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Developing an Early Warning Tool for Use in Risk Management and Decision-Making

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Abstract

This thesis is written in light of recent concerns in the Norwegian petroleum industry about increased risk exposure and lowered safety due to the cost cutting measures implemented in the last few years. The objective was to develop a tool, that uses indicators to be used in the day to day management of the operation, that could be easily understood by anyone and that would show negative trends in aspects of operation that heavily influence the level of safety. This tool would act as an aid in decision-making and risk assessment. A general tool was developed, named the EWT (Early Warning Tool), which uses indicators to show trends in areas where initiating events could result from poor or compromised operation. Warnings are given based mainly on negative trends in these areas. The warnings are classified from grey through yellow to red, increasing in severity respectively. From this, a specific configuration was developed for this thesis. This configuration of the EWT also focused on aspects especially affected by cost cutting. In addition, organisational learning and safety culture have an important role. The indicators are discussed and reasons given for why these specific ones are chosen. Also, maintenance and optimisation of the tool is described and discussed, so that companies can make necessary adjustments depending on their needs and their assessments of the performance of the tool. In the end, it is concluded that implementing EWT or a similar tool is in line with the ALARP principle, as it can provide increased safety at a fairly low economic cost.

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Useful Abbreviations

PSA	Petroleum Safety Authority Norway
EWT	Early Warning System, name given to the tool developed in this thesis

1 Introduction

1.1 Background

In the last few years there has been focus on cutting costs in the Norwegian petroleum industry. This in large part due to the dropping price of oil and increasing costs. In this climate a growing concern is whether the safety situation on the installations suffer from this. The report from the Petroleum Safety Authority describing the 2015 period, expressed worry about an increase in certain incidents. A large fatal helicopter accident in the spring of 2016 further exasperated concerns like these.

The Norwegian newspaper VG, in the days following this helicopter accident writes an article discussing the safety on the Norwegian continental shelf. Ketil Karlsen, director of the European office of the trade union Industri Energi claims that the focus on cost cutting in the later years has lead to a considerably lower level of safety and that fatalities should now be expected. Vice managing director of the Norwegian Oil and Gas Association, does not agree and points to improved safety seen from a longer perspective of time (Matre, Larsen-Vonstett & Braaten, 2016). It is not a given that cutting costs results in lower safety, but it is definitely a challenge to uphold the same level with less resources and special vigilance is required during periods of transition.

Companies will want to make sure that the changes they make and the areas where they cut costs will not lead to unacceptably high risks to HSE, health, safety and the environment. The challenge is to find and use techniques and tools that can help in this area. The PSA, the Petroleum Safety Authority Norway, issues an annual report that uses certain indicators, and the report mainly focuses on differences in the absolute numbers of these indicators. They are called DFUs, which translates from Norwegian to defined hazard and accident conditions. These are mainly regarding incidents and/or initiating events that can cause different consequences.

There are many tools used to support decision-making, many tools for risk analysis and risk treatment. There is however a need for effective tools that can be used in real time to check that operations are running in a safe way and give early warning if safety is or could be compromised.

1.2 Objective

The objective of this thesis is to discuss how to develop and maintain a tool using indicators to give early warning should the safety level of operations deteriorate. The tool developed is given the name EWT, an acronym for Early Warning Tool. The suggestion given in this thesis has in mind the context of the cost cutting happening in the Norwegian petroleum industry. The tool does not directly indicate whether the cost cutting measures specifically causes the lowered level of safety, but can be used during a period of transition. Some of the indicators relate to aspects that might be especially influenced by cost cutting measures such as reducing personnel.

Instead of making subjective judgements on the situation, quantitative data can be used. This is also useful since the management and team performing risk assessment and treatment, often is somewhat removed from the day-to-day operation at the facility or installation they manage. The EWT will still require qualitative investigations into some of the causes of the trends shown and what the solutions are. However, it is important to remember that the tool does not aspire to give an exact solution to the problems it indicates. It aims to be an aid in decision-making and to give a better, more complete picture of the situation at the installation or facility earlier. The thesis is not meant to thoroughly describe the subjects that are mentioned, but rather to be somewhat innovative and come up with a tool to support in decision-making, building upon previous knowledge. This thesis aims to show how this type of tool can be put together and how a company can use it.

1.3 Extent of, and Limits to, the EWT

This thesis does not intend to comment on or analyse the actual situation on the Norwegian continental shelf or the way companies control risk. No actual numbers gathered from the industry is used; they are generated randomly to illustrate how the tool would work. This thesis focuses instead on how to develop this tool and also how it can be used in practice.

The EWT does not aim to provide numbers that directly tell the company the expected number of deaths, accidents or production stops per year. As such, this is not a tool intended for use in a comprehensive risk analysis, but as an early warning system and an aid in near term management of installations and facilities. It aims to give an output that can easily be read by anyone involved in making decisions on which areas to focus on to make sure the level of safety is not lowered to unacceptable levels. Due to its nature the EWT does not evaluate or put a figure on the current risk exposure. It only reveals changes, but this is also what makes it useful in a period of transition, such as when cost are being cut. While it would be ideal to have a model that gave an exact representation of reality, reacting perfectly to changes made in the field, this is usually an unrealistic goal. However, it is important to keep in mind that this tool only needs to be an improvement to be useful. It is in this spirit that the model will use objective numbers to indicate changes in a complicated reality.

Also, note that giving this tool a name, EWT, does not mean it is claimed that this is an completely new or original way of thinking about assessing risk and the situation on an installation or facility, the name is given to make it easy to refer to. Indicators are already in use, of course, but the goal with EWT is to suggest how these can be used and compiled for the purpose given in this thesis. Used specifically, as the name implies, as an Early Warning Tool.

1.4 Structure of the Thesis

Below is a general description of the most sections in this thesis, what they contain and what their purpose is.

Section 2 describes theoretical knowledge that is useful for the development of the EWT. It will give a basic description of risk and risk analysis, some organisational aspects important to the EWT configuration developed in this thesis and some information on indicators, which is a central concept used in EWT. This section is not meant to give an exhaustive and complete description of the topics discussed, but rather to give an overview of these topics and concepts, which the EWT will make use of and deal with.

Section 3 describes the EWT as a general tool and what use and place it has in a company's decision-making and risk assessment process. Maintenance and optimisation of the tool for different companies and uses is also discussed here. The general structure of the EWT is described.

Section 4 describes the specific configuration of the EWT arrived at in this thesis. This concerns the specific indicators, limits, form factor and function of this exact version of EWT. It describes the indicators selected and gives reasons for why they are selected.

Section 5 concludes, summarises and gives some last thoughts on the EWT and its use.

Appendix A contains the specific configuration of the EWT arrived upon in this thesis. It is advised that the reader looks this up and familiarises themselves with this appendix as well as the rest of the thesis if they wish for a better understanding of the tool. Seeing the configuration might make it easier to understand the functionality of the EWT.

2 Theory

2.1 Definition of Safety

A definition of the term safety can be useful going forward, seeing as it is a central term in this thesis and in the EWT. Safety will in this thesis mean the lack of unacceptable risk of injury, harm or damage towards people, equipment and the environment. When the term risk is used in this thesis, it generally refers to risk in a safety context. Meaning that risk exposure is exposure to risk of harm, injury and damage to people, equipment and the environment, as opposed to, for example financial/market risk or operational risk. In a few cases, the indicators used later will also correlate somewhat with the risk of operational stop, which is economic in nature. Still, risk in this thesis concerns risk to safety.

2.2 A Brief Discussion of Risk

It is widely stated that there is no generally agreed upon definition of risk and so there are several ways of looking at it. A general description is that risk is the chance that an activity or event will have certain consequences. The consequences of interest here are the ones that are undesirable, harmful or detrimental to our interests (Aven 2014). In this thesis, the concern is with risk from a safety aspect, as opposed to for example financial risk. This means that the main concern is with consequences that could harm people, equipment and the environment the operation is in.

2.2.1 A Description of Risk

The more traditional way of describing risk, is as a combination of probability, in this case usually calculated from the historical frequency of the incident or event, and the consequences, losses or effects of the incident occurring. Simplistically this can be represented like this:

$$R = P * C$$

Where R would be the risk, P the probability and C the consequences. As an example, calculating the risk of losing your house in a fire:

R (loss as a function of probability) = P (historic frequency of fire) * C (value of house)

Many problems with using this approach has been pointed out. They generally point out how simple numbers of probability might hide the possibility of outliers or unknowns and that there is no description of the strength of the probabilities and the data they are based on.

A more modern and wide reaching description is using the factors represented by C, C*, U, P, K. Here C denotes the actual consequences of the incident, which is unknown to us. You might also include another letter, A, to describe the initiating events leading to the incident. In some cases A can be included in C. C* is what the consequences is predicted to be. It is our best guess as to the consequences of the incident, but might not exactly match what happens in reality. U describes our uncertainty about C. In general, more previous experience and prior knowledge about an incident and its consequences will lead to less uncertainty. P are the probabilities of certain events and consequences. P is based on prior knowledge and data from earlier similar incidents. In some cases where the uncertainty is high, P might have a weak basis. K is the background information currently available. This can include data from similar incidents, expert opinions, computer simulations and models, specifications and so on (Aven 2008).

The Petroleum Safety Authority Norway has recently released an updated and concise definition of their view of risk, which has moved in this direction. The 2016 Risk Report states that ”risk means the consequences of the activities, with associated uncertainty” (Petroleum Safety Authority Norway, 2016).

2.2.2 Common Ways to Describe Risk Relating to Safety

Many terms, metrics and values are used to indicate a level of risk in a safety context. Many of these deal with fatality as the as the consequence and have different ways of calculating the number of expected values as a function of different factors. PLL, Potential Loss of Life, is the expected number of deaths per year. FAR, Fatal Accident Rate, is the expected number of fatalities per 100 million hours of exposure to an activity or environment. AIR, Average Individual Risk, is expected number of deaths per person exposed to risk.
An F-N curve shows the relationship between number of deaths ber accidents and frequency of accidents. All of these indicators are based on historical data and you could have equivalent metrics for other consequences besides fatality, like injury, damage and so on (Aven 2008).

2.2.3 Risk Analysis

A risk analysis is performed to get a better understanding of the possible risk you are or might be exposed to, to assess and find the factors that matter most for risk exposure and to better manage and respond to risk and evaluate these efforts. The risk analysis can be used to make decisions about future investments, designs, implementations, personnel and so on and to show that you meet the set requirements for the level of risk exposure, set both by the company itself and regulating bodies outside the company. (Aven 2008)

Typically, the risk analysis will consist of planning the analysis, risk assessment and then a reaction, risk treatment.

The planning stage involves defining the extent and goal of the analysis and choosing the analysis method. There are many methods that can be used and they are given a short description in section 2.2.4. These methods can be combined to give the best description according to what has been defined as the problem and extent in the planning stage.

The risk assessment revolves around identifying the initiating events and the causes of these, the consequences and the uncertainties or probabilities connected to these. This gives a description of the risk that correlates to the A, C and U/P discussed earlier in section 2.2.1. From this the whole picture consisting of the mentioned A, C, C*, P, U, K can be built up. A sensitivity and robustness analysis will also be included to indicate how certain, stable and robust the findings in the analysis are (Aven 2008).

In the risk treatment part of the risk analysis the implications of the results are discussed. Solutions or barriers might be suggested. In addition to this, an important aspect is to discuss if both the current situation and the solutions suggested are according to the desired level of risk exposure set by the company and within external rules and regulations.

2.2.4 Common Risk Analysis Methods and Techniques

In this section a very short description will be given for some examples of common methods and techniques used in risk analysis. This section is not meant to be exhaustive and only contains a selection of the tools and techniques available.

2.2.4.1 Risk Matrix

Using a risk matrix is a common way of categorizing risk. The rows might indicate the historical or estimated probability or frequency and the columns the consequences, such as number of fatalities. This is a fairly coarse way of categorizing incidents to show in a visual way the risk exposure. The most feared incidents would then be a frequent incident with devastating consequences, in one corner of the matrix, and least fear a rare incident with no serious consequences, in the opposite corner (Aven 2008).

2.2.4.2 Bow Tie Diagram

A bow tie diagram is a simple and very common way to illustrate the relationships between threats or initiating events, an incident and the consequences. The diagram shows the barriers in place to hinder the initiating events to escalate into an incident and for the incident to escalate into serious harmful consequences. In general it is drawn resembling a bow tie, with the initiating events on one side, the incident in the middle and the consequences on the other side, with the barriers and recovery controls between these three (Aven 2008).

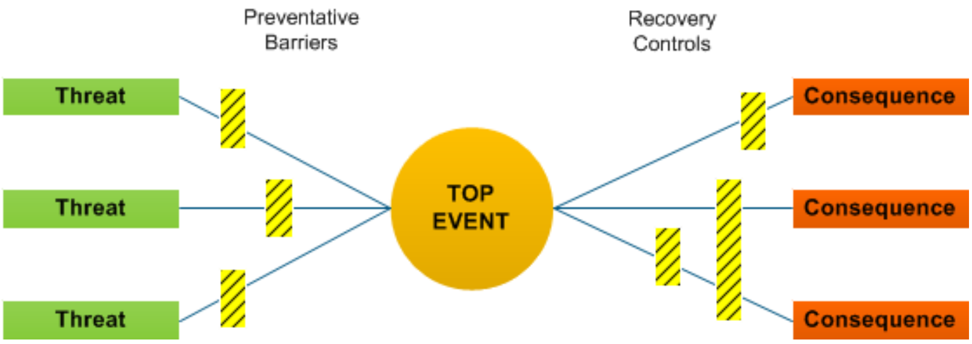

Illustration 1: Example of bow tie diagram (ASEMS 2016).

2.2.4.3 Failure Modes and Effects Analysis (FMEA)

In an FMEA, a system or process is evaluated to find the ways failure can occur, called a failure mode, and the effects this failure mode will have. The significance of the modes are rated to get a ranking. The ranking is used to prioritise where to make improvements. (Price 2001)

2.2.4.4 Hazard and Operability Studies (HAZOP)

HAZOP is usually used in the planning and design stage to identify weaknesses and hazards in a production or processing facility. HAZOP uses sets of guidewords, such as NO/NOT, OTHER THAN and so on to find deviations. When these are found the causes and consequences can be assessed (Aven 2008).

2.2.4.5 Structured What –If Technique (SWIFT)

SWIFT, in a similar fashion to HAZOP, uses the question ”What If?” applied to a list of elements or components in a process, product or system, to find what can go wrong and to consider the consequences of these events (Aven 2008).

2.2.4.6 Fault Tree Analysis

A fault tree is a visual model where you have a top event, which is an incident of some kind, connected to intermediate events, the causes of the incident, connected to basic events, which are the initiating events. This way is represents the causal relationship between different components in a system, at the bottom level, and the possibility for a catastrophic incident, at the top level (Gertler 2008). Different symbols and tools can be used such as logic gates (and/or, if etc.) and it can be used as a qualitative analysis, just graphically, or as quantitative, if there are connected probabilities, uncertainties or ranking of the components (Aven 2008).

2.2.4.7 Bayesian Networks

A Bayesian network is a quantitative method that uses nodes and arrows to show causal relationship between the nodes. The arrows indicate which direction the causality goes. The nodes are given values like probabilities and the network can then be updated using proofs for the different nodes or updated information. A proof would be that a node that previously could have a value of yes or no, with connected probabilities, is set to either yes or no. This is will update the network so that other nodes that depends on this node has updated probabilities for the different states they could have. This way, if new information is obtained about a node in the network, this can be used to update the nodes values, which in turn updates the values for all the nodes in the network depending on the node being updated (Aven 2008). An example with an illustration is given below.

