Detection and interpretation of weak signals

Author's name: Richard Wiik

Handledare/Tutor: Björn Johansson
Examinator: Arne Jönsson
Copyright

The publishers will keep this document online on the Internet – or its possible replacement – for a period of 25 years starting from the date of publication barring exceptional circumstances.

The online availability of the document implies permanent permission for anyone to read, to download, or to print out single copies for his/her own use and to use it unchanged for non-commercial research and educational purpose. Subsequent transfers of copyright cannot revoke this permission. All other uses of the document are conditional upon the consent of the copyright owner. The publisher has taken technical and administrative measures to assure authenticity, security and accessibility.

According to intellectual property law the author has the right to be mentioned when his/her work is accessed as described above and to be protected against infringement.

For additional information about the Linköping University Electronic Press and its procedures for publication and for assurance of document integrity, please refer to its www home page: http://www.ep.liu.se/.

Upphovsrätt

Detta dokument hålls tillgängligt på Internet – eller dess framtidiga ersättare – under 25 år från publiceringsdatum under förutsättning att inga extraordinära omständigheter uppstår.

Tillgång till dokumentet innebär tillstånd för var och en att läsa, ladda ner, skriva ut enstaka kopior för enskilt bruk och att använda det oförändrat för ickekommersiell forskning och för undervisning. Överföring av upphovsrätten vid en senare tidpunkt kan inte upphäva detta tillstånd. All annan användning av dokumentet kräver upphovsmannens medgivande. För att garantera äktheten, säkerheten och tillgängligheten finns lösningar av teknisk och administrativ art.

Upphovsmannens ideella rätt innefattar rätt att bli nämnd som upphovsmann i den omfattning som god sed kräver vid användning av dokumentet på ovan beskrivna sätt samt skydd mot att dokumentet ändras eller presenteras i sådan form eller i sådant sammanhang som är kränkande för upphovsmannens litterära eller konstnärliga anseende eller egenart.

För ytterligare information om Linköping University Electronic Press se förlagets hemsida http://www.ep.liu.se/.

@Richard Wiik
Foreword

With the much appreciated help of many people this report has been written during the spring of 2015. To better understand this report follows a short summary of its background. My background lies in cognitive science, where I have focused on user-centred design and behaviour in complex systems, depending on who you ask, synonymous with the field human factors. Before my masters in cognitive science, I took a one year masters in Ergonomics, Human-Technology and Organisation. This master’s take on from that, viewing the human element in a larger organisation. The report came to be through the company Vattenfall and their department of Nuclear Safety, specifically the Human, Technology, and Organisation (MTO) department, Helena Broberg have been of great help to introduce me to the field and get me in contact with the right personnel at the nuclear power plant where this study was conducted. I’m very grateful to the departments and the people there who invited me in and let me be a part of their daily work for a week’s time. As a student you often feel you are taking other people’s time, and there is nothing better than to find yourself surrounded by people with interest in what you do.

My mentor from the university, Björn Johansson, has helped me a lot on the way with his genuine interest for the field and knowledge. Also a big thanks to Staffan Bram, Linda Haugsnes, Christer Axelson and Anders Tilstam for all their help before, during and after the data collection phase. Without the help with coordination, workspace and feedback this essay would not have been possible.
Abstract

Managing safety at a nuclear power plant is about a complex system with demanding technology under time pressure where the cost of failure is exceptionally high. Swedish nuclear power plants have over the last few years introduced Pre-job Briefing and other so called Human Performance Tools to advert errors and strengthen control. By using the Systemic Resilience Model different views of safety are taken to understand the origin of the signals that leads to a Pre-job Briefing, and how the signal is interpreted, re-interpreted, and presented.

The study took place at a Swedish nuclear power plant and included four days of observations and 20 interviewees. The thematic analysis shows a similarity between mentioned origins of Pre-job Briefings and the intended use of Pre-job Briefing. Characteristics of a High Reliability Organisation is shown in practice by a culture of that one will to have a Pre-job Briefing is enough, that sharp end workers is used as a valuable resource for safety and a systematic support to screen jobs over time without influencing non-job related factors.

The signals acted upon matched well with the intended, and personnel get several opportunities to evaluate the signals together, striving for best possible circumstances. The Systemic Resilience Model was successfully applied together with a thematic analysis, which strengthens its validity as a holistic model that combines different views of safety in one coherent model. SyRes allowed to present additional themes, leaving the question at what stage SyRes is optimally implemented in a thematic analysis.
# Table of contents

1. Introduction ........................................................................................................... 1  
   1.1. Research questions ......................................................................................... 2  
   1.2. Delimitations of this study ............................................................................. 3  
2. Background ............................................................................................................. 4  
   2.1. The nuclear power plant .................................................................................. 4  
   2.2. HP-Tools ......................................................................................................... 4  
3. Theoretical framework .......................................................................................... 9  
   3.1. Views on safety ............................................................................................... 9  
   3.2. Being robust and handling the unexpected ..................................................... 10  
   3.3. Be wary of pressure from driving variables .................................................... 13  
   3.4. Systemic Resilience Model .......................................................................... 17  
   3.5. Applying safety theory on the use of PJB ....................................................... 19  
4. Method ................................................................................................................... 21  
   4.1. Data ............................................................................................................... 21  
   4.2. Data analysis .................................................................................................. 26  
5. Results ................................................................................................................... 30  
   5.1. Description of roles ....................................................................................... 31  
   5.2. Descriptions of maintenance types ............................................................... 39  
6. Thematic analysis .................................................................................................. 42  
   6.1. Similar origins of PJB between roles ............................................................. 42  
   6.2. Several screenings over time ........................................................................... 43  
   6.3. Easy process, but experience is crucial .......................................................... 45  
   6.4. PJB as a quality job walkthrough among others ............................................. 46  
7. Applying the Systemic Resilience Model ............................................................. 47  
   7.1. Anticipation of weak signals to performed PJB .............................................. 47  
   7.2. Establishing premises for intended use of PJB .............................................. 50  
   7.3. Reinforcing and inhibiting loops .................................................................. 52  
8. Discussion of results ............................................................................................. 53  
   8.1. Weak signals and one will is enough ............................................................. 53  
   8.2. Sharp end workers as a valuable resource for safety ...................................... 53  
   8.3. PJB and other job walkthroughs to be used as intended ............................. 54  
   8.4. Constant communication between roles ...................................................... 54  
   8.5. Show reinforcement through SyRes ............................................................... 56  
9. Discussion of method ........................................................................................... 57
9.1. Experiences of observations ........................................57
9.2. Interviews ....................................................................58
9.3. To solely focus on one department ............................... 59
9.4. SyRes in relation to the thematic analysis ......................59
10. Conclusion ...................................................................61
10.1. Origin of signals ......................................................61
10.2. Interpretation and representation of signals ................61
10.3. The Systemic Resilience Model .................................62
11. References ..................................................................63
Appendix I – interview questions .....................................67
1. Introduction

Maintenance work is associated with damages that affect the operational drift, bodily injuries and the development of latent faults into the nuclear plant’s daily operation (Baker, o.a., 2007; Reason, 1998). The work that is being done by maintenance is a work between several involved parties under time constraints in a dangerous and complex environment (European Standard EN 13306, 2010). With the main purpose of avoiding unwanted outcomes and reinforcing the maintenance personnel’s ability to anticipate, prevent and detect errors, Human Performance-Tools (HP-Tools) was introduced (Skjerve & Axelsson, 2014). One of these ten HP-Tools is the Pre-job Briefing (PJB) (DOE, 2009b). A PJB is a meeting between involved parties of a job that is to be performed at the plant, a meeting that can be called by anyone involved (DOE, 2009b). Critical steps, risks, tasks and precautions are the intended topics to be discussed during PJBs (DOE, 2009b). There exist both the small and full PJB. There are lesser and bigger forms of job walkthroughs for coming jobs. The purpose of the PJB and job walkthroughs are both that involved personnel follow procedures and be aware of roles and responsibilities to keep the work robust and stable, but also to prepare for unexpected events that might occur (Skjerve & Axelsson, 2014). Safety can be viewed from different angles, which ultimately effects how safety is handled in a proactive sense as well as when an accident occurs (Lundberg & Johansson, 2015). According to Reason (2000), errors are consequences to be expected, and human variability is as much a source to error as it is to averting them. Personnel part of a High Reliability Organisation (HRO), such as a nuclear power plant, manage complex and demanding technology under a large organisation within time pressure where the cost of failure is exceptionally high (Reason, 2000).

HP-Tools is in this case a strategy chosen by the HRO to strengthen the human resource to act to advert error, as a part of many strategies to handle all types of events that can disrupt the HRO (Skjerve & Axelsson, 2014). Regular events are typically anticipated and precautions are made to avoid or immunize the HRO from the source of danger, which increases system stability (Johansson & Lundberg, 2010). But resilience is needed when handling events that are not as well-defined due to their irregularity (Hollnagel, Leonhardt, Licu, & Shorrocks, 2013; Hollnagel, 2012; Johansson & Lundberg, 2010). A PJB aims at strengthening the system’s stability, such as adherence to procedures and barriers, but also to be mindful for unanticipated risks (DOE, 2009b; Skjerve & Axelsson, 2014). Both stability and resilience enhancing activities are needed in a HRO such as a nuclear power plant to maximize safety (Hollnagel, Leonhardt, Licu, & Shorrocks, 2013; Johansson & Lundberg, 2010; Weick, Sutcliffe, &
Obstfeld, 1999). Resilience and stability are however often viewed separately (Hollnagel, Leonhardt, Licu, & Shorrock, 2013), the Systemic Resilience Model (SyRes) combines stability and resilience in one coherent model (Lundberg & Johansson, 2015).

As a set of tools to increase safety, one could reason that HP-Tools should be used as extensively as possible. However, for HP-Tools to have a positive impact on safety, they need to be used as intended, under the right circumstances (Skjerve & Axelsson, 2014). The intended use of HP-Tools is not promoted when they are used routinely or when it is not perceived as necessary for a specific job (Skjerve & Axelsson, 2014; NKS, 2014). PJB is a job walkthrough that is intended to be reacting to weak signals of unwanted events. Weak signals being indications that something might

Lacking the requisite imagination and interpretation (Lundberg & Johansson, 2006) means not being able to detect and react to weak signals (Weick, Sutcliffe, & Obstfeld, 1999). By not using PJBs as intended would lead to an organisation that slowly normalize deviate in daily work (Vaughan, 1997). Detecting and reacting on weak signals are one of the main characteristics of a HRO (Coutu, 2003; Weick, Sutcliffe, & Obstfeld, 1999; Reason, 2000).

A PJB can be requested from any person involved in a future job, who, for some reason, thinks that a PJB is necessary (DOE, 2009b). For the PJB to be effective, signals need to be detected and interpreted to match the PJB. The signals that are the origin to the PJB are therefore important for HP-Tools to be used as intended.

The signal that leads to a PJB should reflect the intended use of the PJB (Skjerve & Axelsson, 2014). Identifying what kind of signals that are identified as leading to the decision to initiate a PJB validates that this type of identified events are handled by the HRO. Additionally, the signal travels over time, interpreted from different perspectives between groups and roles. Naturally, if the PJB is intended to counter the origin of the signal, the very cause of the signal to start with must be reflected in the PJB. As one coherent model is SyRes (Lundberg & Johansson, 2015) a possibly powerful tool to describe dependencies and relations within the system of interest and its functions of stability and resilience.

1.1. Research questions
The aim of this study is to get a deeper understanding of signals that leads to a PJB by performing a case study in one nuclear power plant located in Sweden. A specific interest is what kind of signals results in a Pre-job Briefing and how the interpretation and presentation of the signal changes over time and between groups and roles. Additionally, it is of interest to evaluate how the Systemic Resilience Model can be applied in this case to describe in a systematic way the process from signal identification to a completed Pre-job Briefing.
The research questions for this study are:

1. What is the origin of signals that results in a Pre-job Briefing?
2. If, then so how, do these signals get interpreted, re-interpreted and presented over time between roles?
3. How does the Systemic Resilience Model fare as a tool used in combination with a traditional thematic analysis for studying the use of Pre-job Briefings?

1.2. Delimitations of this study

There are many different groups within maintenance that use HP-Tools, including PJB. Delimitation had to be made as to which groups to focus on. This choice was mainly made by the supervisors at the nuclear power plant, as their knowledge of what groups deemed good to do this study with, considering access and amount of work that was being done at the time of data collection. Initially it was decided to focus on two groups within maintenance, but after the observation phase and the initial interviews it was decided to focus on just the mechanical maintenance department. This was due to in comparison insufficient interviewees and workers’ less involvement in PJBs.

Jobs performed at a nuclear power plant can be viewed as a cycle. A full cycle of the signal can be said to start with the initial origin, to the PJB or another job walkthrough, how it manifests itself in the job the PJB was intended to, to a Post-job Debriefing, and lastly to how the signal can be used as learning for future situations where it might be of use. It was not possible within the scale of this study to include the full cycle. Therefore, this study studies the first two parts, the initial origin to the PJB or another job walkthrough. Future studies could explore this further, especially comparing the signal between PJB and Post-job Debriefing.
2. Background

Maintenance work is associated with damages that affect the operational drift, occupational injuries and the development of latent faults into the nuclear plant’s daily operation (Baker, o.a., 2007; Reason, 1998). Effective and reliable maintenance is therefore crucial for safe operation. Considering technical, human and organisation factors produce reliable maintenance activity results (Reiman, 2011).

The work that is being done by maintenance is a work between several involved parties under time constraints in a dangerous and complex environment (European Standard EN 13306, 2010). The use of Human Performance Tools aims at lowering the risks safety and increase controls, which is presented in the second part. Firstly however is a brief section of the targeted nuclear power plant, presenting roles by what work is being performed.

2.1. The nuclear power plant

For this study a favourable distinction between the plant’s maintenance personnel can be done by for example which type of maintenance is being performed. Three groups can be decomposed, as defined by Skjerve and Axelsson (2014, s. 12):

- Instrumentation: Test and service on Instrumentation & Control systems.
- Electrical: Test and service on Electrical power systems and motors.
- Mechanics: Test and service on Mechanical equipment, engines, valves and pumps.

