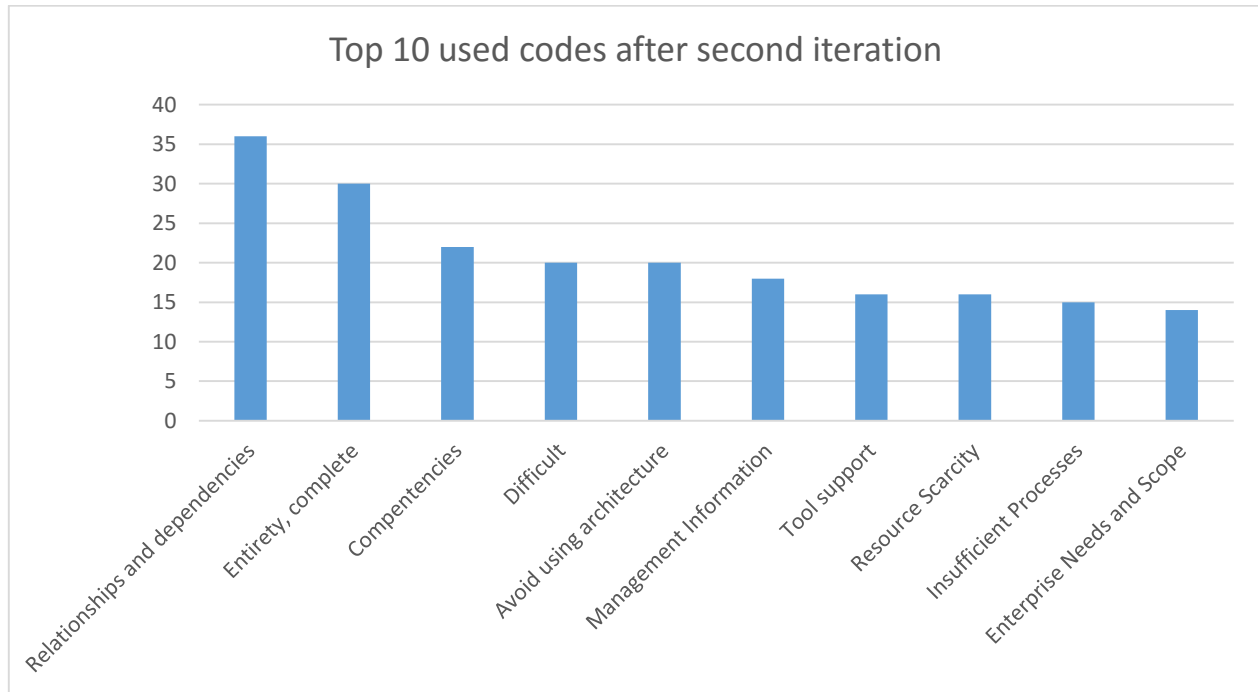
Figure 18: Top 10 most used codes after second iteration (from MaxQDA)

Themes and Categories after second iteration

As a code system evolved, themes got more and more succinct and the same was the case for categories belonging under each themes. Figure 19 presents the code system after second iteration. At that stage five themes existed [14]:

- Presentation
- Architecture
- Ways of working
- Resources and training
- Challenges

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[14] Translated from Norwegian: *Presentation* from *Presentasjon*, *Architecture* from *Arkitektur*, *Ways of working* from Arbeidsform og prosesser, *Resources and Training* from *Ressurser og opplæring*, and *Challenges* from *Utfordringer.*

∨ ⬛ **Code System**	492
∨ ⬛ Presentasjon	0
> ⬛ Designkriterier	23
> ⬛ Designprinsipper	17
> ⬛ Designutfordringer	4
> ⬛ Typer av presentasjoner	13
∨ ⬛ Arkitektur	0
> ⬛ Arkitekturverktøy	20
> ⬛ Arkitekturattributter	69
> ⬛ Arkitekturavklaringer	31
> ⬛ Helhetlig styring	48
> ⬛ Mangler og utfordringer	29
∨ ⬛ Arbeidsform og prosesser	0
> ⬛ Effekt og verdiskaping	19
> ⬛ Strategier for å håndtere kompleksitet	3
> ⬛ Roller og ansvar	27
> ⬛ Utfordringer knyttet til arbeidsform	52
∨ ⬛ Ressurser og opplæring	0
> ⬛ Kompetanse og opplæring	35
> ⬛ Ressurser	33
> ⬛ Utfordringer	69

Figure 19: Themes and categories as part of the code system after second iteration (from MaxQDA)

Codes, categories and themes after third iteration

After completion of the second iteration it came clear that all themes encompassed one or more categories related to challenges. In addition, one theme was devoted solely to capture coded related to various challenges. A closer look was given at all codes and related text from the transcripts, and a third iteration of coding resulted in re-categorizing of codes related to challenges. The theme dedicated to challenges could be eliminated and codes found place in more specific themes and categories, as depicted in Figure 20.

Figure 20: Overview over themes and categories after completion of a third iteration (from MaxQDA)

This third iteration did not have noteworthy impact on the overall coding, however, the final results from the interviews should now be clearer. Number of codes increased slightly from 74 to 77, distributed into 15 categories and 4 themes. A complete overview over codes, categories and themes is offered in Appendix G.

Results above and beyond the numbers

It is time to return to what was promised in the beginning of this chapter and take a closer look at some of the results from the interviews. The themes emerged during the data analysis are used as organizing elements. The one given most attention, *Architecture*, as shown in Figure 21, will be presented first.

Code System									
> Presentasjon	●	·	·	·	·	·	·	·	62
> Arkitektur	●	●	●	●	●	●	●	●	217
> Arbeidsform og prosesser	●	●	·	●	●	·	·	●	123
> Ressurser og opplæring	·	·	·	●	●	·	·	●	71
∑ SUM	72	50	77	41	32	38	63	100	473
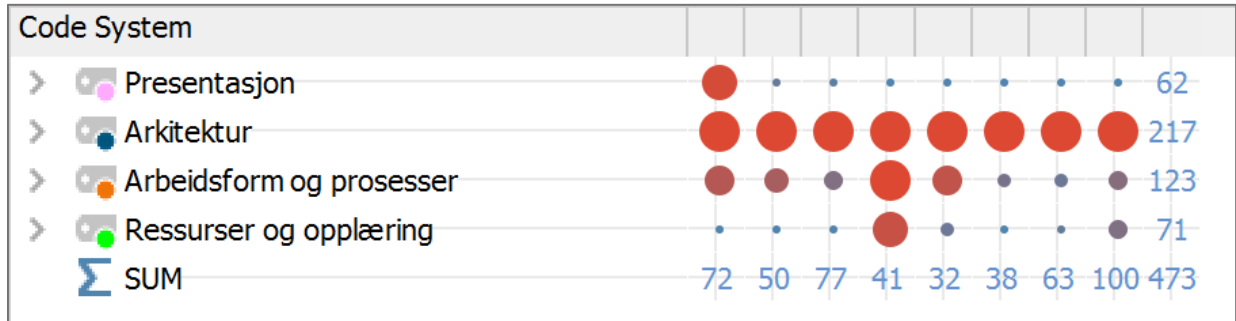
Figure 21: Overview over number of codes per interview (columns) and per theme (rows), (from MaxQDA)

Results related to Architecture

∨ Arkitektur	217
> Arkitekturverktøy	21
> Arkitekturattributter	78
> Arkitekturavklaringer	34
> Helhetlig styring	45
> Mangler og utfordringer	39
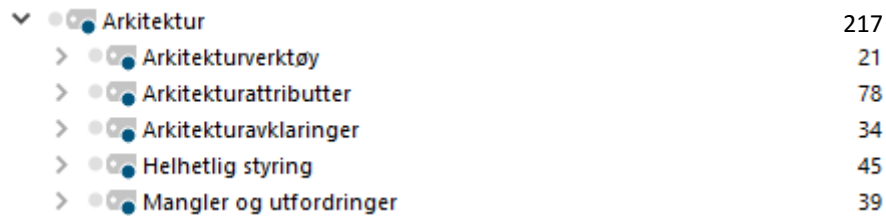
Figure 22: Categories under the theme Architecture (from MaxQDA)

Architecture was the topic given most consideration during the interview sessions. Figure 22 shows the different categories belonging to the theme *Architecture*. Interesting findings related to them will now be offered. Not only does the topic belong at the core of this study, but in addition all interviews were launched with two simple warm-up questions about architecture; 1) What is the first thing that comes into your mind when I say architecture? and 2) And what is the first if I say Enterprise Architecture? The idea was, besides getting the interviewees acquainted to the role of being interviewed, to correlate their understanding of the subject with the one of mine. Many interesting short answers were given, among them *boxes and arrows*, *complexity*, *flow diagrams, and enterprises' demands*, however it was most frequently associated with *relationships and dependencies*, *and processes and information*. Moreover, many participants agreed about the importance of *using architecture for governance* and the ability it provided for *attaining overview over a complex situation*.

One participant explained it like this:

"og det er for i større grad å finne ut av og få mere klarhet i hva det virkelig er vi skal løse i prosjektet, og da å se det i en større virksomhetskontekst" [15]

This twist was found to serve as a good basis for further questions and in particular it triggered the possibility to learn more about how the situation of today was perceived.

All participants remarked lack of entirety, and most of them pointed out an imbalance between operational and technical architecture. One of the participants described it like this:

"vi trenger begge, men det ligger et sånt lite tåkelag i midten der hvor man ikke greier å strekke seg de siste cm i mellom hvor du klarer å koble dette litt mer visjonære og ustrukturerte inn det mere strukturerte og reelle." [16]

When they were asked why they thought it was so, the replies were either that there is a lack of understanding how architecture can be used as a tool in the development process or an alienation caused by unfamiliar terms and innate complexity.

Moreover, the interviews revealed that several subjects regarding the architectural products need more clarity; level of details, who the audience is, should it be communicable or consistent to name but a few. In conclusion, many of them suggested something had to be done to make architecture more widely accepted and integrated into ordinary working processes. More about this is in the next theme – *ways of working*.

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[15] Translated from Norwegian: "The reason is, to a greater extent finding out and get more clarity on, what it really is we must solve in the project and then to see it in a larger business context".

[16] Translated from Norwegian: "we need both, but there is this small layer of fog in the middle where we are unable to extend the last cm in between where we're able to connect this some more visionary and unstructured into the more structured and real".

Results related to Ways of working

∨ ◯◻◉ Arbeidsform og prosesser	123
＞ ◯◻◉ Effekt og verdiskaping	19
＞ ◯◻◉ Strategier for å håndtere kompleksitet	3
＞ ◯◻◉ Roller og ansvar	36
＞ ◯◻◉ Utfordringer knyttet til arbeidsform	65

Figure 23: Categories under the theme Ways of working

Figure 23 shows the different categories belonging to the theme *Ways of working*. Interesting findings related to them will now be offered. The most predominant factors or issues revealed from inquiries related to ways of working were insufficient or inadequate processes and workers deliberately avoiding use of architecture. Some participants believed lack of understanding could be the reason, while others meant this is related to lack of continuity and routines, lack of standardization and difficulties in changing already established ways of working, or as expressed by one of the participants:

> "Men det er ikke noe tradisjon for å jobbe på denne måten, med denne type prosesser. Det betyr jo ikke at det ikke hadde vært behov for det, men det er en lang vei å gå og det er et langt lerret å bleke." [17]

Another participant expressed it like this:

> "Det er litt sånn låst situasjon da, vi får ikke noe driv i arkitekturarbeidet før vi har arkitekturprodukter som viser nytten. Også får vi ikke laget arkitekturprosjekter som viser nytten før vi har driv i arkitekturarbeidet." [18]

Insofar, it seems like nothing works. Having said that, some success stories exist. For instance, some participants pointed to the importance of mandatory board meetings for scrutinizing architectural products before project documentation was handed over to decision-makers. Others explained how well architecture worked in meeting with users and other stakeholders when suitable architectural products were selected and terminology adapted properly. One

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[17] Translated from Norwegian: "But there is no tradition of working in this way, with this type of processes. It does not mean that it had not been necessary, but it's a long way to go and there is a long and arduous task".

[18] Translated from Norwegian: "It's a bit like stalemate then, we get no impetus in architecture work until we have architectural products that show usefulness. And we do not get any architectural products that show the usefulness until the architecture work gaining momentum."

participant emphasized the importance of proving added value to gain more positive attention. Finally, there existed a shared view that roles and responsibilities need further clarifications in order to establish integrated and well-functioning teams, using embedded architect resources.

Results related to Resources and training

However, architects are a scarce resource. That is pointed out by all participants. When asked about their access to architects when needed, one participant explained it like this;

 "Nei … de er opptatt hele tiden. Det er mange prosjekter som går og linjeaktivitet i tillegg." [19]

This was followed up by asking them why they believed architects were such a limited resource and one participant gave quite an exhaustive answer to that;

"For det første er det en veldig vanskelig jobb, tror jeg. Krever en viss kompetanse og arkitekturressurser, folk som kan arkitektur da som klarer å løfte seg opp fra det tekniske, men forstår virksomhetsarkitektur. Men så er det også at man må sette av ressurser i de miljøene som kjenner virksomheten godt. Så det er ressurs og prioritet på en sånn type aktivite 71 *nan prøver jo å få til det, men man ser jo at det vanskelig å få til uansett.20".*
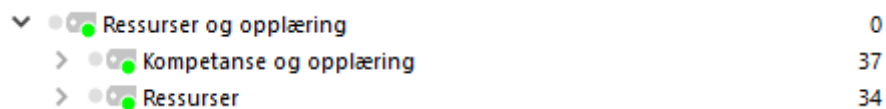
Figure 24: Categories under the theme Resources and Training

Figure 24 shows the two categories belonging to the theme *Resources and training.*

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[19] Translated from Norwegian: "No … they are busy all the time. There are many projects going and line activity as well."

[20] Translated from Norwegian: "Firstly, it is a very difficult job, I think. Requires a certain competence and architectural resources, people who can architecture and are able to elevate themselves from the technical, but understand Enterprise Architecture. But then there is also the need to allocate resources in the communities who know the business well. So it's resource and priority on such kind of activity then. There is an attempt, but you see, it is difficult to get there anyway."

There exists a coherent view in the group that Enterprise Architecture requires a very particular competency. It is also apparent from the interviews that a differentiation in training is needed, one for those who makes the architectural products and another for those who shall read and understand them.

One participant expressed it like this;

"Vi har to typer det er snakk om, det ene er de som skal bruke det og se arkitekturen, og skjønne den og forstå hvordan man skal lese diagrammer. Så har vi også de som skal inn å vedlikeholde og lage arkitekturen. "[21].

Many participants stated that adequate training at an earlier point in time related to their job situation would have made their tasks at hand easier. They also pointed out lack of knowledge of architecture challenged the communication between, for instance project managers and architects.

Results related to Presentation

∨ Presentasjon	72
> Designkriterier	23
> Designprinsipper	17
> Designutfordringer	9
> Typer av presentasjoner	13
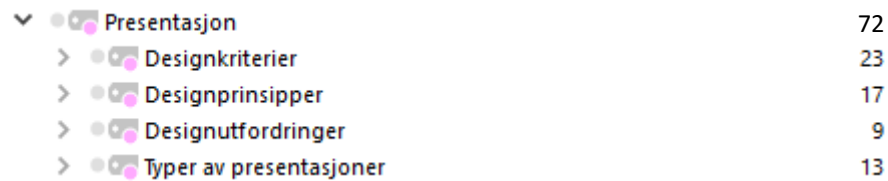
Figure 25: Categories under the theme Presentations

Challenges regarding communication can also be traced to the last theme derived from the interviews – presentation. The theme and its four sub-categories are depicted in Figure 25. This theme is presumably the one most directly relevant for the topic of research and will therefore be allotted some extra attention. The most noticeable fact pointed out by most of the participants was recipients' lack of understanding of architectural products. One participant described it like this:

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[21] Translated from Norwegian: "We have two types in question, one is those who will use it and see the architecture, and understand it and understand how to read models. In addition, we have those going into maintaining and creating architecture."