2.2.4.8 An example of a Bayesian Network

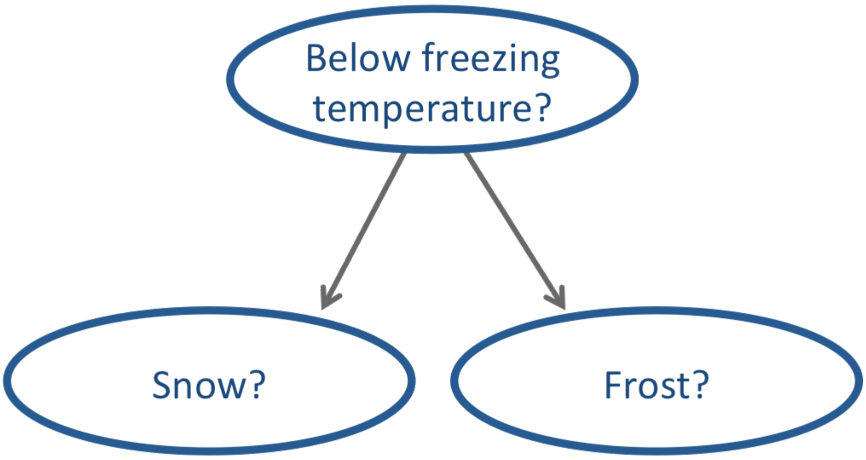

Illustration 2: Example of a very simple Bayesian network.

The illustration above gives a very simplified example of a Bayesian network. The top node is the cause, freezing temperature, it can have the two states ”yes” or ”no” (alternatively ”freezing” and ”not freezing”). By freezing temperature is meant the temperature of the air at ground level, in this case. These states have probabilities based on frequency, meaning how often there are freezing temperatures. These probabilities are a property of the node. Freezing temperature causes it to snow, however since the snow is formed in the atmosphere the temperature on ground level could be above freezing. There are conditional probabilities based on the state of the first node, when there are freezing temperatures there is a higher probability of snow and so on. These are placed into a matrix as shown in the table below.

Snow? / Freezing?	Yes	No
Yes	0,5	0,05
No	0,5	0,95

Table 1: Matrix for probabilities for a node in a Bayesian network

A similar matrix is made for the ”Frost?” node. Frost is very unlikely if the temperature is not freezing, but for a short while there might be frost on the ground while the air temperature is higher. For this example a proof would be that the state of one of the sub-nodes ”Snow?” or ”Frost?” is determined. Because of the conditional relationship between freezing temperatures and snow, given that there is in fact snow, the probabilities for the node ”Freezing temperature?” is updated. For the probabilities above and from real life, it is known that the precipitation in the form of snow, increases the likelihood that there is freezing temperature. It is important to remember though, that snow is not the cause of the freezing temperature. More advanced meteorological effects are not taken into consideration in this example.

2.2.4.9 Monte Carlo Simulations

These are simulations that can be run when a purely analytical calculation would take too much time, effort or computing power. This is very relevant in cases where there are large uncertainty and complexity (O'Neill, T.J., Barry, S.C & Puza, B. 2008). A model of the system being analysed is developed using input values regarding the different elements such as lifetime and the distribution of these values. A Monte Carlo simulation can be very good at describing a complex system, but requires a lot of work to develop (Aven 2008).

2.2.5 Risk Management

Risk management mainly deals with how a company can balance profit and progress from a financial perspective with safety. In general, in cases with small uncertainties, more concrete measures can be put in place, such as accurate statistics, regulations and requirements. Dealing with larger uncertainties, the measures become a lot more theoretical and imprecise. In general, companies with low tolerance for risk will use the cautionary principle, which motivate many of the other principles, such as the ALARP principle mentioned below (Aven 2014). Risk management can be described as decision-making regarding what measures should be put in place. Some decision-making tools and principles are described in the following sections, again highly non exhaustive and general in nature.

2.2.5.1 The ALARP Principle

ALARP should be briefly discussed due to its extensive use. ALARP stands for As Low As Reasonably Practicable. This basically means that you should implement every risk reducing measure you can as long as it is not unreasonable from an economic perspective, meaning that the cost is too high for the benefit. In this sense the ALARP principle balances out the more profit focused cost-benefit analysis (Aven 2008).

2.2.5.2 The Cost-Benefit Analysis in a Risk Context

A cost-benefit analysis compares the cost of an investment or implemented safety measure with the long term benefits or profits. One common way of doing this is by calculating net present value (NPV), where NPV takes into consideration the current spending on the cost against the long term income or saved costs in the future. It might be difficult to include values to the company that are not easily converted into monetary values, like the public's views, employee satisfaction, increased interest in your company from job applicants because of your reputation for safety, and so on.

2.2.5.3 The Cost-Effectiveness Analysis
This can be used to compare several safety measures. Aven states:
"We may think of a safety measure as cost-effective if it is (Petitti 2000):

- Less costly and at least as effective
- More effective and more costly, with the added benefit worth the added cost.
- Less effective and less costly, with the added benefit of the alternative not worth the added cost.
- Cost-saving with an equal or better outcome."

(Aven 2014 p.168)

2.2.5.4 Expected Utility Theory
This is a way of making decisions where instead of pure profit it is possible to calculate the utility to the company. This means that the company's attitude towards risk can be incorporated. If a company is risk averse, a serious accident will be counted as a large negative towards the utility of the company. Aven calls this "the ruling theoretical paradigm for decision-making under uncertainty" (Aven 2014 p.169).

2.2.5.5 An Extended Perspective
Aven states "The risk-based approaches incorporate risk assessments, but they need to be extended and have a broader scope than the standard probabilistic analysis commonly seen in text books and practise today . . . A Focus on knowledge building, transfer of experience and learning represents and important means to manage the risk related to surprises and black swans . . ." Black swans referred to here are incidents that were not foreseen or known about by the experts or the common risk assessment paradigm. The reason for including this quote, however, is to put emphasis on learning as mentioned in this statement. This will be an important part of the paper later on and will transition into the next section, which will concern organisational culture, including learning, decision-making, communication and change.

2.3 The Organisational Aspect

The organisation of a company is in itself a whole field of study. Some concepts will be mentioned here because of their usefulness later on, since they relate to how a company can manage risk and how well the risk measures put in place are followed up by the employees.

2.3.1 Organisational Culture
The organisational culture is a complex concept, but it basically comes down to a shared set of assumptions, thoughts and attitudes among the employees of an organisation. The employees influence each other by their behaviour and there is established a common culture. It can be very interesting for a company to see how the culture matches up to the company's official goals, strategy, rules and regulations, especially when it comes to the topic of safety (Jacobsen & Thorsvik 2013). For a more systematic approach, it is possible to divide organisational culture into four categories, listed and given a short explanation below.

2.3.1.1 Basic Assumptions
These are opinions or views that are held as true by the group in general. They may be described as the right way to think, handle or feel about certain subjects. These are typically so foundational that they are not regularly questioned or brought up in a conscious way. Some examples of this might be to what degree rationality is valued compared to emotions, how power should be distributed and respected, how to decide on what is true, what level of conflict is accepted, if humans are basically selfish or altruistic and so on. These are underlying in a way that they might not be brought up explicitly, especially by someone on the inside (Jacobsen & Thorsvik 2013).

2.3.1.2 Values
This is what the company views as desirable. This is often connected to the basic assumptions and thus influences how the company acts. An example could be that if the company's basic assumption is that employees should not question their managers and hierarchy should be strict, they might react harshly to any insubordination or criticism of the managers' decisions (Jacobsen & Thorsvik 2013). There might be a difference in the espoused values, what the company says it values, and the enacted values, what the company shows it values through action. The espoused values could also be used as an interchangeable term for the norms a company has. If there are norms that no one follows, that would indicate a difference in the espoused and the enacted values (Kreitner & Kinicki 2006).

2.3.1.3 Norms
Norms are rules, sometimes unwritten, that people are expected to follow. These can also be shared by many companies in a country or industry. The norms might often be put into writing and many companies have extensive guidelines to everything from how to handle gifts, dress code and what fonts should be used in official documents. Safety procedures and guidelines are also part of this category. Breaking a norm will normally lead to a punishment of some sort. In more extreme cases, the punishment might be that the employee is fired and reported to the police and for some of the unwritten rules the punishment could be the disdain of the co-workers (Jacobsen & Thorsvik 2013).

2.3.1.4 Artefacts
Artefacts are physical object, language, text, symbols, figures of speech, unwritten dress codes, behaviour, body language and similar phenomena that are a physical expression of the culture in the company (Jacobsen & Thorsvik 2013).

2.3.2 Organisational Learning
Organisational learning concerns how good a company is at picking up information about the company's internal affairs and the external environment and forces and make changes to better meet the challenges posed to them (Jacobsen & Thorsvik 2013). There are many benefits for a company that is effective at learning, but the main concern in this paper is the improved safety that can result from a good learning process. For a company to be good at

managing risk it might be useful to be mindful of how good the company is at adjusting to safety problems. It is important for a company to make sure that problems present on production facilities are properly reported, informing decisions made and that measures are taken. If this process is impaired, problems might go unnoticed until a major accident occurs.

There are different definitions of organisational learning. Jacobsen and Thorsvik (2013) give four common aspects in the different definitions. When an organisation is learning, it:

- registers stimuli, meaning the organisation notices a trend or a problem they want to change or fix.
- assesses and/or analyses the problem, the organisation tries to understand what causes the trend or problem.
- comes up with measures to treat the cause and solve the problems.
- implements these measures effectively, meaning that the organisations actions are changed, not just it's words

2.3.2.1 PDCA as an Approach to Improvement

PDCA is an acronym of Plan-Do-Check-Act. It is also called a Deming Cycle. It is a general approach to improving any type of process or product. The steps will be described briefly here, because this approach is mentioned later in the thesis.

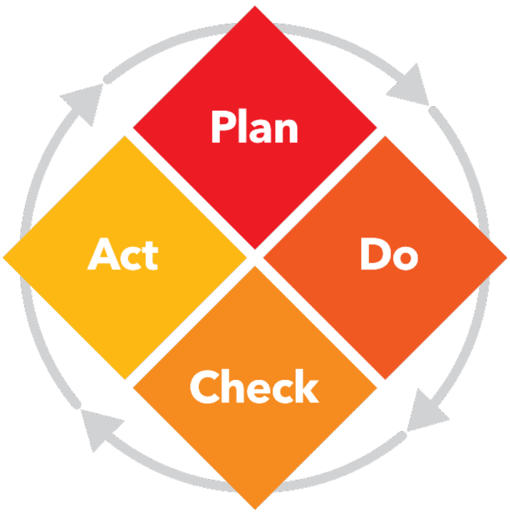

Illustration 3: PDCA or Deming Cycle (Mertz 2011)

- Plan
    - In this phase assessing and defining the problems is the focus.
    - Solutions are proposed and planned for.
- Do
    - Test the solutions, in smaller scale implementations or for a test period.
- Check
    - Evaluate the solutions found and tested in the ”do” phase.

- Act
    - Full implementation of the solutions developed in the ”do” and ”check” phases.

This process can be repeated periodically to ensure continuous improvements are made (American Society for Quality, 2016).

2.4 Indicators

An indicator is a parameter or measurement that is chosen to represent a wider set of parameters. Data is gathered and processed. A simple example could be using test scores to indicate a student's knowledge of a certain subject. It could be that the student only knew the specific knowledge asked for in the specific test, but it will tend to be the case that students with high knowledge get high scores and students with poor knowledge get low scores. Indicators are often used to evaluate the performance of a company in financial terms and also in safety terms, which is of most interest in this paper. Many times the indicators will be referred to as KPIs, Key Performance Indicators. This phrase suggests that these indicators are seen as especially good at indicating performance in a certain field. In this paper, the term indicator will be used alone, but explanations will be given for why they are chosen. Part of the reason for this is that each company will have to develop a set of indicators that work for them specifically.

There are different methods for choosing indicators. In general, it can be said that they focus on how a company can select the ones that pertain to areas that are especially important to the company.

2.4.1 Balanced Scorecard Method and Variations

Variations on this method exist, but the main focus is that the company has a balanced strategical approach to its operation and that the performance indicators are focused on showing to what degree the strategical goals are being fulfilled. It is important that the indicators deal with aspects that the company has control over and so that they can react to the information they gather. Parmenter suggested a change of the focus to what he calls the critical factors, which are those aspects that are critical to achieving success in one area of your strategy (Parmenter 2015).

2.4.2 The Petroleum Safety Authority Norway's Use of Indicators

Yearly reports are released that contain analysis called RNNP, a Norwegian acronym meaning risk level in the Norwegian petroleum industry. Two methods are used, one is general studies, interviews and such which are used for broader analysis. More relevant here is the second, more central aspect, which is using indicators called DFUs. DFU stands for defined hazard and accident conditions (Norwegian acronym). For some of these, several sub-indicators are used. The DFUs are the basis of the analysis and they are divided into categories depending on the potential consequences. As an example of the categorisation, some DFUs are indicators for major accidents, while others are indicators for minor accidents or personal injury (Petroleum Safety Authority Norway 2016).

2.4.3 Leading vs. Lagging Indicators

The terms leading and lagging are often used to describe indicators. Leading indicators are chosen for their assumed ability to show signs of a coming trend. In our case concerning safety, it could be to show a detrimental trend that could lead to an incident the company wishes to avoid or prevent. A lagging indicator shows incidents that have already happened, but can show how the trend is for these incidents. Many of the DFUs mentioned in the above section is lagging, in that they show what has happened and the analysis is based on the rate of these compared to previous years.

The EWT tool described in the rest of this thesis makes use of some leading indicators. Meaning indicators that deal with data before or without failure occurring. However, for some of the indicator, the leading/lagging description might not be as easy to apply. Leading and lagging might be better described as a spectrum (Rogers, Evans & Wright, 2009). A decidedly lagging indicator might be the number of fatalities per year. A leading indicator might be how often the safety guidelines are updated. Something that might land more in the middle of the spectrum could be maintenance performed after a component or a system has failed, but that has not lead to an incident.

When selecting a leading indicator, it is important that the aspect the indicator measures is related to the incidents the company wants to avoid by using the indicator. The indicator is useless if the output it gives does not adequately describe the actual situation (Rogers, Evans & Wright, 2009).

3 The Early Warning Tool (EWT)

3.1 The EWT name

EWT is an acronym of Early Warning Tool and is used in this thesis to make it easier to refer to the specific tool or method described here.

3.2 Introducing the EWT

EWT combines indicators mainly relating to measures and work that can prevent the initiating events. EWT is set in the context of cutting costs and the indicators that are chosen are focused on aspects that are heavily influenced by typical cost cutting measures like reducing the number of personnel. Thus, it serves as an early warning system for when the cost cutting measures, or possibly other factors, have led to an unacceptable situation. The purpose of the tool is not to provide absolute measures of risk or risk level. Instead, it will show trends for the indicators, giving warnings if there is a significant change compared to the historical data. In some cases, absolute limits might also be applied. As such, it is meant to be a tool to assist in risk management by telling you that certain aspects of the operation show a detrimental trend. The EWT also does not provide you with an exact answer to why a trend is happening. This has to be investigated separately, the tool only tells you when investigation and control is urgently required.