Within these types of maintenance, there are different departments working on different reactors. Third party groups such as painters and cleaners are also active and affect the maintenance work. “Operations” is used throughout the report as a word describing the control-room operators. The use of the word “department” is in this study used to distinguish third party groups, operations, maintenance types and subgroups within the same maintenance type. Each maintenance category can be further decomposed into different staff categories. But for the purpose of this study categorisation is done by the data collected in this study and is therefore presented in the result section.

At every plant there are outtakes (also sometimes named revisions) where one or more reactors are taken down for maintenance. During this time a lot of jobs are performed, with more hired personnel than normally working in the plant.

2.2. HP-Tools

The uses of Human Performance Tools (HP-Tools) was introduced at the studied plant as a way of lowering the risk of unwanted events and reinforce the personnel’s ability to anticipate, prevent and detect
errors (DOE, 2009b). The type of errors that the HP-Tools hope to eliminate are all kinds of errors (latent, slips, lapses, active errors and so on) that has a negative impact on the nuclear facility’s ability to maintain in control. (DOE, 2009a; DOE, 2009b)

The HP-Tools are developed based on a set of human performance principles, which define the human role and the view of humans in work (DOE, 2009a):

- People are fallible, and even the best people make mistakes.
- Error-likely situations are predictable, manageable, and preventable.
- Individual behaviour is influenced by organizational processes and values.
- People achieve high levels of performance because of the encouragement and reinforcement received from leaders, peers, and subordinates.
- Unwanted events can be avoided through an understanding of the reasons mistakes occur and application of the lessons learned from past events (or errors).

Originally, the HP-Tools were developed by practitioners (Oedewald, o.a., 2014). They might also have been in practice before the introduction as HP-Tools, but when introduced as HP-Tools, the procedure differs in some ways from before (Skjerve & Axelsson, 2014). A subset of the work practices now that now constitute the HP-Tools had prior to the formal implementation already been applied at the targeted Swedish power plant. A formal introduction came after reports of that the work practices were not used as it was intended to.

As of now a total of ten HP-Tools have been introduced at the targeted plant (Skjerve & Axelsson, 2014). DOE (2009a) categorises HP-Tools into HP-Tools for individuals, HP-Tools for work-teams or as management tools. Skjerve and Axelsson (2014) categorises the ten HP-Tools used at the targeted plant by its level of performance prescription:

- Promoting adherence to procedures/instructions
  - Procedure Use and Adherence
- Catching errors
  - Clear Communication
  - Peer-Checking
  - Independent Verification
- Sharing insights and experiences to promote performance
  - Pre-job Briefing
  - Post-job Debriefing
  - Task Observation
  - Operational Experiences
- Sensitizing to unexpected states/events
Pre-job Briefing

The Pre-job Briefing (PJB) is a meeting with workers and supervisors before performing a job to discuss the tasks, critical steps, hazards and safety precautions. By so, the intention is for individuals to better understand the task(s) and associated hazards (DOE, 2009b). The PJB is a job walkthrough that is meant to be used before work activities and involve facility equipment. It can be used once per shift, and again if the activity exceeds the one shift duration, but also if there has been extended delays in an activity. Instructions for PJBs states that any person can request a PJB. (DOE, 2009b)

As categorised in the second lowest performance prescription by Skjerve and Axelsson (2014) the PJB can (and should) be adapted for each specific job (DOE, 2009b). The level of PJB- detail depends on job hazard, job complexity and assigned individuals (DOE, 2009b). This is why DOE (2009b) only presents a recommended agenda for a detailed PJB in this sequential order:

1. Task purpose
2. Review of procedures
3. Task assignment
4. Human performance
5. Operating experience
6. Stop-work or Pause Work criteria
7. Oversight
8. Questions and concerns

Two agendas are used at the targeted plant, which are named the full PJB and the small PJB. The full PJB contains the whole agenda, while the small PJB are reduced to ten questions.

Job criteria’s, questions to be raised, checklists that are available and formal instructions of affected personnel for the job should be used during the PJB. It is also important to note that there are lesser and bigger forms of job walkthroughs and preparations for a future job. Job walkthroughs just before a job, on site walkthroughs of procedures and possible dangers, but a job can also be prepared for by a project, which allows for a separate budget with training and prototype building. A combination of these preparations can also be used, for example a project can be followed by a PJB and an onsite job walkthrough.

If any HP-Tools is to be expected to have a positive effect on safety and work as intended it is important that the PJB are perceived as they promote safety for the specific job the PJB is intended for (Skjerve & Axelsson, 2014). Original categories of good mindful safety praxis from Skjerve (2008), did Skjerve and Axelsson (2014) categories that
good pre-conditions for maintenance personnel to use HP-Tools are when:

- Maintenance personnel are willing or motivated to use HP-Tools. The use of HP-Tools makes sense.
- Maintenance personnel have the ability to know how, when and why HP-Tools are to be used.
- Maintenance personnel have the possibility to use the HP-Tools, as adequate time and space.

In cases where the tools are not perceived as being used as intended, for example when a PJB is perceived to be used as an end in themselves, the positive effect can be expected to be minimized or neglected (Skjerve & Axelsson, 2014). All three pre-conditions needs to be acknowledged for the PJB to work.

Previous studies have shown that time is perceived to be taken from the actual work to use HP-Tools, which inhibits willingness to use them (Skjerve & Axelsson, 2014; Oedewald, o.a., 2014). This is in accordance with the ETTO-principle, that there is a constant trade-off between efficiency and thoroughness in work (Hollnagel & Woods, 2005). Willingness to use the HP-Tools comes then when the perceived time taken from actual work for the PJB is perceived to be worth it. To promote use of the HP-Tools, an organisation can formally dedicate time for them. This supports the possibility to use the HP-Tools and could lower the risk that focus ends up on efficiency, rather than thoroughness. However, it could inhibit willingness, as the origin might be more formal, than an identified need of a HP-Tool.

The relation between the three pre-conditions sets for a complex decision making of how the HP-Tools should be used.

By interviews and questionnaire with maintenance personnel at the targeted plant, Skjerve and Axelsson (2014, s. 62) lists that PJB is seen as useful when at least one of the following characteristics are perceived for future jobs:

- A non-routine task.
- Requires people from different departments/professional groups to work together and/or to carry out individual but interdependent tasks.
- Involves one or more components of critical importance for plant operation.
- Is complex.
- Is new to some of the participants.

Skjerve and Axelsson (2014, s. 63) further identified three main positive categories associated with using PJBs by maintenance personnel:
• PJBs help to ensure that safety issues (operational and occupational) are identified and optimally addressed prior to a task performance process.
• PJBs improve the quality of collaboration and coordination during task performance.
• In the longer-term perspective, PJBs promote the competence development of maintenance personnel and increase the familiarity between staff members across group boundaries.

Studies regarding the positive and negative factors influencing a PJB are very similar in their results (DOE, 2009b; Skjerve & Axelsson, 2014). A combined list of factors that neglects intended use of a PJB would result in:

• To use PJB as a routine tool.
• When the use of PJB is decided by management, but not perceived to be needed by those performing the PJB.
• When documentation of a PJB is too demanding or irrelevant to the task is to be filed. Also when PJB instructions are changed too often.
• When the PJB are sub-optimally performed (wrong focus, not taken seriously or unnecessarily long).
• Waiting time to get everyone summoned gathered.
• When not everyone that is supposed to attend are attending.
• When the participants of the PJB are not involved in the PJB.
• Variation in competence of attending personnel is too big.
• Performed in a disturbing (loud) environment.
3. Theoretical framework

Different views on how safety is reached in a complex system such as a nuclear power plant facility differs, which is brought up in the first subchapter. This is brought down to a systems ability to be robust and stable, handling difficulties by resisting them, such as strong barriers. The same system can however (and it is argued that it should) also be resilient, no matter how robust the system is perceived to be. An important characteristic of a system that wishes to be resilient is to be able to admit the imperfection of any system, no matter how stable it may seem, and search for signals that indicates unwanted events. By so, drifting into failure and a HROs ability to detect and act on weak signals is lastly discussed. These different views of safety is then brought together in the Systemic Resilience Model

3.1. Views on safety

The view of what safety is and how it can be reached differs between domains and throughout time. Traditional safety management sought to control the system process, breaking down each action needed to be completed the task in accordance with Scientific Management or behaviour models of punishment or rewards. By viewing safety according to the person approach (Reason, 2000) or “bad apples” as Dekker (2014) names it, the humans in work are error prone, reckless and forgetful. The human element is a necessity, but a source that needs to be reduced and controlled as much as possible (Reason, 2000). The person approach view is still dominant in many domains, but as system complexity increases alternative views of the human role for production and system safety arises.

The human variability that in the “person approach” was viewed as a negative force to maintain control, is in the system approach also seen as a force that can strengthen the overall system performance, as well as be a cause for fallible states (Reason, 2000). The human condition as such is accepted in the system approach, but the context in which the conditions for work is set, are not (Reason, 2000). By viewing complex, technological work environments as an open, socio-technical system the human element cannot be distinguished from its context on a functional level (Hollnagel & Woods, 2005; Pew & Mavor, 2007).

The Swedish Accident Investigation Authority did their first ever investigation of an accident on a hospital in Stockholm as late as 2013 (Statens Haverikommission, 2013). The investigation emphasized the system approach, leading to conclusions and recommendations beyond at the time of the accident present individuals, highlighting organizational and technological factors affecting human behaviour. Comparing with the original accident analysis done by the hospitals own accident investigation, whom highlighted factors according to the person approach, this accident and investigations displays the difference of working paradigm between the person and
system approach. The system approach opens up to see a wider range of contributors and solutions to safety issues (Hollnagel & Woods, 2005; Reason, 2008; Ödegaard, 2013).

At the top of handling complex socio-technical systems are the High Reliability Organisations (HRO). Organisations that have high reliability are not defined by what domain they operate in, but rather by their unforgiving social and political environment, possible scale of consequence if there is a loss of control, complex processes for complex technology and therefore a daily work process where a lot can go wrong (Rochlin, 1993). A HRO can also be characterised by what it does to stay in control (Weick, Sutcliffe, & Obstfeld, 1999). Reason (2000) and Weick, Sutcliffe and Obstfeld (1999) highlights that HRO differs by having “mindfulness”, that is to:

- Have a constant focus on the possibility of failure
- Be reluctant to simplify interpretations
- Be sensitive to how operations are really performed - work-as-done rather than work-as-imagined.
- Be committed to be resilient – can reconfigure themselves to suit local circumstances and handle high peak demands
- Show deference to expertise - personnel at the sharp end are one of the HRO’s most important resources for safety

Many organisations, typically in aviation, healthcare, aircraft or nuclear power plants show these characteristics fully or to a certain degree, and are typically placed in the HRO category (Reason, 2000). However, HRO are the prime examples of the system approach (Reason, 2000), and by defining HRO as a set of characteristics, it is more of an ideal than organisations within a certain domain (Hopkins, 2007).

The characteristic of a HRO stresses the importance to be ever wary of failure in domains where risk assessment is a part of the daily work. Risks are assessed and acted upon all the time in our daily life - aviation would only ever be safe if no planes ever took off or no driving accidents would occur if no one drove. It is for the HRO to achieve a safety that is as high as possible, minimize damage when error occurs and regain control as soon as possible (Weick, Sutcliffe, & Obstfeld, 1999). Naturally, this is something the nuclear power plant in this case study strives for. The next chapter presents one view of how a HRO can manage to be as safe as possible.

3.2. Being robust and handling the unexpected
The two views of safety named Safety I and Safety II might at first glance be thought of as hard to distinguish, but in their cores lies a difference that affects an organisations work towards being safer (Hollnagel, Leonhardt, Licu, & Shorrock, 2013; Hollnagel, 2012). According to Safety I, safety is the absence of accidents and incidents, possible errors are built away as to decrease the system’s varia-
bility (Hollnagel, 2012). Because of this, humans are predominantly seen as something that needs to be controlled for safety to be maintained (Reason, 2000). This can for example be seen written by the Department of Energy (2009a):

“Controls, barriers, or safeguards tend to be more reliable when they are not dependent on people to carry out their protective functions.”

(DEO, 2009a, ss. 3-4)

When the effectiveness of a defence mechanism relies on the performance of people—as do procedures, training, self-checking, and verifications—then it is less reliable (DEO, 2009a, ss. 3-4 and 5).

The approach of safety as Safety I is reactive as it focuses on what has gone wrong and how to prevent it from happening, or by identifying risks and taking measures to counter them (Hollnagel, 2012). By so, safety is also defined by that as little as possible should go wrong (Hollnagel, 2012). Safety II aims at highlighting why performance practically almost always goes right in complex systems, and tries to ensure that things go right (Hollnagel, 2012). By understanding the HRO’s ability to succeed under varying conditions, the focus of safety moves over to how the system succeeds, rather than why it from time to time fails (Hollnagel, Leonhardt, Licu, & Shorrock, 2013; Weick & Sutcliffe, 2011). These definitions are somewhat vague; lowering the amount of accidents increases statistically Safety II, and adding additional events will likely result in that more goes right. The point to be made here is that Safety II stresses the importance to study how variability in complex systems is controlled and learn from this (Hollnagel, 2012).

The barrier systems in an organisation are part of the measures taken to protect the operation from anticipated dangers (Skjerve, 2008). Hollnagel (1993) for example categories barriers into material, functional, symbolical and immaterial that are either meant to be preventive, to deflect or to minimize consequences from unwanted events. Either way, barriers are set for known risks, even if they might unintentionally have a protective effect of unknown dangers. A critical characteristic of a HRO is to accept the possibility of failure, and by so, aware that every event cannot be anticipated and prevented (Weick, Sutcliffe, & Obstfeld, 1999). Barriers, by Hollnagels (1993) definition, are therefore not enough to strive to be a HRO. Being aware of its own inability to anticipate every danger i.e. being mindful is therefore a key component in a HRO (Weick, Sutcliffe, & Obstfeld, 1999). Johansson and Lundberg (2010) differ here between an organisation’s stability and its resilience.