" Jeg ser at i en del møter hvor det presenteres arkitekturprodukter så sitter folk og sier jeg ser ikke hva som står der, også forstår de ikke produktene fordi de klarer ikke å lese dem."[22]

When they were asked why they believed it was so, answers as *they are not pedagogical good*, *they are complex*, or *they are confusing* were given, or as expressed by one of the participants:

"… de var ofte veldig «busy» kan du si … og vanskelig å lese. Veldig mange elementer inni og mange knytninger."[23]

These answers triggered my curiosity about what types of presentation they used regularly. Their replies were *Executive Summary Views*, *Decision Support Briefs, Process Diagrams, Hybrid Figures*, and *One-sheeters*. They were also asked to recall some good examples from their experiences and use that to propose some useful design criteria. Among the answers were simple terms as *understandable*, *presentable* and *recognizable*, unquestionably terms subject for interpretation. However, if we take a look behind the scene to see what they really mean it gets clearer. As one participant cleverly expressed:

"Jeg tror jo det ene er å lage arkitekturprodukter som er … kanskje ikke nødvendigvis kommuniserbare i utgangspunktet … men at du har laget det mange nok ganger, og viser dem igjen og igjen … at de er like fra prosjekt til prosjekt."[24]

One participant stated that a presentation needs to be autonomous, i.e. it needs to bring added value by itself, another emphasized the importance of adapting the presentation to fit the audience. These last findings are supported by other statements from the participants as well.

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[22] Translated from Norwegian: "I see in several meetings where it is presented architectural products, people say I do not see what's there, they do not understand the products they are unable to read them."

[23] Translated from Norwegian: "… they were often very "busy" you can say ... and hard to read. Very many elements inside and many ties".

[24] Translated from Norwegian: "I think the one is to create architectural products ... maybe not necessarily communicable basically ... but if you make it several times, and show them again and again ... that they are the same from project to project."

Nearly all of them pointed to standardization of which models or diagrams should be used and how they should look like, exemplified by this statement:

"Oppdragsgiver har uttrykt ønske om at det skal ligge en del mer arkitekturinformasjon i selve FL dokumentet. Det har derfor blitt laget en liste over hvilke produkter som skal inn i FL."[25].

Standardization is here categorized as a design principle, together with *navigable*, *simplify* and *show different perspectives*. In this context, navigable is used for being able to go from one view to another by exploiting connection between different elements. Simplify is used as a term to make a complex model more understandable, described by one participant as:

" …ta masse kompleksitet og prøver å forenkle det – sånn passe. Sånn at de forstår det, og faktisk begynner å diskutere."[26]

These are somewhat connected to the last code – show different perspectives, where it is highlighted that new insight can be achieved, at least if we follow a statement given by one of the participants:

"Du greier ikke å holde det i hodet, også tar man og strukturerer det på en gitt måte og presenterer forskjellige synsvinkler av det. Da plutselig oppstår det sånn «hmm …, hvorfor har vi ikke noe der?"[27]

This section will be concluded with a useful argument expressed by one of the participants:

" Vi tilpasser presentasjonen avhengig av kompleksiteten til det som skal presenteres."[28]

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[25] Translated from Norwegian: "Project Owner has expressed a demand for more architecture in the FL documentation, based on that a list of products required was composed."
[26] Translated from Norwegian: "take a lot of complexity and try to simplify it – in right portions, in such a way that they understand it, and start discussions."
[27] Translated from Norwegian: "You cannot hold everything in your mind, and then you structuring it in a particular way and present different viewpoints of it. Then suddenly arise like *eureka* … why do we not have anything there?"
[28] Translated from Norwegian: "We adapt the presentation depending of the complexity of what shall be presented."

5.1.2 Results from Observation

One observation was conducted with the main purpose to supplement findings from interviews - to fill in the picture, to get insights into how architectural products are really used, not how they say they are using them. The observation took place during a meeting called Architecture Board, chaired by the board's Chairman, and administratively supported by the board's Secretary. There were fourteen participants at this meeting representing most of the different stakeholders described in the method chapter, see Table 4 for details. The meeting started with the chairman explaining the purpose of the meeting and what they were looking for. A representative from the subject matter authority put the project in a context and introduced the project coordinator. The project coordinator is the role responsible for making sure the project is well-connected to overarching goals and objectives, and that users' needs and requirements are identified and captured. The project coordinator was the protagonist in this meeting. He gave a presentation about the project and answered questions asked from participants, whereas the Project Manager played in a supporting role. The Project Manager has the role "to take over" the project when it moves from definition to acquisition phase. The presentation contained both models representing architectural products and graphics not following any formal notation. A reproduction of the models of architectural products is offered in Appendix H. All information related to the specific project is scrutinized for confidential reasons, however notation should remain untainted. A problem observed was inconsistency between some architectural products presented and the text in the FL-document. Another issue observed was, although all expected products were represented it seemed like they did not facilitate, or gave sufficient support when content was discussed. For instance, in a discussion about the different options in selection of the most appropriate solution, other graphics seemed to do that job better. In the same discussion, one remarked the lack of information in the model to what extent requirements were supported. One interesting observation was the identification of difficulties of understanding the meaning of some of the symbols (notation), for instance there were questions about arrows; what is the difference between dotted and solid line, what is the difference between open and closed tip on the arrow, and why a connection sometimes goes in one direction and sometimes in another.

Also different colors were used without legend indicating the meaning. All these leave too many parameters open to interpretation.

The architecture board took place in a meeting that also contained some other aspects of project management, such as time and cost management. Although, the participants strived to distinguish those different parts they sometimes got lost. Nevertheless, the observation focused only on the part of interest for this study. The meeting concluded the architecture board after 2.5 hours.

5.1.3 Result from Document Inspection

Mandate Architecture Board

Mandate for the Architecture Board is given in *Bestemmelse om bruk av arkitektur i utviklingen av Forsvarets informasjonsinfrastruktur (INI)"*[29]*(Cyberforsvaret, 2016)*. This document is currently a draft version. The first version issued for endorsement was too broad regarding organizational scope and level of authority. The 2016 version is more focused on architecture and will, when issued, provide a sound basis for Enterprise Architecture for the Norwegian Defense. It defines fundamental properties related to architecture, both procedural and organizational. The interviews in this study revealed issues in ways of working and a deliberate avoidance of architecture and architectural products. A document like this might give the necessary weight to change these situations. Even more important than formally stating roles and responsibilities is the more practically grips taken, such as stating that a set of architecture principles based on recognized standards should be adhered to. These principles are published in an Intranet solution where all stakeholders have access. There are no requirements set out in this document with regards to how architectural products should be represented and presented. It is therefore important that this is captured as part of the aforementioned set of principles, or published in a separate guidance document.

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[29] This document is still in a draft version due to unresolved issues related to scope and level of authority. A revised version is about to be released.

Project Architecture – Diagrams

An example of a guidance document is *Project Architecture – Diagrams* (IKT, 2015). This is a document that specifies what kind of architectural products which should be developed under each phase of a procurement project. This document is a draft version and not yet formally issued. It gives the impression of being a design guide for architects and provide guidelines for how to model separate views (diagrams) in a project. It is a thorough description and nicely organized in chapter for each different part of an architecture. However, the order could probably benefit from being aligned with the order of the documents it supports, the FL documents. There is a strong linkage to NATO Architecture Framework (NAF), for instance naming conventions. However, there should have been an indication of what version of NAF it refers to.

Terminology

A common terminology for use at development, procurement and management related to security accreditation of ICT-systems. (Materiellavdeling, 2015). This document is mainly intended for security accreditation purposes, however the idea of having a document providing a common terminology could benefit Enterprise Architecture as well. Interviews revealed problems in communication between different actors, and a common language (terminology) is a pre-requisite for basic communication. Another aspect is that this document is limited to the technological part of the architecture. At the least, this could have been used as a starting point, and from there expand and extend to include other parts of the Enterprise Architecture.

Checklist FL

Checklist FL is a document provided to guide the development process of a FL-document and the assessment process in the Architecture Board. (Cyberforsvaret, 2015a). It starts with an explanation of the documents purpose and a guidance about how to use it. There are ten main check points, and it concludes with a summary and a recommendation. The document lists a set of architectural products expected to be presented for review. It would probably help the review process if the check list is consistent with or harmonized with the list of diagrams.

5.2 Findings from EA Case Study

This section is a summation of the most relevant findings from the case study, starting with a tabular presentation of findings from the interviews in Table 6. They are sorted in two different quantities, one for those findings assumed to have a direct influence on the visualization at the end results (identifier starts with *IDI, Interview Direct Influence*), and another for more peripheral, in-direct relations (identifier starts with *III, Interview Indirect Influence*). It continues with presentation of findings from the observation in Table 7, and ends with findings from the document study in Table 8. Regarding findings from the observation this will part focus on how they were presented and how they were received by the audience, not so much on how they technically fulfill requirements from the field of information visualization. Identifier used is *ODI*, *Observation Direct Influence.* Finally, the document inspection will summarize the findings following the same logic. Identifiers are either *DDI, Document Inspection Direct Influence* or *DII, Document Inspection Indirect Influence*.

Table 6: Findings from Interviews

ID	Title	Description
IDI-1	Lack of understanding	Recipients lack of understanding of architectural products is likely to cause a lack of interest. The core of the problem points at too complex and/or too confusing models.
IDI-2	Standardize	Repeated and standardized models might reduce or eliminate the problem described above (in IDI-1).
IDI-3	Simplify	Reduced complexity by simplifying the models whenever possible to do so, without loss of information, might reduce or eliminate the problem described above (in IDI-1).
IDI-4	Adapt	Adapt the level of complexity and the amount of information to fit the audience/ recipients.
IDI-5	Show different perspectives	Another way of making it more understandable is to offer different viewpoints of the same information.
III-1	Architectural considerations	A both broader and deeper understanding of architectural products by all stakeholders is needed to make it more attractive. Some factors which need attention are level of details, who is the audience, should it be communicable or consistent
III-2	Insufficient or inadequate processes	Related to lack of continuity and routines, lack of standardization.
III-3	Avoiding use of architecture	Deliberately avoiding use of architecture based on lack of understanding and difficulties in changing already established ways of working.
III-4	Deadlock situation	No impetus in architecture work before architectural products show usefulness, and no architectural products that show the usefulness until the architecture work gain momentum.

III-5	Architects a scarce resource	Too many projects that require same type of limited resources at the same time.

Table 7: Findings from Observation

ID	Title	Description
ODI-1	Inconsistency	Some examples of mismatch between the text in the document and the figure/model/architecture product supporting the text. Conversions with participants after the revealed that this could be caused by the demand of architectural products to pass the board, not necessarily to support the project development.
ODI-2	Lack of understanding	This was in particular related to not understanding the formal notation in use. Architecture products are following a strict notation to avoid misinterpretation, however this can sometimes be difficult to understand by laymen.
ODI-3	Insufficient	The figures/models/architectural products presented were sometimes insufficient in support discussion between different actors to get a better understanding of the project.
ODI-4	Lack of legends	Some of the problems listed in the above findings could likely have been reduced or eliminated with use of legend explaining the meaning of symbols and colors used in the presentation.
ODI-5	Lack of text	Some of the problems listed in the above finding could likely have been reduced or eliminated with use of explaining text, e.g. text supporting direction and meaning of arrows and boxes.

Table 8: Findings from Document Inspection

ID	Title	Description
DDI-1	Lack of description how to present information	Although there exist thorough descriptions of which architectural products (diagrams) to make, which components and elements to include, there are missing some guidance on how they make them communicable to all stakeholders.
DDI-2	Lack of legacy	An example of a low-hanging fruit, easy to implement and provides great value.
DII-1	Not formally issued	Documents not formally issued need to be completed and issued to carry the necessary weight as governing documents. Today this deficiency gives room for different actors to implement as they find convenient, without sometimes seeing the bigger picture.
DII-2	Correlation and harmonization	All supporting and guidance documents need to be harmonized, for instance the order should be aligned for readability and usability purposes.
DII-3	Completion	The collection of governing and guiding documents need to be completed to help the stakeholders producing and presenting proper architectural products. An example could be to produce a presentation of an example project showing architectural products expected presented for the Architecture board.

5.3 Results from IV Literature Review

This chapter presents results and findings from Information Visualization Literature Review. First the results from the literature search process is offered. Thereafter results from the literature survey is presented, organized by the two topics, (also called building blocks) representation and presentation. The chapter is finalized with a collection of findings, or best practices.

5.3.1 Results from Literature Search

A broad search process was conducted, containing both skimming, scanning and mapping of data. Relevant data of potential sources were captured and stored in Table 9 in an arbitrary order. The purpose was to get a broad overview over available literature. The literature survey process was not limited to use literature discovered in the search process.

Table 9: Result from literature search, possible sources of information related to Information Visualization

Title	Author	Published
The functional art	Cairo, Alberto	2013, Pearson
Key Idea	*Descriptor*	
Introduction to information graphics and visualizations	Journalist with experience from producing graphics for newspaper to illustrate a story. Communication and story to tell is important. It provides fundamentals about how to evaluate, and thereby create visualizations. It goes in direction of info graphics, which could be interesting for the study. It also provides insights into human vision and cognition.	
Title	Author	Published
Design for information	Meirelles, Isabel	2013, Rockport
Key Idea	*Descriptor*	
Effective information visualization, methods for design, how to scrutinize IV	An introduction into the histories, theories and best practices behind effective information visualization. As she says in the book, the goal is to provide readers with a critical and analytical tools. It covers different types of visualization and explains when and why a certain IV is more appropriate.	
Title	Author	Published

Visualization for information retrieval	Zhang, Jin	2008, Springer
Key Idea	*Descriptor*	
Information retrieval, cognitive perspectives, perceptual perspectives	It provides a systematic explanation of the latest advancements in information retrieval visualization. This is a very technical book. It might give some help in the area of information seeking processes.	
Title	*Author*	*Published*
Visual Cognition	Humphreys, Glyn Bruce, Vicki	1989, LEA
Key Idea	*Descriptor*	
Visual attention, visual memory, visual processing	Provides an introduction to visual cognition, about spatial information, color and texture, about how vision enables us to perceive the objects and events we are exposed for. This book describes how the processes behind visually driven behavior.	
Title	*Author*	*Published*
Information Visualization, perception for design	Ware, Colin	2004, Elsevier
Key Idea	*Descriptor*	
Foundation, Information that pops out, interaction, gestalt theory	It describes fundamentals for information visualization, including the eye and the environment, color, lightness, brightness, contrast and constancy. Most interesting for this study is the chapter about visual attention and information that pops out.	
Title	*Author*	*Published*

The visual organization	Simon, Paul	2014, Wiley
Key Idea	*Descriptor*	
Data visualization, big data, quest for better decisions	It is more about turning data into useful insights. It is interesting to see if there is anything from this book about how to become a visual organization that can be applied into working processes to make information more understandable and attractive.	
Title	*Author*	*Published*
Envisioning information	Tufte, Edward	1990, Graphics Press
Key Idea	*Descriptor*	
Learning by means of images, visual thinking, displaying information	It is a classic, and therefore it needs to be in the portfolio of books to survey. Expecting to find helpful hints about layering and separation, zooming, colors and other elements used in display of information.	
Title	*Author*	*Published*
The Tell-Tale Brain	Ramachandran, V.S.	2011, Norton Paperback
Key Idea	*Descriptor*	
The artful brain, emergence of aesthetics	Add-on material on how the human brain think about art and aesthetics. Back-up material, at most.	
Title	*Author*	*Published*

Basic Vision	Snowden, Robert Thompson, Peter Troscianko, Tom	2012, Oxford University Press
Key Idea	*Descriptor*	
Visual perception, spatial vision, color vision, perception of motion, attention and neglect.	This book goes through the various elements of visual perception. Using an informal way to explain complicated topics. Most likely the chapter about attention and neglect will be of most relevance.	
Title	*Author*	*Published*
Information Visualization, design for interaction	Spence, Robert	2007, Pearson
Key Idea	*Descriptor*	
Representation, presentation, interaction, and encoding.	One of the main books, already used for setting the scene of this study in the introduction chapter. Useful organization of main themes of information visualization. Thorough chapter on interaction.	
Title	*Author*	*Published*
The symbolic species	Deacon, Terrence	1997, Norton Paperback
Key Idea	*Descriptor*	
Human brain, symbols.	Add-on material on how the human brain interprets and use symbols to understand graphics. Backup material, at most.	
Title	*Author*	*Published*

Vision and brain	Grossberg, Stephen	2004, Elsevier
	Finkel, Leif	
	Field, David J.	
Key Idea	*Descriptor*	
Understand how brain see, motion perception, attention, search, object recognition.	This is a collection of research papers covering aspects from earlier to higher levels of visual organization. This book will probably only be of limited interest to this study, since the topics covered are in the more peripheral zone.	
Title	*Author*	*Published*
The truthful art	Cairo, Alberto	2016, Pearson
Key Idea	*Descriptor*	
Data, charts and maps for communication.	This book goes deeper into how to provide a true representation. It brings fundamental principles on board, such as truthful, functional, beautiful, insightful, enlightening and goes into the deep of how to achieve so.	
Title	*Author*	*Published*
Storytelling with data	Nussbaumer Knaflic, Cole	2015, Wiley
Key Idea	*Descriptor*	
Visual storytelling, techniques, pre-attentive means.	This book is teaching how to do storytelling with data. It is very descriptive, but in the same time provides good background and arguments for why it should be like described. It provides a lot of good examples.	
Title	*Author*	*Published*

Semiology of graphics	Bertin, Jaqcues	2010, Esri Press
Key Idea	*Descriptor*	
To provide a grammar for the graphics.	The original edition is from 1967, a second edition appeared in 1973. The first English translation came in 1983, translated from the second French edition. Version used in this study is an updated English version (from 2010). Use of graphical methods for both exploration and communication of complex data.	