3.2.1 How the EWT is Structured

The EWT makes use of three levels of warnings; grey, yellow and red, in ascending order. A grey warning might be given where there is a slight deviation from the historical average, yellow being more severe and red representing a large deviation. Certain indicators have been selected. The fact that these specific ones are chosen should not be seen as stating that these are objectively the best ones to use. Companies themselves have to select these based on their own assessments. Nonetheless, these are chosen because they relate to certain aspects of the operation that a company might or should want to supervise and regulate. In most cases, warnings are given based on how many standard deviations the latest values are from the historical average. In a few cases, absolute limits to the data are used instead of standard deviations. Standard deviation is used because it shows if the latest data is in line with the historical data. The standard deviation is a calculation of variation for a dataset. In all cases the warnings will only be issued if the trends move in a negative direction. If the trend moves in a direction deemed desirable, warnings will not be issued, even though the data lies outside the standard deviation limits. This means that a significant drop in the number of findings during inspections will not issue a warning, even if it is a new trend. Efforts should be made to make sure the reason for a drop is not because the inspections have grown ineffective at uncovering the problems that are present.

3.2.1.1 Issued Warnings

When certain limits are exceeded for the indicators a warning will be issued. The categories are as mentioned, grey, yellow and red in ascending order of severity.

The warnings will show up on pages dedicated for each warning, this way, these pages can be looked at to see if there are issued any warnings without searching through the entire EWT. This also means that just the warnings could easily be printed or extracted and used as background information for meetings concerning the installation's status. There are many ways this could be done. Warnings could automatically be sent to people responsible for the safety on the installations. Many companies focus on visibility to increase focus and they could display the warnings. Seeing something visually helps people have a clear picture of it and to prioritise it.

3.2.2 The Technical Structure of the Tool

For most indicators, there will be a datasheet, where the data is listed against the date it was recorded. Then there is a page, later described as the indicator page, where the calculations are done, showing the averages, maximum standard deviations and absolute limits for the warnings to be given, and if any warning is being issued. If an indicator has a value that exceeds the warning limits, a warning will be issued. This will show up on the pages dedicated to each of the types of warning.

3.2.2.1 Data Sheets, -Collection and -Treatment

In this thesis and in the MS Excel based version of the EWT described here, data is put in manually. It is also not actual data from the real world, but just randomly calculated to simulate a possible dataset. If a company wishes, it could build separate software, for example in Java or a different programming language, to deal with the data collection and treatment done in the model. This would take a little effort, but might make it a close to automatic process for the tool to run and update when new data comes in. The company will have to find efficient and reliable ways for data to be recorded and collected from the installations and production facilities.

3.2.2.2 Warnings, Historical Averages and Standard Deviation Limits

In most cases the indicators will have a dataset of values within a range. In this thesis most of the datasets are normally distributed. There will be averages for last month, last three months, last six months and last twelve months to compare with the historical average. For each of these, the data is excluded from the historical data it is compared to, so that for comparing the last three months to the historical average, the last three months are excluded from the historical average in this specific comparison. The standard deviation limits for the different warnings used in this thesis are set at basically arbitrary levels, in the sense that they are not based on analysis, data or expert opinion. They do however have the property that for the shorter periods, for example last month, a large deviation will be required for a warning to be given. For larger samples, such as the last 12 months, smaller deviations will give warnings as they better represent a trend compared to the historical average. The company should try to find the standard deviations that are appropriate for them, through analysis and review. Maintenance and further development of the EWT is discussed in section 3.5.

3.2.3 Configurations of EWT

To simplify the descriptions in the rest of the thesis, it is important to define what is meant by a configuration. In this thesis, configurations of the EWT will refer to a tool that has been constructed in the same way and has the same purpose as the EWT described here, but might uses different indicators, software, parameters and warning limits. Thus, the specific indicators and warning limits chosen in this thesis is one configuration of EWT. This is not done to envelop other pre-existing methods and approaches using indicators. It is only done to make it simpler to describe the same general tool, meaning using indicators in a similar fashion as an early warning system to prevent the initiating events, and to describe the specific indicators and limits chosen in this thesis, which is one configuration of EWT. Also included in the term configuration is the form factor, style and visual representation of the EWT.

3.3 The EWT's Place in Risk Management

The EWT is meant as a help in decision-making regarding the day-to-day operation of an installation or facility, to give early warning when safety in the operation has been compromised and to be a supplement to more rigorous and in depth risk analysis. It will most likely be used by the management that oversees the installation or facility to gauge the situation. The EWT is made so that it is easy to print or extract the warnings for use when discussing the situation in weekly or monthly meetings. The tool indicates areas where an initiating event could happen, leading to a more serious incident and also shows holes in the barriers or recovery controls put up to deal with incidents, mainly regarding the safety protocols put in place. As mentioned throughout this thesis, it is not meant to be the sole support when making decisions, or as the only tool of finding problems in the operation. It is an implementation to be used in the spirit of ALARP, described in section 2.2.5.1, that could promote and improve safe operation, eliminating certain threats. The ALARP principle states that the measure should be put in place if it does not put an unreasonable financial strain on the company (Aven 2008). In the case of EWT, it is a relatively small cost for a potentially important benefit. It does, however, give the management a better view of the situation, so that the risk can be treated before an incident has occurred, instead of as a reaction to harmful incidents occurring.

3.4 Selecting Indicators

In this section a short explanation of how and why indicators have been chosen for this specific configuration of EWT and how companies can go about choosing and modifying the indicators that work best for them, meaning to find their configuration.

3.4.1 Basis for Selection in this EWT Configuration

Further discussions on this point will be made for every indicator later on, but a general discussion follows here. The indicators are selected for areas where problems can lead to initiating events. There is special focus on aspects affected by cutting costs, typically personnel or manpower assigned to a certain area. In this way, controlling for the increased risk exposure indicated might often involve increasing the amount of personnel or making their work more efficient. Another important focus has been on the organisational learning and safety culture in the company. This involves how thoroughly the situation is evaluated, how well measures are implemented and if the rules are being followed.

3.4.2 Brief Discussion on General Basis for Selection

Companies should find indicators that work for them and that relate to the aspects that matter in their case for showing a negative trend in the safety of the operation. The specific indicators chosen in this thesis is a suggestion. Continuous improvement of the EWT should be strived for and maintenance and improvement of the tool is discussed in section 3.5.

3.5 Maintenance and Improvement of the EWT Configuration

To ensure that the configuration of the EWT is continuously updated and improved, a plan and measures should be put in place. The tool should be evaluated at set time intervals. The company could use a PDCA principle, Plan-Do-Check-Act, when evaluating the model.

In the ”plan” stage, it would be investigated whether the current indicators catch the negative trends happening in the areas the company would like to control. The company would also see if there are any areas that they otherwise have seen a negative trend or problems in, that are not caught by the indicators currently used. The warning limits should also be evaluated, so that warnings are not given to frequently or easily, resulting in delegitimising of the more serious warnings. It is highly undesirable for the red warning, for example, to cause little to no concern, because the management has seen it before without there being a serious problem. Solutions are proposed and planned for.

In the ”do” stage, new indicators, limits and other modifications to the configuration, set-up and implementation would be tested or implemented. The new suggestions could be tested using older data, comparing it to the current configuration and so on.

In the ”check” stage the group would evaluate whether the new suggestions should be implemented. There is no problem in adding new indicators, as far as the tool itself is concerned. The only issue would be to make sure the tool is not cluttered or that there is information overload, making it unmanageable to use. In the case of new indicators, the warning limits have to be evaluated as well.

In the ”act” stage, the updated configuration will be fully implemented and put into use. If the check stage concludes that the implementation in the ”do” phase is unacceptable, a new cycle might be initiating, starting again with the ”plan” stage.

There are different ways of arranging the assessment and maintenance of the tool and using PDCA is one suggestion. The most important thing is that the tool is questioned and looked at, so as not to give a false sense of safety and relied upon too heavily. Changes in the operation and unavoidable trends are also important reasons to continually assess the EWT configuration.

3.5.1 Concerning the Limits

The group evaluating the configuration should also investigate whether the limits are appropriate for the data group. It is possible to ”cheat” by removing unwanted statistical anomalies and periods of operation at an unacceptable level that increase the variation in the historical averages. It is after all, a tool meant to give warning that a trend deemed undesirable is showing up, this is especially true for aspect where the company is very sensitive to a negative trend. Of course, removing data is basically the same as lowering the maximum deviation limit, if a maximum deviation from the historical average is used to determine when a warning will be issued.

4 Description and Discussion of the EWT Configuration Developed in This Thesis

This section will in detail describe the specific EWT configuration that has been developed in this thesis and give reasons for why it is this way. Some general considerations about this configuration have also been made in section 3. It is important to remember that the fact that this configuration has been developed in MS Excel has implications for the form factor of the tool, however the content could be represented just as well using other software or form factors. The configuration is included in full form in appendix A. To get a full picture of this configuration it is strongly recommended to use appendix A as a reference to follow along with the descriptions in these sections. Short descriptions of the elements on each page are also given in appendix A, for each page of the configuration.

4.1 Indicator Grouping

Some of the indicators used in this configuration, could be split into two or more separate indicators, but are combined into one as they are closely related. An example of this is the grouping together for the safety critical maintenance

4.2 Structure

There will be pages where the indicator results are calculated and where the warning limits and status is given. There will be one or more of these for each indicator and will be referred to in this thesis as an ”indicator page”. The data for the indicators will be on separate pages and will be called the ”data pages” for the indicator. This structure is in part influenced by MS Excels format, using spreadsheets.

4.3 The Warning Pages

Three pages at the front of this EWT configuration is dedicated to displaying the warnings that are issued based on the latest data. These are coloured in the respective colours of the warnings to emphasise their meaning. Large fonts are used to make the warnings stand out. Red is displayed first, since these are first priority and must be dealt with urgently. Yellow follows and grey is last. The grey warnings imply a trend, but do not mean a drastic change has happened.

4.3.1 Options

Many different variations and modifications on this solution can be made. Companies might want to make technical solutions where warnings are sent automatically to people in management, or displayed, printed or similarly conveyed. Different stylistic choices might improve or worsen the visual impression a warning gives. It is desirable for a warning to stir up an appropriate response from the viewers assessing the situation, so as to call for action. Depending on the software and technology used to run the EWT, different ways of displaying or conveying the warnings might be appropriate or preferable.

4.4 Indicator #1: Safety Procedures

4.4.1 Description

Most companies have safety procedures and guidelines set in place. In this configuration, 10 procedures are used, an arbitrary number. The procedures are not defined and are called procedures, but could just as well refer to certain guidelines or rules the company might wish to update with some regularity. These are updated regularly within deadlines set by the company, in this configuration this is called the update cycle. This indicator checks if the procedures are updated, and if the deadlines have passed, how many weeks overdue they are. Warnings are given at certain numbers of weeks past deadline. Warnings are also given when certain numbers of procedures are past deadline. A grey warning will be issued the moment any procedure is past deadline.

The second part of the indicator checks if the training has been updated following an update of the procedures, meaning that the training that the personnel receives includes the new information and guidelines given in the last update of the procedure. The training is also numbered from 1-10, not to denote 10 trainings regimes, but to denote procedures and the training that involves the procedures. Some training might involve more than one procedure. After each procedure is updated, all training that is relevant to what the procedure describes, should be updated to make sure it complies. Again, warnings are given if a certain number of weeks, the set limit, have past since the update of the procedure. In addition, warnings are given based on how many procedures have been updated, but where training has not been updated to follow. If even one procedure has been updated, without the relevant training being updated, a grey warning is issued.

For both tables the last column states whether a warning is issued for any of the procedures/training, or for the total number that have passed the deadline.

4.4.2 Reasons for Inclusion and Discussion

This indicator relates to a few factors. One aspect is organisational learning and risk treatment, in that it shows that the company is on top of keeping its safety procedures updated. Of course, it is important to keep in mind that the indicator says nothing about the quality of the updates or the degree of which the company actually responds in a correct way. This will be the case with several indicators in this configuration and that is mostly due to the nature of the tool. The quality of learning and risk treatment, meaning how well the company's treatment will have to be evaluated in other ways, using other methods. Another factor is showing if there is a trend towards procedures being overdue that might be the cause of the updates being of low priority or drowning in other responsibilities of the group that is tasked with updating. This will have to be investigated and corrected if needed. If the resources are there and the company uses tests to evaluate the employees' knowledge, test results could be included in this indicator. In this case, both an absolute numbers and trends could be used to issue warnings.

4.4.3 Comments on the Limits

The limits are set somewhat arbitrarily. In the case of the safety procedures, there will be a grey warning if deadline is exceeded, a yellow at 4 weeks past deadline and red for 8 weeks past deadline. This is for procedures with update cycles of 24 months, another arbitrary number. Some procedures have shorter update cycles and also shorter limits for weeks past deadline. This reflects a need for some procedures to be updated more often and to make sure that they are updated in time. This could be for special processes that change, new technology, or involving especially high risk exposure.

For the training, a grey warning is given if a procedure is updated without the relevant training being updated. A yellow warning is given after 3 weeks and red after 6 weeks for most cases. Again, for some there is a need to be quicker, as they are especially safety critical, and so the limits are set lower.

4.4.4 The Data Page

The dataset include the current date, the update cycle for each procedure, the time of the last update and deadline for the next update and how many weeks have passed over the deadline, if this is the case.

4.5 Indicator #2: Safety Critical Maintenance and Inspection

4.5.1 Description

This indicator has several sub-indicators contained in it. It has three separate parameters and two datapoints that are recorded for every month. The three separate parameters are safety critical preventive maintenance, corrective maintenance and inspection. By safety critical it is meant components, machines, sensors, bolts, electrical wiring and so on, that will have a negative impact on the safety if they fail or are compromised. Some examples might be smoke detectors, safety valves, bolts securing walkways, railings and equipment, chains used in lifting, ropes et cetera. Failure of these might lead to an initiating event that could lead to a serious incident, or might be a barrier for hindering incidents or recovery control for reducing the consequences. By preventive maintenance is meant regular maintenance that is scheduled based on the knowledge of the lifetime of certain parts, requirements for lubrication, replacing certain types of isolation and so on. This is done without any sign that there is a problem requiring maintenance, but to pre-emptively deal with the problems that could happen if the maintenance was delayed. Corrective maintenance refers to maintenance performed after something has gone wrong, a problem has been detected or detection of a compromise or weakness during an inspection. This definition could be changed to only mean parts that have already broken, and not include parts that are only weakened and replaced pre-emptively, but here these are both included in corrective. To clarify, scheduled maintenance without any detected problem, is classified as preventive. If any problem or weakness has been detected, it is classified as corrective. Inspection is any inspection scheduled on parts, machines or systems that are safety critical.

For these three categories, preventive, corrective and inspection, two datapoints are registered from the installation or facility after each month. These are the planned or scheduled hours and the finished hours. Since its being recorded after the month is over, any corrective maintenance scheduled during the month is counted in the planned/scheduled amount of hours and the same goes for preventive and inspection. The finished amount of hours is the number of hours actually finished. For the indicator, the ratio between the planned and the finished amount of hours is used, this is referred to as the ratio from now on. This is then compared to the historical average and the warning limits are given in how far removed the last ratio is compared to the historical average. The deviation is measured in standard deviations, where the standard deviation is calculated from the historical average.

This process is done for last month's ratio, for the average ratio of the last three months, six months and twelve months. This is to catch trends happening over different time periods. Using only short time periods would only catch rapid changes, however, there might be a slower upward trend over a year that is nonetheless problematic. In each case, the historical average is calculated from the months leading up to that period. An example to clarify would be that the indicator would compare the average ratio between planned and finished corrective maintenance for the three month period February-April, to the historical average ending at January the same year. The comparison would be done by seeing how many standard deviations the average ratio for February-April, is removed from the historical average. The standard deviation is calculated from the historical data, which includes January and earlier.

To summarise, there are three parameters, preventive, corrective and inspection, where the ratio between planned and finished, is compared to the historical average monthly ratio by how many standard deviations they are removed. This is done for last month, the last three months, the last six months and last twelve months.