3.2.1. Stability and resilience

An organisation that has a high stability is robust system that withstands expected variation by immunizing, eliminating and controlling dangers, which the barrier system does (Johansson & Lundberg,
To be resilient system on the other hand, is to have the ability to control uncertainty and variability (Johansson & Lundberg, 2010; Lundberg & Johansson, 2006). Both strategies are needed to maximize safety (Hollnagel, Leonhardt, Licu, & Shorrock, 2013; Lundberg & Johansson, 2006; Weick, Sutcliffe, & Obstfeld, 1999).

HP-Tools support both stability and resilience. The HP-Tool “Procedure use and adherence” aims at strengthen stability by following procedures, an immaterial barrier, while having a questioning attitude and operational experiences rather promotes to be wary of the flaws of the barrier system (DOE, 2009b). The difference between stability and resilience can be viewed from what type of events they intend to protect the system from (Lundberg & Johansson, 2006). Figure 1 shows the relation between stability and resilience and a potential balance between the two.

Westrum (2006) defines three type of events, namely the regular, irregular and unexampled events. The regular event is well known and defined, while irregular events are possible to anticipate, but so seldom appear the event is not well defined and proper precautions are often not taken. Unexampled events cannot be anticipated, so coping with them becomes extremely hard. For regular events is a high stability good, but for less well-defined events such as irregular events and unexampled events, the less suitable is stability. A system can therefore have a high stability, without having a high resilience. A system can have a high performance with just a high stability as long as the context of which it operates does not change more than expected. A system that wants to be able to handle unexpected and unexampled events needs to also be resilient. A balance needs to be found between the two to have a system that can handle next to all kinds of events (Hollnagel, Leonhardt, Licu, & Shorrock, 2013; Lundberg & Johansson, 2006).
The PJB is a HU-Tool that strengthens both stability and resilience, by adherence to procedure, defining roles and so on, but also to highlight possible unknown events that can occur. Stability and resilience are not opposites, but rather in co-dependency to maximize safety (Johansson & Lundberg, 2010; Hollnagel, Leonhardt, Licu, & Shorrock, 2013), which is exemplified by the PJB.

### 3.3. Be wary of pressure from driving variables

In a complex socio-technical system some variables are ever affecting the system’s operation, as different goals pressures the organisation towards a certain state. According to Rasmussen’s (1997) Dynamic System Model organisations are constantly pressured by economic goals and humans desire to work more efficiently and simplify work e.g. reducing workload. These two variables do to some extent apply pressure to each other, but primarily against the systems performance, which, when crossed, opens up for accidents. Within these variables are the systems possible room of operations to remain in a controllable, functional state. If the boundary of either of the three variables are crossed, it loses its functional state. (Rasmussen, 1997)
Organisations are not static within the room of operations, even if there might be one optimal state (Rasmussen, 1997). Represented in above figure 2, the “Stable, low risk organisation” experiences low economical and workload pressure. It is also quite stable, as represented by its small circle, in comparison to the “Unstable, high risk organisation” which has a bigger circle. The “Unstable, high risk organisation” is working closer to the unacceptable performance boundary, pressured by high economic goals. Unlike “HRO”, the “Unstable, high risk organisation” operation crosses the margin of safe performance. Any system should be aware of its dynamic movement, the margin of safe performance is therefore a boundary that when crossed should be identified and efforts put in to get to a state of the right side of the boundary (Cook & Rasmussen, 2005).
A HRO strives to have a large marginal to unacceptable performance as to handle variation, but also to have stable operations (Cook & Rasmussen, 2005). To be, and maintain in the desired state, the HRO needs to constantly monitor itself, and be monitored by others, as to where the HRO is in relation to the boundary of unacceptable performance (Cook & Rasmussen, 2005). A common understanding of the operation point in relation to the margin of acceptable performance is needed to assess trade-offs in work (Cook & Rasmussen, 2005). When an organisation fails to cope with driving variables it slowly moves closer towards the boundary of safe performance.

3.3.1. To not drift into failure
Drift into failure is an organisations slow, incremental drift closer to the unacceptable performance boundary, which ultimately leads to a loss of control and unwanted events (Dekker, Why we need new accident models, 2004; Hollnagel, 2012). In a complex socio-technical system it is hard to identify signals that indicate that a system is drifting into failure, as it is normal people doing normal work (Dekker, Why we need new accident models, 2004). However, what over time occurs is that pressure from driving variables and the organisations inability to adapt to changing circumstances changes the acceptable risk-taking at work.
Figure 4. The system drifting into failure with the green dots, drifts into failure by having strong signals on both sides of the margin of safe performance.

Vaughan (1997) describes how a certain level of risk-taking in work is accepted to meet demands higher than normal. Over time this level becomes the norm, which then gets pressed further as expectations of increased production remains (Vaughan, 1997). Signals that once indicated an unacceptable risk becomes accepted, and the organisation instead reacts on stronger signals. Vaughan (1997) termed this organisational behaviour “normalization of deviance”, a behaviour that well describes how a system can over time drift over the boundary of unacceptable performance. Figure 4 visualises how the system that drifts into failure, represented with green dots, detects less signals than the blue system, the HRO. Also, the system that is drifting into failure has strong signals on both sides of the margin of safe performance.

Weick, Sutcliffe and Obstfeld (1999) also points out how a long period of success can become a liability, as it can reduce awareness, reduce resources to safety and an aversion to admit the existence of near misses and failures when they occur. Drift into failure can therefore come from different sources, but are united by signals once thought of as risks are normalized.

To counter this the organisation needs to monitor its own functions (Lundberg & Johansson, 2006) as to not drift into failure. Paradoxically is that self-monitoring in theory requires another function that monitor that one, creating an infinite control loops. This is called the Matryoshka problem (Lundberg & Johansson, 2006), which is needed to take into consideration in system design.

3.3.2. Acting on signals
Weak signals are indications or “signals” that something is not as intended, and if not the detected or later signals are acted upon, damages will occur. Identifying and responding to weak signals are central to a HRO (Coutu, 2003; Reason, 2000; Weick, Sutcliffe, & Obstfeld,
Detecting weak signals is especially important in maintenance, as they see large amount of failures (Weick, Sutcliffe, & Obstfeld, 1999; Reason, 1998), takes part at an early stage of development and gains a closer sense of vulnerabilities in technologies (Weick, Sutcliffe, & Obstfeld, 1999). Some experts argue that it is impossible to anticipate every weak signal, as their numbers are almost infinite, but also because the tools to detect all these signals do not exist (Weick & Sutcliffe, 2011). However, as Weick and Sutcliffe (2011) argue, even if HRO have their share of accidents and near misses, they do understand the meaning of weak signals and can act on them confidently. Anticipating events through weak signals naturally gives more time to respond and lessens the workload of addressing stronger signals of unwanted events, near misses and accidents. Mindful organisations see significant meaning in weak signals and reacts to them strongly (Weick, Sutcliffe, & Obstfeld, 1999).

To act on a signal, it first has to be anticipated, which enables the system to identify it and then take actions to prevent or control the future event. Hopefully, the organisation can also learn from this event, strengthening systems for future events. An organisation that has the ability to properly anticipate, monitor and detect signals of unwanted events has requisite imagination (Adamski & Westrum, 2003). However, it is not only about identifying weak signals. In the process of identifying signals by monitoring, the organisation will surely encounter insignificant glitches or in other way false signals (Hopkins, 2007). Distinguishing false signals from signals that should be responded to focuses the organisation’s resources. Also, in the case of HP-Tools, as previous studies have shown, is it important that HU-Tools make sense and are used when they are needed i.e. when they are based on real signals (Skjerve & Axelsson, 2014). Once a signal is identified to be a deeper cause of oncoming unwanted events, the organisation must have requisite interpretation that is to be able to recognize danger and have the ability to act on it, initiating strategies to manage unwanted events (Lundberg & Johansson, 2006; Johansson & Lundberg, 2010).

Signals of unwanted events can be identified in different phases, from very weak to very obvious ones, which has to be distinguished from false signals, correctly anticipated and responded to. An organisation’s ability to discover and act on signals is brought together in the Systemic Resilience Model.

### 3.4. Systemic Resilience Model

The Systemic Resilience Model (SyRes) combines stability and resilience in one coherent model (Lundberg & Johansson, 2015). By doing so it also includes drift into danger, functional dependencies to identify and respond to signals, strategies on how to handle unwanted events and constraints the unwanted events sets on the organisation.
3.4.1. The relation between event-based constraints and functional dependencies

Event-based constraints are the conditions it applies on the system in relation to what functional dependency that can be activated at the earliest. A precondition for monitor for example is that there are onset cues to identify, as much as a precondition for monitoring is that a latent condition has been anticipated. Requisite imagination, to be able to imagine unwanted events and monitor for them, is represented in anticipate event and monitor. Monitor is also done on the inner levels of SyRes, as monitoring takes place of effects and damages to the system.

Time is essential in the relation between event-based constraints and functional dependencies. According to drift into failure this model illustrate that if a signal of an unwanted event is first detected at effects, there is less time to respond. In relation to Rasmussen’s (1997) Dynamic System Model, the boundary of unacceptable performance is reached if the signal is detected first at damages – then the system is just a reactive force which can only go into restoration time and recover. Hopefully the system will learn from this, which is visualized adjustment of capabilities.

The most inner part of SyRes constraints the self-monitoring function. Self-monitoring is related to the Matryoshka problem (Lundberg & Johansson, 2006). By being in the innermost part of SyRes, it represents how it affects all functions.
3.4.2. Adjustment of capabilities

*Adjustment of capabilities* is the ability to establish monitoring to detect signals. Monitoring is established either proactive, by successful anticipation of events, or reactively, from *recover*. Adjustments of monitoring are also made from the other functional dependencies. A strengthened monitoring enables the system to set the right system mode or repertoire as to handle the unwanted events the system has detected. As monitoring is a pre-condition to know what mode or repertoire to use, *set mode/reertoire* is a system response. However, like monitoring, *set mode/reertoire* gets adjusted and established both pro- and retroactive. Note also that the organisations requisite interpretation takes place here, as even if *onset cue/effects* are detected, a response is needed.

3.4.3. Strategy

The bottom part of SyRes presents different strategies to maintain and strengthen system safety. If an unwanted event is anticipated, the best strategy would be to immunize itself from danger. *Immunize* and *avoid* differs by its relation to monitoring. To immunize itself from danger, one needs not to monitor for the signal anymore, as it cannot be threatened by it. *Avoid* on the other hand sets high demand on monitoring by monitoring for the signal, and in case it shows, more drastic actions are to be taken. An example for this is a lighted fire, where extinguish the fire would be to immunize oneself from the danger of a fire spreading when asleep. Setting a fire watch, that in case of the fire spreading and control is lost, is to wake everyone up and get to safety – avoiding the damage of the fire. To build on this example, building a fireplace that is deemed safe is a *Control* strategy. From *Control* is a backtracking loop back to latent conditions, showing how changes to a system can give new latent conditions. The controlling strategy changes the context in which the system operates, which can create *side-effects, delayed effects and latent conditions*. Naturally, combinations of these strategies are used continuously to give redundancy, and some may work up to a point, then other strategies take on.

If proactive strategies fail, the system enters *rebuild* and *knowledge*. However, *rebuild* don’t necessarily has to come from unwanted failure, but can also be a strategy of change to strengthen the system. *Knowledge* lastly comes to increase the systems knowledge to better handle *functional dependencies* and is precondition to system learning.

3.5. Applying safety theory on the use of PJB

By reviewing articles and perspectives on how safety should be managed within complex systems, two main views on how safety is reached are identified. The “human element” has historically been seen as the systems’ “bad apples”, error prone, unreliable and overall the biggest source of accidents (Dekker, 2014). On the other hand, viewing the “human element” from the system approach, human
error origin from trouble deeper into the system, interconnected with tools, organisational structure and tasks (Dekker, 2014). In fact, the human variability is a very important safeguard for the system’s safety (Reason, 2000). From these two perspective of safety, an organisation can have strategies of being a stable system and strategies that makes the system resilient (Hollnagel, 2012; Johansson & Lundberg, 2010).

From these two views on safety, it is argued that both strategies are needed to maximize safety (Hollnagel, Leonhardt, Licu, & Shorrock, 2013; Lundberg & Johansson, 2006; Weick, Sutcliffe, & Obstfeld, 1999). Barriers are typical strategies to use to handle possible unwanted events that has been anticipated and make the system stable (Skjerve, 2008), but does not necessarily handle unexpected unwanted events. At the top of handling complex socio-technical systems are the High Reliability Organisations (HRO) (Reason, 2000; Weick, Sutcliffe, & Obstfeld, 1999). Several characteristics of a HRO are defined, (Weick, Sutcliffe, & Obstfeld, 1999), one of which are to accept the possibility of failure, and by so, be aware and take action for that every event cannot be anticipated and prevented.

Viewing the HP-Tool PJB in the light of the two strategies stability and resilience of how to maximize safety, PJB contains both strategies. As a HP-Tool with low performance description, how the tool is used will be adapted to the organisational circumstances in which the workers at the targeted plant work. To show characteristics of a HRO is to act and on weak signals and not to simplify interpretations of them (Coutu, 2003; Reason, 2000; Weick, Sutcliffe, & Obstfeld, 1999). Ultimately observing the origins and interpretation and presentations of signals that leads to a PJB is about that the organisation stays within the margin of safe performance (Rasmussen, 1997) and not drift into failure (Dekker, Why we need new accident models, 2004; Hollnagel, 2012). Signals are presented and interpreted that leads to a PJB at the targeted plant. By studying how this occurs, it can be compared with the two strategies and characteristics of a HRO.
4. Method

The data collection took place during eight work days, including observations of the daily maintenance work and both formal and more informal interviews. Observations gave an understanding of the maintenance work in practice, which also allowed for the spot informal interviews. After an initial four days of observation of both instrumentation maintenance and mechanical maintenance, interviews with in total 19 interviewees were conducted. Due to insufficient data to make good comparisons, it was decided to exclude interviews from the instrumental department. This left remaining interviewees for the data analysis phase. The analysis phase was initiated with transcribing interviews and field notes, from which initial themes was created. The initial themes laid ground for both this studies main themes, and the application of the Systemic Resilience Model.