Title	*Author*	*Published*
Show me the numbers	Few, Stephen	2012, Analytics Press
Key Idea	*Descriptor*	
Use of tables and graphs to communicate quantitative information	It is about "giving a voice" to numbers, and to do so in an understandable way. The book is meant as one of those books you keep in the shelf for reference and consultancy when needed. It covers both representation and presentation of data.	

Title	*Author*	*Published*
Design of Everyday Things	Norman, Don	2013, Basic Books
Key Idea	*Descriptor*	
Some essential characteristics are common to all design	This book is included based on its descriptions of basis characteristics of all designed objects, hereunder affordance, signifier, discoverability and constraints.	

5.3.2 Results from Literature Survey

This literature survey can be thought of as a continuation of Chapter 3.2 where some facts about human's visual perception and cognition are offered. One important issue mentioned was that visualization relies on the formation of a mental model.

Representing information

What are the particular things with representation that can help form the aforementioned mental model? According to Spence (2007), visual coding is substantial, hereunder encoding of values and relations. Included here is the selection of an appropriate representation. That means deciding on a representation that impose as little cognitive load as possible. Tufte (1990) says a visual design is good if it says a lot with little. In the selection process the first thing to consider is who your audience is. Using representation known or understandable for the intended audience will reduce the probability of being misunderstood or misinterpreted. As depicted in Figure 26 all visualization has to go through the same process of encoding and decoding, which leaves room for misunderstanding. It is therefore of utmost importance to choose an encoding that is as precise as possible, where the intended audience is taken into consideration.

design…   use…

| Information | Encode | | Decode | Understanding |
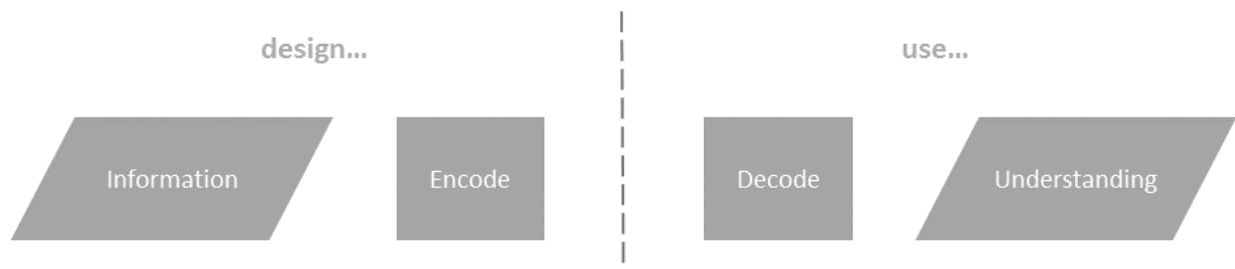
Figure 26: Encoding - decoding process

The second thing to consider is: What is the story to be conveyed, and what kind of representation supports that story best? For instance, if values are to be compared they have to be represented, or portrayed in a way that easily allows for comparison. Many studies have been performed to come up with a set of representations best suited for particular use. This will be offered later in this study, but first a look at some typical pitfalls enabled by widespread software tools. The brain is not particular good in comparing size, such as areal and volume. Nevertheless, a much used representation of values is bubbles, or squares. Figure 27 shows the same value represented with

two different figures to illustrated the problem. The charts show prices on crude oil in 2011 and 2015. Both the bubble chart on the left hand side and the more traditional bar chart on the right hand side show a reduction of oil prices[30] by fifty percent.

Figure 27: Shows the importance of selection an appropriate representation

According to Cairo (2013) more than 70% underestimate the reduction when shown a bubble chart. This is simply due to the fact that human beings judge the size by the vertical height, not by the size of the surface. For bubble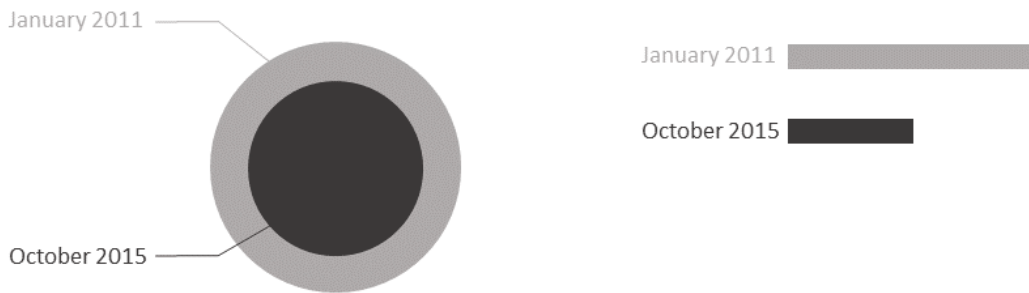 charts Cairo refers to this as *the bubble plague*. New software tools, with a high proliferation rate, allow people to pick from a rich variety of charts. It is likely that the aesthetics overrule the functionality aspects when an average person selects what type of chart to use. More about the aesthetics versus functionality is offered under *Presenting information (Chapter 5.3.2).* Knaflic has some similar pet peeves about other types of charts. She refers to the misuse or overuse of pie charts, donut charts, 3D and secondary y-axes. As a rule of thumb, she says, use of these should be avoided (Knaflic, 2015). In the book several good illustrations are given to exemplify the problem. In general, it can be summarized to the fact that these types put an unnecessary burden on the brain to interpreted and understand the visuals. These are therefore in most cases counterproductive, but not always. Both Cairo and Knaflic provide examples of suitable usage, however the main takeaway is that these have to be used with awareness to the outcome.

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[30] Prices are approximately and collected from http://www.infomine.com/investment/metal-prices/crude-oil/5-year to illustrated importance of selecting appropriate representation.

To assist the selection of when to use what representation, several models exist. Already in 1967, Bertin, a French pioneer of information visualization proposed a guidance on how to choose encoding based on the effectiveness of the graphical language. Bertin based his work on experimental psychology's definition of depth perception, and described visual variations available to a designer (Bertin et al., 2010).
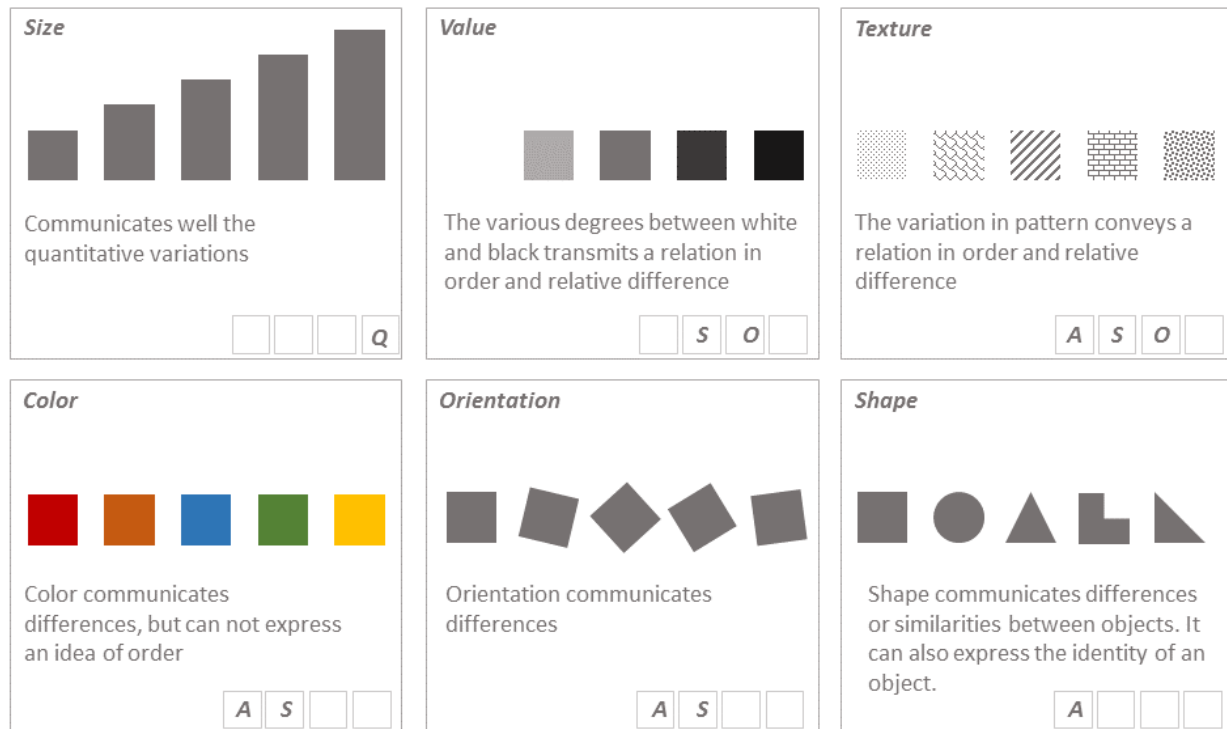
Figure 28: The retinal variables (Bertin, 2010)

Furthermore, for each retinal variable (encoding mechanism) he described four planner dimensions (association, selection, order, quantity) considered suitable for each of them. Each square in Figure 28 is annotated with letter(s) to depict the connection.

Another model was developed by the statisticians Cleveland and McGill, emphasizing the quantitative dimension. The model shows the relative difficulty of assessing qualitative value as a function of encoding mechanism (Cleveland and McGill, 1984). Their research proposed guidelines for graph construction, however limited to encoding of quantitative information. See Appendix I for details. So far only representation of values (quantitative) has been discussed. Other type of encoding exists as well. Inspired by the work from Cleveland and McGill, Mackinlay

(1986) studied the effectiveness of the graphical language. In addition to quantitative data, ordinal and nominal data were included in the study. As an outcome, Mackinlay suggests a theory of how effective a representation is relying on its elementary perceptual tasks. Figure 29 shows in which order his model suggests use of encoding for different types of data. Knaflic (2015) has a rather pragmatic approach to the selection process as she states that the right representation is the one easiest for your audience to read. However, knowledge about perceptual challenges would make it easier to select a better option.

Quantitative	Ordinal	Categorical
Position	Position	Position
Length	Density	*Color Hue*
Angle	Color Saturation	*Texture*
Slope	*Color Hue*	*Connection*
Area	*Texture*	*Containment*
Volume	*Connection*	Density
Density	*Containment*	Color Saturation
Color Saturation	**Length**	Shape
Color Hue	**Angle**	**Length**
Texture	**Slope**	**Angle**
Connection	**Area**	**Slope**
Containment	**Volume**	**Area**
Shape	Shape	**Volume**

Figure 29: Guidance for encoding of quantitative, ordinal and categorical data, from Mackinlay (1986)

Presenting information

> *Though accurate data and real facts are valuable, when it comes to getting results the manner of presentation is ordinarily more important than the facts themselves. The foundation of an edifice is of vast importance. Still, it is not the foundation but the structure build upon the foundation which gives the results for which he whole work was planned. As the cathedral is to its foundation, so is an effective presentation to its data.[31]*

Now, moving from a set of carefully selected representations to presentation, the words cited above, stemming from a book written over 100 years ago is considered being a firm start. As it points out, it is with the presentation that the data, the representations come alive.

However, it is not always easy to draw a distinct line between representation and presentation. Rather than being a line, it is more like an overlapping area where level of abstraction and interpretation decides where the line is drawn. For instance, in the previous chapter regarding representation, knowledge about the audience was expressed as an important factor. In the same way, knowing the audience is as important for presentation matters. Different communications for different audience. Not only knowing the audience, but also have a clear understanding of the purpose of the visualization. Knaflic (2015) promotes an early decision on the purpose; is the visualization intended to be exploratory or explanatory? Meaning that, is the visualization intended to present everything, or is it to present the result of for instance an analysis? Most of the literature discuss the latter, as this is the form of visualization appropriate for telling a story. Storytelling is an important part of presentation, the building of a narrative structure that informs and form the visualization.

After concluding on audience, context, purpose and the story to be told, forming the visualization - the presentation, can take place. Limitation in space is normal when dealing with presentations.

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[31] Citation taken from Willard C. Brinton (1914) Graphic Methods for presenting facts, perhaps the first book about graphical data presentation. The citation is a reprint from the preface of FEW, S. C. 2012. *Show me the numbers : designing tables and graphs to enlighten,* Burlingame, Calif, Analytics Press.

If a computer screen is used as the media; zooming, paning and scrolling are available techniques to "enlarge" the real estate. However, as this study defines those techniques to belong to interaction, only the static, visual part is considered.

Eye tracking studies have revealed patterns in the way a screen is read. Most commonly is a F-pattern, at least this is true in the western society and where no scents or hints "steal" the attention (Nielsen, 2006). Also Z-patterns are recognized as common on plain text (Boiko, 2013). What those patterns have in common, is that upper and left part of the screen is favored, based on that these areas are sometimes referred to as precious real estate. This is important knowledge when arranging graphs and visual representations on a page. Later studies have revealed different patterns when the visual hierarchy increases in complexity, among these are Djamasbi et al. (2011). They state that both the visual complexity and type of task affect the viewing pattern. They also say this is consistent with theory of visual hierarchy. The model of visual hierarchy talks about two distinct cognitive processes guiding the viewing patterns: searching and scanning. Searching is about finding an entry point and scanning is about extracting information surrounding that point. Their study tells that both processes can be influenced by introducing certain visual elements. For the search process, color, size and location are examples of such elements whereas proximity and order of elements are types relevant for the scanning process. This is related to what was earlier discussed about pre-attentive processing and corresponds well with Ware's list (see Table 2) over features that are pre-attentively processed. Designers and others who make presentations (or visualizations) should take advantage of those features. Knaflic (2015) states it like this:

> "if we use pre-attentive attributes strategically, they can help us enable our audience to see what we want them to see before they even know they're seeing it!" *(p.104).*

Stephen Few is also concerned with pre-attentive attributes and based on Colin Ware's work discussed in 3.2, he made an extract of those attributes most used in static visualizations (Few, 2012), as shown in Figure 30.
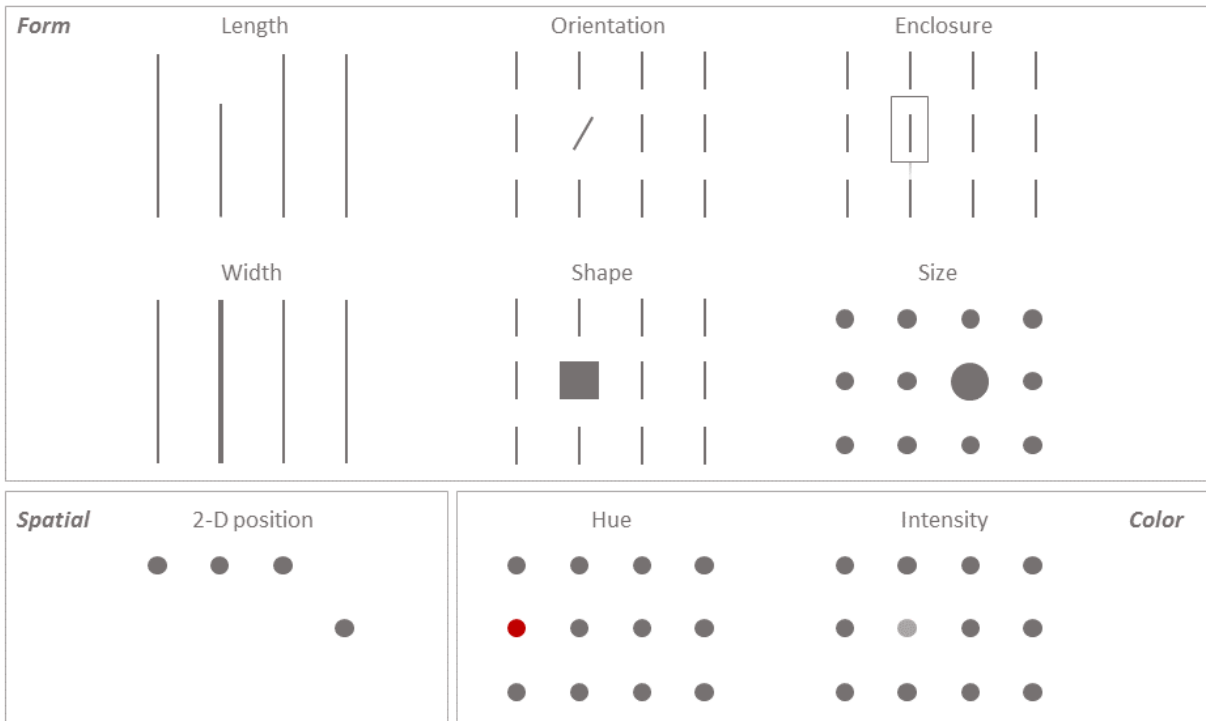
Figure 30: Pre-attentive attributes, from Few (2012)

According to Few (2012), research have shown the limitations to be as follows:
- No more than eight different hues
- No more than about four different orientations
- No more than about four different sizes

When mixing different types of attributes, it reduces the effect of pre-attentiveness as human beings usually can only handle on visual attribute of an object at time.