For all these there are warning limits, which are given as numbers of standard deviations removed. For a grey warning, a low number of standard deviations are required and for a red warning a high number of standard deviations are required.

There is one more factor that is calculated in the indicator and that is the total number of planned hours for corrective maintenance. The total number for the last month, average monthly number for the last three, six and twelve months are compared to the historical average and the difference is calculated in the number of standard deviation removed from the average. Standard deviation limits are given for the last, last three, last six and last twelve months. This factor is used to detect a trend of increasing corrective maintenance, meaning a probable increase in maintenance performed after a problem has been detected.

For all these numbers, the table showing the deviation also announces whether or not a warning is issued. Graphs for the ratios of the three, preventive, corrective and inspection is also given, for visual reference.

	Preventive		Corrective		Inspection	
	St.Dev removed	**Warning**	St.Dev removed	**Warning**	St.Dev removed	**Warning**
Last month	0,50	**No**	-1,64	**No**	-1,91	**No**
Last 3 months	0,51	**No**	-0,54	**No**	0,20	**No**
Last 6 months	0,38	**No**	-0,42	**No**	0,18	**No**
Last 12 months	-0,33	**No**	-0,23	**No**	0,20	**No**

Table 2: Example from Appendix A, showing the number of standard deviations the data is removed from the historical average, and whether or not a warning is issued. Here, no warnings are issued.

4.5.2 Reasons for Inclusion and Discussion

There are two main reasons for including this indicator. The first is because this directly deals with preventing initiating events caused by component and systems failure and maintaining the barriers and recovery controls to hinder incidents and reduce the consequences when an incident has occurred. Many typical initiating events is due to component or system failure, examples could be a broken safety valve, hydrocarbon leak due to a broken seal or a falling object due to a weakened chain snapping. The second reason is because it correlates with a common cost cutting measure, reducing personnel, and one of the main focuses of this thesis and EWT as a tool is controlling risk at an early stage during a period of cost cutting. The corrective maintenance increasing also shows that more preventive maintenance should be scheduled. Because corrective maintenance basically represents a close call for an initiating event, the company should try to reduce this as much as possible by preventive maintenance where it is practically possible. The reason for separating preventive and corrective maintenance is that a lower amount of corrective maintenance correlates with a safer and better maintained installation and facility. A lot of corrective maintenance is a negative thing, while preventive maintenance does not have to be, from a safety standpoint. Because corrective maintenance is a result of something being wrong, it is desirable for the company to reduce the amount by preventing these problems in the first place.

4.5.3 Comments on the Limits

The limits set here are numbers of standard deviations that the datapoint being evaluated is removed from the historical average. Two general principles are used to guide the selection of the limits, although they are still close to arbitrary. The first principle is that a small number of standard deviations is required to issue a grey warning, a larger amount is required for yellow and an even larger for a red warning. In addition to this, a larger number of standard deviations are required to issue a warning for the last month, compared to issuing a warning for the last three months, and even more so compared to the last six months. This is because the dataset becomes larger as more months are included. If no real change has happened compared to earlier periods, it is expected that the monthly average for twelve months will tend towards the historical average. Therefore, a smaller deviation is required to give a warning for a larger period of time. For a single datapoint, larger variation is possible compared to an average for a number of datapoints.

4.5.4 The Data Page

The dataset includes amounts of hours, planned and finished, for preventive maintenance, corrective maintenance and inspection. The ratio is also calculated on the datapage, eventhough this is just a function of the planned and finished amount of hours. The data is randomly generated, but the planned hours are normally distributed, which quite possibly is the case in reality. The data is listed for every month since 2013.

4.6 Indicator #3: Non-Safety Critical Maintenance and Inspection

4.6.1 Description

This indicator is in many ways similar to indicator #2, and will be described in somewhat shorter terms because of this. It is highly advisable to read section 4.5 on indicator #2, first. As with indicator #2, this one also involves preventive maintenance, corrective maintenance and inspection. In this case it is categorised as non-safety critical, meaning components, systems, parts and machines where failure will not cause a significant threat to safety. There are other things it will affect, such as operation. Examples of this could be a compressor used in production, where failure would halt operation, a light bulb flickering in a bathroom, broken air-condition in living quarters, a stuck valve not letting liquid through and so on. In some of these cases the argument could be made that it has some influence on the safety on the installation or facility, but here it will be classified as non-safety critical unless it has a significant effect on the safety level and could easily lead to an initiating event. As mentioned for indicator #2, preventive maintenance is scheduled maintenance where no problem has been detected, but is based on the previous knowledge of typical component lifecycles and similar information. Corrective maintenance is maintenance where something is broken or a weakness has been discovered during inspection.

For these three, preventive maintenance, corrective maintenance and inspection, the planned and the finished amount of hours are recorded at the end of each month. A ratio between planned and finished is calculated and used as the basis for determining a trend. This ratio is calculated for last month and the monthly average ratio is calculated for the last three months, six months and twelve months. A historical average ratio and standard deviation for all the monthly ratios in the dataset is calculated. For every one of the periods, last month, three, six and twelve months, a historical average and standard deviation is calculated, excluding the period itself and only using the data preceding the period. For example, the average for March-May, is calculated using data from February and earlier.

To summarise, there are three parameters, preventive, corrective and inspection, where the ratio between planned and finished, is compared to the historical average monthly ratio by how many standard deviations they are removed. This is done for last month, the last three months, the last six months and last twelve months.

As before, limits are set using standard deviations to denote a limit where a warning will be issued. This means that if the trend is that less and less of the planned maintenance and inspection is being finished, a warning will be issued based on how the trend deviates from the historical average.

For all these numbers, the table showing the deviation also announces whether or not a warning is issued. Graphs for the ratios of the three, preventive, corrective and inspection is also given, for visual reference.

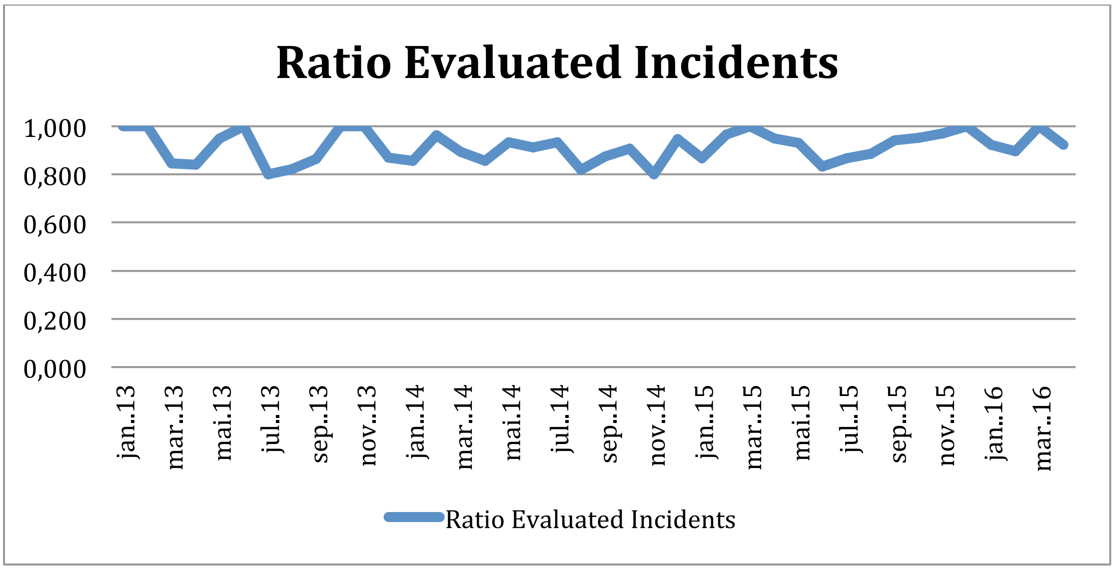

Illustration 4: Example from Appendix A, graph showing the historical data for the ratio between reported and evaluated incidents.

4.6.2 Reasons for Inclusion and Discussion

The reason for including this indicator is that is shows a negative trend in the maintenance and inspection of components and systems needed for proper operation and acceptable working conditions. While not critical for safety, these have an effect on the profits, in case of having to stop operation, and on the employees working environment. In addition, in the same way as indicator #2, it relates to the common cost cutting measure of reducing personnel. Again treatment of a problem could often be done by putting more personnel in or by better managing the current personnel's time. In addition, having good housekeeping can reduce many hazards in the working environment and also help the organisational culture. Housekeeping refers to keeping a clean, orderly and well maintained work environment (CCOHS 2016).

The definition and classification of safety non- critical, is something the company will have to find for themselves. The most important aspect is that it is clearly divided, thought through and that the management is aware what the term safety non-critical denotes in their case. Different terms might be used instead of safety non-critical. It is also possible to put all maintenance and inspection together, but this classification gives extra significance to the maintenance and inspection of components and systems, which are highly important for safety.

For safety non-critical maintenance, it is perhaps acceptable to have more corrective maintenance, than it is for safety critical maintenance. However, not having enough preventive maintenance might be damaging for operation, profits and the work environment. This is why the ratio between preventive and corrective is a factor included in the indicator. It might be desirable for the company to reduce the amount of corrective maintenance for the reasons listed above, concerning a stop to operation.

4.6.3 Comments on the Limit

Again the limits are given as a number of standard deviations removed from the historical average. These are arbitrarily set, but influenced by the principle that a larger deviation will have to occur for the shorter periods of time, such as one or three months, than the averages for longer periods, such as six or twelve months. Of course, in the same way as for other indicators, the limits set reflect the company's sensitivity to a change in this indicator. This has to be taken into consideration when setting and evaluating the limits. If it is regarded has highly undesirable the limits should be lowered.

4.6.4 The Data Page

The dataset includes amounts of hours, planned and finished, for preventive maintenance, corrective maintenance and inspection. The ratio is also calculated on the data page, even though this is just a function of the planned and finished amount of hours. The data is randomly generated, but the planned hours are normally distributed, and it is likely that there is some sort of distribution to the data in reality as well, so long as there are no large changes occurring during the data collection. The data is listed for every month since 2013. This has the same form as for indicator #2.

4.7 Indicator #4: Safety Critical Personnel Lacking Training

4.7.1 Description

This indicator uses the percentage of safety critical personnel lacking certain training to issue warnings. By safety critical personnel is meant personnel that carry out jobs that could lead to an initiating event or an incident if carried out in a wrong way. On an installation, this might involve most employees. There are two categories used, full training and critical training. Full training involves all the training the company wants the employees to complete. Critical training involves the training needed for safe operation for the different types of roles the employees fill. For each of these categories limits are given in percentages. A grey warning is always issued if anyone is lacking critical training, but there is a separate grey limit for full training. Limits are also set for yellow and red.

Percentage of safety critical personnel lacking critical training		
Lacking critical training	1	%
% at which yellow warning is given	2	%
% at which red warning is given	4	%
Warning?	**Grey**	

Table 3: Example from appendix A, table showing percentage of safety critical personnel lacking critical training, and limits for yellow and red warnings. Notice that a grey warning is issued, since the percentage is above 0 %.

4.7.2 Reasons for Inclusion and Discussion

This indicator is included for two main reasons. The first is that proper training is important to hinder initiating events, and also to act as a barrier to hinder an incident from occurring and a recovery control to reduce the consequences. Having employees act quickly and efficiently in a correct way could mean the difference between life and death for the employees themselves and could prevent a major accident involving several fatalities, injuries, damage to equipment and environment. As an example, consider an employee quickly extinguishing a fire that could have developed into an explosion because the employee knew where fire extinguishers where kept and how to use it. Or how clear escape routes and proper training could mean the difference between everyone getting on lifeboats and escaping from a major accident versus chaos causing people to die before escape can happen.

The other reason is to make sure that risk treatment measures that are instated by the management, reaches the employees and the installation or facility. Measures are of course only effective if the employees practise them and training is one part of making sure that this happens. It is of course no guarantee that the employees will follow the training, but a later indicator is used for this purpose.

4.7.3 Comments on the Limits

The limits are set arbitrarily here, but a company will have to decide how sensitive they are to employees not having full training. Naturally the limits for critical training are set considerably lower, since this training is deemed critical for safe operation. If any employee is lacking critical training, a grey warning will be issued. Note that in appendix A, this is one of the indicators where a yellow warning is issued as an example of what that would look like.

4.7.4 The Data Page

For this indicator there is no data page as there is no requirement of historical data to be used for comparison. It is assumed that the data is gathered directly from a database of the personnel and put straight into the indicator page. The datapoints for full and critical training is arbitrarily selected. It is possible to include historical data and compare the current data to this, if this is desired. It is not included here since it is seen as more likely that the management would not be satisfied that any personnel is lacking training. This is especially true for the critical training. Therefore, keeping it within certain limits of a historical average is useless.

4.8 Indicator #5: Evaluated Incidents

4.8.1 Description

This indicator describes how many of the incidents happening are evaluated. The incidents are evaluated to learn from them and to create a better picture of the risk exposure on the installation or facility. One datapoint is collected from the installation or facility, the number of incidents reported. In addition, the number of incidents evaluated is gathered. This happens monthly and it is assumed that the reported incidents each month is the incidents being evaluated. This might not be the case, but for simplicity's sake it is assumed here. An incident being evaluated means that the report is gone through and the causes of the incident is assessed. Possible solutions might be given as well, especially for recurring problems.

The indicator calculates the ratio between the number of reported incidents and the evaluated incidents. This is done for last month, the averages for the last three months, six months and twelve months. This is then compared to the historical average. The deviation from the historical average is given in number of standard deviations it is removed from the historical average. The historical average used excludes the period being assessed. Meaning that for the six month period November-April, the historical average and standard deviation is calculated from earlier data up to and including October.

Upper limits are set, in a number of standard deviation, for when warnings should be issued. As usual they give a grey, yellow and red warning, with increasing deviation. A chart showing the historical numbers in a visual way is also included.

4.8.2 Reasons for Inclusion and Discussion

This indicator is included to give a better picture of how the situation is as it relates to organisational learning and the risk assessment carried out by the management and assisting groups. Evaluating incidents can provide support for decision-making and provide background data for a more extensive risk analysis. Again, the indicator cannot directly tell us whether or not the evaluations that are made are of any use or correct, but it highlights an aspect that is important. A danger to this indicator is of course that the evaluation becomes little more than checking a box, rather than a proper assessment. This is where separate work is required to make sure that the process for evaluating incidents is carried out properly and that the information from this process can be used to support decisions. Still, it is useful to have this as an indicator to make sure that there is not a drop in the number of incidents being evaluated to a level that is not acceptable.

4.8.3 Comments on the Limits

These are set arbitrarily, but as usual increase with the severity of the warning. Again, the limits should reflect the company's sensitivity towards a negative trend in this area. If the company has decided that it is important for them that a high number of incidents that are reported also pass through the evaluation process, then the limits should be set at a low level.

4.8.4 The Data Page

The datapage gives data back to 2013. It is randomly generated and normally distributed, which might be the case in a real world implementation. The numbers of evaluated incidents are also recorded and a ratio between these is calculated.

4.9 Indicator #6: Findings During Safety Inspections

4.9.1 Discussion

This indicator uses the number of findings on the safety inspections performed on the installation or facility. By findings is meant any deviation from what have been laid out in the procedures and guidelines by the company, relating to safe operation. The inspections will check personnel and equipment. The inspections should be conducted at random times and without warning to give the best possible picture of the real situation. It is assumed that the EWT will deal with one installation or one facility without any significant expansion over the period used as historical data. The inspections might be conducted in different areas, at different times, and this should be adjusted for. If this is an issue, it would be possible to divide this indicator into inspections of different areas of the installation or facility, but this is not done here. As such, it is assumed that the inspection is conducted on the entire installation or facility at the same time. For larger facilities this might be done using several inspectors to make sure word does not spread for employees to adjust their behaviour and thus giving a false picture of the situation. The findings might be found using a checklist developed beforehand for this purpose. A monthly average is recorded on the datapage. Data from last month is used, in addition to the average for the last three months, six months and twelve months. Historical averages and standard deviations are calculated, excluding the periods above, to use for comparison. As an example, for comparing the three months December-February, the historical average and standard deviation is calculated using earlier data up to and including November.