Alternative methods such as using a questionnaire survey and video recordings was thought of, but chosen not to be used. Using a questionnaire survey gives the natural advantage of reaching a wider audience both within and over several departments. With the initial explorative method of observations, it was thought that a questionnaire survey could not be used initially, but rather as confirmation of results from interviews and observations. Sadly there was insufficient time to perform this, and it was instead decided to perform a bigger analysis with the big amount of data from the interviews and observations.

Due to the restrictions by security rules at the targeted plant, field notes had to be an important part in the data collection process in this study. The use of video recordings for example is a great data type for more detailed analysis (Heath, Hindmarsh, & Luff, 2010), but not possible to use in this study. By dedicating more time observing, similar results can be reached, especially when the purpose of observing is mainly to gain insight of work, rather than a detailed analysis of a defined process (Heath, Hindmarsh, & Luff, 2010). Doing observations served as a source of data, gave insight into the daily work and served as a tool to form the interview questions.

4.1. Data

The data in this study was collected during the early summer of 2015 at a Swedish nuclear plant. The collected data consisted of field notes from observations, informal, unstructured interviews and recorded interviews that has been transcribed. The data collection took place over eight full days at the targeted nuclear plant. The complete data process is circular visualised in Figure 6.

Baecker (2014) presses on the issue to introduce the observer and the study to the people being under the scope of the study and spend time with them. It gains social approval from the workers; the ob-
server gains experience of the working environment and its workflow, and lastly to gain insight in the best possible way to collect further data (Baecker, 2014). Interviews were chosen, and the observations also helped to form the interview questions. The intention of the study was known for all people that were being studied. This was done by an initial meeting with group managers from mechanical maintenance and instrumentation maintenance. This was followed by a morning meeting with each department, where the personnel from the respective department attended. It was explained during these two morning meetings for the attending that the purpose was to get a feeling for work as being done and especially regarding PJB and job walkthroughs.

Figure 6. Data process used in this study.

How much the people that are being observed know about the purpose of the observation have their pros and cons (Mulhall, 2003). Not knowing might make the observation more unaffected by the
knowledge of what is of interest, but it has to be valued against people’s right to know why they are being observed (Clark, 1996). For this study the purpose of the study was explained, hoping they feel the importance of the purpose of why the observation was conducted. By so social trust would come, which in turn would give access to data of how work is really conducted.

4.1.1. Observations
Observations were conducted the first four days. The last four days of observation was more sporadic; observations were done in between interviews that took place or since earlier planned times of observations. Divided between the two groups’ instrumentation maintenance and mechanical maintenance, about one day was spent with instrumentation maintenance and three with mechanical maintenance.

Types of observation
During the two introducing morning meetings several jobs was identified and decided on to be observed. For mechanical maintenance three PJBs was observed. In between these jobs and meetings, time was also spent in office. By so, observations done can be categorized in three different types:

- Observing a PJB or another type of meeting
- Spending time in office
- During jobs being performed

The three served different purposes and different observation roles was taken. By using Golds (1958) different categorizations of observer roles, varying forms of the role participant as observer was taken. Golds (1958) categorization of roles are in large focused on the relation between observer and workers. The roles between the three observation types are rather of the level of involvement with workers, irrelevant of the relation with the individuals taking part of the observation.

Observing a PJB or another meeting
To gain insight in how PJBs are performed, attending as many PJB as possible was considered important. Attending PJB and other meetings was also seen as opportunities to get in touch with people that are involved in PJB, but not reachable by spending time in the office, as they have their offices elsewhere. Of the three types of observation, this one consisted of the least interaction with the workers, speaking only when spoken to and taking a physical location that differs from the others attending the meeting.

Spending time in office
Observation in office was an active interaction with people, often taking place between observed jobs, during breaks and before and after meetings. The purpose of this observation type was to coordi-
nate other observations, plan interviews and ask informal questions relating to the study. As Baecker (2014) stresses the importance of social approval from the workers, this observation type was important. The office environment also assumed to be important for the origin and interpretation of signals.

Of the three types, this was the most participating, active one. Engaging conversation, asking questions and observing in close vicinity to the workers.

**During jobs being performed.**

Work being performed in the nuclear facility was done to get a feel of the work being done on the facility itself and get in touch with the workers who spends most of their time there. Studying origins of PJB, gaining an understanding of work in the nuclear facility thought to be important. The role for this observation type was mainly observation, but also conversation and interacting with the workers, asking questions when there was time for it.

**Field notes**

Extended field notes were being done during observations as main data collection method. There is no natural best practice for when and where to write field notes (Mulhall, 2003). Write too much and the observer might lose scope and important bits of what is being observed; writing too little might leave the field notes insufficient to be of any real use (Mulhall, 2003). A popular way to take field notes that was also used in this study is to complement quickly made notes with additional thoughts, reflections and detail when there is an opportunity to do so, during breaks or directly after an observation (Mulhall, 2003). To take a step back and reflect after observation is also mentioned by Gold (1958) as a way to gain distance and time to reflect over the observation, but still remembering details.

Field notes was done from a series of pre-defined questions made beforehand related to the research questions, along edited version of a schema by Mulhall (2003). The pre-defined questions were:

- What kinds of signals are reacted upon?
- By who and how is a signal caught up and reacted upon?
- How is the signal taken to the next step towards a PJB?
- How is the signal interpreted and presented by those involved?
- What factors influence the interpretation of the signal?

The edited schema (Mulhall, 2003) to gain an understanding of what was being observed was:

- Structural and organisational features
- Relations between roles/hierarchies
  - Lines of communication
- People and roles
- Process of observed activity
- Special events related to safety
- Relevant dialogue
- Reflection of self

The pre-defined questions worked as guiding of what to look for during observations, and the schema worked as a way to structure the pre-defined questions and put it into context. The questions and schema was kept at the first page of the field notebook, often viewed as a reminder on what to look for. The field notes were written down on paper during observation, to at the end of the day be written down digitally.

4.1.2. Interviews
Interviews used for the analysis phase was conducted with personnel from mechanical maintenance and one interview with two interviewees from another group. A total of 14 interviewees from mechanical maintenance participated. The same interview questions were used for all participants in a semi structured form (Valentine, French, & Clifford, 2010). This means that the interviewer has a set of pre-defined questions for the interviewee to answer, but the interviewer is encouraged to follow up on interesting things said during the interview and ask side questions (Creswell, 2012; Valentine, French, & Clifford, 2010). The interview form used consisted of eight questions and was asked in a sequential order. However, if the interviewee started to talk about a question that was not in the sequential order, he or she was not stopped, but rather encouraged to keep going. Alternative being to come back to the subject later. Follow-up questions on interesting subjects that came up was also used during interviews.

All questions were asked in Swedish (see Appendix I), and presented below are translated versions.

1. What is your role at the plant and what is your formal title?
2. How long have you been working in the nuclear industry, especially related to experience of use for your current role?
3. Related to PJB, how are you specifically involved in the PJB you perform here at your department, both before, during and after the PJB?
4. What do you think is the origin or cause that a PJB is performed at your department?
5. What are the foremost sources of information for you to be able to do what you do related to PJB at your department?
6. Which critical steps do you think are to be passed for a PJB to successfully be performed?
7. Do you think that the selection of PJB at your department is optimal or well balanced?
8. By being asked and answering the previous questions, is there anything you would like to add to anything? Also if you found it surprising I did not ask you of something, now once you heard the questions I wanted to ask?

All questions were asked the same way with a few variations, but some questions had to be explained additionally or examples given for the question to be understood. It also occurred that follow up questions were asked in situ, in relation to the topic. Quite often some open discussions related to the subject came up after all the questions was answered, which also proved to be relevant for the study.

4.2. Data analysis

The data analysis consisted mainly of transcriptions of interview and field notes, followed by the application of the Systemic Resilience Model and a thematic analysis of said data. Due to an insufficient amount of data, it was decided to not include the data from the instrumental department.

Data comes in many forms and types. A common separation is by qualitative and quantitative methods, even if it is arguably better to distinguish the two in terms data of written words and numbers, or as qualitative and quantitate data (Åsberg, 2001). Thematic analysis is a widely used, but poorly demarcated way of analyse sets of qualitative data (Boyatzis, 1998; Roulston, 2001). Using an analytical guideline for the analysis was therefore deemed important. This study has followed the guidelines set by Braun and Clarke (2006) on how to perform a thematic analysis.

Braun and Clarke (2006) presents several questions and a six step guideline on how to perform a thematic analysis. According to Braun and Clarke (2006) each study must first, and throughout the study, ask itself a few central questions regarding the nature of the study and therefore the thematic analysis. Below are each of questions asked and this study’s stance:

- First question is to answer what counts as a theme, where Braun and Clarke (2006) highlights that a theme captures something important in relation to the research question, and how big the pattern must be in relation to for example number of interviewees. For this study, it was the “keyness” of the themes as Braun and Clarke (2006) puts it that mattered. For example, data keyness means that it is enough that one interviewee mentions something for it to be included in the study, rather than how big the pattern was across the total data set.

- Secondly, the analyser needs to decide of the description should represent the whole data set or just particular aspects. In the explorative approach used, the analysis in this study
was done towards particular aspects. This means that some data can be left out due to not being of interest to the study.

- Thirdly, the analyser needs to decide whether to do an inductive or a theoretical thematic analysis (Braun & Clarke, 2006). In short, this means whether to let the research questions be guided by the data, or if the analysis is driven by the research questions. The questions asked to the interviewees were all asked in relation to the research question, and so the data was theoretical thematic analysed.

- Fourth question is regarding whether to do semantic or latent themes (Braun & Clarke, 2006). Difference is that semantic themes aims at identifying underlying ideas, assumptions and conceptualisations; latent themes does not look beyond what is being said, but rather doing a description by organisation data. The purpose of this study was to bring together a collected view of several roles regarding PJB. By so, latent themes were created.

- Lastly, the researcher should decide the epistemological stance for the analysis (Braun & Clarke, 2006). Whether that meaning and motivation reside within individuals, or in the socio-cultural contexts and organisational structure individuals are a part of, named the constructionist thematic analysis. The constructionist thematic analysis was chosen for this study, to enable to highlight the organisational conditions the workers at the nuclear power plant acts within.

Braun and Clarke (2006) suggests a six steps guide on how to thematically analyse data. The six steps are to:
1. familiarise yourself with your data, which includes transcription of verbal data
2. generate initial codes
3. search for themes
4. review themes
5. define and name themes
6. produce the report

In the end seven different roles within the maintenance personnel was identified and interviewed in this study. To ease differentiating between them an iteration of the six step guideline by Braun and Clarke (2006) was used. All interviews were first transcribed and then each interviewee was group by their role, which was possible from question one in the interview form. Relevant notes and citations from the field notes were added at the end of question 8. Each individual question for each role was brought together and separately coded and searched for themes regarding the research questions, not the interview question itself. At this point step 3 was done according to Braun and Clarkes (2006) guidelines, as each roles’ questions was themed. Once this was done, all initial themes for each question per
role was brought together, reviewed by step 4 from the guidelines by Braun and Clarke (2006), and the final themes for each role was made, step 5. Step 6, to produce the report, was from this iteration the result section in the report.

Following the first iteration of the guideline from Braun and Clarke (2006) guidelines followed two smaller iterations from the forth step from the first iteration. These two iterations produced the analysis section and the SyRes analysis section. For the analysis section all seven roles’ themes were brought together and reviewed as of step 4. This resulted in that new final themes were created by step 5 from the guidelines by Braun and Clarke (2006). This iteration of step 5 and the natural following step 6, produce the report, resulted in the

---

*Figure 7. The performed analysis visualized.*
analysis part of this report. The analysis with SyRes used the same source, the step 4 from the first iteration. Themes from each role was brought together, viewed with SyRes in mind and grouped together into larger themes. These larger themes were created and mapped into SyRes. This analysis resulted in the SyRes section.

4.2.1. Data presentation as a type of personas
A persona is the archetype presented in a storytelling form to convey attitudes, goals and behaviour with the purpose of bringing data together from several sources in a meaningful way (Goodwin, 2009). The maintenance engineer as a role, reflects the tasks formally associated with that role. The maintenance engineer as a persona is the archetype of the skills, attitudes, mental models and goals within the role from collected data (Goodwin, 2009).

Personas are useful for a wide range of activities for most things that can be used and experienced by a human, even if they are typically used in design processes to pin point the archetype users of the product or service (Goodwin, 2009). Using this format as data presentation deemed useful as to show possible differentiations between formal roles within the department regarding attitudes, goals and behaviour. Naturally, using personas comes with the benefit of anonymity for the interviewees. What was partly neglected from how personas are usually done is the use of excerpts from the transcribed interviews. Personas usually being in a third person storytelling, felt it would have a lacking connection to the data. A wider use of excerpts thought to give the reader more control of the interpretation of the data.

Excluding the instrumental department, several days of observation and data in form of field notes and recordings from 15 interviewees was collected. Transcribed and thematically analysed together with the Systemic Resilience Model.
5. Results

A description of involved roles that has been in contact with during the data collection phase is presented by the use of personas, as described in section 4.2.1. These personas highlight years of experience, their work regarded PJB but also each roles’ view and attitudes towards PJB.

To understand how signals are detected and interpreted it is important to understand how the observed departments plan their maintenance work from the perspective of evaluating jobs regarding PJBs. From the data collected by interviews and observations, the perceived view of how this is done is presented.

The citations that are used throughout this chapter are actual citations from either transcribed interviews or written down field notes.

Excerpts are in marked by role and specific file, followed by the citation at a specific turn. The frame looks like this: TR:ID TurnNR "citation". Abbreviations used for each role are as follows:

- RM (Outtake leader)
- HOMM (Head of Mechanical maintenance unit)
- GM (Group manager)
- P (Planning Engineer)
- E (Maintenance Engineer)
- T (Technician)
- F (Fitter)

Each questions’ abbreviation is a shorter name for each question asked during interviews, for the complete questions see subchapter 4.1.2. Lastly is also observation notes in regards to the specific role or complementary notes written during interviews.

- R (Role)
- T (Time)
- I (Involvement)
- OR (Origin)
- IS (Information sources)
- CS (Critical Steps)
- OP (Optimal)
- AE (Anything else)
- OB (Observation)

An example would for example be: TR:GM CS-A5 “We shall send in the jobs 14 days before executing them. During that time, we have control and time to perform a PJB”. This means the excerpt is a transcript (TR) from the GM (Group manager), during the question Critical Steps (CS) and cell A5 in the Excel file.
5.1. Description of roles
The following subchapter presents the people interviewed and observed that was involved in work regarded to PJB as personas. The outtake leaders and head of mechanical maintenance spans over all for blocks, while the remaining roles works on block 3 and 4, as one department. Each subchapter contains a table with all mentioned origins of PJB.