Other similar effects or methods exists, too. Gestalt laws, originating from research performed by a group of German psychologist in the beginning of the 20th century. Gestalt is the German word for pattern. It provides a set of laws of pattern perception, and describes the way we see patterns

in visual displays. Ware (2004) describes how eight of these laws can be turned into design principles; proximity, similarity, continuity, symmetry, closure, relative size and common fate. Figure 31 provides examples from some of the laws mentioned above, to illustrate some of the visual perception effects. In addition to those three specifically illustrated (and named) a fourth is apparent, too. The law of closure is demonstrated simply by adding frames to separate the three for better readability. Wherever a closed contour is seen, there is a strong tendency to see this as an object, by categorizing the elements to be either inside or outside of that contour.

Similarity

Objects of similar color, shape, size, or orientation are perceived as related or belonging to part of a group. In the left figure you see rows due to similarity of colors. In the right figure you see columns due to similarity in shape.

Rows   Columns

Proximity

Objects of spatial proximity are perceptually grouped together. A small change in spatial position changing a perceived set of rows into a perceived set of columns.

Rows   Columns

Continuity

The law of continuity states that we are more likely to construct visual entities out elements that are smooth and continuous. Most people will perceive the figure in A to consist of two squares like in B, although it could as well have been as in C.
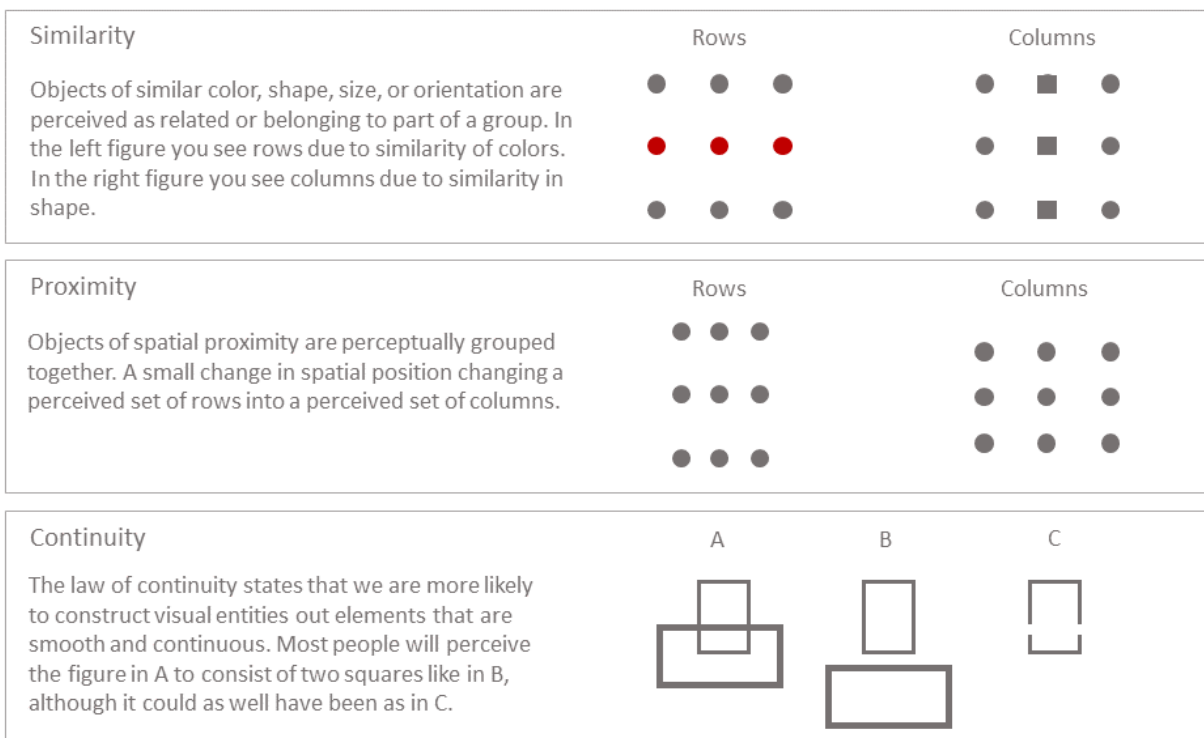
A   B   C

Figure 31: Some illustrations of Gestalt Laws

Connectedness is pattern overlooked by the German psychologists (Ware, 2004), even though connectedness can be a stronger grouping principle than proximity, color, size, or shape. Figure 32, borrowed from Knaflic (2015), demonstrates the stronger grouping of connectedness. However, as shown at the right-most in the same figure, enclosure has an even stronger visual effect.
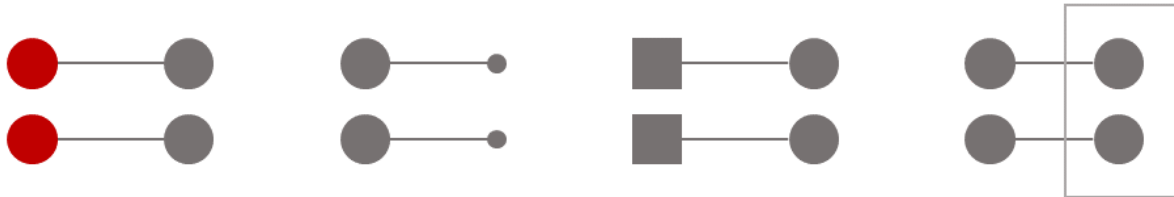

Figure 32: Demonstration of connectedness (Knaflic, 2015)

This demonstrates that a clear understanding of visual perception, and a sensible use of visual hierarchy can be implemented to avoid misapprehension and misinterpretation.

"Confusion and clutter are failures of design, not attributes of information.

And so the point is to find design strategies that reveal detail and complexity –

rather than to fault the data for an excess of complication. Or worse, to fault

viewers for lack of understanding."

These are the words of Edward Tufte from his classic book about visualization, Tufte (1990). He suggests, when dealing with complexity the technique of layering and separation is among the most powerful to reduce noise and enrich the content. However, he continues:

"Effective layering is often difficult; for every excellent performance, a hundred

clunky spectacles arise".

What he means is, when putting together different elements, different representations, often other patterns or texture appears, simply through their presence. Then unplanned clutter can turn up. Tufte (1990) refers to Josef Albers, who called this separation effect one plus one equals three or more, first demonstrated in his *Search versus Re-search,* published in 1969.

Figure 33 illustrates this effect by "adding" a white space, or actually only separating the blue and the red stripes, and "Le Tricolore[32]" appears.
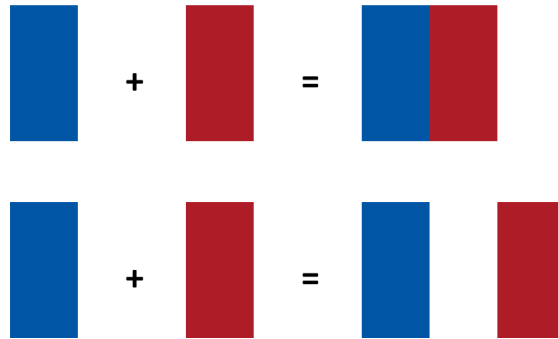

Figure 33: One plus one equals three or more

Tufte is also a firm believer in minimalism when it comes to visualization, and coined the term *chartjunk* when he attacked the practice of adding cosmetic decoration to enliven presentation containing quantitative data and information. He finds support in a quote from Pugin[33], that once said:

"It is alright to decorate construction but never construct decoration."

To use Tufte's own words *(Tufte, 1990):*

"Cosmetic decoration, which frequently distorts the data, will never salvage an underlying lack of content … credibility vanishes in clouds of chartjunks …"
(p.34).

Amongst those who support this view of minimalism is Ben Shneiderman. He states in (Card et al., 1999) that the purpose of visualization is insights, not picture. Others again, are more in favor of some decoration as long as this support the message meant to be conveyed. Stephen Few is one of them. A study (Few, 2011) he performed about the use of decoration or embellishments to enliven a presentation of data showed that there actually was none or little change in the

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[32] The French name of the French flag. Source: https://en.wikipedia.org/wiki/Tricolour_(flag).
[33] Augustus Welby Northmore Pugin (1 March 1812 – 14 September 1852) was an English architect, designer, artist and critic. Source: http://archinect.com/forum/thread/82242284/interesting-quote

immediate recall. For long-term recall the decorated *chartjunks* came out better. One of the conclusions from the study is:

> *"… it reminds us that simple messages can at times be presented in a more engaging and memorable manner through the use of properly designed embellishments."*

Cairo (2013) does also take this balanced approach and remind us that:

> *"Decoration is not bad per se, but it can interfere with the information in a chart if not handled well".*

As a support for his own work with visualizations, Cairo constructed a tool he called the visualization wheel (Figure 34). This was an aid for thinking about visualization, as it corresponds to the main features that need to be balanced when working with visualizations.
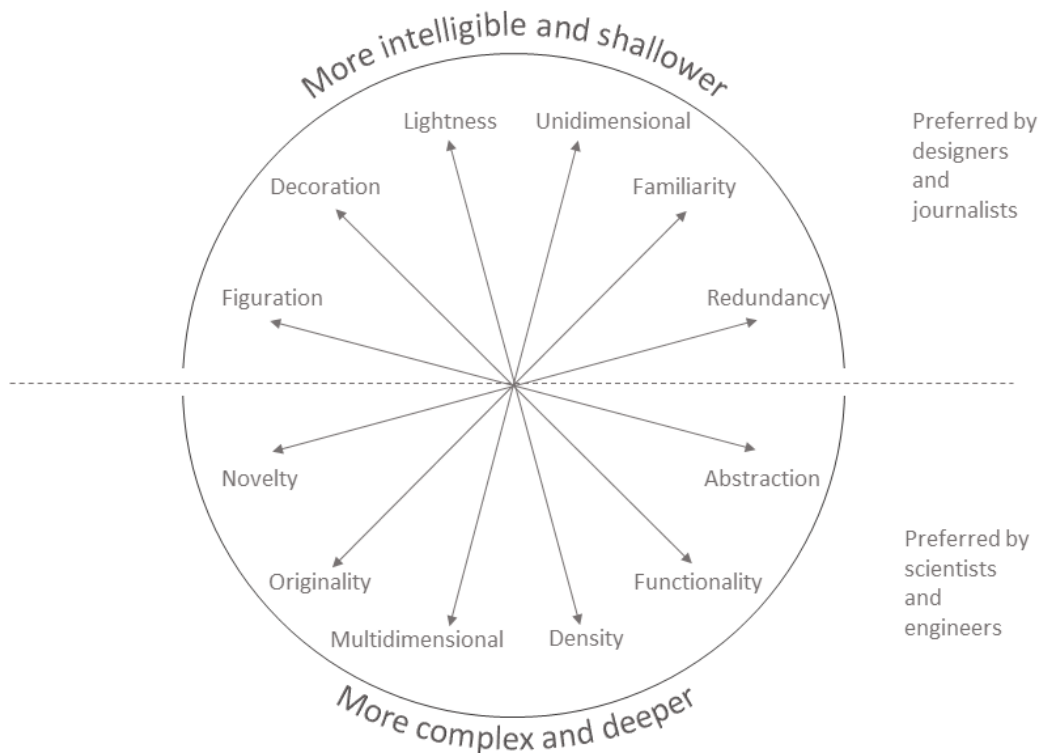

Figure 34: The visualization wheel (Cairo, 2013)

5.4 Findings from IV Literature Review

The following two tables are used to summarize findings from literature review considered most important. The purpose is to allow easy access to these findings, and to establish some hooks for later discussions related to how this can benefit Enterprise Architecture. This can also be looked upon as *a set of best practices*. Table 10 offers findings/best practices related to representations and Table 11 offers findings/best practices related to presentation.

Table 10: Findings on Information Visualization - representing information

ID	Title	Description	Hint
IVR-1	Familiar to the audience	Representations familiar to the audience are more intelligible. These hinder also misinterpretation. The reason is the human attention. This is based on the fact that human attention is a very limited resource.	Use of standards
IVR-2	Support the story	Representations that support the story is more convincing, because of consistency. This is rooted in the encoding – decoding process all visualizations have to go through.	Consistent
IVR-3	Be sensible on type of representation	Consult Mackinlay's guidance on encoding to decide what kind of encoding supports what kind of data best.	Consistent
IVR-4	Choose correct encoding (overall)	Consult Bertin's model to select the most appropriate encoding for the task at hand. For instance, for quantity use size, for association use shape and for order use value and so on.	Use of standards

IVR-5	Choose best encoding for quantitative data	Consult Cleveland and McGill's work in order to select the most appropriate encoding available for quantitative data.	Use of standards
IVR-6	Use with care, avoid pitfalls	Some representations should be used with care (or avoided) since these are easy to misuse. These are included but not limited to [bubble charts, pie charts, donut charts, 3D, secondary Y-axes]. The reason is the way human brain judge sizes.	Simple

Table 11: Findings on Information Visualization - presenting information

ID	Title	Description	Hint
IVP-1	Know the audience	Knowledge about the audience is of outmost importance to make a digestible presentation.	Customizable
IVP-2	Know the story	Be conscious about what story to tell. Is the presentation meant to inform only, or is it meant to prompt any actions?	Understandable
IVP-3	Be aware of the visualization's complexity	A visualization with little complexity often trigger "normal" viewing patters. Upper and left part of the media. More complex visualizations may lead to other viewing patters caused by visual elements that "steal" the attention.	Inviting
IVP-4	Think about the visual hierarchy	Be aware how the visual hierarchy influence the searching and scanning patterns.	Inviting/ understandable
IVP-5	Use pre-attentive attributes strategically	Wise use of such elements can enable audience to discover insight not else revealed. Consult	Based on guidelines

		Few's work to select the most appropriate element that support the presentation.	
IVP-6	Do not overuse pre-attentive attributes	Overuse of attributes will reduce or eliminate the effect of pre-attentiveness. Consult Few's work to learn more about limitations.	Understandable
IVP-7	Consult the Gestalt principles	Use the principles from the Gestalt Laws when grouping of elements is important to the visualization. Likewise, consult them to avoid misuse of patterns that potentially could clutter the presentation, and cause misinterpretations.	Understandable
IVP-8	Clever use of layering and separation	Layering and separation are effective techniques to reveal details and complexity. However, be aware of unexpected effects when playing with these techniques. In example how the one plus one equals three or more effect works.	Understandable
IVP-9	Balanced use of decoration	Be aware how use of decoration can distort the data and transform the visualization into chartjunk. On the other side, proper use of decoration can make a visualization more attractive and even cause a better recall of the information conveyed.	Inviting/ understandable
IVP-10	Use the visualization wheel	Whenever considering a presentation of data and information consult Cairo's visualization wheel. It offers a set of features that have to be balanced to meet the demands of the audience and the characteristics of the data conveyed.	All

6 Discussion

This chapter covers two parts. In part one, findings from the EA Case Study are evaluated against findings from the IV Literature Review. That entails to discuss the applicability of the findings (read: best practices) from the field of Information Visualization for the identified issues of Enterprise Architecture. Part one is concluded with a set of recommendations based on the discussions. In part two, the quality of the applied research design will be discussed to answer fundamental properties of decent research, such as validity and reliability.