This indicator includes some absolute limits set. This means that a warning will be issued if a monthly average for number of findings found during an inspection exceeds a certain limit.

In addition the average for the periods mentioned, last month, last three, six and twelve months, are compared to the historical average. The deviation is given in number of standard deviations it is removed from the historical average. Upper limits are set for a specific number of standard deviations removed when a warning will be issued. A chart showing the historical monthly averages of findings found per inspection is also included to give a visual representation.

4.9.2 Reasons for Inclusion and Discussion

There are two related reasons for why this indicator is useful to include in the model. First of all, the risk treatment measures, guidelines and procedures are put in place to lower the risk exposure. Failing to comply with these will raise the risk of something going wrong. An example might be someone not wearing a helmet. This could lead to fatal or severe head injury in case of a falling object. Showing to what degree the regulations put in place are being followed will give the company a more complete picture of the actual situation. A company might be satisfied with its rules and regulations, considering them safe, well thought out and exhaustive, but this is useless if the employees ignore them. This transitions into the other reason for including this indicator. It gives the company a better understanding of, and the opportunity to build and influence, the organisational culture on the installation or facility, and in the company as a whole, as it relates to safety and risk exposure. If it is seen as unnecessary to follow the regulations when they seem inefficient, time consuming or requiring some paperwork, this means that any risk treatment and safety measures being put into place are at the risk of being heavily compromised. A company needs to make changes to ensure that the regulations are being followed. Another aspect to this is that with reduced personnel and more work for the personnel left, often consequences of cost cutting, the organisational culture for safety could decline as this is not seen as a high priority and less effort is made in this area. The company should make an effort so that cutting costs do not lead to this trend.

4.9.3 Comments on the Limits
This indicator has both an absolute limit for the average monthly numbers of findings per inspection and standard deviation limits to compare the current data to the historical average. The reason for the absolute limit is to act as an extra measure to ensure that problems in this area are quickly found and treatment can be enacted. The limits here are set arbitrarily, depending on the severity of the warning. In addition, a larger deviation is required for shorter periods. The limits should represent the company's sensitivity towards findings being found, meaning that the regulations and procedures are not being followed. Note that in the appendix A, this is one of the indicators where a red warning is issued as an example of what that would look like.

4.9.4 The Data Page
The datapage gives data back to 2013. It shows the monthly average of number of findings per inspection. The numbers are randomly generated, with a normal distribution, as might be the case in reality where a changing trend is not present.

4.10 Indicator #7: Near Miss Incidents

4.10.1 Description

This indicator uses the number of reported incidents that have had no really harmful consequences. Some examples of this could be a chain breaking as a lift is started, not causing a falling object, a fire quickly being extinguished, a literal near miss collision by vehicles or object being lifted and similar events. The data being collected are reports of such incidents that did not lead to sever consequences. In a similar way to earlier indicators, the last month's number and the monthly averages of the last three, six and twelve months are compared to the historical average using standard deviations. The historical average and standard deviation is calculated excluding the period it is compared to. This means that for the six months August-January, the historical average and standard deviation is calculated from earlier data up to and including July. The deviation is measured in standard deviations and upper limits are given for the different periods. A graph showing the historical numbers is also included.

4.10.2 Reasons for Inclusions and Discussion

This indicator essentially reports incidents that have already happened. As such it deviates somewhat from the earlier indicators. It is included because it is important to take note of these situations, which are in fact incidents. Including it in the EWT makes sure to draw extra attention to an increase in these events. Practically speaking, only chance prevented injury or damage from happening. An increase in near miss incidents can indicate a decline in the safety culture, meaning that guidelines and procedures are not being followed. Near misses could also show up as a result of personnel being reduced or forced to work under more difficult conditions with less support. It is important to remember that it is a possibility that near misses are happening and not being reported. For this reason it is important that the company makes it easy for the employees to report such events and also make it easy for them to voice any worries about incidents not being reported. The management should also make it so that it is not tempting to avoid reporting a near miss incident. This is where the company needs to make some decisions about how to handle the information in these reports. Hard sanctions against people involved and a lot of extra work required from filing a report might act as an incentive to avoid reporting these. This is not desirable and will give a false picture of the situation at the installation or facility.

4.10.3 Comments on the Limits

The limits are influenced by the severity of the warning and the sample size. This results in the limit for a warning being higher for last month than for twelve months, since the larger dataset will tend towards an average. These limits should reflect the company's sensitivity towards changes in these near miss incidents.

4.10.4 The Data Page

The datapage gives data back to 2013. It shows the number of near miss incidents reported per month.

4.11 Comments About Including Other Lagging Indicators

The EWT and this configuration includes mainly leading indicators focused on preventing the initiating events, improving safety and reducing risk exposure from the start, rather than dealing with incidents once they have occurred. It would be possible to combine the EWT with other indicators. An example of this would be the indicators and DFUs used by the Petroleum Authority Norway. These generally deal with incidents that have already happened and show trends over larger periods of time, typically years. This means that they have a somewhat different purpose. Most of these, particularly the ones dealing with serious accidents, will only show change once the situation has deteriorated significantly. Another problem is, of course, that one major accident can show up as a huge deviation, but the problems causing the major accidents have been there all along and only chance caused the accident to happen at this moment. This means the company has little data to deal with and to use for risk assessment and treatment. This is where EWT aims to aid and that is also why these lagging, major incident indicators are not included in this configuration. As mentioned earlier, a company could of course choose to incorporate these if they wish

One aspect that might prove useful is to have lagging indicators used to check the leading indicators. The lagging indicators will have to be directly connected to the outcome of the aspects the leading indicators describe. This is a way to check if the leading indicators are effective. Using this type of method it is important to be mindful of how well the indicators chosen relate to each other.

5 Ending Remarks

In the beginning of the thesis, it was stated that the objective was to develop a tool to aid in decision-making using indicators. In this thesis EWT has been presented as a solution to this and a specific configuration has been developed. Indicators were chosen that focused on controlling aspects that could lead to initiating events. This way the indicators can be used to make sure safety does not suffer while cutting costs, which is the other focus when choosing the indicators. It is important to remember that EWT is just meant as an aid to decision-making and as an extra measure to give early warning.

Companies that wish to follow the ALARP principle should develop tools like EWT as a supplement to more extensive risk analysis and other risk assessment tools. They will have to evaluate their particular needs and situation, and use this information to choose correct indicators and factors to evaluate. EWT or a similar tool would be a relatively simple and inexpensive measure that could be implemented.

5.1 Further Work

Many of the indicators described in this thesis, deals with a certain aspect of the operation, such as the safety culture on the installation or facility. Many of these deal with amounts, such as number of findings on an inspection. An interesting further development would be to develop good indicators, for the different areas of operation, that can better test the quality of the operation and safety measures put in place. An example might be the percentage of personnel with training. Using the percentage only says how many sat through the training, which is useful, but being able to indicate how well trained and prepared the personnel is would be better. Written and practical tests are suggestions, but would need to be implemented well. In addition, it is important that the indicators cover all the areas that the company wants to control. A systematic approach to finding these areas and indicators should be used.

Another interesting aspect would be to look at integrating more advanced methods into tools like the EWT and other decision-making aids. An example would be to incorporate risk analysis and probability tools, such as Monte Carlo simulations or Bayesian networks, to see whether these could be useful for improving the tools. The EWT only deals with known hazards. Maybe it could be possible to include some considerations about so-called black swans, unknown unknowns, in such a tool as well.

Further work could also be done; looking into how decision-making tools can best be put into use to manage change. This relates to the role these tools have, when and how they are applied, improvements that could be made to them and how the companies can best learn from and act on the output of these tools. Developing good ways of delivering the information and visual aids is also part of this.

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6.1 Illustrations

Illustration 1: Example of bow tie diagram.
Aquisition Safety & Environmental Management System ”Bow-Tie Diagram”, accessed 10. june 2016. <https://www.asems.mod.uk/content/bow-tie-diagram>

Illustration 3: PDCA or Deming Cycle.
Mertz, J. (2011)”Plan-Do-Check-Act Your Health IT Initatives” Corepoint Health, accessed 10. june 2016. <http://corepointhealth.com/geni/plan-do-check-act-your-health-it-initiatives>

Appendix A

In this appendix the full EWT configuration used/found in this thesis is included. For each inidcator there will be one or more indicator page(s), and usually a data page.

Before each page, a page comments on what the following page contains. These comment pages are marked at the top with lines and the word "Commentary".

Explanation of historical averages and standard deviations
Several places in this configuration hsitorical averages and standard deviations are used for comparison against data from a certain period. To compare the historical data to this period, the data from the period itself is excluded.

Example
For comparing data from february 2015 to the historical average, the historical average is calculated from earlier data, up to and including january 2015.

For comparing data from january and february 2015 to the historical average, the historical data is calculated using earlier data, up to and including december 2014.

This will be denotes in the tables as:
Historical average

ex last month	XX
ex three months	XX

and so on, indicating that last month is excluded for the row "ex last month" and the last three months are excluded for the row "ex three months"

Commentary

The following page shows all the red warnings issued by the EW. One warning is issued, that red limits have been exceeded in indicator #1.

Red Warnings

Limits exceeded for Indicator #1: Safety Procedures

Commentary

The following page shows all the yellow warnings issued by the EW. One warning is issued, that yellow limits have been exceeded in indicator #4.

Yellow Warnings

Limits exceeded for Indicator #4: Safety Critical Personnel Lacking Training

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Commentary

The following page shows all the grey warnings issued by the EW. Three warnings are issued, that grey limits have been exceeded in indicator #1, #3 and #4.

Grey Warnings

Limits exceeded for Indicator #1: Safety Procedures

Limits exceeded for Indicator #3: Non-Safety Critical Maintenance and Inspection

Limits exceeded for Indicator #4: Safety Critical Personnel Lacking Training

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Commentary

The following page is the indicator page for indicator #1: Safety Procedures. There are two squares, the upper dealing with the safety procedure and the lower dealing with the training.

The upper square
Column one lists the procedure numbers.
Column two lists the update cycles for the procedures, meaning how many months maximum should pass between updates.
Column three lists whether the procedure is currently updated, meaning that the update cycle/maximum month limit has not passed since the last update.
Column four lists how many weeks have passed over the deadline for the procedures, if the procedure is within the update cycle, "No" is listed.
Column five lists the yellow warning limits for each procedure.
Column six lists the red warning limits for each procedure.
Colum seven lists whether or not a warning is issued, the options being "No", "Grey", "Yellow" and "Red".

Below the procedure rows is listed the total number of procedures lacking update, and the limits for the grey, yellow and red warning. Lastly, it is listed whether or not a warning is given, the options being "No", "Grey", "Yellow" and "Red".

The upper square
Column one lists the procedure numbers, representing the training that involve these procedures.
Column two lists whether the training has been updated following the last update of the procedure
Column three lists how many weeks have passed since the procedure was updated, if the trainig has been updated "No" will be listed.
Column four lists the yellow warning limits for each procedure.
Column five lists the red warning limits for each procedure.
Column six lists whether or not a warning is issued, the options being "No", "Grey", "Yellow" and "Red".

Below the procedure rows is listed the total number of procedures lacking update, and the limits for the grey, yellow and red warning. Lastly, it is listed whether or not a warning is given, the options being "No", "Grey", "Yellow" and "Red".

Grey and red warnings are issued for this indicator in this example.

1	2	3	4	5	6	7
Procedures	**Update cycle** (months)	**Updated?**	**Weeks over time?**	**Yellow warning limit**	**Red warning limit**	**Warning?**
1	24	Y	No	4	8	No
2	24	Y	No	4	8	No
3	24	No	2	4	8	Grey
4	18	Y	No	3	6	No
5	24	Y	No	4	8	No
6	12	No	6	2	4	Red
7	24	Y	No	4	8	No
8	24	Y	No	4	8	No
9	24	Y	No	4	8	No
10	24	Y	No	4	8	No
		# lacking	**# for grey warning**	**# for yellow warning**	**# for red warning**	**Warning?**
		2	1	4	6	Grey

1	2	3	4	5	6	7
Training involving Procedures	**Updated?**	**Weeks over time?**	**Yellow warning limit**	**Red warning limit**	**Warning?**	
1	Y	No	3	6	No	
2	Y	No	3	6	No	
3	Y	No	3	6	No	
4	No	6	2	4	Red	
5	Y	No	3	6	No	
6	Y	No	2	4	No	
7	Y	No	3	6	No	
8	Y	No	3	6	No	
9	Y	No	3	6	No	
10	Y	No	3	6	No	
	# lacking	**# for grey warning**	**# for yellow warning**	**# for red warning**	**Warning?**	
	1	1	3	5	Grey	

Commentary

The following page is the data page for indicator #1: Safety Procedures

Procedure 1-5 is listed on top and 6-10 below.

The rows list

- update cycle, meaning how many months maximum should pass between updates.

- date for last update

- deadline for next update

- weeks left until deadline

- whether deadline is passed and how many weeks

- whether the training has been updated

- how many weeks since update, if training is not updated

	Procedure 1	Procedure 2	Procedure 3	Procedure 4	Procedure 5
Current date	15.05.16	15.05.16	15.05.16	15.05.16	15.05.16
Update cycle	24	24	24	18	24
Last update	01.07.14	01.02.15	01.05.14	01.04.16	01.03.15
Update deadline	01.07.16	01.02.17	01.05.16	01.10.17	01.03.17
Weeks left	7	37	-2	72	41
Over time?	No	No	2	No	No
Training updated?	Y	Y	Y	No	Y
Weeks over time?	No	No	No	6	No

	Procedure 6	Procedure 7	Procedure 8	Procedure 9	Procedure 10
Current date	15.05.16	15.05.16	15.05.16	15.05.16	15.05.16
Update cycle	12	24	24	24	24
Last update	01.04.15	01.08.14	01.05.15	01.09.15	01.11.15
Update deadline	01.04.16	01.08.16	01.05.17	01.09.17	01.11.17
Weeks left	-6	11	50	68	76
Over time?	6	No	No	No	No
Training updated?	Y	Y	Y	Y	Y
Weeks over time?	No	No	No	No	No

Commentary

The following three pages are the indicator pages for indicator #2: Safety critical maintenance and inspection.

Page one, columns are assigned for preventive maintenance, corrective maintenance and inspection.

In descending order is listed last month, last three months, last six months and last twelve months. For each of these these the monthly average of planned hours, finished hours and ratio between planned and finished is listed.

Below is listed the historical averages. The average is calculated four times, excluding last month, the last three months, six months and twelve months. Ths same is done for the standard deviation.

The square below shows how many standard deviations removed from the historical average the data for all the periods are. The data compared is the ratio between planned nad finished. Next to it is listed whether a warning is issued or not, based on the limits on page two.

At the top of **page two** is the different warning limits for the maximum number of standard deviations removed. These are all the same for preventive, corrective and inspection, in this configuration.

Below is listed the historical monthly averages and standard deviations for planned corrective maintenance. These are all calculated excluding the periods last month, last three, six and twelve months respectively.