5.1.1. Outtake leader
Dennis has been an outtake leader for the past two years, a job he performed with a second outtake leader. This means planning when things are to be executed during outtake and creating the outage plan by receiving and planning all jobs. Schedule during outtake is often slim, and many parallel jobs are being performed in a tight time span. He also leads the executing of the outtake. Prior to this, Dennis has been working at the nuclear plant at maintenance and operations for ten years.

Dennis has an overview viewpoint of the collaborative planning during outtake. His overview gives him a perspective that allows him to see connections between various activities, as he puts it: TR:RL I-A3 "If there are several different groups inside working at the same time then we can sit down and talk about this and maybe do a PJB". With over 2500 jobs passing through during outtake, Dennis adds: TR:RL AE-A2 "There are so many jobs that there is not enough time to go through all and assess them".

Dennis describes an example where TR:RL OB-A1 "A heavy lift of a turbine was to be performed inside the control room. Under this lift parallel maintenance work took place that controlled the cooling of the reactor. If the lift failed, both system and occupational safety were at great risk. By noticing this relation, the two work forces had not, Dennis demanded a PJB between the two groups."

Mentioned origins of PJB by the outtake leader are:

- Several groups sharing same physical space during work
- Radiation
- Viewpoint of collaborate planning

5.1.2. Head of mechanical maintenance unit
As head of all mechanic maintenance units Alex started out in the nuclear power plant 30 years ago, and has been head of mechanic maintenance for the last five years. Alex’s main responsibility is to lead the work being done at mechanical maintenance, the economy and personnel related tasks. As of work related to PJB, Alex says: TR:HOMM I-A5 "Be present as a way of steering the department, follow ups and encourage to that work regarding PJB is done and that it is important". Regarding the main source of information regarding PJBs Alex says TR:HOMM I-D1 "...is to ask the group managers for each block"
One of the things Alex does is work with the cyclic plan for outtakes and other maintenance work. The cyclic plan means that each outtake has a working cycle, which among other things includes how the departments should be using PJB. Alex adds the following regarding what mechanical maintenance do: TR:HOMM I-A4 "We go through a number of activities from the nuclear power plants shared activities before outtake. One of our own in this cycle is to review each job if a PJB is needed".

Alex thinks it is important is to have a good foresight and give personnel opportunities and time to review jobs. Regarding how to achieve this so they reviewing of jobs is done well, Alex says: TR:HOMM O-A5 "Positive management, encourage people and give space to work in a good way is the best way" and to TR:HOMM AE-B2 “Not control too much but rather use the brain and think”. This is also done by seeing so that economy and other factors not related to the need affects the decision making of when and which job walkthroughs to use.

Alex acknowledges that there is a balance between the different job walkthroughs and which one to use for each job. He reasons as follows regarding the screenings of jobs and job walkthroughs: TR:HOMM O-A3 “We look at our jobs, by so I feel confident our needs are covered… to not control too much and use our brain and think”. Alex is of the opinion that if every department does this, needs regarding job walkthroughs would be settled.

Mentioned origins of PJB by the Head of mechanical maintenance are:

- Make use of prior experience
- Perform the job safety
- Everyone gets to speak together
- Involved personnel is adequately prepared

5.1.3. Group manager

Daniel has been working in the targeted plant since about 15 years, this being his third job, which he had for the last five years. As group manager Daniel’s main role is to make sure the maintenance department tasks are being handled. Regarding PJB the role is not much as a main actor but rather having a supporting role and being a driving force. For example says Daniel: TR:GM I-A3 "Me and the other group manager ask control question such as have u considered using a PJB and so on. As a barrier if that role is not already taken... It can happen in every step prior to a job." For the PJB itself Daniel explains it like this: TR:GM I-A1 "Not usually a main actor, instead that is someone else within the department. I can be present if summoned or as a supporting role".

Daniel comments the process of making a PJB happen like this: TR:GM I-A3 "I see it as a short process", rather highlighting that the important part is making the decision. Databases and meetings works as a source for Daniel to gain an oversight view of the work being
done, but he does not see these information sources as a support of whether a PJB should be used or not, but rather that experience is.

Daniel expresses his role like a balance between encouraging without getting too involved in factual issues, TR:GM I-A4 "More just listening, I don’t interfere in the subject itself". Also important is to build a systematic structure to support the department’s ability to review jobs, giving opportunity to discuss each job between roles. Daniel points out the value to discuss jobs between roles within the mechanic department, but also as a department among others. Daniel says: TR:GM I-A35 "Priority is set by operations in how important a potential error is, then we assess the job from a maintenance perspective".

Daniel often gets in touch with monitoring organisations and personnel from other nuclear power plants working with the HU-Tools. Daniel says: TR:GM OP-A17 "When people from monitoring organisations visits the plant and ask how many PJB we do, they are often surprised by how few that are made". The less formal job walkthroughs are often highlighted then as the tools being used instead of the PJB. Daniel stresses that the more informal job walkthroughs are also powerful tools and in ways equals with PJB. PJB is a great, more formal tool, when different professions and departments are involved. For remedial maintenance Daniel comments: TR:GM I-A36 "very rarely is there an acute case on the daily things, so it is a lot of focus once it is. Then it can be a good thing to gather everyone and go through it some extra".

Compared to previously when a certain number of PJBs had to be done, Daniel thinks a balance in the amount of performed PJBs has been reached. TR:GM OP-A17 "We have an open climate at the department and PJBs are appreciated once we have them, as they are relevant for the job".

Mentioned origins of PJB by the group manager:

- Extra important from a technical perspective
- Extra important from a system safety perspective
- Extra important from an occupational safety perspective
- Getting a flow in work
- Talk about risks
- Get everyone on track
- Big job that involved several professions and departments
- Ensure common understanding
- Not to rush work
- Time pressure during the job

5.1.4. Planning engineer

Jacob has been a planning engineer (henceforth called planner) for the last seven years at the targeted department, but also as a planner at other departments and as a technician for 12 years. Planners are either focused on outtake or preventive and remedial maintenance.
Jacob is currently working with outtake planning. However, the two roles usually blur a bit during outtake. Except from planning the jobs and handle side activities related to jobs, a planner often helps others out and handles practical things that comes up. Communication is key both within the department and outside, as Jacob says: TR:P I-A20 "I've a very good communication with operations", who says operations is a common source of jobs and PJBs.

For outtake, Jacob sets up a working package for each job given to him, with all relevant paper work and information to carry out the job. All job packages are then put into a binder. The planner then has a binder walkthrough with the performing technician for each job, as a type of open discussion. Jacob says the following regarding the binder walkthrough: TR:P I-A10 "We have divided it up between us planners and the engineers, who focuses on the technical aspects, while we focus on planning and side activities".

The need of a PJB can be discussed and decided at all times, usually surrounding the side activities to the job. Many jobs come from operations, and Jacob feels that discussing each job gives a maintenance perspective on the job, as opposed to an operation perspective. Jacobs continues: TR:P OR - A16 "We work a bit different, operations thinks in their way and we in ours. So we had some problems that we assume we think the same but we don’t. Now we sit down and get a common view of the job to be performed". Screenings from both different department perspectives, but also different perspective of roles within mechanical maintenance assures a common view. Foresight, several screenings and communication are pointed out by Jacob is central for PJBs to be thoroughly evaluated. During outtake kick-off, Jacob and the other maintenance planners takes part, planning the outtake jobs.

There is a lot of information, such as planning and orders to be made in relation to the work itself, old debriefings, job history and more that Jacob and other planning engineers look up to properly plan the jobs. However, Jacob says the following regarding the everyday assessing of jobs and information sources: TR:P IS-A17-19 "We discuss during the morning meetings or in our forums that here at this time should or would have a PJB… We communicate a lot with each other!

Jacob says that PJB must have some dignity and that it is often enough with just a less formal job walkthrough. Even though, as Jacob says it: TR:P IS-A17 "In reality are there no easy jobs, as every job can become complicated", but job walkthroughs can also handle that. TR:P IS-A17 "The PJB should be correlated to dignity. That maybe a usual job walkthrough is enough for smaller jobs". Attending people should feel the importance of the PJB once they are summoned.

Mentioned origins of PJB by the head of planning engineer:

- All heavy lifts
Many involved
Inopportune times
Work done at night
Coordination
Common understanding of tasks
Common understanding between groups
Operations demands one
Different groups at different times
Different groups, all at the same time
See so that everything is in place for the job (preparation PJB)
Coordination and production of equipment
Highlight critical steps
Different technician groups
A lot of people at the same space

5.1.5. Maintenance engineer

Hanna has been in the nuclear power plant domain for 20 years, doing the first ten in the control room at the targeted plant, before she changed to being a maintenance engineer (henceforth just engineer) at the mechanical department. Some engineers are specialised in valves, while others, one of them Hanna, works mainly with pumps. There is ongoing work with remedial maintenance, but also planning and executing jobs during both outtake and preventive maintenance.

Hanna puts it like this regarding her work: TR:E R-A16 "I don’t know for sure what is going to happen when I go to work. Anything can pop up". Hanna has a couple of technicians that she works close with; she explains it like TR:E R-A11 “…it is like a service profession for our technicians”.

Tasks prior to the PJB after deciding if a PJB is needed is not that complex. Hanna explains: TR:E OP-A23 "It is not the time aspect that is important, but rather the grade of how important the PJB for the work is"

Summon the involved people and have them attend, which usually is done by email. However, if it is an urgent remedial PJB, Hanna says: TR:E OP-A23 "People understand… the more urgent the PJB is summoned the more pressing is the matter". Regarding her role during PJBs she says: TR:E I-A2 "I am the one holding the PJBs, summons the correct people and performs it together with the attending”.

Hanna is also involved in the assessment of whether or not to have a PJB for the jobs to be performed. Some jobs are known a very long time in advance and PJBs or other job walkthroughs can be decided at any time, as Hanna explains it: TR:E IS-A23 "It can be long before the job is performed, the first time you get to know it is going to be performed. Can be the week before, months or over half a year. With as good foresight as possible"
There are meetings during this time where each job is discussed. TR:E IS-A37 "During outtake kick-off is the whole department gathered and their do we formally go through which jobs that we are going to have a PJB on". A so-called binder walkthrough is also done before the kick-off meeting for outtake. Hanna is involved in both screenings, discussing all jobs individually with her technicians who are the jobs’ performer. Hanna says the following regarding the physical placement of the involved: TR:E IS-A30 "Can talk to someone quickly when getting a coffee or in the corridor. We also have a morning meeting at nine, then you can talk to them afterwards, to not disturb a meeting with 30 people".

Remedial maintenance often comes from operations, where Hanna can review the job from a maintenance perspective and have a discussion with them. Hanna puts it like this regarding who summons a PJB: TR:E OP-C9 "When we summon people for a PJB it is because it is needed… It is because someone realises it is needed we have it. There is a need for it if one is summoned".

Experience and knowledge is important to screen jobs of whether a PJB is needed or not. Databases, work instructions, flowcharts and other aids does not play a big part in the phase of deciding if a PJB is needed, but rather for bringing information to the PJB or detailed planning of the job itself. Hanna says the following regarding different aids: TR:E IS-A22 "…it is not enough, you must also consider the other things, risk evaluation and such".

Hanna finds it great that the choice of having a PJB is not based on influence of management, and instead based on the need of personnel using it. She says: TR:E OP-A14 "A rut, because it comes from above. It needs to be adapted to the need. Can’t force a need, then there is a conflict… Got to choose the important jobs". Hanna further explains: TR:E OP-A6 "Now it is no one who controls and tells us to have a PJB just because, it is the need which guides the amount of PJBs", and: TR:E OP-A33 "Some time ago we decided on a lot of PJBs and in the end did we only have time for half of them. Pointless. It looks good in the statistics but what does that do in reality". Better is to use other job walkthroughs when there is no need for a PJB.

Mentioned origins of PJB by the maintenance engineer:

- Other groups involved
- Difficult work
- Working environment
- Get everyone on the same page.
- Clear misunderstandings
- Difficulty in executing. Non-routine work
- Many involved and different working tasks
- Everyone to know what, when and how
- Jobs rarely done
- Complicated
• High risk for occupational safety
• System safety
• New personnel for the task
• Get the job done in time
• As Low As Reasonable Achievable
• Different conditions from last time
• Get everyone on track
• High risk of production loss by outage
• It is not enough to discuss it internally

5.1.6. Technician
Since eight years Anton has been working at the targeted plant as a maintenance technician (henceforth technician). Anton works mainly with valves, but not strictly. It is varying work with different tasks that might come up on short notice.

Usually being the performer, Anton is one of the responsible technicians do execute the job while the maintenance engineer leads the PJB. However, it does occur during outtake that he is the one leading the PJB. There is a close relation between the engineers and the technicians, as Anton puts it regarding when he needs help or to discuss something: TR:T IS-A10 "I go to my engineer in almost all the cases" and TR:T I-A11 "It's a conversation with the engineer. If she says we should have one because of something, then we have it. Then we also discuss every job, then might we or I want one, in which case she is of course fine with that".

For Anton, the binder walkthrough and the kick-off are opportunities to discuss the same jobs several times, but with different people. Anton said the following regarding to when discussing jobs with the engineer: TR:T IS-A8 "…the best source of information is all the people around here".

For the PJB itself, Anton feels the use of PJB has reach a good balance, something that was lacking a couple of years ago: TR:T OP-6 "You had a list with PJBs. It was a lot of papers and questions to cross off and you asked yourself oh god why am I doing this". The PJB now is more formal, good for bringing different groups together for more complex jobs. Coordination and a common understanding regarding the job through the PJB lowers the risks of occupational and component accidents. As Anton puts it: TR:T I-A6 “The PJB is more complex. When departments crosses each other’s path”.