6.1 Discussion of results – bringing it all together

The following discussion seeks to answer the study's research question:

To what extent is it possible to take advantage of methods and techniques from the field of Information Visualization to increase attractiveness of Enterprise Architecture?

To be in position to answer that question, it was essential to learn more about the phenomenon – *why is there a perceived reluctance to use - and a lack of interest in - architectural products*? This was researched in the EA Case Study, and its results constituted the grounds for the second part of this study. This chapter reflects that relationship, therefore methods and techniques for representation and presentation purposes are often discussed in close connection to discovered underlying issues.

From the EA Case Study, perhaps the most prevailing finding was *the expressed lack of understanding*, as this was a recurring issue during the interview sessions and from all categories of interviewees. It was explained by innate complexity, alienation caused by unfamiliar terms, not pedagogically good design and confusing presentations. Some interviewees also pointed in the

direction of difficulties in changing already established ways of working by certain categories of stakeholders. This lack of understanding did not include stakeholders directly involved in the development of architectural products, but rather those intended to make (strategical) decisions based on the products presented.

Forming a logical path; if there is a lack of understanding, it is likely that the products can be considered as useless (based on: "what's in it for me?"). Thus; reluctance to use. So who is responsible for this lack of understanding. Is it the producer or the consumer? In chapter 5.3.2 it was stated that all visualizations have to go through the same process of encoding and decoding, and that this could leave room for misunderstanding. Moreover, it states that the encoding has to be precise and adapted to the intended audience in order to reduce or avoid misinterpretations. In the world of design, the designer (producer) is responsible to make every product as useful as possible. Norman (2013) says designers should not blame people when they fail to use a product properly. He assigns this to a philosophy of positive thinking. To achieve well-designed products, he promotes to consider *what to accomplish* as a first step. Additionally, he describes seven fundamental principles of design. Albeit these are easier to understand for physical products, two of the principles are quite useful for designing visualizations as well; affordances and constraints. Affordances exist to make the desired action possible, whereas constraints provide logical and semantical limitations to guide action and ease interpretation. Affordance is probably also what Steve Krug had in mind when he stated that self-evidence is the overriding principles of design. Further he said this is the ultimate tiebreaker whether a design work or not (Krug, 2014).

The lack of understanding was also apparent during the observation. In several occasions, symbols and graphics (representations) used in the presentation, were subject to discussions, questions and misinterpretations. All this can be rectified, at least to a certain point, by selecting appropriate representations. This will be addressed later in this chapter. Another interesting finding from the observation session was *the lack of interest* in formal models (architectural products), and the fact that more informal drawings to a larger extent generated discussions about the project's content. In what is called the information age, there is an abundance of

information. This has resulted in a habit of rapidly judging - *is this information useful?* The time available for a piece of information to get attention is limited. Often the consumer will consider the effort one is willing to spend, in form of time and cognitive workload, towards the assumed opportunities embedded in the piece of information. Although there exist some indicators of lack of interest in formal models, as discussed above, this study did not deduce any clear causal relationship between lack of interest and type of presentation (formal vs. informal). Nonetheless, it is tempting to suggest that the opposite characteristics of what intimidate decision-makers from engaging with formal model, is the same that invites them to interact with the informal ones; simple, familiar, good design, and clear presentations. Before moving in to a discussion of more technical details, some principle matters should be addressed. The first to be discussed is use of embellishment to make a visualization beautiful, hence attractive. How far can usage of cosmetic decoration go before it interferes with the communication? The second one is the availability and use of resources. Does an average enterprise possess employees with a necessary skill-set to make a visualization act as functional art? The literature review in this study shows that there has been a debate about decoration versus functionality for a long time. As the literature review shows, there are strong voices advocating views in both directions. Perhaps the best take-away points from that discussion, useful to this study, are that cosmetic decoration:

- will never salvage an underlying lack of content,
- may distort the data and steal the attention, but
- can be engaging if properly designed.

In the end, the most successful visualizations do not only display data, but in a way that is both visually appealing and simplistic enough for anyone to understand (Martin and Miller, 2016).

In relation to this, Cairo (2013) argues different professional backgrounds having different ways in facing visualization projects (Cairo, 2013). Engineers and scientists prefer deeper and more complex visualizations, whereas graphic designers, journalists and artists favor shallower and more intelligible visualizations. It is likely to believe that decision-makers fit into the latter category. This may cause a cliff between producer and consumer as most of the architectural products (visualizations) are created by engineers. It is therefore tempting to suggest a change in focus in direction of some less formal presentation. Not that the formal presentations should be

abandoned entirely, but rather used for the "right" audience. More intelligible visualization would probably generate a more positive attitude towards architectural products. In turn, this could bring an end to the experienced deadlock situation reported in 5.1.1 (limited resources give "bad products" and "bad products" give limited resources). However, making proper informal visualizations is not a straight forward task. Although Schriver (1997) argues that deciphering of bad visual design has been a coping skill in the information age, this is not where the bar should be set. Enterprise Architects need to master other (presentation) tools than specific EA tools. That is supported by findings from the EA Tool Study (Chapter 2.3.2), as this revealed that most graphics used for Enterprise Architecture were manual drawings produced or modified in either Microsoft Visio or Microsoft PowerPoint. The literature review found how easy it is to step into the pitfall of unconsciously selecting a representation more or less randomly offered by the aforementioned presentation tools. Thus; the producer has to be careful when selecting from the many types of encodings offered by standard presentation tools. This is underscored by Few (2012) who clearly express his disappointment to the lack of development regarding charting capabilities of a similar product, this time Microsoft Excel. Stating the possible to use even more dysfunctional visualizations.

Documentation, in form of guidelines, is an essential means to achieve a desired use of visualizations, avoiding pitfalls. In the concrete case analyzed in this study, the document inspection in chapter 5.1.3 revealed that the current documentation was in one way or another influenced by the lack of an agreed overall governance model. Either an issued document was only applicable to a limited set of practitioners or it had issues with its endorsement process, where to many stakeholders had to reach consensus before an enterprise-wide implementation could take place. Therefore, local approaches have flourished where passionate enthusiasts have developed guidelines and procedures in a bottom-up manner. Hopefully the revised top-level document will be endorsed and issued shortly. Directly following should be a harmonization and alignment of existing documentation to get a full-stack set of guidelines supporting the overall development process. This documentation could be leveraged upon for training purposes as well. This shows how important it is to have an overarching policy document endorsed by the

leadership early in the process. Paralleling the aforementioned documentation with a continued use of bottom-up activities, it is likely that (more) decision-makers would recognize architectural products as an efficient tool for IT-governance.

Although issues discussed above, are relevant for an increased attractiveness, the pure remedy is likely to be found in the creation of architectural products. However, that calls for a broader take on what an architectural product may comprise. Today, as mentioned in the introduction (see 2.2), the forming of architectural products is following strict guidelines by adhering to two different frameworks (NAF and TOGAF). For modelling purposes this is absolutely essential to ensure internal consistency and to maintain external relationships. For communication purposes however, this particular use of notation seems to keep untrained (in architecture) personal out of the loop. An example is the confusion about arrow directions pointed out during the observation (see 5.1.2). Even though this is not researched here, for the purpose of this study it is assumed that not every person exposed for architectural products will have be trained for it. For that same reason, the emphasis has to be put on the production. The rest of this chapter is therefore devoted how the best practices (see 5.4) discovered during the literature review may salvage some of the issues revealed in the case study (see 5.2).

There are, at least, two pre-conditions that have to be met in order to make a visualization useful for the purpose of decision-making. The story to be told needs to be clear, and the audience addressed needs to be known. As discovered during the observation, most of the visualizations used (redacted versions available in Appendix H) at the meeting did not support, nor facilitate discussions regarding the project. It is reasonable to ask whether that is caused by the lack of the two abovementioned pre-conditions. Looking at all architectural products, displayed in Appendix H, they all consist of boxes and arrows, and they do present different views on the project. For architects these are probably simple to understand, conveying the underlying information purposefully. However, for a decision-maker exposed to this for the first time, it can be difficult to extract any useful information. Why is it so? First of all, the representation used (boxes and arrows) do not resonate with the semiology and language normally used by the audience (so: not

knowing the audience, or not leverage upon that knowledge). Further there is no clear story, it is more a collection of architectural products presented to satisfy an expected use of architectural products. Therefore, without a clear story adapted for the intended audience, it will be tough to get the audience's attention and to obtain the envisioned goals.

Could this lack of attention also be attributed to the fact that boxes and arrows are boring? Probably! But are they wrong, encoding-wise? Probably not. In according to the finding from the literature review, connectedness is a very strong grouping principle. Thus, arrows as a representation of connectedness should be easily decodable by any audience. The same hold truth for boxes, as they represent an even stronger grouping. So from this it is clear that not even strong visual attributes as connectedness (arrows) and encapsulation (boxes) are alone sufficient to take hold of the attention.

Another finding from the case study is that complex and confusing models contribute to the described lack of understanding. Despite the presented architectural products (see Appendix H) tell otherwise, this study accepts that fact, as it represents a coherent view by the majority of the interviewees. This study interprets this as a situation that occurs as the number of boxes and arrows grow. Thus: visualization complexity needs to be managed. Presentation techniques, such as layering and separation could be one approach. The key is to build an understanding of the visual hierarchy, and taking advantage of available methods and techniques to manage it. For instance, use of pre-attentive attributes to catch the attention can assist the viewer to find the intended entry point. This refers to the cognitive process of search (see 5.3.2). In addition, an appropriate use of gestalt laws, for instance the law of proximity, would assist the viewer in discover elements close to the entry point. When applying pre-attentive attributes, it is of outmost importance to not overuse it, as that will be counterproductive. Consult guidelines by Few (see 5.3.2). As an overall guideline, sparingly application of elements will in general help tackling complexity, and to make architectural products more intelligible.

A famous French poet once expressed it like this:

"It seems that perfection is attained not when there is nothing more to add,

but when there is nothing more to remove".[34]

Perfection is not the goal per se, it is rather an aspiration. Substituting perfection with *clarity* and the meaning is still valid for information visualization. It forces creators of visualizations to have a good reason for every element added, and to remove everything that does not contribute to the message conveyed in the information. Few (2012) amplifies it like this; Sometimes adding improves things. Sometimes removing improves things. Sometimes switching things, improves things. Sometimes something cannot be improved at this time. Applied this way, clarity is a means giving impression of simplification. However, it is important to bear in mind that clarification should never be done at the expenses of the underlying information.

This chapter has discussed how decision-makers' reluctance to use architectural products may be cured by applying best practices for information visualization. The next chapter will discuss the research design and methods used to achieve the study's results.

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[34] Quotation from Antoine de St-Exupéry. Originally in French: "Il semble que la perfection soit atteinte non quand il n'y a plus rien à ajouter, mais quand il n'y a plus rien à retrencher".
Source: https://en.wikiquote.org/wiki/Antoine_de_Saint_ Exupéry

6.2 Discussion on research design and methods

This section discusses the applied research design, what the weaknesses and limitations are, and what the strengths and promises are. More concrete it evaluates to what extent the research design did facilitate the data capturing and data analysis processes (validity), and to what extent the collection and analysis of data is trustworthy (reliability). As the research design consist of two main parts, each part is discussed separately. Before that, an overall assessment of the research design is provided.

6.2.1 Overall research design

Based on nature of this study, a two-folded approach was considered necessary. The main reason for that was an insufficiency in the body of knowledge regarding use of visualization in Enterprise Architecture. It was therefore found necessary to launch a case study to learn more about the problem of the unattractiveness of architectural products. In addition, a literature review was selected as the most suitable method to learn more of Information Visualization.

At certain points during this study, change of scope was considered. The reason for that was mainly to avoid jeopardizing the entire study by wanting too much. It would have been possible to build a complete study by addressing merely the first part of the research question. However, it was so enticing to find and suggest possible solutions, not only investigate the problem. In the end, the risk was considered manageable, and the return of investment considered high enough to take that risk. Saying that, at times it was truly demanding to balance all these different methods within the same research design. As a result, there were also attempts to manage the complexity by incorporating the information visualization part into the background material. The condition that tipped the scales in favor of conducting a separate literature review, was the possibility to inform the review from the findings of the case study. A such focused review was considered more efficient.

6.2.2 EA Case Study

Internal Validity in qualitative research refers to whether the results are perceived as *correct*. Here, *correct* is understood as *an agreed description* of the researched topic, not the absolute truth. Jacobsen (2005) provides two main methods of evaluating the internal validity. One is to present the achieved results to research participants and ask their response, which was considered not feasible due to resource constraints. The second is a critical self-evaluation of the results, which is used in this study. Firstly, sources were evaluated - did this study get access to sources that could contribute to correct answers? And did they provide the correct information? Thereafter an assessment of the first part of the analyses was conducted i.e. how the data were categorized.

For the interview, participants were recruited to amount for a broad understanding of the phenomenon researched, as they represented most of the categories of identified stakeholders. Having said that, regrettably only one interviewee represented what can be seen as the pure decision-making level. With the benefit of hindsight, further participants should have been recruited from that level, as first-hand data could have been collected to a larger extent. As of now, the data collection has an overweight of interpreted understanding on how decision-makers consider architectural products to be. On the other side, there are several benefits associated with the participants. Most of the participants have been working with architecture for many years, they possess a rich experience-base, and are close to the phenomenon researched. Thus, both knowledge about and proximity to the topic and issues speak in favor of the fact that *right* information is provided. Yet another argument for the *right* information, is that none of the participants would likely benefit from hiding or altering information. Rather opposite, they would potentially benefit from an *as true as possible* description of the situation. Another factor pulling in the right direction, is how the small N design benefits to the completeness of the description. Even with the same interview guide, the results from the interviews were quite individual i.e. what themes were given most attention and at what time in the interviews these were addressed. This is illustrated in Figure 35. Each color represents a theme, and placement represents where it occurred in the interview session.
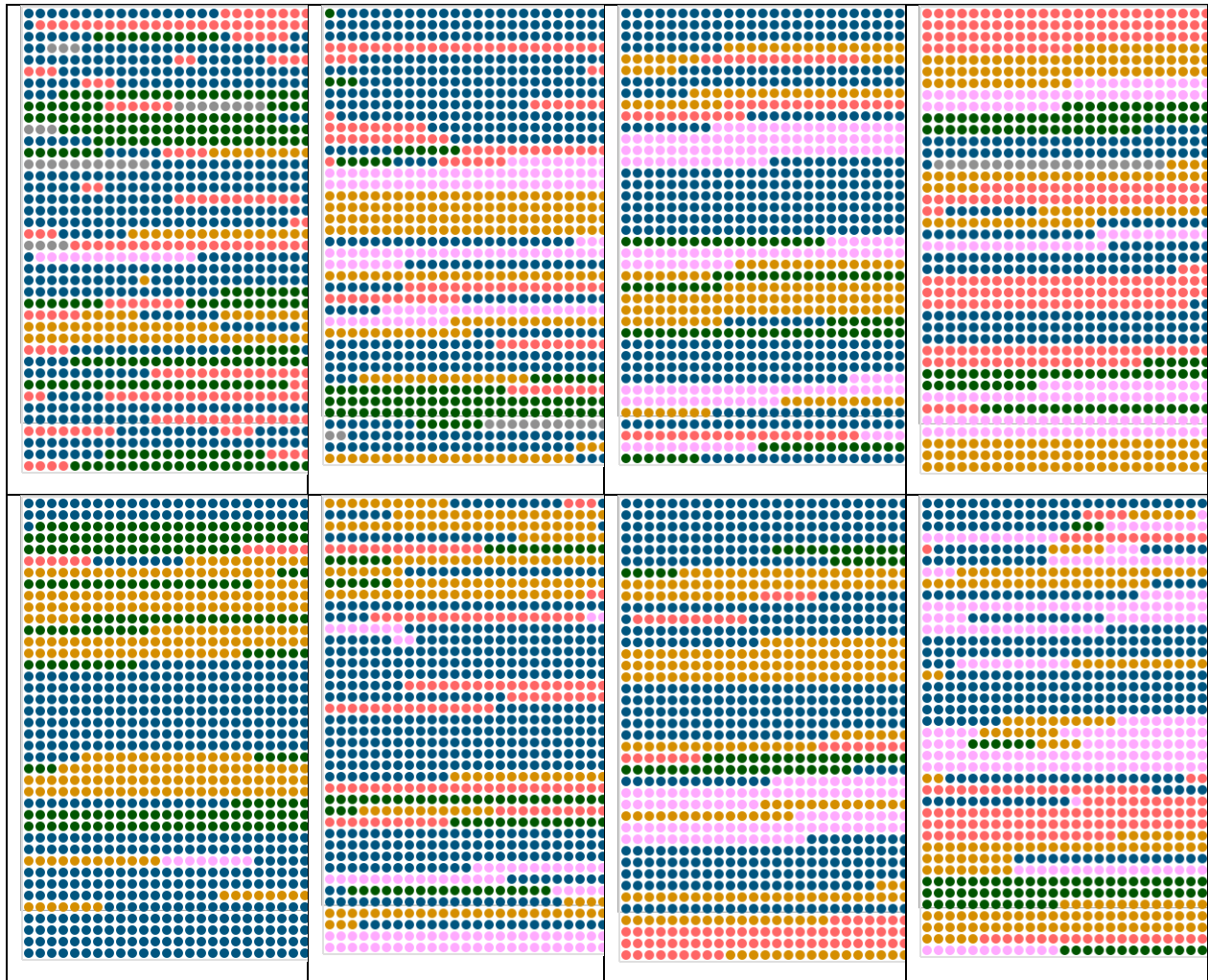
Figure 35: Documents codes from all interviews

Small N design is demanding when it comes to the analyses part. As demonstrated with Figure 35, no interviews were identical. It was therefore challenging to directly compare the results from the interviews, to ensure a common understanding. It was also time consuming, as many different viewpoints had to be included in the analysis.