Below, is listed the number of standard deviations the monthly average for planned corrective maintenance during the periods are, compared to the historical average.This data, the monthly average of planned corrective maintenance, is listed on page one for the different periods. Listed next to it is whether or not a warning is issued, based on the limits listed below.

Page three shows the graphs for preventive maintenance, corrective maintenance and inspection.

No warnings are issued for this indicator in this example.

Unfinished safety critical

		preventive maintenance	corrective maintenance	inspection
Last month	planned	294,5	94,0	89,8
	finished	264,9	94,0	89,8
	ratio	0,900	1,000	1,000
Last 3 months	planned	274,5	100,4	85,1
(monthly	finished	247,0	98,6	80,6
average)	ratio	0,900	0,983	0,945
Last 6 months	planned	286,4	105,0	89,3
(monthly	finished	261,1	102,9	84,5
average)	ratio	0,907	0,981	0,946
Last 12 month	planned	282,0	102,6	87,6
(monthly	finished	262,9	100,3	82,9
average)	ratio	0,931	0,977	0,946
Historical	**Ratio**			
ex last month	Average	0,9217	0,9738	0,9490
ex quarter	Average	0,9229	0,9738	0,9507
ex 6 months	Average	0,9237	0,9734	0,9510
ex year	Average	0,9168	0,9733	0,9520
ex last month	St.Dev	0,0445	0,0160	0,0266
ex quarter	St.Dev	0,0453	0,0164	0,0262
ex 6 months	St.Dev	0,0442	0,0170	0,0266
ex year	St.Dev	0,0444	0,0167	0,0277

Test	St.Dev removed	**Warning?**	St.Dev removed	**Warning?**	St.Dev removed	**Warning?**
Last month	0,50	**No**	-1,64	**No**	-1,91	**No**
Last 3 months	0,51	**No**	-0,54	**No**	0,20	**No**
Last 6 months	0,38	**No**	-0,42	**No**	0,18	**No**
Last 12 months	-0,33	**No**	-0,23	**No**	0,20	**No**

Limits for standard deviations removed to give warnings

	Grey warning	Yellow warning	Red warning
Last month	1	2	3
Last 3 months	1	2	2,5
Last 6 months	1	1,5	2
Last 12 months	0,5	1	1,5

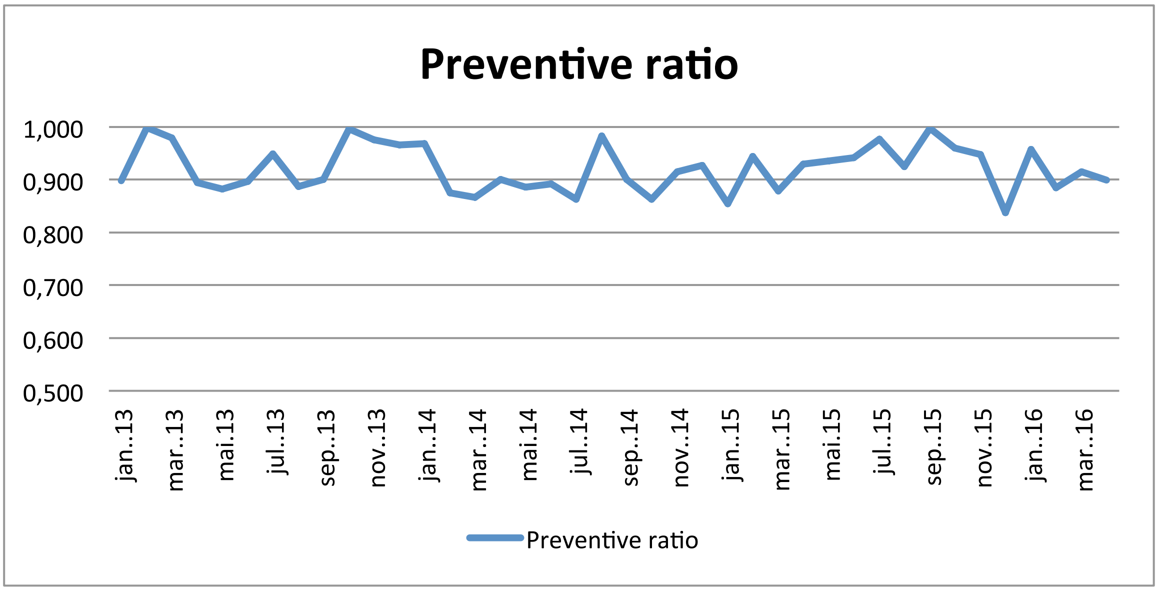
Historical	**Planned Corrective**			
ex last month	Average	97,9	St.Dev	10,68
ex quarter	Average	97,6	St.Dev	10,89
ex 6 months	Average	96,6	St.Dev	10,59
ex year	Average	95,8	St.Dev	10,62

Standard deviations removed from historical average for planned corrective maintenance

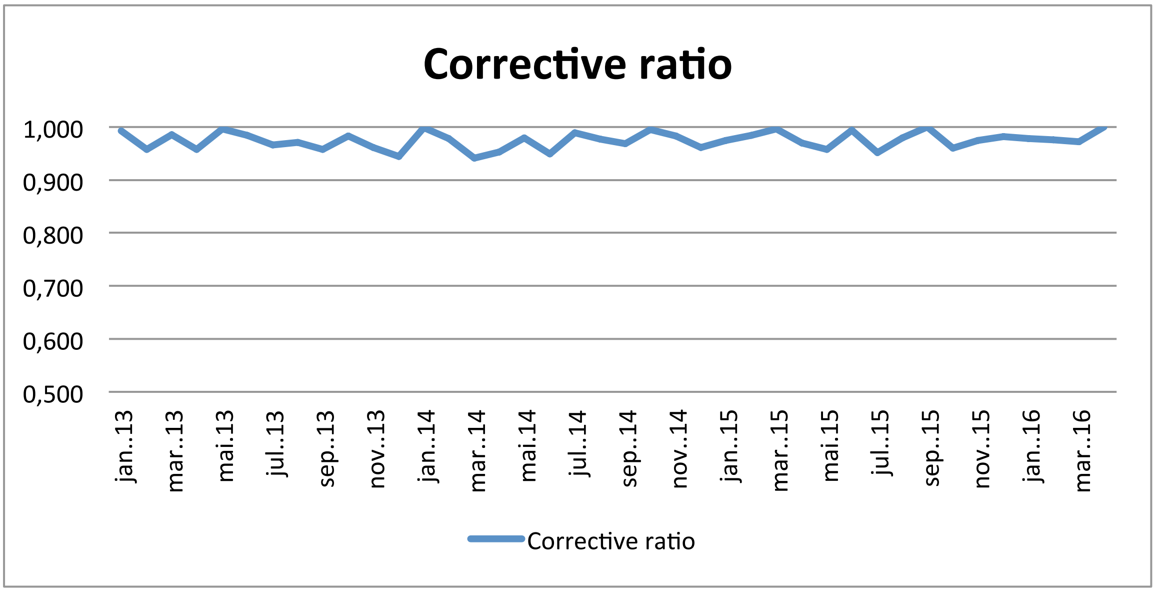
Test	Std. Dev. removed	Warning?
Last month	-0,37	**No**
Last 3 months	0,25	**No**
Last 6 months	0,80	**No**
Last 12 months	0,64	**No**

Limits for standard deviations removed to give warnings for planned corrective maintenance

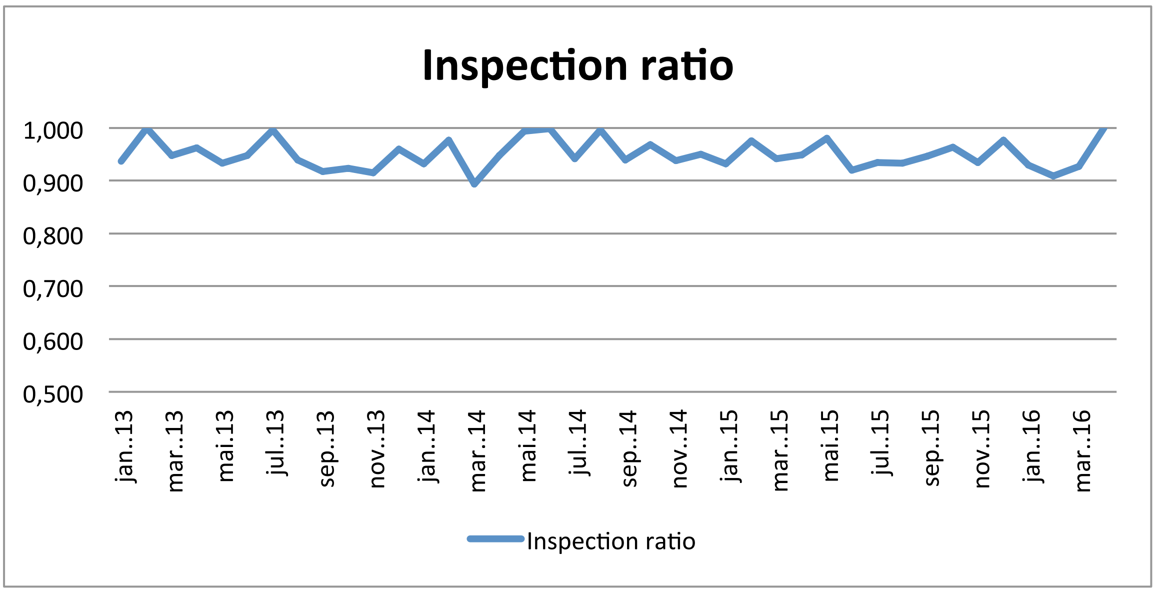
	Grey warning	Yellow warning	Red warning
Last month	1,2	1,8	2,3
Last 3 months	1,2	1,6	2
Last 6 months	1	1,4	1,6
Last 12 months	1	1,2	1,4



Preventive ratio
1,000
0,900
0,800
0,700
0,600
0,500
jan..13
mar..13
mai.13
jul..13
sep..13
nov..13
jan..14
mar..14
mai.14
jul..14
sep..14
nov..14
jan..15
mar..15
mai.15
jul..15
sep..15
nov..15
jan..16
mar..16
Preventive ratio



Corrective ratio
1,000
0,900
0,800
0,700
0,600
0,500
jan..13
mar..13
mai.13
jul..13
sep..13
nov..13
jan..14
mar..14
mai.14
jul..14
sep..14
nov..14
jan..15
mar..15
mai.15
jul..15
sep..15
nov..15
jan..16
mar..16
Corrective ratio



Inspection ratio
1,000
0,900
0,800
0,700
0,600
0,500
jan..13
mar..13
mai.13
jul..13
sep..13
nov..13
jan..14
mar..14
mai.14
jul..14
sep..14
nov..14
jan..15
mar..15
mai.15
jul..15
sep..15
nov..15
jan..16
mar..16
Inspection ratio

Commentary

The following page is the data page for indicator #2: Safety Critical Maintenance and Inspection.

The columns list the planned and finished amount of hours and the ratio between these for preventive, corrective and inspection. The rows list moths going back to and including 2013.

	Planned preventive	Finished preventive	Ratio preventive	Planned corrective	Finished corrective	Ratio corrective
jan.13	319,9	287,3	0,898	89,3	88,6	0,992
feb.13	269,7	269,5	0,999	95,0	91,0	0,958
mar.13	294,1	288,0	0,979	97,9	96,5	0,986
apr.13	345,1	308,6	0,894	89,3	85,5	0,957
mai.13	265,5	234,2	0,882	99,8	99,4	0,996
jun.13	382,5	342,9	0,896	98,1	96,5	0,984
jul.13	364,9	346,2	0,949	88,5	85,5	0,966
aug.13	297,0	263,4	0,887	95,0	92,2	0,971
sep.13	297,7	268,1	0,901	114,5	109,6	0,957
okt.13	280,1	279,0	0,996	78,4	77,1	0,983
nov.13	375,0	366,1	0,976	96,8	93,0	0,961
des.13	263,6	254,7	0,966	86,3	81,5	0,944
jan.14	339,9	329,3	0,969	93,0	92,9	0,999
feb.14	318,4	278,5	0,875	81,6	79,8	0,978
mar.14	284,5	246,7	0,867	81,7	76,9	0,941
apr.14	358,7	322,9	0,900	93,5	89,1	0,953
mai.14	295,8	262,1	0,886	101,4	99,3	0,979
jun.14	199,7	178,1	0,892	78,2	74,2	0,949
jul.14	271,7	234,3	0,862	111,1	109,9	0,989
aug.14	378,4	372,0	0,983	109,7	107,2	0,977
sep.14	356,7	321,1	0,900	94,9	91,9	0,968
okt.14	291,5	251,6	0,863	97,4	96,9	0,995
nov.14	280,7	257,0	0,916	106,1	104,3	0,983
des.14	420,2	389,7	0,927	117,3	112,7	0,961
jan.15	250,8	214,2	0,854	108,5	105,8	0,975
feb.15	386,7	364,9	0,944	99,6	98,0	0,984
mar.15	319,1	280,3	0,878	97,7	97,4	0,997
apr.15	336,3	312,6	0,930	81,6	79,1	0,969
mai.15	272,6	255,0	0,935	96,3	92,2	0,957
jun.15	312,2	294,1	0,942	117,4	116,7	0,994
jul.15	245,3	239,5	0,976	86,2	82,0	0,951
aug.15	293,2	271,0	0,924	105,2	103,0	0,979
sep.15	235,1	234,4	0,997	101,0	101,0	1,000
okt.15	306,8	294,4	0,960	94,8	91,0	0,960
nov.15	266,9	253,1	0,948	114,9	112,0	0,975
des.15	240,0	200,9	0,837	112,0	110,0	0,982
jan.16	387,9	371,4	0,957	102,2	100,0	0,978
feb.16	263,2	232,9	0,885	103,8	101,3	0,976
mar.16	265,9	243,3	0,915	103,3	100,4	0,972
apr.16	294,5	264,9	0,900	94,0	94,0	1,000

	Planned inspection	Finished inspection	Ratio inspection
jan.13	95,0	89,0	0,937
feb.13	89,5	89,5	1,000
mar.13	91,3	86,5	0,947
apr.13	94,9	91,3	0,962
mai.13	83,8	78,2	0,933
jun.13	96,3	91,3	0,948
jul.13	79,6	79,3	0,996
aug.13	105,5	99,1	0,939
sep.13	91,1	83,6	0,918
okt.13	97,1	89,7	0,924
nov.13	87,1	79,7	0,915
des.13	116,4	111,7	0,960
jan.14	90,9	84,7	0,932
feb.14	101,7	99,3	0,976
mar.14	64,0	57,2	0,894
apr.14	73,0	69,2	0,948
mai.14	88,4	87,9	0,994
jun.14	111,2	111,1	0,999
jul.14	92,6	87,2	0,942
aug.14	97,7	97,3	0,996
sep.14	69,0	64,8	0,939
okt.14	84,7	82,0	0,968
nov.14	83,8	78,6	0,938
des.14	113,3	107,7	0,951
jan.15	108,7	101,3	0,932
feb.15	98,8	96,4	0,976
mar.15	85,8	80,8	0,942
apr.15	106,8	101,4	0,949
mai.15	93,8	92,0	0,981
jun.15	86,1	79,2	0,920
jul.15	95,9	89,6	0,934
aug.15	96,3	89,9	0,934
sep.15	65,7	62,2	0,947
okt.15	77,8	75,0	0,964
nov.15	94,2	88,0	0,934
des.15	86,8	84,8	0,977
jan.16	99,1	92,1	0,929
feb.16	78,9	71,7	0,909
mar.16	86,7	80,4	0,927
apr.16	89,8	89,8	1,000

Commentary

The following three pages are the indicator pages for indicator #3: Non-Safety Critical Maintenance and Inspection.