For internal jobs, Anton thinks more informal job walkthroughs suits the situation better. A PJB should only be summoned when needed, when it suits the job better than a more informal walkthrough. It has also helped that there is now a simplified version of the PJB, allowing the personnel to choose which one fits best: TR:T OP-A11 "Then we don’t need the questions of radiation, fire hazards and so on, we already know that all these things are not an issue".
Also, the right people need to be summoned. When the wrong people attend or a PJB is held when all participants don’t feel the need of one, the quality of the PJB drops. Anton brings up an example (TR:T CS-A3) where one department sent their engineer to the PJB, rather than the performers of the job. This gives the performers no chance to bring up their own questions, all information is second hand, and the people actually performing the job haven’t been introduced to each other.

Mentioned origins of PJB by the technicians:

- Departments need coordination
- Heavy lifts
- Same information at one point to everyone involved
- Component safety
- Occupational safety
- Something is different, somehow
- Non-routine jobs
- Short time frame
- As Low As Reasonably Achievable principle

5.1.7. Fitter

Patrick has been working at the targeted nuclear power plant as a fitter for the last eight years. He describes it as varying work where you might get to know the day before or same day what job is to be performed. The day starts with a morning meeting, which is followed by the day’s task. During these morning meetings or just in conversation with his technician, Patrick can add something regarding having a PJB for a certain job or not: TR:F I-A4 "If you have anything relevant to add then you can say that during the morning meetings or so" The need for that however has not been felt, but not that there are too few or too many PJBs. Regarding PJBs Patrick says: TR:F I-A4 "the PJBs has become more and more chosen with care the last few years", but also points out that other job walkthroughs does a god job as well. The function of PJB feels vague sometimes, and that the uses of PJB differ between power plants.

Regarding PJB, Patrick describes it as he is there to listen and add something if he thinks it is relevant for the PJB. Patrick thinks: TR:F I-A4 "We don't participate in the preparations of PJB, we are fitters, we work". Naturally, there is a lot of communication with the technician that is the performer. It is with the performer that job walkthroughs are done and experience is brought back for future jobs.

Mentioned origins of PJB by the fitters:
• All big jobs
• Improving work flow
• cooperation
• Simplifying work
• occupational safety

5.2. Descriptions of maintenance types

Three main types of maintenance have been identified during the data collection phase, namely preventive, remedial and outtake maintenance. Preventive and outtake maintenance are by and large handled the same way as they are having a preventive role, but differs in time and by outages. Remedial maintenance, sometimes also called acute maintenance, is a reactive form of maintenance.

5.2.1. Preventive maintenance

At the start of the year all preventive maintenance work are given to the mechanical maintenance department, mainly by operations: TR:P AE-B9 "All history is available for each job exist. For preventive maintenance we receive all information automatically". Information of all jobs are given to the preventive planning engineer and put together to a work package: TR:GM I-A21 "The planner does that together with the engineer in the normal work flow". As help and approval of the job package is the responsible maintenance engineer. The engineer discusses jobs with the technician that is the performer of the job: TR:P AE-B7 "Everyone has their specific knowledge so you got to talk". A PJB might have been planned for some jobs by operations, but this phase serves as a screening process from a maintenance perspective. That there might be a long time to when the job is to be executed is not a factor, as Jacob, the engineer puts it regarding when to decide on having a PJB: TR:E IS-A28 "As soon as you know that a complicated job is coming up, no matter the timespan".

Closing in on when the planned preventive maintenance is to be performed, all preventive maintenance job goes through the monthly, 14 days plan which planners have with other departments and morning meeting, where the jobs are reviewed. If for example the performer is sick, the situation might change so much a PJB is decided to be performed.

5.2.2. Outtake maintenance

It is the outtake planner engineer that sets up a working package for every job that is to be executed during outtake. The engineer plays a part in this as support and as approval of that the job packages are in order. This is followed by two binder walkthroughs, between the performing technician and the planning engineer, and between the technician and the engineer. There is different focus for each binder walkthrough, as explained by the planner: TR:P I-A10 "We have divided it up between us planners and the engineers, who focuses on the technical aspects, while we focus on planning and side activities".
After the binder walkthroughs the mechanical maintenance unit has a whole day kick-off with the purpose of identifying jobs that are extra important and or hard to perform. During the kick-off technicians together go through each of their job together with their maintenance engineer in small groups: TR:GM I-A21 "Everyone gets to sit with their technic groups and identify which jobs that are extra important from system and occupational safety view". Planners are also there: TR:GM I-A20 "The planners sits on the side and have an overarching control and are involved in the whole planning phase". During binder walkthroughs, kick-off or in informal conversations, the need for a PJB and decided on at any time in this process. The kick-off is though often an event where the PJB is formally brought into the system.

When outtake starts, a monthly and a 14-day detailed schedule plan are set, where the jobs that are soon to be done goes through a revival and planning: TR:GM CS-A5 "We shall send in the jobs 14 days before executing them. During that time we have control and time to perform a PJB". Every day starts with a morning meeting, where today’s schedule is reviewed. These meetings and detailed planning works as screenings the jobs of if a PJB is needed and if anything changed since the binder walkthroughs’ and the kick-off.

During the planning phase each job is sent to the outtake leaders during outtake. As outtake leaders they have a screening ability over the collaborate planning of all outtake jobs and if jobs can affect each other by their physical location.

5.2.3. Remedial maintenance
During morning meetings all received errors from operations are gone through and screened of their severity from a maintenance perspective. The group manager Daniel describes the process: TR:GM I-A34 “Prioritizing is set by operations in how important a potential error is, then we revise the error from a maintenance perspective”.

The jobs are then planned in the monthly and 14-day plan, which gives time to properly plan and react. Daniel explains: TR:GM CS-A5 “We shall send in the jobs 14 days before executing them. During that time we have control and time to perform a PJB”. Rarely happens anything that it is very urgent in remedial maintenance, but when it does, Daniel, group manager, comment it like this: TR:GM I-A36 “… very rarely is there an acute case on the daily things, so it is a lot of focus once it is. Then it can be a good thing to gather everyone and go through it some extra”, explaining how he sees the PJB at those times as a force to slow down a process, giving time for thought.

5.2.4. A collected view of evaluation of jobs
During normal operation PJBs are seldom used due to being less complex jobs, as the power plant is running. However, jobs are also reviewed regarding if a PJB is needed when preventive maintenance
is planned. Figure 8 shows the formal screening opportunities for each maintenance type.

Figure 8. Timeline of formal screening opportunities for each maintenance type

All screenings up until the outtake leaders planning are made months ahead of the actual work. A differentiation can be made between these and the monthly and 13 days’ plan and the morning meeting by how close they are to when the job is to be performed.
6. Thematic analysis
The analysis has its origin from the thematic analysis done where all themes of all roles was brought together. Four major themes were created from this process, which is presented below.

6.1. Similar origins of PJB between roles
There is in general a common understanding between roles of the origins of signals that result in a PJB, even if there are differences between professions. Bringing all mentioned signals for PJB, four categorisations can be made. At least one of the below categorised signals are mentioned is enough for a PJB to be decided upon:

- When there are several involved professions and departments, to ensure a common understanding of the job.
- When time is of the essence in some way.
  - Work flow is desired due to time constraints or sequential steps that needs to be completed to continue.
  - Inopportune times, such as night time.
  - During remedial maintenance, as a force to not rush work.
  - The job performed with radiation risks, and therefore a low as reasonably achievable exposure to radiation is sought.
- A job that is harder than normally to perform/non-routine job.
  - The environment where the job is being performed is harder, such as different jobs active on the same physical space, radiation levels, heat, or other factors.
  - Preparation of equipment and Pre-job coordination is harder than normally.
  - Jobs that are rarely done, difficult or different from last time which makes the job harder to perform.
- There is an identified higher risk of occupational, component or system safety than normally.

Especially that jobs are done between several groups and that the job is for some reason non-routine or more complex than normally are repeatable mentioned between roles as signals indicating the need for a PJB. Non-job related factors influencing the choice of having a PJB or not was not mentioned. When asked, it was mentioned that after PJB stopped having a quota, no non-job related factors influenced the choice. Some differences between roles can be noticed, for example the engineer, who mentions preparation of equipment and Pre-job coordination as a reason to have a PJB.

In large, this categorisation is in line with Skjerve and Axelssons (2014) list of when the PJB is seen as useful, see the comparison in table 1 below.
Table 1. Comparing origin of PJB and when PJB is seen as useful by Skjerve and Axelsson (2014)

<table>
<thead>
<tr>
<th>Categorisation of mentioned origins for a PJB</th>
<th>Skjerve and Axelssons (2014) list of when the PJB is seen as useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>When there are several involved professions and departments, to ensure a common understanding of the job.</td>
<td>Requires people from different departments/professional groups to work together and/or to carry out individual but interdependent tasks</td>
</tr>
<tr>
<td>There is an identified higher risk of occupational, component or system safety than normally.</td>
<td>Involves one or more components of critical importance for plant operation</td>
</tr>
<tr>
<td>A job that is harder than normally to perform/non-routine job.</td>
<td>A non-routine task / Is complex / Is new to some of the participants</td>
</tr>
<tr>
<td>When time is of the essence in some way.</td>
<td></td>
</tr>
</tbody>
</table>

Differences can partly be seen in the aspect of time, even if it could fall under the category of “is complex” from Skjerve and Axelssons (2014) list. Comparing the maintenance types, outtake has the most preparations, and also contains most of the complex work in a tight time schedule. A common understanding and good planning is preferable to get a flow in work, stay on schedule and avoid avoidable hold ups.

6.2. Several screenings over time

Prior to every job is a process in which the work gets screened several times by different roles regarding the job’s safety. At any of these screenings, the need of a PJB might be felt and decided upon. Analysis of data collection stresses that these screenings over time and by different roles are important to match the right job walkthrough with each job. Having foresight for each job gives more time for reflection and discussion of the job months ahead of time, and screenings close to when the job is to be performed gives time to react to sudden changes.

The next page shows each formal screening that takes place for each maintenance type and which roles are active for each screening.
**Formal screenings**

**Morning meeting**
Assessing every job through remedial maintenance and all coming jobs. Attending are fitters, technicians, engineers planners and group managers.

**Confirmation of work package**
Maintenance engineer confirms work package.

**Monthly and 14 day meeting**
Detailed planning and assessing coming jobs. Attending are technicians, engineers planners and group managers.

**Revision leader planning**
Revision leaders plans all revision jobs, assess from an overview viewpoint of the physical location of jobs being parallel performed.

**Binder walk-through**
Technician assess each job that he/she is the performer of. First together with the planner, focusing on side activities, then with the engineer, from a technical perspective.

**Kick-off**
Each engineer goes through all work together with the technicians she is working with. Group managers having an overview role. Planners sits together by the side of the technician and engineer.

**Involved roles**
- Fitter
- Engineer
- Group manager
- Technician
- Planner
- Revision leader

**Initiated**
- Preventive maintenance
- Revision maintenance
- Remedial maintenance

**Performed**
Each role takes part in at least one screening process, except for the head of maintenance, whose work tasks differs from the others.

Everyone but the fitters, who are only at the plant during the 14-day planning and morning meeting, takes part in both at least one screening long before the job and one screening just before the job. This ensures that all roles have the possibility to screen each job if a PJB is needed and interpret the signal if a PJB has already been decided.

A difference of the screening process can also be noticed between the three maintenance types, depending on how complex the jobs for each type usually are. The outtake and preventive maintenance is both evaluated and planned well ahead of time, but also when up close for the job to be carried out. For outtake maintenance the binder walkthrough and kick-off are screenings that does not occur for preventive maintenance. Preventive maintenance jobs are however also not as complex, as the plant is active at the time. Remedial maintenance is planned and evaluated as maintenance gets notified of them during morning meetings. PJB can for this outtake type be used as a slowing force, forcing involved to consider the job ahead of them.

Each of the interviewees mentioned by each role is that there is an attitude at the mechanical maintenance unit that it is enough that one person feels the need of having a PJB, to actually have one. Throughout the screening process, there is a culture of rather why there should not be a PJB, rather than why it should.

6.3. Easy process, but experience is crucial

The group manager, planner and engineer all mentions that there are databases, work instructions, flowchart and other aids to assess and plan a job. However, these aids are not seen as important on whether a PJB is needed or not, but rather that experience and communication is. Risk evaluation of the job is centralised around experience, as the maintenance engineer puts when asked whether the work instructions and flowcharts are needed to assess a PJB: “No, it is not enough, then you have to take into risk evaluations and such”

The engineer, who usually is the one summoning the attending for the PJB, mentions that the tasks after a PJB has been decided is not hard. One mentioned crucial step is the summoning, which is done by email or, when urgent, by phone. The technician and the planner says that the right people needs to attend, so that everyone feels that attending the PJB is important. The technician raises an example where one department used to send their engineer, rather than the performer of the jobs. This does so that the performers won’t meet before the job is to be performed and makes all information between them second hand. By so, it is believed that the signal might get wrongly interpreted by having another step of interpretation and presentation.
6.4. **PJB as a quality job walkthrough among others**

Signals that are origins to a PJB are presented and interpreted in relation with the other job walkthroughs that are being used. Several roles stresses that PJB needs to be used with dignity and stresses that PJBs should not become a rut. Other job walkthroughs are seen as less formal but also powerful tools that in a lot of ways are equivalent to the PJB.

By having the several job walkthroughs, the workers have tools to choose a job walkthrough that suits each job. The need of a PJB is interpreted with this in mind. This is a constant balance of matching each job with a suitable job walkthrough. Using a too comprehensive job walkthrough for a job creates disinterest in being active in them or at all attending, but a too small job walkthrough might not be sufficient for the need of the job. Even though this balance is met with an attitude of “rather be safe than sorry” the workers puts effort in combining the right job walkthrough with the right job to avoid the PJB becoming a rut. By giving formal opportunities several times between roles to assess each job and a close physical placement during daily work, opportunities to correctly assess each job is given. As mentioned by the engineer, the formal meetings are also opportunities to meet relevant personnel and discuss jobs before and after the meeting itself. If not, interest of attending and commitment to PJBs would decline, and by so, the quality of job walkthroughs.