External Validity is about to what extent the study's findings are generalizable. This case study was aimed at getting a better understanding of a phenomenon, not the scale nor the frequency of it. It is therefore difficult to statistically generalize based on e findings from this research. Another argument towards that form of generalization is the skewed participation used in the

case study. As the recruitment was selective to get the best informed participants, the participation is not representative for the entire population.

However, another form of external validation (transferability) more often used for quantitative studies is found appropriate. Jacobsen (2005) points out that theoretical transferability is a strength with quantitative studies. Based on the thorough work with the case study, this study has the potential to contribute to better knowledge about why there exists a reluctance among decision-makers, to take advantage of Enterprise Architecture for business development purposes.

Reliability can be addressed in several ways (Creswell, 2007). The purpose is to assess how, and to what extent the research design and the quality of the performed research influenced the results. In other words, the credibility of the results. For the case study, the credibility was assessed by; the impact of the research design and how captured data were managed. For the research design there are mainly two conditions that can influence the results. One is how the participants are influenced by the researcher, the other is how the researcher is influenced by the relationships that occur during the study. For the interviews, semi-structured interviews with open questions were used to avoid the issue of leading question, and answers influenced by the interviewer. Furthermore, voice recorder was used to allow a more fluent conversion between interviewer and interviewee. All participants were asked in advance whether voice recording would be an issue. All replied no, and the impression from the interviews support that. All interviews were held in familiar of neutral settings.

For the observation session many pre-conditions were built into the research design to minimize the observer effect. For ethical reasons, the calling note informed all participants about the observations. Information about the overall purpose of thesis where disseminated (see Appendix A), but no details about the observation were provided. It is difficult to state to what extent the observation affected the discussions in the meeting. However, the consistency between findings in interviews and observation indicates the influence as limited, or even absent.

The second issue to be addressed was the quality of storing and analysis of data. To ensure an accurate reproduction of the content from the interviews, these were all audio-recorded and transcribed in full. Thereafter, transcripts from interviews were uploaded into the text analysis software, MAXQDA. This was an invaluable tool as it assisted in the traceability between the underlying data source and the developed code set. The code set, consisting of codes, categories and themes, emerged through a bottom-up process. Empery-near coding was used to avoid or reduce researcher predisposition, and to make sure the interviewees own terms and vocabulary were echoed.

In retrospect, data sources from observation and document inspection could with advantage have been managed in the same way as the interviews. Not only would that have provided more independent findings, it would have allowed for a valuable triangulation to increase the overall reliability.

6.2.3 IV Literature Review

As stated in Chapter 4.4, the literature review in this study followed a model from Machi and McEvoy (2009). In addition, Leedy and Ormrod (2010) was consulted. Here the authors advised a decomposition of the research question to guide the review process. This was found challenging for two reasons. Firstly, the knowledge about the topic possessed by the researcher at that moment in time was to limited. Secondly, it was considered wise to let findings from the EA Case Study inform the decomposition. Therefore, an adjustment was applied. The decomposition was replaced by a set of hints from the EA Study. This adjustment was considered necessary in order to guide both the searching and scanning processes in this massive information landscape constituting the body of knowledge for information visualization.

The *internal validity* of the literature study is evaluated to answer if the results can be perceived as correct. A central question to be answered is whether the study had access to the right sources. A broad collection of literature was consulted, including a mixture of classics and novel books, blogs and best practices found on internet, as well as research and conference papers.

External validity was considered as irrelevant for this study as the literature was particularly aimed at answer one concrete topic.

Are findings from the literature review trustworthy? The *reliability* is evaluated based on how date were extracted. The stepped process should assure a fair treatment of all sources. The building of cases was there to assure that best practices set out is founded on evidence. On reflection, it might have been possible to use a similar method for data collection and analyses as used for the case study. In that case, an abstract of all source documents had been required prior to an upload into the document analyses tool (MAXQDA). Not only would that have been an extremely human-intensive activity, it could further have limited the possibility to single out the most applicable parts from each source.

6.2.4 Ethical considerations

Voluntarily participation is central to research where human beings are involved. Potentially participants were given a written invitation. Included was a project description (see Appendix B). Not only should the participation be voluntarily, the participants should also fully understand what they are consenting to (Cottrell, 2014). All interviewees were presented an Informed Consent sheet (see Appendix C) prior to the interview sessions, where they were requested to sign to confirm their consent and understanding.

Even though none of the participants claimed anonymity, all documentation was managed as if it had been. The audio recorder was uses solely for the interviews and never connected to a computer. All audio files were deleted immediately after transcription. Names, organizations and departments were left out from the transcripts, and avoided used in citations.

All participants are employed by the same employer as the researcher, but not in close working relationship, prior to the study. The researcher has no vested interests in the results.

7 Conclusion

This study suggests that use of appropriate methods and techniques from information visualization can potentially affect the interest in architectural products by decision-makers. However, achieving so will require some changes in established ways of working and the skill set of those creating and maintaining architectural products. A balanced set of top-down and bottom-up activities need to take place. As procedural changes are required, leadership involvement is a pre-requisite for success.

Amid the first changes to the bottom-up activities that has to be instituted, is a modification of architectural products claimed to be too complex and confusing. These need to be adapted to meet the needs and preconditions of the intended audience. The complexity should be reduced by clarifying the content not simplifying it – to avoid loss of information. Furthermore, these products should be used repetitively to increase familiarity. Adhering to the best practices set out in this study should ensure required quality. This, in turn may eradicate the deliberate avoidance of including offered visualizations in already established decision-making processes.

Among the top-down activities that is essential for success, is an institution of a comprehensive set of governance documentation, where roles and responsibilities, processes and procedures are clearly defined. Moreover, adequate training is of outmost importance. All these supports standardization, and makes it easier to produce, not only the pure architectural products but also more overarching, clarifying visualizations customized to satisfy decisions-makers.

8 Future Work

As this study suggest that appropriate application of techniques from information visualization could have a positive impact on the attractiveness of architectural products, it would have been interesting to run some experiments in an attempt to confirm so.

There are several options available for further research. Three of them are listed in the subsequent sections.

New architectural products for decision-makers: With support in a user-centered design approach, develop novel architectural products customized for decision-makers, utilizing best practices put forward in this study.

Refined architectural products for architects: Reform and refine existing architectural products by applying findings put forward in this study. Deeper research in information visualization may be needed.

Include Interaction in the research: As this study had to limit its scope, interaction was left out from the literature review. Interaction may introduce exiting elements in how to use and understand architectural information for decision-making.

"People almost invariably arrive at their beliefs not on the basis of proof but on the basis of what they find attractive."[35] *- Blaise Pascal*

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[35] https://en.wikiquote.org/wiki/Blaise_Pascal

9 Bibliography

AGAR, M. H. 1980. *The professional stranger : an informal introduction to ethnography,* New York, Academic Press.

APALVIK, K. G. 2015. Making Enterprise Architecture visible and understandable. HIG.

BERTIN, J., BERG, W. J. & BARBUT, M. 2010. *Semiology of graphics : diagrams networks maps,* Redlands, Calif, ESRI Press.

BOIKO, A. 2013. *Eye tracking the user experience : a practical guide to research,* Brooklyn, N.Y, Rosenfeld Media.

BOOTH, W. C., COLOMB, G. G. & WILLIAMS, J. M. 2008. *The craft of research,* Chicago, University of Chicago Press.

BREDEMEIER, K. & SIMONS, D. 2012. Working memory and inattentional blindness. *Psychonomic Bulletin & Review,* 19**,** 239-244.

BYGSTAD, B. & PEDERSEN, N. 2012. Arkitektur handler om praktisk arbeid i en organisasjon. *NOKOBIT 2012.* Bodø: NOKOBIT.

CAIRO, A. 2013. *The functional art : an introduction to information graphics and visualization,* Berkeley, Calif, New Riders.

CARD, S. K., MACKINLAY, J. D. & SHNEIDERMAN, B. 1999. *Readings in information visualization : using vision to think,* San Francisco, Morgan Kaufmann.

CLEVELAND, W. S. & MCGILL, R. 1984. Graphical Perception: Theory, Experiments, and Application to the development of graphical methods. *Journal of the American Statistical Association,* 79**,** 531-554.

COFFEY, A. & ATKINSON, P. 1996. *Making sense of qualitative data : complementary research strategies,* Thousand Oaks, Calif, Sage.

COTTRELL, S. 2014. *Dissertations and project reports : a step by step guide,* Basingstoke, Palgrave MacMillan.

CRESWELL, J. W. 2007. *Qualitative inquiry & research design : choosing among five approaches,* Thousand Oaks, Calif, Sage.

CYBERFORSVARET 2015a. Sjekkliste for FL.

CYBERFORSVARET 2015b. Sjekkliste for PI.

CYBERFORSVARET, S. 2015c. Plan for den videre utvikling av Forsvarets informasjonsinfrastruktur (INI) mot 2030. Forsvaret: Forsvaret.

CYBERFORSVARET, S. 2016. Bestemmelse om bruk av arkitektur i utviklingen av Forsvarets informasjonsinfrastruktur (INI). FOBID: Forsvaret.

DALEN, M. 2011. *Intervju som forskningsmetode,* Oslo, Universitetsforl.

DEACON, T. W. 1997. *The symbolic species : the co-evolution of language and the brain,* New York, W.W. Norton.

DEY, I. 1993. Qualitative data analysis : a user-friendly guide for social scientists. London: Routledge.

DJAMASBI, S., SIEGEL, M. & TULLIS, T. 2011. Visual Hierarchy and Viewing Behavior: An Eye Tracking Study. *In:* JACKO, J. (ed.) *Human-Computer Interaction. Design and Development Approaches.* Springer Berlin Heidelberg.

FEW, S. C. 2011. *The Chartjunk Debate - a close examination of recent findings* [Online]. https://www.perceptualedge.com/: Few, Stephen C. Available: https://www.perceptualedge.com/articles/visual_business_intelligence/the_chartjunk_debate.pdf [Accessed 24 Apr 2016].

FEW, S. C. 2012. *Show me the numbers : designing tables and graphs to enlighten,* Burlingame, Calif, Analytics Press.

FORSVARET 2014. Veiledning for prosjektkoordinatorer. FOBID: Forsvarstaben.

GARTNER. 2013. *IT Glossary* [Online]. Available: http://www.gartner.com/it-glossary/enterprise-architecture-ea/ [Accessed 03 Nov 2015].

GRAY, D., BROWN, S. & MACANUFO, J. 2010. *Gamestorming: a playbook for innovators, rulebreakers, and changemakers,* Bejing, O'Reilly.

GUNTHER, W. 2014. Measuring Enterprise Architecture Effectiveness. Leiden University: Leiden University.

HARISHANKAR, R. & DALEY, S. K. 2011. Actionable Business Architecture.

IKT, F. 2015. Prosjektarkitektur - Diagrammer. FISBasis: FMA.

JACOBSEN, D. I. 2005. *Hvordan gjennomføre undersøkelser? : innføring i samfunnsvitenskapelig metode,* Kristiansand, Høyskoleforl.

JENSEN, C. T., CHARTERS, I., AMSDEN, J., DARLINGTON, S., OWEN, M., HERNESS, E. & IRASSAR, P. 2008. Leveraging SOA, BMP and EA for Strategic Business and IT Alignment. IBM: IBM.

JENSEN, C. T., CLINE, O. & OWEN, M. 2011. Combining Business Process Management and Enterprise Architecture for Better Business Outcomes. IBM: IBM.

KNAFLIC, C. N. 2015. *Storytelling with data : a data visualization guide for business professionals,* Hoboken , N.J, Wiley.

KRUG, S. 2014. *Don't make me think, revisited : a common sense approach to web usability,* Berkeley, Calif, New Riders.

LANGELAND, L. 2015. Virksomhetsarkitektur

Hva er de viktigste faktorene for å lykkes med innføring? : University of Oslo.

LEEDY, P. D. & ORMROD, J. E. 2010. *Practical research : planning and design,* Boston, Pearson Educational International.

MACHI, L. A. & MCEVOY, B. T. 2009. *The literature review : six steps to success,* Thousand Oaks, Calif, Corwin Press.

MACKINLAY, J. 1986. Automating the design of graphical presentations of relational information. *ACM Trans. Graph.,* 5**,** 110-141.

MARTIN, N. & MILLER, C. 2016. *Creating Great Infographics* [Online]. www.howdesign.com. Available: http://www.howdesign.com/infographic-design-how-to-make-infographics/ [Accessed 2016].

MATERIELLAVDELING, F. 2015. Begrepsapparat for fremskaffelse, forvaltning og tilrettelegging for sikkerhetsgodkjenning av IKT-systemer.

MCCORMICK, B. H., DEFANTI, T. & BROWN, M. D. 1987. Visualization in Scientifc Computing. *Computer Graphics,* 21.

MILES, M. B. & HUBERMAN, A. M. 1994. *Qualitative data analysis : an expanded sourcebook,* Thousand Oaks, Calif, Sage.

NATO. 2014. *NATO Architectual Framework v 4.0* [Online]. NATO. Available: http://nafdocs.org/ [Accessed 22.09.2015 2015].

NATO. 2015. *EA Hackathon* [Online]. Available: https://tide.act.nato.int/tidepedia/index.php/EA_Hackathon [Accessed].

NIELSEN, J. 2006. *F-Shaped Pattern For Reading Web Content* [Online]. Nielsen Norman Group. Available: http://www.nngroup.com/articles/f-shaped-pattern-reading-web-content/ [Accessed 27 oct 2015].

NORMAN, D. A. 2013. *The design of everyday things,* New York, Basic Books.

OP 'T LAND, M., PROPER, E., WAAGE, M., CLOO, J. & STEGHUIS, C. 2009. *Enterprise architecture : creating value by informed governance,* Berlin, Springer.

PESHKIN, A. 1993. The goodness of qualitative research. *Educational Researcher,* 22**,** 23-29.

PICKOVER, C. A. & TEWKSBURY, S. K. 1994. *Frontiers of scientific visualization,* New York, Wiley.

RAND. 2016. *Delphi Method* [Online]. http://www.rand.org/topics/delphi-method.html: RAND Corporation. Available: http://www.rand.org/topics/delphi-method.html [Accessed 2016-04-21 2016].

ROTH, S., ZEC, M. & MATTHES, F. 2014. Enterprise Architecture Visualization Tool Survey 2014. Sebis: Technische Universitat Munchen.

SCHRIVER, K. A. 1997. *Dynamics in document design : creating text for readers,* New York, Wiley.

SPENCE, R. 2007. *Information visualization : design for interaction,* Harlow, Pearson Prentice Hall.

SYSTEMS, S. 2015. *Enterprise Architect* [Online]. Sparx Systems. Available: http://www.sparxsystems.com/products/ea/ [Accessed 22.09.2015 2015].

TAMM, T., SEDDON, P. B., SHANKS, G. & REYNOLDS, P. 2011. How Does Enterprise Architecture Add Value to Organisations? *Communications of the Association for Information Systems,* 28.