Page one, columns are assigned for preventive maintenance, corrective maintenance and inspection.

In descending order is listed last month, last three months, last six months and last twelve months. For each of these these the monthly average of planned hours, finished hours and ratio between planned and finished is listed.

Below is listed the historical averages. The average is calculated four times, excluding last month, the last three months, six months and twelve months. Ths same is done for the standard deviation.

The square below shows how many standard deviations removed from the historical average the data for all the periods are. The data compared is the ratio between planned nad finished. Next to it is listed whether a warning is issued or not, based on the limits on page two.

At the top of **page two** is the different warning limits for the maximum number of standard deviations removed. These are all the same for preventive, corrective and inspection, in this configuration.

Page three shows the graphs for preventive maintenance, corrective maintenance and inspection.

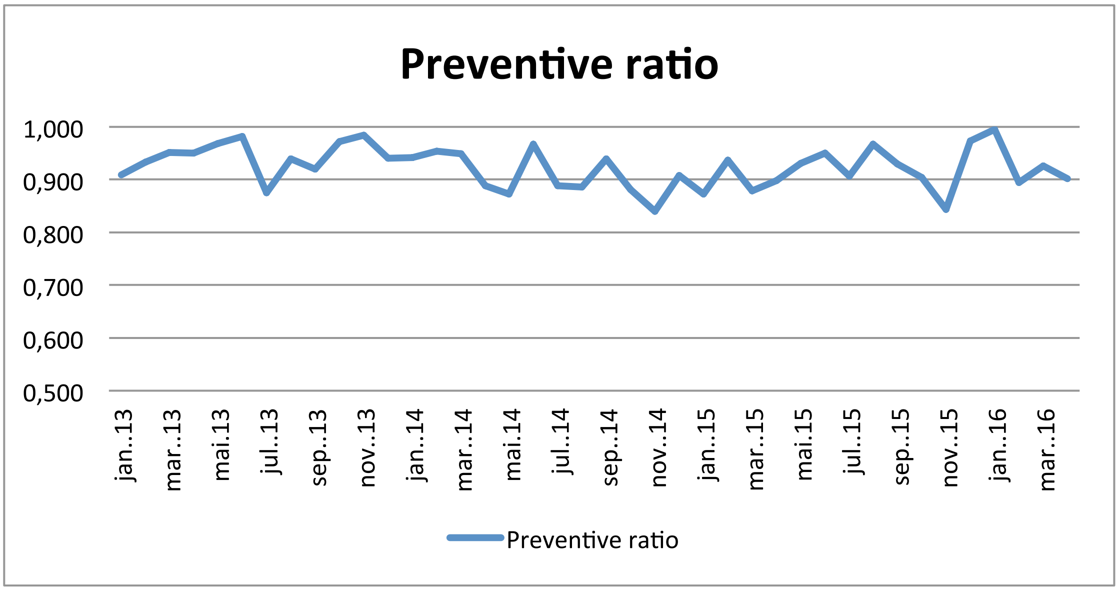
A grey warning are issued for this indicator in this example.

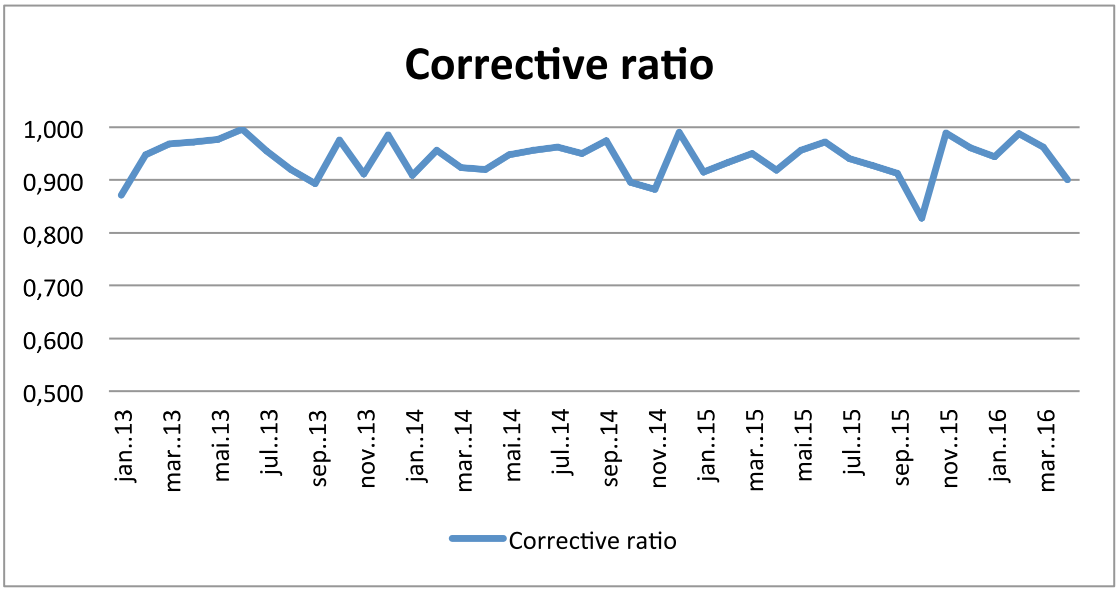
		preventive maintenance	Unfinished non-safety critical corrective maintenance	inspection
Last month	planned	357,7	292,3	102,1
	finished	322,5	263,3	95,3
	ratio	0,902	0,901	0,933
Last 3 month	planned	325,6	368,1	97,3
(monthly	finished	295,5	351,7	91,7
average)	ratio	0,907	0,950	0,941
Last 6 month	planned	307,8	339,8	88,6
(monthly	finished	284,8	326,1	84,0
average)	ratio	0,922	0,958	0,947
Last 12 mont	planned	310,1	307,7	90,0
(monthly	finished	287,8	291,1	84,8
average)	ratio	0,927	0,940	0,940
Historical				
ex last montl	Average	0,9244	0,9420	0,9478
ex quarter	Average	0,9252	0,9403	0,9479
ex 6 months	Average	0,9241	0,9381	0,9474
ex year	Average	0,9226	0,9414	0,9505
ex last montl	St.Dev	0,0395	0,0368	0,0295
ex quarter	St.Dev	0,0403	0,0369	0,0292
ex 6 months	St.Dev	0,0367	0,0373	0,0283
ex year	St.Dev	0,0390	0,0340	0,0268

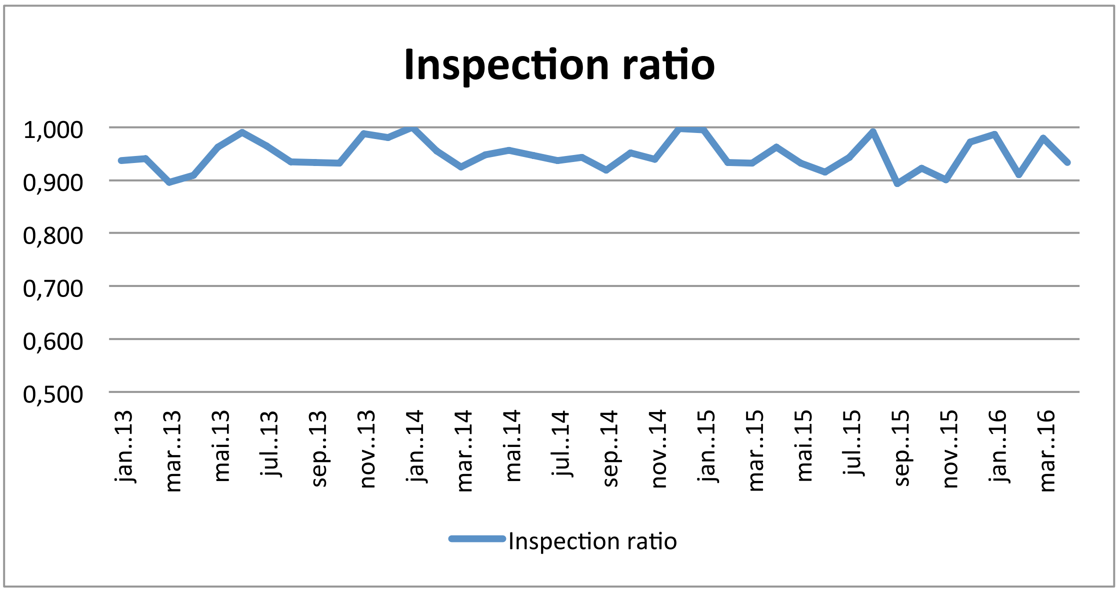
Test	St.Dev removed	**Warning?**	St.Dev removed	**Warning?**	St.Dev removed	**Warning?**
Last month	0,58	**No**	1,12	**Grey**	0,49	**No**
Last 3 months	0,45	**No**	-0,27	**No**	0,22	**No**
Last 6 months	0,05	**No**	-0,52	**No**	0,00	**No**
Last 12 months	-0,11	**No**	0,04	**No**	0,38	**No**

Limits for standard deviations removed to give warnings

	Grey warning	Yellow warning	Red warning
Last month	1	2	3
Last 3 months	1	2	2,5
Last 6 months	1	1,5	2
Last 12 months	0,5	1	1,5


Preventive ratio
1,000
0,900
0,800
0,700
0,600
0,500
jan..13
mar..13
mai.13
jul..13
sep..13
nov..13
jan..14
mar..14
mai.14
jul..14
sep..14
nov..14
jan..15
mar..15
mai.15
jul..15
sep..15
nov..15
jan..16
mar..16
Preventive ratio


Corrective ratio
1,000
0,900
0,800
0,700
0,600
0,500
jan..13
mar..13
mai.13
jul..13
sep..13
nov..13
jan..14
mar..14
mai.14
jul..14
sep..14
nov..14
jan..15
mar..15
mai.15
jul..15
sep..15
nov..15
jan..16
mar..16
Corrective ratio


Inspection ratio
1,000
0,900
0,800
0,700
0,600
0,500
jan..13
mar..13
mai.13
jul..13
sep..13
nov..13
jan..14
mar..14
mai.14
jul..14
sep..14
nov..14
jan..15
mar..15
mai.15
jul..15
sep..15
nov..15
jan..16
mar..16
Inspection ratio

Commentary

The following page is the data page for indicator #3: Non-Safety Critical Maintenance and Inspection.

The columns list the planned and finished amount of hours and the ratio between these for preventive, corrective and inspection. The rows list moths going back to and including 2013.

Safety Non-Critical

	Planned preventive	Finished preventive	Ratio preventive	Planned corrective	Finished corrective	Ratio corrective
jan.13	259,8	236,3	0,910	164,5	143,3	0,871
feb.13	318,0	296,6	0,933	239,8	227,2	0,947
mar.13	323,5	308,0	0,952	446,0	432,1	0,969
apr.13	340,3	323,5	0,951	407,5	395,9	0,972
mai.13	190,6	184,5	0,968	291,4	284,6	0,977
jun.13	287,1	282,0	0,982	371,2	369,7	0,996
jul.13	287,8	251,9	0,875	380,7	363,8	0,956
aug.13	265,9	249,8	0,939	309,6	284,8	0,920
sep.13	362,3	333,4	0,920	266,5	237,9	0,893
okt.13	362,3	352,3	0,972	280,1	273,2	0,975
nov.13	340,0	334,5	0,984	349,3	318,2	0,911
des.13	256,0	240,7	0,940	268,4	264,6	0,986
jan.14	326,1	307,3	0,942	341,1	309,9	0,909
feb.14	356,2	339,9	0,954	280,7	268,6	0,957
mar.14	358,6	340,2	0,949	359,2	331,8	0,924
apr.14	323,8	287,8	0,889	367,7	338,1	0,919
mai.14	221,1	193,0	0,873	300,4	284,9	0,948
jun.14	346,3	335,0	0,967	383,7	366,8	0,956
jul.14	338,7	301,0	0,889	299,3	288,2	0,963
aug.14	260,1	230,6	0,887	346,3	329,2	0,951
sep.14	287,8	270,5	0,940	327,0	318,5	0,974
okt.14	296,2	261,0	0,881	301,1	269,8	0,896
nov.14	217,1	182,3	0,840	185,4	163,7	0,883
des.14	299,3	271,7	0,908	294,4	291,7	0,991
jan.15	302,5	264,1	0,873	222,2	203,2	0,914
feb.15	292,8	274,3	0,937	302,3	282,2	0,934
mar.15	233,9	205,6	0,879	343,1	325,9	0,950
apr.15	294,9	264,9	0,898	344,0	316,0	0,919
mai.15	232,8	216,6	0,930	264,7	253,1	0,956
jun.15	355,3	337,8	0,951	349,6	339,7	0,972
jul.15	355,5	322,3	0,907	225,4	211,9	0,940
aug.15	294,5	284,7	0,967	336,2	311,7	0,927
sep.15	287,9	267,5	0,929	287,1	262,1	0,913
okt.15	348,7	315,3	0,904	191,1	158,2	0,828
nov.15	247,6	208,8	0,843	297,6	294,4	0,989
des.15	256,0	249,1	0,973	350,5	337,0	0,961
jan.16	366,2	364,6	0,996	286,2	270,2	0,944
feb.16	294,7	263,5	0,894	411,2	406,3	0,988
mar.16	324,5	300,5	0,926	400,8	385,6	0,962
apr.16	357,7	322,5	0,902	292,3	263,3	0,901

Safety Non-Critical

	Planned inspection	Finished inspection	Ratio inspection
jan.13	89,0	83,4	0,937
feb.13	86,9	81,8	0,941
mar.13	76,3	68,4	0,896
apr.13	86,2	78,4	0,910
mai.13	90,7	87,3	0,963
jun.13	91,2	90,3	0,990
jul.13	77,3	74,6	0,965
aug.13	92,4	86,4	0,935
sep.13	93,7	87,5	0,934
okt.13	75,4	70,3	0,932
nov.13	91,8	90,7	0,988
des.13	103,6	101,6	0,981
jan.14	79,6	79,6	1,000
feb.14	103,6	98,9	0,955
mar.14	105,1	97,2	0,925
apr.14	99,2	94,0	0,948
mai.14	92,0	88,0	0,957
jun.14	81,3	77,0	0,947
jul.14	103,6	97,1	0,937
aug.14	102,6	96,8	0,943
sep.14	78,1	71,8	0,919
okt.14	86,2	82,0	0,951
nov.14	95,0	89,3	0,940
des.14	83,7	83,5	0,998
jan.15	96,1	95,6	0,995
feb.15	97,2	90,7	0,933
mar.15	85,3	79,5	0,932
apr.15	84,1	80,9	0,962
mai.15	93,0	86,7	0,932
jun.15	93,3	85,4	0,915
jul.15	104,7	98,8	0,944
aug.15	101,1	100,2	0,991
sep.15	69,4	62,0	0,893
okt.15	87,0	80,3	0,923
nov.15	73,7	66,4	0,901
des.15	81,8	79,5	0,972
jan.16	84,1	83,0	0,987
feb.16	89,8	81,8	0,911
mar.16	99,9	97,9	0,980
apr.16	102,1	95,3	0,933

Commentary

The following page is the indicator page for indicator #4: Safety Critical Personnel Lacking Training.

The **top square** shows what percentage of safety critical personnel lacks full training. Below is given the warning limits for grey, yellow and red warning. At the bottom is shown whether or not a warning is issued.

The **bottom square** shows what percentage of safety critical personnel lacks critical training. Below is given the warning limits for the yellow and red warnings. As long as the percentage is above 0%, a grey warning will be issued. At the bottom is shown whether or not a warning is issued.

A yellow warning is issued for this indicator in this example.