The quota of the amount of PJB is gone, and the process of matching each job with a suitable walkthrough has been decentralised to the workers performing the job. This is mentioned as positive by both leadership and front line workers to increase quality of job walkthroughs and help the PJB to maintain an aura of dignity. Previously seen as overcomplicating routine jobs, window dressing or the PJB becoming a rut, PJB is now being regarded on a wide scale as a tool used only when really needed, associated with importance. This is perceived to be even more so when the PJB is summoned on short notice as a sudden change to preventive and outtake maintenance or on a remedial job on short notice.
7. Applying the Systemic Resilience Model

This section applies the Systemic Resilience Model (SyRes) on the data collected at the nuclear power plant. First is the process of detection, interpretation and reinterpretation the type of signals that leads to PJB is shown with SyRes. Secondly SyRes is used to map how intended use of SyRes is reached regarding detecting and interpreting signals that lead to a PJB. Thirdly a potential area of improvement of SyRes is pointed out regarding its ability to be able to have feedback loops in terms of negative side effects and latent conditions, but not positive effects of strategies used.

7.1. Anticipation of weak signals to performed PJB

By acknowledging that weak signals exist as Latent conditions, that hidden vulnerabilities can damage the daily work being performed, gives the mechanical maintenance department the ability to anticipate these events. In SyRes this is put under functional dependencies. To systematically perform the task of detecting weak signals, monitoring is established to detect onset and effects. To be able to react to the weak signals that now have been imagined as possible and anticipated, the targeted power plant established modes to be able to react on them. Both the established monitoring and the established modes are in SyRes outer layer under adjustments of capabilities. In this case, it is the implementation of PJB as an established mode.

Following SyRes, looping around back to event-based constraints, the onset cues are signals to PJB that is seen as useful, as prior study by Skjerve and Axelsson (2014) identified. During the functional dependency Monitor takes the mechanical department’s screening processes of jobs place, including the attitude and quality of the assessing jobs regarding if a PJB is needed. At the Detect Onset/Effects is the actual origin of the signal that leads to a PJB is detected, which this study has been researching. By the Adjust & Mobilize a PJB is decided on and the right people are summoned. Once the PJB is performed, as going in towards the model directly to Set mode/Repertoire. Granted the PJB was used as intended, if the strategy Immunize, Avoid or Control is used depends on each job. Focus for this study being the detection and interpretation of the type of signals leading to PJB, it is not of much importance for this study. Control might be the chosen strategy but Avoid is a reasonably the most common strategy by avoiding unwanted outcomes. Immunize could mean not performing the job at all, which could be possible if the job is for example deemed too expensive or too dangerous. Assuming Avoid is used, delayed effects do not occur, and the loop ends.
Figure 9. SyRes visualizing the process from anticipation of weak signals to that a PJB is performed

In the case that that the PJB is not used as intended can it create delayed effects, as visualized in figure 10. Delayed effects affect the workers monitor function and the ability to Adjust & Mobilize. Even if a type of signal that would warrant a PJB is detected, Adjust & Mobilize may not initiate a PJB due to the feeling that the PJB does not make sense (Skjerve & Axelsson, 2014). The way the formal screening process is taking place at the Monitor layer would likely not change due to this, meaning meetings where each job is discussed will continue. However, with a growing feeling that the PJB does not make sense, the workers attitude and the discussion regarding if and when to use PJB can be affected, leading to that signals that used to be reacted upon with a PJB at Detect Onset/Effects is no longer reacted upon.
In the case that there is a lacking common ground of what signals that should lead to a PJB by the Set mode/Repertoire, leading to an opinion that PJBs are in some way sub-optimally used, can it lead to that the workers are less and less willing and motivated to use PJB. How this can affect the quality of the PJB is exemplified by the Engineer: TR:E O-A3 "Should not have unnecessary PJBs. It is very important as if not people will just show up but not actually participate in the PJB". Ultimately, too much negative attitude towards PJB due to not being used as intended would affect the outer layer, and question if weak signals can be detected. Going further, the belief of PJB as a working tool would diminish and established monitoring function seize to exist.

Figure 10. SyRes visualizing how a PJB not used as intended over time affects the monitor function, future PJBs and ultimately the anticipation
7.2. Establishing premises for intended use of PJB

The Goals with using PJB is for individuals to better understand the task(s) to be accomplished and associated hazards of a job to be performed (DOE, 2009b). A prior study has shown the Facts for the goals of PJB to reached PJB has to be used as intended (Skjerve & Axelsson, 2014). By that knowledge organisations using PJBs should seek a state where the PJB is driven by the need of the workers performing the PJB and to maintain the PJB as a tool viewed with dignity, as explained by the planner: TR: P IS - A17 "There should be dignity associated so you don't get a rut regarding PJB, so that it is used on everything. Everyone in the group should be a little passionate about PJB". Making adjustments to reach a state where PJB is regarded as a dignity tool, used by the needs of the workers is represented in the second most inner layer of SyRes. Knowing if adjustments are needed to reach this desired state are done by the inner most layer of SyRes, the Self-Monitoring function.

The Self-monitoring function has ultimately led to a learning process creating adjustments of the Detect Onset/Effects function by the adjustments of capabilities. Figure 11 shows how this is visualized in SyRes. Adjustments were needed as it was learned that PJB need to be driven by the need of the workers. Establishment of a more decentralised process on how to choose PJBs was introduced. TR: GM O - A26 "...I've noted that not like we have them by ourselves but we get to choose more nowadays than before of when to have a PJB…" and by the technician TR: T O - A2 - 3 "Nowadays there is a good balance of PJBs, but it was a ridiculous amount of PJBs on everything when it was introduced". By having the front line workers in control the type of signals that was detected was in accordance with the need of the workers who performs the jobs and PJBs. In addition, with the formal screening process that allows for several screenings over time for all roles the workers possibility to detect and interpret signals that leads to PJBs.
Figure 11. SyRes visualizing how the Self-monitoring function has led to a learning process creating adjustments of the Detect Onset/Effects function by the adjustments of capabilities.

Viewing adjustments of capabilities and Set mode/Repertoire part, the smaller PJB, the full PJB and other job walkthroughs are alternative Set modes/Repertoires used by the nuclear power plant. The fitter explains: TR:T OP-A11 "Then we don't need the questions of radiation, fire hazards and so on, we already know that all these things are not an issue", and the planner: TR:P IS-A17 "The PJB should be correlated to some dignity. That maybe a usual job walkthrough is enough for smaller jobs". The technician highlights the difference between the small and full PJB and how they have different purposes on who is attending: TR:T OP-A11 "We did just the small PJB when it was me and my fitters, and my engineer, then we didn’t need the questions of radiation, fire hazards and so on, we already know that all these things are not an issue".
Seeing PJB in the context of other job walkthroughs and projects, having options other than the PJB gives the workers the option to match signals with an appropriate job walkthrough. By so, PJB is a reaction to appropriate weak signals and used as intended. Reinforcing the ability and possibility to use PJB strengthen workers’ willingness and motivation to use PJB as it makes sense.

7.3. Reinforcing and inhibiting loops
The detection, interpretation and usage of PJB is dependent on the workers using the tool. As described in section 6.5.1., using SyRes to describe the process from anticipating to performed PJB, when the PJB is not used as intended, can delayed effects affect the outer layers of SyRes that inhibits future detection and interpretation of PJB.

However, a perceived positive outcome of using PJB where it felt it made sense would have the effect of reinforcing the use of future PJBs. Workers using PJBs and getting the impression that the PJB made sense, would mean a higher interest in matching the right job walkthrough with each job. Also, belief in that the PJB makes sense strengthens that workers react on detected weak signals with the appropriate reaction. Today at the plant this can be exemplified that one will is enough to warrant a PJB. As described by the engineer when a PJB is summoned on short notice: TR:E OP-A22 "If there is a summon in just an hour then people gather up as they understand the importance and they are more interested if there is a hasty PJB", is a result from a reinforced view of the value of PJBs.

SyRes has a loop for potential negative effects when using the Control strategy, but lacks the possibility to show the positive effects of when things go well and the strategies Avoid and Immunize is used.
8. Discussion of results

This section discusses the analysis of the result in relation to the theoretical framework. The screening process and the front line workers’ attitude is regarded in relation to detection of weak signals, which is then seen in relation to how the department functions in relation to characteristics of a HRO. The PJB is discussed as its role among other job walkthroughs and lastly a possible limitation of Syres that could be improved.

8.1. Weak signals and one will is enough

PJBs and other job walkthroughs used are matched through risk assessments for each job to be performed. A PJB is decided upon after one or more signals that indicates that a PJB is needed. This signal could be detected by one person. A weak signal could be seen as one person feeling the need of a PJB. In a culture where just one person is not enough to warrant a PJB, but say rather three, the organisation is not reacting to weak signals, or at least as weak. Currently the department has a culture where one signal is enough to warrant a PJB and a foresight process where all workers are involved at several time to assess each job to be performed. The department do understand the meaning of weak signals and can act on them confidently, as Weick and Sutcliffe (2011) argues a HRO should. By so, the department displays central characteristics of a HRO (Weick, Sutcliffe, & Obstfeld, 1999; Reason, 1998).

In regard to Hopkins (2007) description of false signals this study can’t take a stance on whether false signals are actually identified and disregarded. The studied department have introduced a system where the workers themselves detect and interpreted weak signals, together with a screening process with involved roles over time. PJB decided on the need of the workers performing the job, arguably the number of false signals would be few. Rather, it would be about assuring that as few signals are possible aren’t missed, something which is very hard, if even possible, to know.

8.2. Sharp end workers as a valuable resource for safety

By controlling the choices of PJB top-down with the intention of increasing security, it was experienced by workers to have the opposite effect. This could have made the system drift towards the boundaries of unacceptable performance (Rasmussen, 1997). However, by proper monitoring of itself to how the system drifts in relation to safety boundaries (Cook & Rasmussen, 2005), this was corrected, the process decentralised and a more desirable state has the last few years been reached regarding the use of PJBs.

The solution to reaching a more desirable state was to decentralise the process of assessing the need of PJB and giving the decentralisation top-down support. Both Reason (2000) and Weick, Sutcliffe and Obstfeld (1999) stresses that the personnel at the sharp end is one of
the most valued characteristic of a HRO. Throughout interviews has no non-job related factors been said to influence the choice of having a PJB. The sharp end personnel have been given the organisational support and resources to assess and decide on which job walkthrough is needed for each job. The organisation therefore shows characteristics of a HRO (Reason, 2000; Weick, Sutcliffe, & Obstfeld, 1999) by using the sharp end personnel as a valued resource for safety. The result of this is that the PJB is now a valued tool by workers and the system with job walkthroughs is experienced as working well, and better now as opposed to when it was top-down driven.

8.3. PJB and other job walkthroughs to be used as intended

For the PJB to maintain its dignity as a quality tool and be used as intended (Skjerve & Axelsson, 2014), there needs to be other job walkthroughs and possibilities for the workers to adapt the job walkthroughs to suit each job. Each job is individually evaluated, and there is an attitude of rather be safe than sorry regarding choosing the right job walkthrough. However, using job walkthroughs of higher complexity than needed is perceived to inhibit the quality of the job walkthroughs. If consequently a higher than needed job walkthrough were used, the quality of them would decline.

Having the right set of tools in form of adaptable job walkthroughs of different complexity and the organisational support to use them allows the PJB to be used as intended as Skjerve and Axelsson (2014) puts it. Being used as intended the workers’ view of the PJB as a tool that makes sense should increase, and by so, the quality of coming PJBs. A self-reinforcing loop is such created once the PJB is used as intended. For this to happen, other job walkthroughs are needed. How each department in the nuclear plants that use the HP-Tools use PJB needs to also consider the other job walkthroughs available and how they are used. The group manager in the observed department mentioned how outside observers and interested parties was surprised of the statistically low amount of PJB that was being done in regards to the amount of jobs performed. The fitters also mentioned how the PJB is used differently between the Swedish power plants. What signals are origins to PJB and how they are presented and interpreted might therefore differ between nuclear power plants and countries. When studying PJB (and likely PJD) should not be done explicitly, but rather in context with other similar work tools.

8.4. Constant communication between roles

Even if workers assessing whether a PJB is needed are less experienced as to now, with a maintained culture where one will is enough to warrant a PJB, jobs that need a PJB will likely have one. Less experience might however make the choices to have a PJB less precise, lowering their ability to use the PJB as intended (Skjerve & Axelsson, 2014). This in turn might give the PJB the wrong focus and not being
taken seriously by the participants (DOE, 2009b; Skjerve & Axelsson, 2014). Not being used as intended over a period of time can create a negative enforcement on the dignity of the PJB as a quality tool used only when it really matters. Workers being interviewed in this study all had several years of experience in theirs and often other related roles to risk evaluation of maintenance jobs. Already mentioned in previous studies participants (DOE, 2009b; Skjerve & Axelsson, 2014), too big variation in competence of attending personnel in a PJB might neglect intended use. As mentioned by the planner, older, more experienced personnel and younger, less experienced personnel see safety and risks differently. Too big variation in competence and experience could therefore also spreading the intended use of the PJB, risking making it a rut.

Foresight screening of is a by the workers appreciated formal structure to assess each job regarding which walkthrough to use. The screening opportunities allows for that each role perform at least one screening of each job in the planning phase, and when the job is about to be performed. This is done in communication with other roles, which allows for discussion and to see the job from different perspectives. Formal opportunities of screening give the worker the ability to properly anticipate, monitor and detect signals of unwanted events, which is core abilities for an organisation that has requisite imagination and interpretation (Lundberg & Johansson, 2006; Adamski & Westrum, 2003). Done from a maintenance perspective, having a screening process by other departments that has a different expertise and perspective on each job, would allow for strengthening the whole organisation’s abilities of requisite imagination.

Communication between roles, but also insight and experience between roles seems from observations and interviews as critical to gain a common view on the daily work and other personnel’s needs. The physical placement where all roles have their daily work in the same floor and building allows for easy communication. Doors are always open to office rooms and there were constant conversations both in offices, hall ways and cafeterias during the days of observation. Regarding when and when not to use a PJB, a lot of factors have been mentioned by the interviewed, central being a bridging tool between departments. But it has been hard for the interviewed workers to explicitly point as to why some jobs need a PJB and some don’t, indicating knowledge transfer is hard.