TJORA, A. H. 2012. *Kvalitative forskningsmetoder i praksis,* Oslo, Gyldendal akademisk.

TUFTE, E. R. 1990. *Envisioning information,* Cheshire, Conn, Graphics Press.

WARE, C. 2004. *Information visualization : perception for design,* Amsterdam Burlington, Elsevier.

WEBSTER, M. 2015. Visualize. *Merriam Webster.* http://www.merriam-webster.com/: Merriam Webster.

ZHANG, J. 2007. *Visualization for information retrieval*, Springer.

Appendices

Appendix A   –   Project Description (in Norwegian)

Appendix B   –   Invitation for participation (in Norwegian)

Appendix C   –   Informed Consent (in Norwegian)

Appendix D   –   Interview Guide (translated to English)

Appendix E   –   Observation Guide (translated to English)

Appendix F   –   Affinity Maps

Appendix G   –   Codes, categories and themes

Appendix H   –   Observation results - Architectural product used (from case study)

Appendix I   –   Models for representation of quantitative data
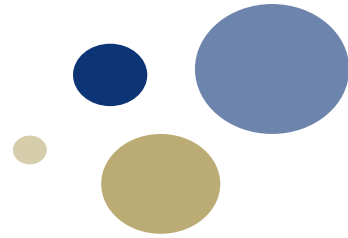
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Prosjektbeskrivelse - virksomhetsarkitektur fremstilt på en forståelig og anvendelig måte

Bakgrunn og hensikt

Prosjektet inngår i den avsluttende delen av masterstudiet i interaksjonsdesign ved NTNU Gjøvik, og skal ende opp i en prosjektrapport.

Bakgrunnen for prosjektet er en erkjennelse av at informasjonselementer knyttet til virksomhetsarkitekturer ofte fremstår som for komplekse og uforståelige, irrelevante for problemløsing og dermed lite attraktive for beslutningstakere.

Målet med prosjektet er å finne nye og inspirerende måter å representere, presentere og interagere med informasjon benyttet i virksomhetsarkitekturer, og derigjennom gjøre denne mer forståelig og anvendelig for strategisk beslutningstaking.

Metoder planlagt brukt i studien

Studien er plassert innenfor rammene av kvalitativ forskning og vil anvende en form for case-studie kalt små N-studier. Denne tilnærmingen er valgt for å avdekke kunnskap og forståelse om et fenomen, og hvor ingen hypotese er dannet på forhånd. Formålet er å få ny innsikt, utvikle nye konsepter og teoretiske perspektiver og oppdage problemer som eksisterer. Små N-studier gir også muligheten for å belyse situasjonen fra flere vinkler. For å få til dette vil både intervju og observasjon bli tatt i bruk som teknikker for å fremskaffe nødvendig informasjon.

Utvelgelse av informanter

Nøkkelinformanter rekrutteres fra arkitekturmiljøene i Forsvaret. Ved hjelp av dem benyttes snøballmetoden for å identifisere og rekruttere andre informanter.

Prosjektets fokusområde

I denne masteroppgaven, vil metoder og teknikker innen informasjonsvisualisering bli undersøkt i et forsøk på å gjøre artefakter, modeller og perspektiver mer anvendelig og forståelig for beslutningstakere. Målet er å gjøre arkitektur mer attraktiv gjennom å finne nye og inspirerende måter å representere, presentere og samhandle med arkitekturinformasjon på, og til sist styrke relasjoner på tvers av strategiske mål, forretningsmodeller og tekniske løsninger.
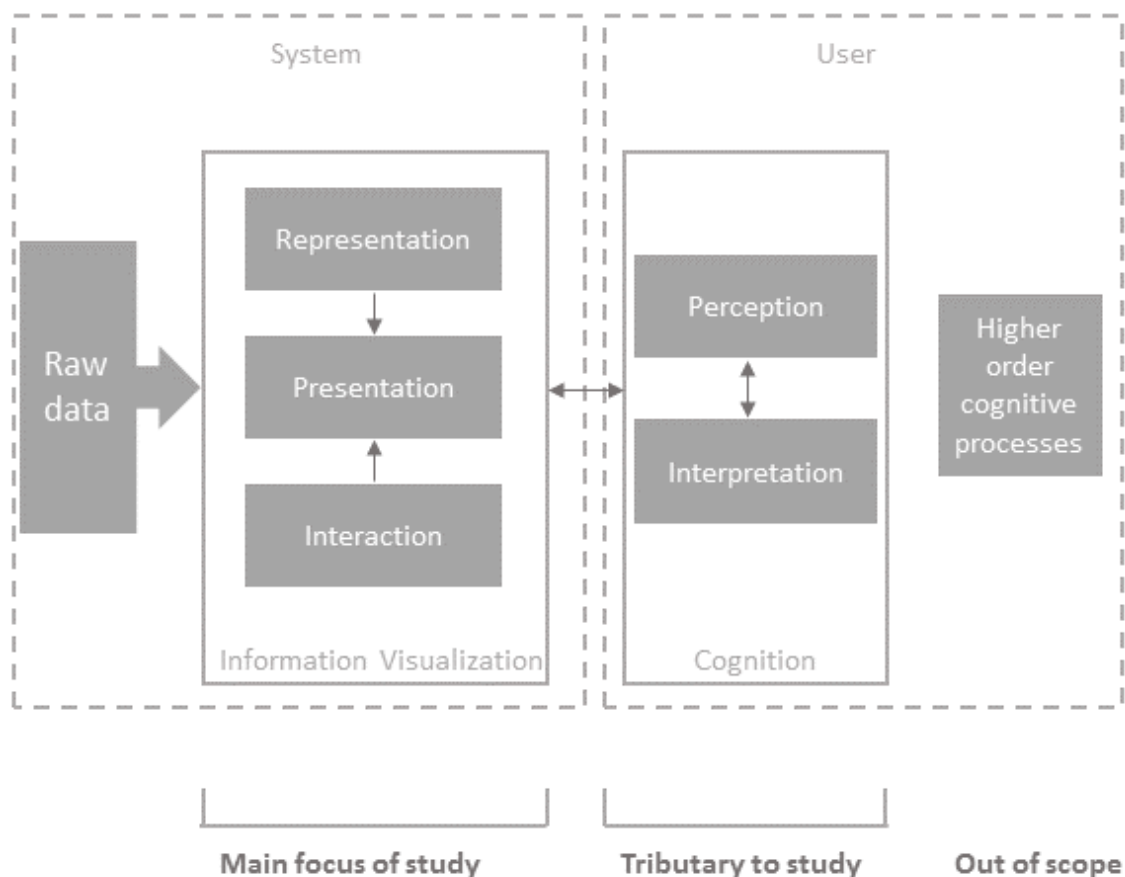
Grov tidsplan

Som vist i tidsplanen under er det planlagt å gjennomføre intervju og observasjoner i perioden februar og mars. Analysen av innhentet informasjon vil foregå delvis parallelt med innhentingen, noe som er vanlig i kvalitative studier. Prosjektrapporten vil bli oppdatert kontinuerlig.
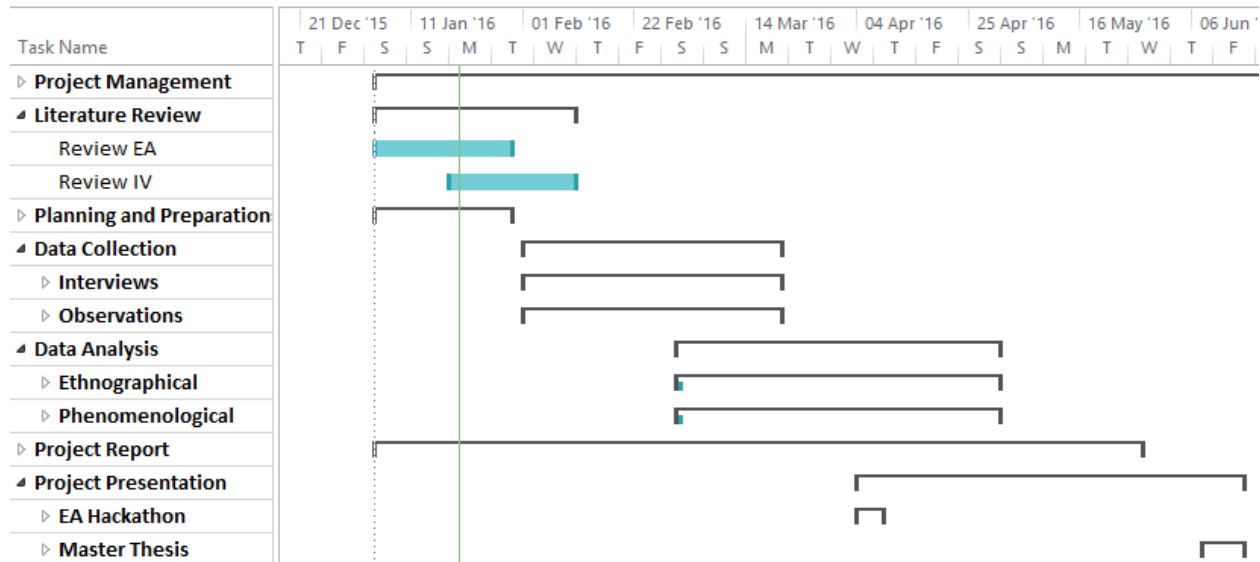
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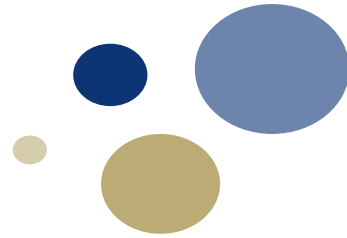
NTNU
Kunnskap for en bedre verden

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Invitasjon til deltagelse i masterprosjekt

Som ledd i min masteroppgave i interaksjonsdesign ønsker jeg å komme i kontakt med personell i Forsvaret som på en eller annen måte er involvert i utviklingsarbeid hvor virksomhetsarkitektur (Enterprise Architecture) benyttes.

Formålet med prosjektet er å gjøre bruk av arkitektur mer anvendelig som virkemiddel for strategiske beslutninger innen utvikling av Forsvarets informasjonsinfrastruktur. For mer informasjon se vedlagt prosjektbeskrivelse.

Deltakelse i prosjektet innebærer intervju eller observasjon.

Dersom du har mulighet til å delta i prosjektet vennligst ta kontakt med prosjektansvarlig innen 22. februar 2016:

Kjell Gunnar Apalvik

Epost: kapalvik@gmail.com
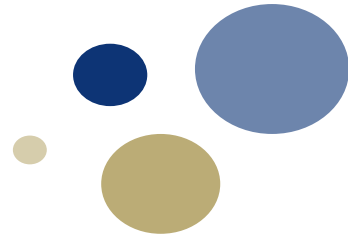
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Samtykkeerklæring

Jeg ber om frivillig samtykke til å delta i mitt masterprosjekt i interaksjonsdesign ved NTNU Gjøvik.

I vedlegget finner du informasjon om prosjektet.

Hvis du velger å delta vil du bli spurt om forhold rundt bruk av arkitektur som virkemiddel for å styre utviklingen av Forsvarets informasjonsinfrastruktur. Varighet 30 til 60 minutter.

Deltakelsen er fullstendig frivillig. Du kan velge å ikke svare på enkeltspørsmål og du kan når som helst velge å trekke deg fra undersøkelsen. All informasjon vil bli anonymisert og slettet ved prosjektets avslutning.

Ved å skrive under bekrefter jeg å ha lest informasjonen over, og frivillig samtykker i å delta.

Dato for gjennomlesing og underskrift _____

_____   _____
Trykte bokstaver   Underskrift

Interview Guide

Semi-structured interview. The Interview Guide includes key themes and underlying issues which together should cover the study's areas of interest.

Tell them about the purpose of the study

The background was a perception that Enterprise Architecture often appears as complex and arcane, irrelevant for solving business issues and thus unattractive for decision makers.

In partial fulfillment of the requirements for the degree of Master of Science at NTNU in Gjøvik should this project examining the possibility of using methods and techniques from a field called information visualization on Enterprise Architecture to make it more understandable - thus more attractive and useful for guiding the development of INI in the right direction.

Definition as used in this study (in case reference should be needed)

Enterprise architecture (EA): A set of artifacts representing the design of an enterprise's business and IT, that alongside a set of principles, roles and processes, direct that enterprise towards a desired future state.

Opening questions

In the context of INI-projects, what is the first thing that comes to your mind when I say architecture?

What about Enterprise Architecture?

Why do you think this is the first that appeared?

What is your experience in use of architecture? Was it positive or negative?

In what way did you use it?

It was you who led the work, or did you get support from others?

Are there any immediate changes you would have done? Or put another way: In what way do you think the Enterprise Architecture should have been used so to give you maximum support?

Detailed questions

Topic 1: Use of EA

Do you currently use architecture?

In what way do you use it?

Why do you use it? (follow-up question)

Is there a reason for not using it? (follow-up)

For how long periods do you work with Enterprise Architecture?

Is that perceived as efficient? (follow-up)

Are people getting tired or disinterested when working with architectural products? (follow-up)

Topic 2: EA suitability to link strategic objectives with IT

Do you think Enterprise Architecture is suitable to describe the relationships between strategic objectives and IT?

What's stopping you from using Enterprise Architecture? (follow-up)

Topic 3: Information needed to govern the INI development

Can you describe what information you think is crucial to govern INI development?

To what extent do you think EA gives you access to this kind of information today?

How do you perceive the quality of information available?

How do you perceive the degree of detail of available information?

Is there any type of information elements you think is missing?

Topic 4: Design/Presentation of EA

In Plan INI 2030 is Enterprise Architecture described as a regulation plan. Do you have any thoughts on how it should be designed, to support you in your role?

Can you say something about your experience in use of Enterprise Architecture, do you preceive it as complicated or easy?

Have you considered zooming, filtering, or other techniques for presenting or hiding information could be useful tools in this context?

Topic 5: Interaction between user and architecture

To what extent can you influence how the information is presented?

Any opportunity to delve into the information?

What about possibilities to apply filters?

Topic 6: Training

Will it be given training in the use of Enterprise Architecture in the role you have?

How do you think the training should be carried out so that it would give you the best advantage in using Enterprise Architecture?

Concluding questions

Are there some things that we not covered, that you think is important to include?

Are there some things that could be done completely different?

Have you seen any examples of use of Enterprise Architecture in other businesses that you think we could learn from?

Observation Guide

Observation as a method is used to record behavior in a specific context, what actually is said and done - not what they say they do.

Situation

The observation is related to the execution of an Architecture Board meeting in the Norwegian Armed Force in which a specific decision document, called Provision Solution (Fremskaffelsesløsning), is presented and discussed with regard to the quality of the architectural products included within the document.

Open observation

Open observation is assumed to be the best option here since we are talking about a relatively small group where it will be challenging to perform a closed observation. Furthermore, it is unlikely the behavior will change significantly as a result of they being observed. The reason is that this is a meeting conducted regularly, most participants know each other and it follows a given agenda. Approval of observation is given by the Head of the architecture council and all participants will be informed about the study and the observation in advance.

Non-participant observation

Non-participant observation is considered to be the best option. This to prevent the observation affects the outcome and thus reliability. In addition, the observer has limited insight into the process observed, restricting appropriate participation. If needed, clarifying questions will be addressed individually after the meeting.

Place, time and duration of observation

Architecture Board Meeting is scheduled from 10.00 to 14.00 on 23 February 2016. The observation will be carried out throughout the meeting's duration.

What to observe

The observation will be geared toward architectural products. The focus will be aimed specifically at how they are discussed and how they are used. Including trying to determine whether the group find the content to be qualitatively good. That includes

- All aspects described (scope)

- The degree of detail is adequate in relation to what you want to achieve

- It is presented in such a way that it is likely that the recipients of the document will understand them

Documentation

Only written notes of academic relevance will be used to document the observation. No use of recorded video and / or audio. Privacy information will not be noted. Personal comments and discussions of non-factual character will not be registered. Documentation will be kept at unclassified level.

Preparations

A walk-through of the calling notes including attachments would be conducted prior to be meeting in order to be as prepared as possible.

Complementary work

Clarify issues that emerged during the observation and clarify whether this was perceived to be "normal" Architecture Board. Based on findings from the observation, consider adjusting the interview guide prior to the interview of business architects to capture specific areas of interest.