Percentage of safety critical personnel lacking full training

Lacking full training	8	%
% at which grey warning is given	10	%
% at which yellow warning is given	15	%
% at which red warning is given	30	%
Warning?	**No**	

Percentage of safety critical personnel lacking critical training

Lacking critical training	1	%
% at which yellow warning is given	2	%
% at which red warning is given	4	%
Warning?	**Grey**	

Commentary

The following two pages is the indicator pages for indicator #5: Evaluated Incidents.

The first page lists the monthly average number of reported incidents, evaluated incidents and the ratio between them. This is done for last month, the last three, six and twelve months.

The historical averages and standard deviations, excluding last month, the last three, six and twelve months are calculated for the ratio. At the bottom of the page is listed the number of standard deviations the ratio for the periods are removed from the historical averages. Next to this is listed whether or not a warning is issued, based on the limits on page two.

On **page two** the warning limits are listed as numbers of standard deviations.

Below is the graph showing the historical numbers for the ratio between reported and evaluated incidents.

No warnings are issued for this indicator in this example.

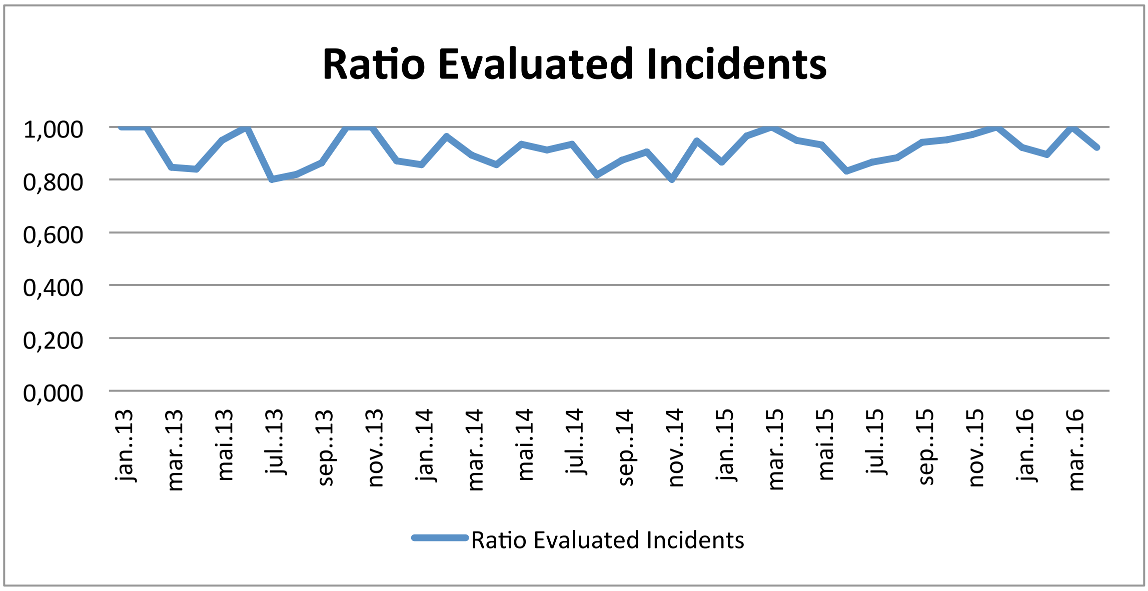
Ratio of reported incidents to evaluated incidents

Last month	reported	26,0
	evaluated	24,0
	ratio	0,923
Last 3 month	reported	25,7
(monthly	evaluated	24,0
average)	ratio	0,940
Last 6 month	reported	27,5
(monthly	evaluated	26,2
average)	ratio	0,952
Last 12 mont	reported	27,4
(monthly	evaluated	25,4
average)	ratio	0,927
Historical		
ex last montl	Average	0,9146
ex quarter	Average	0,9128
ex 6 months	Average	0,9082
ex year	Average	0,9097
ex last montl	St.Dev	0,0635
ex quarter	St.Dev	0,0636
ex 6 months	St.Dev	0,0637
ex year	St.Dev	0,0673

Test	St.Dev removed	**Warning?**
Last month	-0,13	**No**
Last 3 months	-0,43	**No**
Last 6 months	-0,69	**No**
Last 12 months	-0,25	**No**

Limits for standard deviations removed to give warnings

	Grey warning	Yellow warning	Red warning
Last month	1,5	2,5	3
Last 3 months	1	2	2,5
Last 6 months	1	1,5	2
Last 12 months	0,8	1,2	1,5



Commentary

The following page is the data page for indicator #5: Evaluated Incidents. It lists total incidents reported, incidents evaluated and the ratio between these for every month back to and including the year 2013.

Evaluated incidents

	Total incidents	Evaluated incidents	Ratio total:eval
jan.13	25	25,0	1,000
feb.13	29	29,0	1,000
mar.13	26	22,0	0,846
apr.13	25	21,0	0,840
mai.13	20	19,0	0,950
jun.13	22	22,0	1,000
jul.13	15	12,0	0,800
aug.13	28	23,0	0,821
sep.13	22	19,0	0,864
okt.13	17	17,0	1,000
nov.13	25	25,0	1,000
des.13	31	27,0	0,871
jan.14	21	18,0	0,857
feb.14	27	26,0	0,963
mar.14	28	25,0	0,893
apr.14	28	24,0	0,857
mai.14	15	14,0	0,933
jun.14	34	31,0	0,912
jul.14	30	28,0	0,933
aug.14	33	27,0	0,818
sep.14	32	28,0	0,875
okt.14	32	29,0	0,906
nov.14	30	24,0	0,800
des.14	19	18,0	0,947
jan.15	30	26,0	0,867
feb.15	30	29,0	0,967
mar.15	24	24,0	1,000
apr.15	20	19,0	0,950
mai.15	29	27,0	0,931
jun.15	24	20,0	0,833
jul.15	30	26,0	0,867
aug.15	26	23,0	0,885
sep.15	34	32,0	0,941
okt.15	21	20,0	0,952
nov.15	33	32,0	0,970
des.15	29	29,0	1,000
jan.16	26	24,0	0,923
feb.16	29	26,0	0,897
mar.16	22	22,0	1,000
apr.16	26	24,0	0,923

Commentary

The following two pages are the indicatorpages for indicator #6: Findings During Safety Inspections.

At the top of **page one** is listed the monthly average number of findings per inspection for last month, the last three, six and twelve months. Next to this is listed whether a warning is issued, based on the limits given below.

Below this the historical averages and standard deviations are caluclated, excluding last month, last three, six and twevle months. Below this is listed how many standard deviations removed from the historical average the data for each period is. Next to this is listed whether a warning is listed, based on the limits on page two.

On **page two** is listed the limits given in numbers of standard deviations for grey, yellow and red warnings, for the different periods, last month, last three, six and twelve months.

Below this is the graph showing the monthly historical data for average number of findings per inspection.

No warnings are issued for this indicator in this example.

Findings per safety inspection

Inspections to check whether safety procedures/rules are being followed

			Warning?
Last month	Average	10,0	**No**
Last 3 month	Average	9,0	**No**
Last 6 month	Average	8,7	**No**
Last 12 mont	Average	8,9	**No**

	Grey warning	Yellow warning	Red warning
Limit faults reported	15	20	30

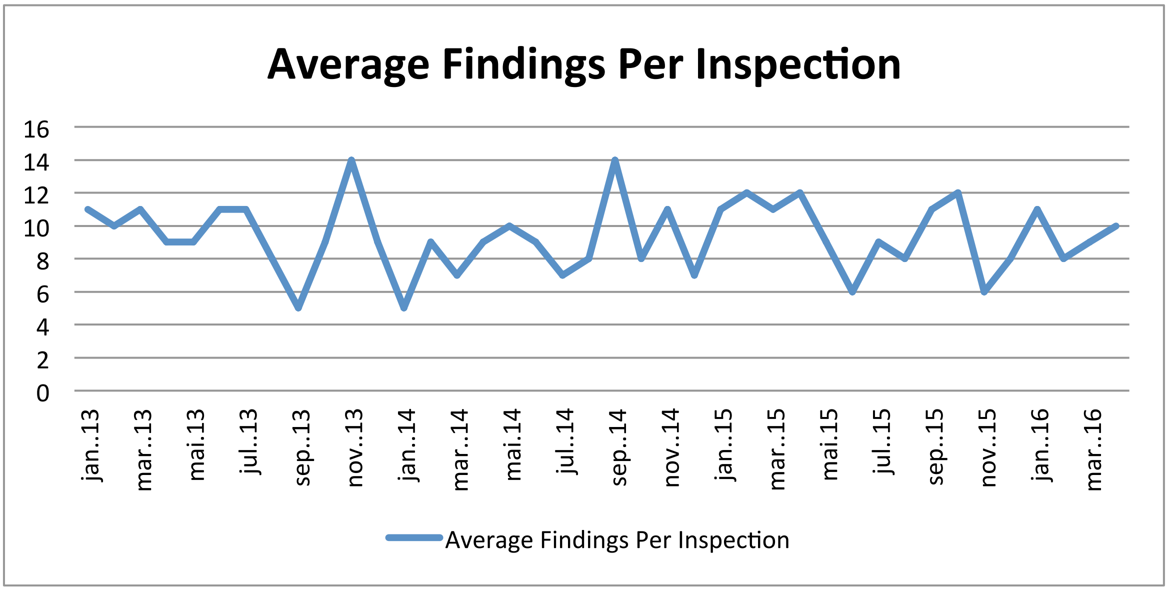
Historical (monthly average)

ex last montl	Average	9,333
ex quarter	Average	9,378
ex 6 months	Average	9,471
ex year	Average	9,536
ex last montl	St.Dev	2,168
ex quarter	St.Dev	2,215
ex 6 months	St.Dev	2,205
ex year	St.Dev	2,252

Test	St.Dev removed	**Warning?**
Last month	0,31	**No**
Last 3 months	-0,17	**No**
Last 6 months	-0,36	**No**
Last 12 months	-0,27	**No**

Limits for standard deviations removed to give warnings

	Grey warning	Yellow warning	Red warning
Last month	1,5	2,5	3,5
Last 3 months	1,5	2,5	3
Last 6 months	1	1,5	2
Last 12 months	0,8	1,2	1,5



Commentary

The following page is the data page for indicator #6: Findings During Safety Inspections. The average number of findings per inspection is listed for each months going back to and including 2013.

Findings per safety inspection

	Average number of findings per inspection
jan.13	11
feb.13	10
mar.13	11
apr.13	9
mai.13	9
jun.13	11
jul.13	11
aug.13	8
sep.13	5
okt.13	9
nov.13	14
des.13	9
jan.14	5
feb.14	9
mar.14	7
apr.14	9
mai.14	10
jun.14	9
jul.14	7
aug.14	8
sep.14	14
okt.14	8
nov.14	11
des.14	7
jan.15	11
feb.15	12
mar.15	11
apr.15	12
mai.15	9
jun.15	6
jul.15	9
aug.15	8
sep.15	11
okt.15	12
nov.15	6
des.15	8
jan.16	11
feb.16	8
mar.16	9
apr.16	10

Commentary

The following two pages are the indicator pages for indicator #7: Near Miss Incidents.

At the top of **page one** is listed the monthly average number of near miss incidents reported for the periods, last month, last three, six and twelve months.

Below this is listed the historical monthly averages and standard deviations, excluding last month, the last three, six and twelve months.

Under is listed how many standard deviation the data for the different periods are removed from the historical average. Next to this is listed whether or not a warning is issued, based on the limits given on page two.

On **page two** the warning limits are given in number of standard deviations, for the different periods.

Below this is the graph showing the historical monthly numbers of reported near miss incidents.

No warnings are issued for this indicator in this example.

Reported near miss incidents
An incident that did not have any particularily harmful consequences

Last month	Reported	36,0
Last 3 month	Reported	30,3
Last 6 month	Reported	28,2
Last 12 mont	Reported	28,8

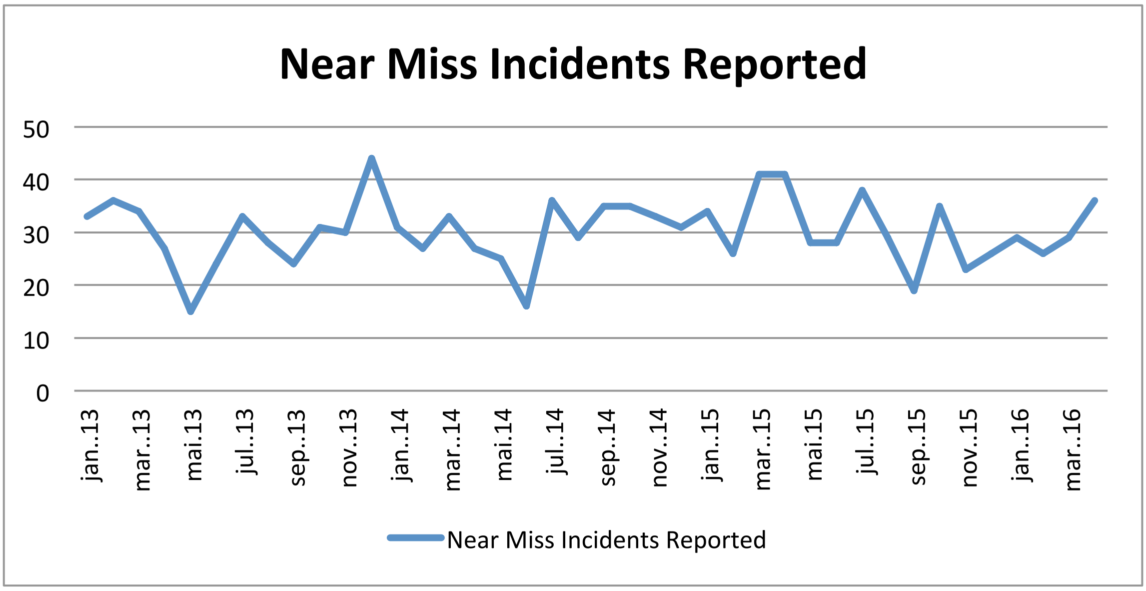
Historical
(monthly average)

ex last montl	Average	30,4706
ex quarter	Average	30,1081
ex 6 months	Average	30,4706
ex year	Average	30,6786
ex last montl	St.Dev	6,2807
ex quarter	St.Dev	6,4152
ex 6 months	St.Dev	6,5331
ex year	St.Dev	6,6224

Test	St.Dev removed	**Warning?**
Last month	-0,88	**No**
Last 3 months	-0,04	**No**
Last 6 months	0,35	**No**
Last 12 months	0,28	**No**

Limits for standard deviations removed to give warnings

	Grey warning	Yellow warning	Red warning
Last month	1,5	2,5	3,5
Last 3 months	1,5	2	2,5
Last 6 months	1	1,5	2
Last 12 months	0,8	1,2	1,5



Commentary

The following page is the data page for indicator #7: Near Miss Incidents.The number of reported near miss incidents are listed for each month back to and including 2013.

Close call incidents reported

	Reported
jan.13	33
feb.13	36
mar.13	34
apr.13	27
mai.13	15
jun.13	24
jul.13	33
aug.13	28
sep.13	24
okt.13	31
nov.13	30
des.13	44
jan.14	31
feb.14	27
mar.14	33
apr.14	27
mai.14	25
jun.14	16
jul.14	36
aug.14	29
sep.14	35
okt.14	35
nov.14	33
des.14	31
jan.15	34
feb.15	26
mar.15	41
apr.15	41
mai.15	28
jun.15	28
jul.15	38
aug.15	29
sep.15	19
okt.15	35
nov.15	23
des.15	26
jan.16	29
feb.16	26
mar.16	29
apr.16	36