As long as it remains both informal, daily communication and formal opportunities to discuss each job regarding risks in good foresight, together with a variation of job walkthroughs to match each job, preconditions to assess if a PJB is needed are good. However, with generation shifts and differences in experience, the PJB can become a rut by other means as to being controlled top-down, which ultimately
also can lead to drift towards the boundaries of unacceptable performance (Rasmussen, 1997).

### 8.5. Show reinforcement through SyRes

One of the strengths with SyRes is its feedback and feedforward possibilities, which allows for descriptions of complex relations and effects of actions taken. The model’s Control strategy includes a backtracking loop back to latent conditions. This backtracking loop allows to describe possible negative changes in the system, as by controlling, changes on the system must occur. A theme generated with SyRes was reinforcing and inhibiting loops as changes occur in the system.

By understanding the HRO’s ability to succeed under varying conditions, the focus of safety moves over to how the system succeeds, rather than why it from time to time fails (Hollnagel, Leonhardt, Licu, & Shorrock, 2013; Weick & Sutcliffe, 2011). The latent conditions created by changes in the system by using the Control strategy can also have indirect, for the system positive effects on itself. The self-monitoring function was in this study used as one active, aware form of learning. Backtracking loop from control would be more a consequence, rather than an active choice, allowing the model show reinforcing loops by the use of strategies. Attitudes for example would be one implicit reinforcing change this kind of loop would allow for.
9. Discussion of method
This part brings first up experiences of observations and interviews, with critical reflections and lessons learned not thoroughly covered by used literature, so they can be used for future studies. Next follows a discussion of the decision to limit the used data and its consequences. Lastly is the use of SyRes discussed, foremost about how SyRes performed and in relation with the more traditional thematic analysis.

9.1. Experiences of observations
With the limited data collection time, open research questions and uncertainty of the daily work at the nuclear power plant and its possible restrictions made for a dynamic data collection phase with many experiences worth taking note of. To support studies in similar environments follows below the main reflections of gathering data.

9.1.1. Attending events
In qualitative studies it is commonly highlighted to get to know the set and the people working there (Baecker, 2014; Creswell, 2012). Participate in events that might not have a direct relation to the research question proved valuable and is recommendable, especially at the early stages of the data collection phase. Becoming a known face by the people working there, meeting different roles and giving opportunities of informal conversations are all positive effects of edging outside of the scope of interesting events. It was noted however how workers associate what you attend with your interest, which guides conversations and tips of people to talk to and events to attend. Beforehand deciding on how and how much to explain of the study being done affects the data collection and the behaviour of the observed personnel (Clark, 1996; Mulhall, 2003). Being open about the purpose of the study supports this way of collection data not mentioned by Mulhall (2003). Even more so when the data collection takes place within time limitations.

9.1.2. Observation role
Initial observations were not planned in where they would take place or which observer role (Gold, 1958) would be taken. Rather, the observation role but rather unfolded over time. What later was categorized in three categorizations of observations (PJB or another type of meeting, spending time in office and during jobs being performed) meant that three different types of observer roles were used. Different observation roles were important as it allowed to reach different roles within the nuclear power plant. Fitters and partly technicians for example, work mostly in the plant and do not spend time in the office. Planners, group managers and maintenance engineers however spend a lot of time in office. None of this was known before the observation phase. It proved valuable in this study to not choose a
specific role as Gold (1958) defined them, but with understanding of the pros and cons of each role adapt to each situation.

9.1.3. Field notes
Having such an open entrance to the observation phase put demands being prepared. There are different ways of taking field notes with different pros and cons (Mulhall, 2003) in regards to affection of the observed and overall possibility to write field notes. The different observation types proved give different opportunities of writing field notes. Observations of work being performed gave the least possibilities to write extensive field notes during the observation, spending time in the office second most, and during PJBs and other meetings gave the most possibility. The opportunity to write extensive field notes did not correlate with the observer role and its level of involvement. Observation in office gave time and opportunity to step back and write field notes, while observation during jobs other factors influenced the ability to write field notes, such as security reasons and lack of space to step back and write. The possibility to write field notes in relation to the environment is something that Muhall (2003) naturally discusses, but it is worth mentioning that a passive observer role does not naturally mean better preconditions to write field notes.

People will want to help you in your study. Attending as much as early as possible makes you a known face, but also direct the assumptions of the workers of what you are interested in. Being open about the purpose of the study supports this way of collection data, as it guides the workers into helping you reach the right people and right events. By being good prepared in different observation styles and roles, gives good preconditions to handle different observations types, rather than beforehand deciding on one. Lastly you should not expect that a passive observation role means more time and opportunity to write field notes, it is rather decided by the studied environment.

9.2. Interviews
When using the same questionnaire for all interviewees, regardless of role at the workplace, questions might be interpreted differently. Partly this is expected and wanted, as this study created latent themes, as decided through Braun and Clarkes (2006) forth question for data analysis. An example would be that the interviewee had different answers related to what was the origin or cause that lead to a PJB. The question regarding the critical steps needed to successfully perform a PJB was however noted to be more elaborately answered by the group leaders, while sometimes not understood by other roles. Examples and work arounds was then needed to make the question understandable. It is to be expected that each role can’t answer all questions equally well, but it proved hard to make one questionnaire fully adaptable to several roles, in his case seven.
9.3. **To solely focus on one department**

Only after observations and interviews were performed was it decided to exclude the data collected from the instrumental department. This was decided due to the lesser amount of interviews than at the mechanical department, lesser observation time and field notes. However, the instrument department was observed and interviewed and might have influenced the data collection phase, including interview questions. It is also worth for future studies to know that even after data collection, exclusion of certain data has been done, but available.

A total of five interviewees participated, compared to the 14 from the mechanical department. With such a large gap between the two data sets it was felt that trade-off was needed between a wide analysis, including both departments, or to focus more on one. Rather than focusing on the two groups where one felt inferior to the other, it was decided to solely focus on the one group. Consequences of this being a stronger, profound analyse of one department, but a lacking ability of comparison with other departments, and so, an ability to generalize the results.

Operation plays a big part in the daily work at the nuclear power plant, who also is excluded from this study. Initially it was not known how large impact operations had on the other departments. The instrument department personnel mentioned in interviews that they got most of their PJB from operations and rarely decide and perform them themselves. The only role outside of the department interviewed was the outtake leaders. Their inclusion in the report was due to them in comparison with operations smaller role, they were a good example on how the screening process continues outside of the performing department and their overview knowledge of the outtake work. Being limited by time and resources, delimitations of departments had to be done as much as the full circle of signal could not be included. It does however leave room for further wider research within the same part of the cycle of the signal and how other departments and roles affect the use of a PJB within the performing departments.

9.4. **SyRes in relation to the thematic analysis**

Following the sequential procedure by Braun and Clarke (2006) the data analysis followed six steps with the purpose of creating themes. This was done in in iterations, creating themes that in the end produced the result and analysis. SyRes was applied from the thematic analysis that resulted in the personas in the result section. The application of SyRes must be critically viewed in regards to the whole data analysis, but it does add new depths to the overall analysis of the study.
Using the sequential procedure by Braun and Clarke (2006) included a thematic analysis of the initial of the first themes created, which resulted in the personas in the results section. This second iteration stands out from the normal procedure that Braun and Clarke (2006) intended, but the bottom-up approach that a thematic analysis is, makes it doable. From the same data set is also the application of SyRes. The analysis with SyRes were also analysed thematically analysed, but the themes are mapped with and can be followed within SyRes. Even though bias must be taken into account, as the same analyst did both analysis, it is noteworthy that new themes could be presented and explained with SyRes. This shows that SyRes was applicable and usable as a tool together with a thematic analysis.

Interesting questions arise though in relation to the positive outcome of using SyRes: in what stage and how in a thematic analysis is a coherent model like SyRes best implemented? Looking back once again at Braun and Clarke (2006) and their six step of thematic analysis, SyRes could potentially lie as a base already for generation of initial codes and search for themes, step 2 and 3. Doing this could potentially strengthen SyRes ability to show the relation between resilience and stability, which is one of the models main strengths and aims. Themes could also be stronger mapped to the different functions and parts of SyRes by implementing it earlier. SyRes could surely work with a non-thematric analysis method. These are all interesting ways to further deepen the knowledge of SyRes and the relation between resilience and stability.
10. Conclusion
The conclusion is divided in the three research questions. First brought up is what origin of signals that could be identified and how they can be viewed in relation with other studies. Secondly is how these signals was interpreted and represented between identified involved roles. Lastly, the Systemic Resilience Model can be used as an analytical tool for studying Pre-job Briefings together with a thematic analysis in the sequential order by Braun and Clarke. In this study SyRes also allowed to present additional themes, leaving the question at what stage SyRes is optimally implemented in a thematic analysis.

10.1. Origin of signals
This study set out to see what signals that results in a PJB, their origin and how they were presented and interpreted over time between roles. From data collection and analysis four categorisations can be made of signals that are mentioned origins to PJB at the department. A PJB can be decided on either when:

- There are several involved professions and departments. PJB ensures a common understanding of the job.
- Time is of the essence in some way. PJB prepares jobs with time constraints and to get a flow in work, or as a slowing force, as not to rush into a remedial job.
- A job that is harder than normally to perform or a non-routine job. PJB functions as extra preparation.
- There is an identified higher risk of occupational, component or system safety than normally.

Overall, all interviewed roles are represented in each of the four categories. In large this is a very similar list by Skjerve and Axelsson (2014) of when the PJB is seen as useful by maintenance personnel. Not explicitly mentioned in previous studies are to get a flow in work with time constraints, or to use PJB as a slowing force. Working under pressuring time constraints most often occur during outtake maintenance, and using PJBs as a slowing force is prior to sudden, urgent jobs, which mostly occurs with remedial maintenance. Origins of PJB can therefore differ between maintenance types.

Slight differences of origin could be noticed depending on roles, for example the planner, who focus on side activities, and the engineer, who focuses on the technical aspects. That all roles are involved in the process of assessing jobs is therefore important to properly assess each job of whether a PJB is needed.

10.2. Interpretation and representation of signals
The second research question was regarding how do these signals get interpreted and presented over time between roles. For each maintenance type there is an organisational structured process of assessing each job, which gives foresight for all involved roles to detect, pre-
sent and interpret signals for a PJB. Outtake maintenance has more formal opportunities to assess each job, as the jobs there are usually more complex than preventive and remedial maintenance. Maintenance personnel gets the chance of requisite imagination (Adamski & Westrum, 2003) and interpretation (Lundberg & Johansson, 2006) by assessing jobs several times between roles over a long period of time. By summoning the right people to PJB simplifies presentation and re-interpretation at the PJB. By so, weak signals can be detected and acted upon.

In a culture where one person presenting one weak signal is enough to warrant a safety reacting, in this case a PJB, the task of presenting the signal is not a complex one. By having no non-job related factors influence the origin the choice of having a PJB and a belief that the PJB is used as intended, the signal is perceived to be true. Having personnel that believes that the PJB makes sense as it is being used as intended, makes presentation of signals and interpretation of them easier.

10.3. The Systemic Resilience Model
The Systemic Resilience Model was applied as one of three iterations after the six steps guideline for a thematic analysis by Braun and Clarke (2006). Applying and incorporating Systemic Resilience Model with the thematic analysis proved successful and generated additional themes, not generated in the also performed thematic analysis. With restrictions for possible bias, as the analysis was performed by the same person, this study does illustrate one way to use the Systemic Resilience Model, be incorporated and strengthen a thematic analysis.

SyRes was in this study used as more than a way to represent relations and dependencies. There was a lot of pre-work by following Braun and Clarkes (2006) sequential six step analysis, with SyRes being applied at the end. SyRes could potentially lie as a base already for generation of initial codes and search for themes, in step 2 and 3 by Braun and Clarke (2006). While this study can conclude that the Systemic Resilience Model can be used as an analytical tool for studying Pre-job Briefings, SyRes could have a bigger influence on the data by being implemented earlier in the data analysis phase, therefore be able to more distinct show the dependency between resilience and stability.
11. References


Hopkins, A. (2007). *The Problem of Defining High Reliability Organisations Professor of Sociology Faculty of Arts and National Research Centre for OHS Regulation*. Canberra: Australian National University.


### Appendix I – interview questions

Table 2. Interview questions, left column in Swedish, right is the translated version in English.

<table>
<thead>
<tr>
<th>Swedish</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vad är din roll här på kärnkraftverket samt vad är din formella titel?</td>
<td>What is your role at the plant and what is your formal title?</td>
</tr>
<tr>
<td>Hur länge har du jobbat inom kärnkraftsverksamheten och på denna avdelning?</td>
<td>How long have you been working in the nuclear industry, especially related to experience of use for your current role?</td>
</tr>
<tr>
<td>Relatedat till PJB, hur är du personligen inblandad i de PJBer ni har här på er avdelning? Både före, under och efter PJBn.</td>
<td>Related to PJB, how are you specifically involved in the PJB you perform here at your department, both before, during and after the PJB?</td>
</tr>
<tr>
<td>Vad tror du ligger till grund till att en PJB genomförs? (Alternativa ord, upphov, anledning eller initiering)</td>
<td>What do you think is the origin or cause that a PJB is performed at your department?</td>
</tr>
<tr>
<td>Vad för dig är den främsta informationskällorna för att du ska kunna göra det du faktiskt gör gällande PJB här på Ringhals? (Kan även prata om förutsättningar)</td>
<td>What are the foremost sources of information for you to be able to do what you do related to PJB at your department?</td>
</tr>
<tr>
<td>Vilka kritiska steg måste passeras för att en PJB ska bli till?</td>
<td>Which critical steps do you think are to be passed for a PJB to successfully be performed?</td>
</tr>
<tr>
<td>Tycker du att urvalet eller fördelningen av PJBer är optimal? (Hur är balansen av PJBer kan även frågas)</td>
<td>Do you think that the selection of PJB at your department is optimal or well balanced?</td>
</tr>
<tr>
<td>Efter att ha frågat dessa tidigare frågor och vi har pratat, är det något du skulle vilja tillägga? Är något du är förvånad över att jag inte frågade?</td>
<td>By being asked and answering the previous questions, is there anything you would like to add to anything? Also if you found it surprising I did not ask you of something, now once you heard the questions I wanted to ask?</td>
</tr>
</tbody>
</table>