Figure 36: Codes before sorting

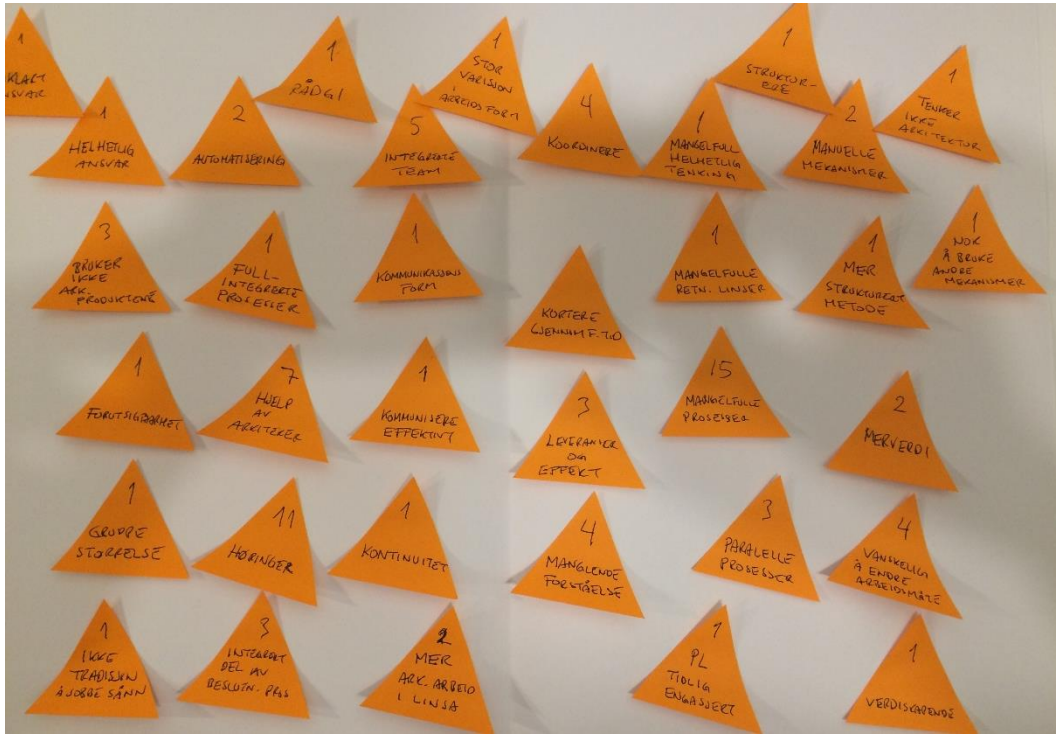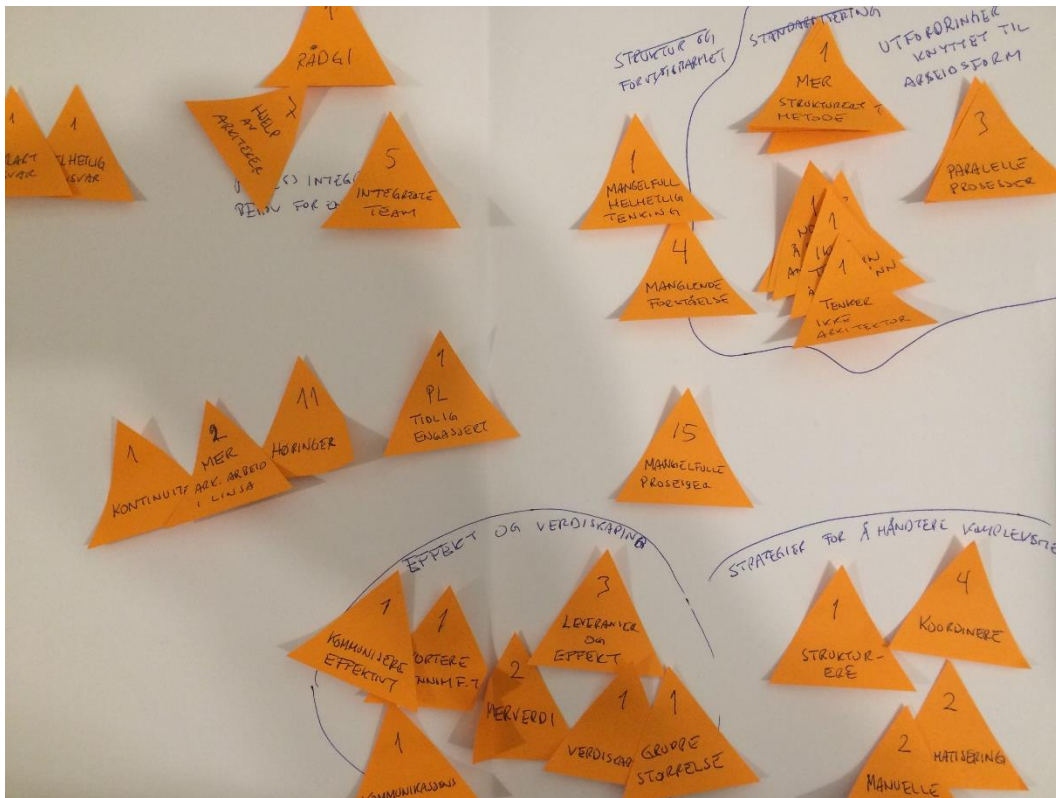*Figure 37: Codes after sorting into categories*

Theme 1 – Presentation

Presentasjon	0
Designkriterier	0
Analyserbar	1
Formkrav	3
Forståelig	4
Gjenkjennbart	5
Selvstendig (verdi på egenhånd)	2
Presenterbare	1
Tilpasset mottaker	7
Designprinsipper	0
Forenkle	3
Navigerbar	3
Standardisering	6
Vise forskjellige perspektiv	5
Designutfordringer	0
Deception by layout	2
Ikke pedagogisk gode	1
Mottaker forstår ikke innholdet	3
Power Point klipp og lim	1
Uoversiktlig	2
Typer av presentasjoner	0
Beslutningsgrunnlag	5
Executive Summary Views	2
Hva skal presenteres	2
Hybridfigurer (forenkling)	1
På et ark	2
Prosessdiagram	1

Theme 2 – Architecture

⌄ Arkitektur	0
⌄ Arkitekturverktøy	0
Metamodell	5
Verktøystøtte	16
⌄ Arkitekturattributter	0
Begreper	5
Bokser med piler	2
Etterspurt og godt mottatt	4
Flytskjema	2
Komplekst og krevende	10
Konseptuelt grunnlag	2
Prosesser og informasjon	4
Sammenhenger og avhengigheter	35
Virksomhetens behov og ytelsesdimensjonen	14
⌄ Arkitekturavklaringer	0
Arkitektur for hvem	4
Arkitekturproduktkrav (hva og hvordan)	9
Detaljeringsnivå	11
Kommuniserbare eller konsistent	4
Uenighet om nøyaktighet	3
Uenighet om rekkefølge	3
⌄ Helhetlig styring	0
Helhet og oversikt	26
Styringsinformasjon	19
⌄ Mangler og utfordringer	0
Alminneliggjøre	7
Fremmedgjort	4
Helheten mangelfull	16
Mangleden forståelse for arkitektur som verktøy	2
Mangel på konsistens	4
Ubalanse operativ/teknisk	6

Theme 3 – Ways of working

Arbeidsform og prosesser	0
Effekt og verdiskaping	0
Verdiskapende	3
Leveranser og effekt	3
Høringer	11
Manuelle mekanismer	2
Strategier for å håndtere kompleksitet	0
Automatisering	2
Strukturere	1
Roller og ansvar	0
Koordinere	5
Avklare roller og ansvar	10
Plan for styring uferdig	6
Hjelp av arkitekter	8
Integrerte og samkjørte team	7
Utfordringer knyttet til arbeidsform	0
Mangel på kontinuitet og faste rutiner	5
Kommunikasjonsutfordringer	8
Unngår å bruke arkitektur	20
Utfordrende å endre arbeidsmåter	2
Manglende forståelse	7
Manglende standardisering	4
Mangelfulle prosesser	19

Theme 4 – Resources and Training

⌄ Ressurser og opplæring	0
⌄ Kompetanse og opplæring	0
Spesiell kompetanse	23
Opplæring	14
⌄ Ressurser	0
Arkitekturressurser	6
Ressursknapphet	17
Ressurskrevende	8
Ressursutnyttelse	3

This appendix offers an overview over all architectural products used in the presentation given in the Architecture Board meeting from the observation session.
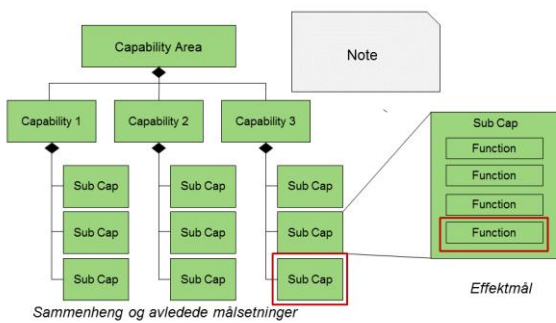
Product 1
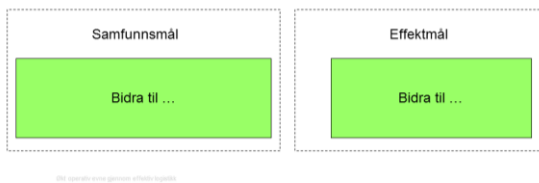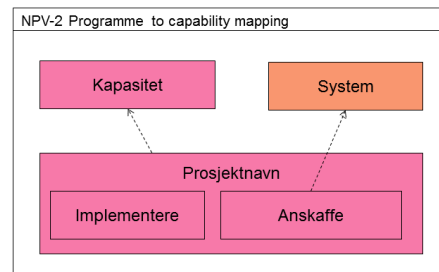
Product 2

Product 3

Product 4

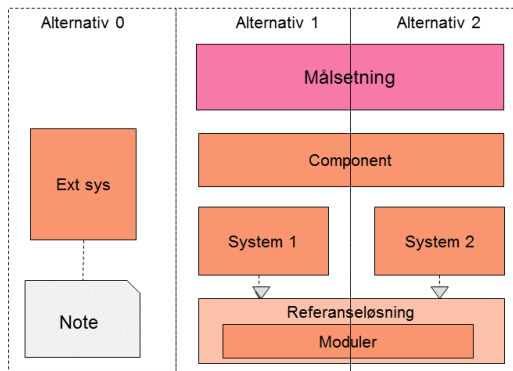Product 5

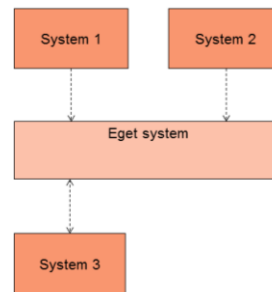Product 6

Brukere (NOV 2)

Systemavhengigheter (NSV-1)
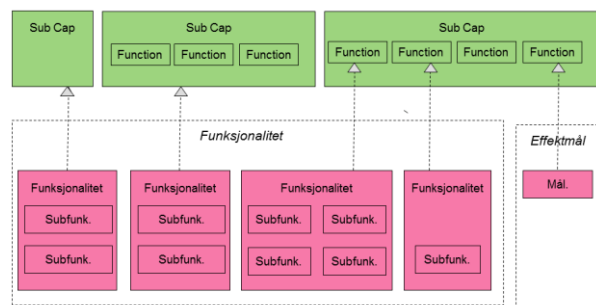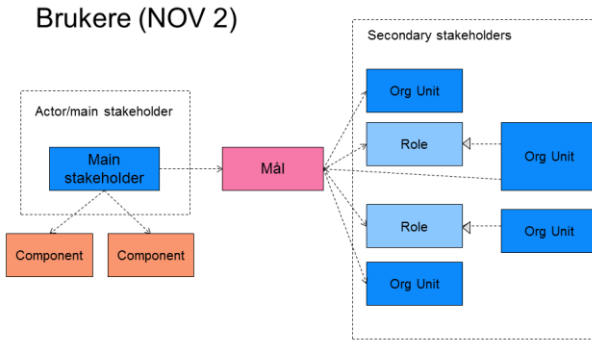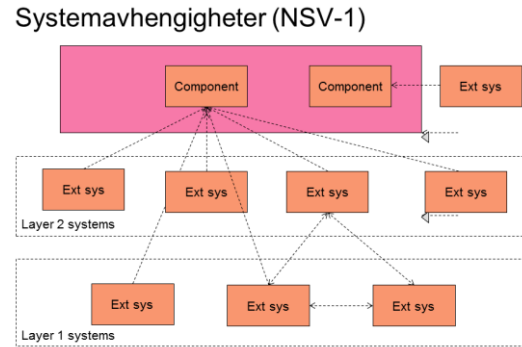
Product 7

Product 8

Løsningsalternativer (NSV-12)
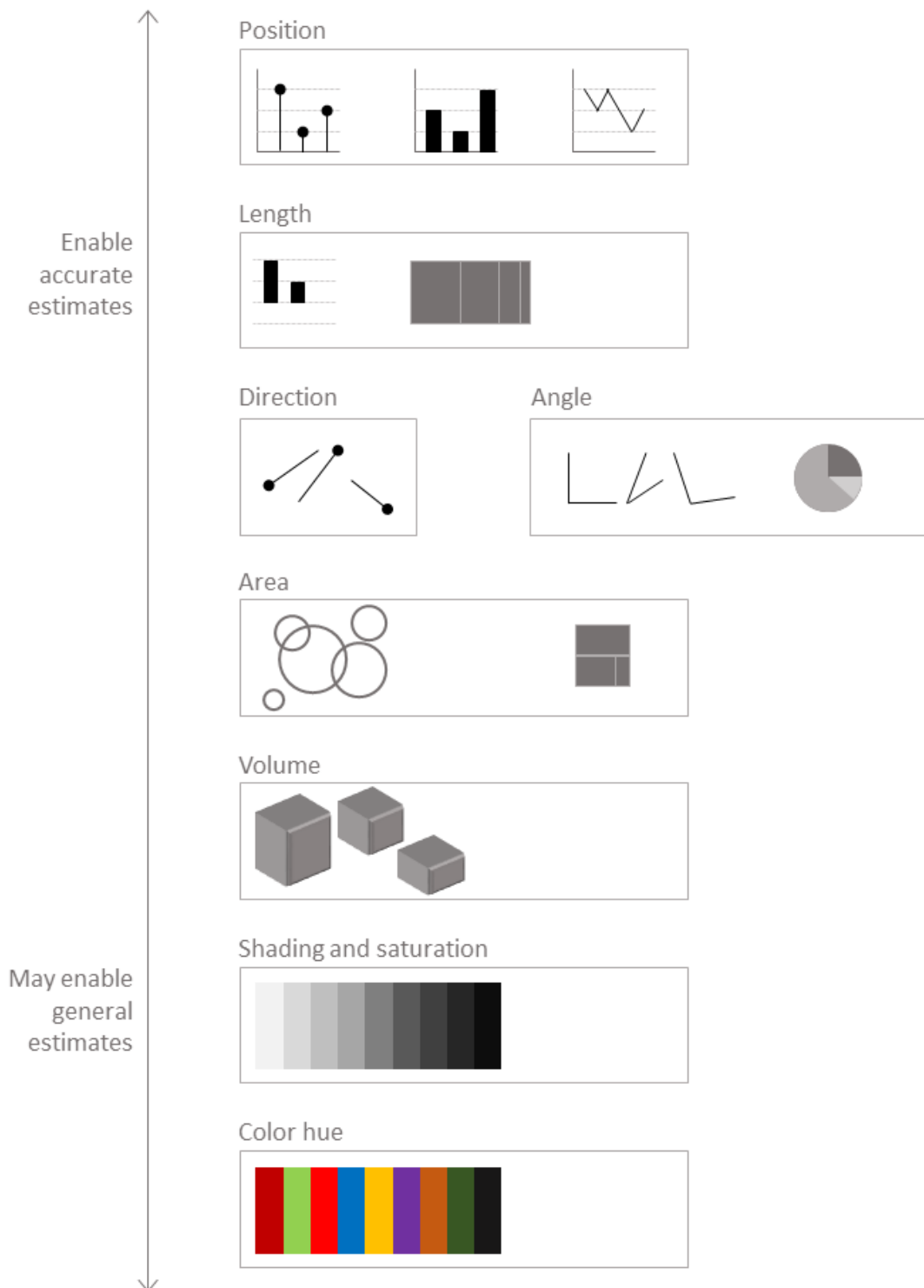
Koordinering med andre prosjekter (NPV 2)

Figure 38: Scale of elementary perceptual tasks, inspired by Cleveland and McGill