Digital lockout routines

Enhancing the safety and efficiency of the industry by the development of a smart technology use case

Msc. Thesis - Integrated Product Design

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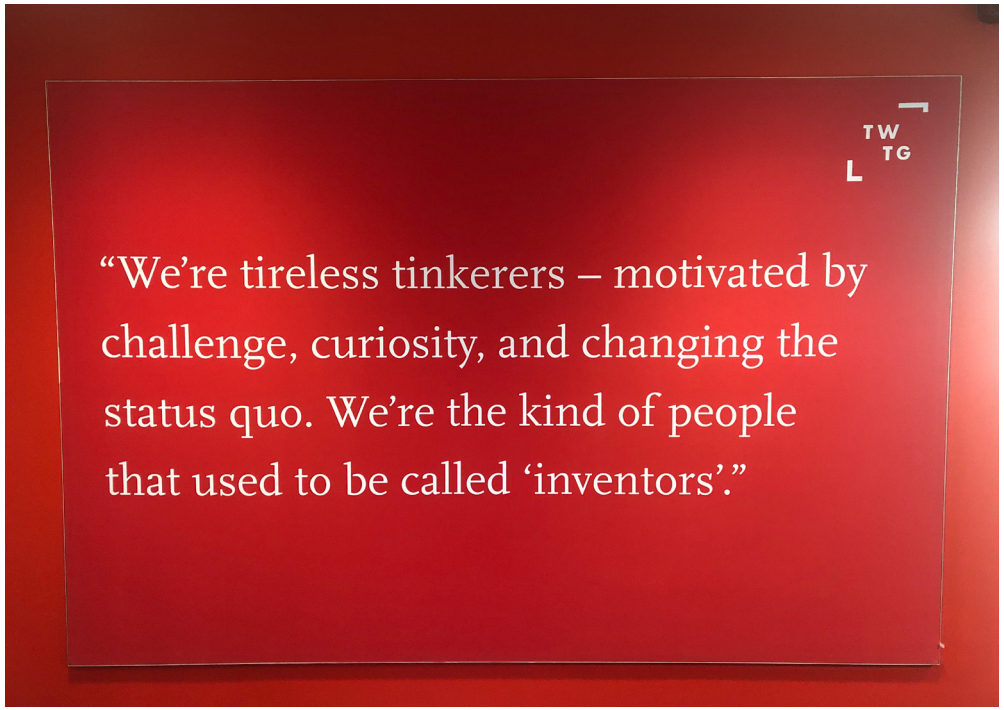
Content



Office entrance TWTG R&D

Preface

There is a famous quote (somewhat dubiously) attributed to Henry Ford: "*If I had asked people what they wanted, they would have said faster horses.*" (Forbes, 2020)

Through personal experience, clients can easily describe the problems that they are having In this scenario getting from A to B faster. However, identifying the best answer is crucial for a disrupter of the status quo. Design thinking practices provide valuable tools to bridge the gap between most companies interests (delivering widely adopted product solutions) and customer interests (having their problems solved). Yet, thorough understanding and an analytical perspective on the problems present are required to understand their context and deliver new market value.

Delivering new market value. That's easier said than done. Just delivering four wheels and the engine will not deliver radical change. Market needs, the present infrastructure, cultural perception and available technologies need to be understand and stretched in order to deliver new, valuable routines and cross the interval from invention to innovation.

In this project, we aim to understand what drives the market of the heavy industry with the aim to develop a new standard on safety. With the support of emerging smart technologies, we strive to replace the traditional work routine and deliver a product that can replace the horse-like practices of the industry — an attractive challenge for a product design engineer.

This thesis elaborates on the problems present in the heavy industry through an in-depth practical research approach, pursuing all perspectives on safety and new product development and providing an objective view on the status quo. Subsequently, a new standard on safety is delivered through the design of a digital use case and connected product, ready to be introduced to the sizeable market by the company of TWTG.

With both the communicational and design experiences gathered through five years of Industrial Design Engineering studies, TU Delft Dreamteam participation, a smart product orientated master program and various foreign product design activities, this Master Thesis remained the most challenging of all.

This challenge is part of a six months individual graduation project and contribution to the heavy industry, company of TWTG R&D and Intergated Product Design Master Program of the Industrial Design Engineering faculty of the TU Delft. The project was executed in challenging times were uncertainties and social distancing were the cultural norm due to the Covid-19 scenario.

Throughout this research, I received the support of my company mentor Joost Peters (TWTG). Many thanks for your flexibility in supporting this project, your critical project approach and delivering this exciting assignment. Accordingly, I would like to express my gratitude towards my supervisory team of the TU Delft. My chair, Jacky Bourgeois, thanks for strengthening my analytical view and reaching out to me on supporting and personal level. Martien Bakker, my TU Delft mentor, thanks for keeping my designer's motivation going through this study and dealing with project uncertainties in times certainties were difficult to be found. Our enjoyable and expecting meetings provided me with great comfort and confidence.

Finally, I would like to thank my family and friends for their continuos support during this thesis, proving their importance by all means.

With graditude,

Karsten Bakker

Abstract

With 2,975 safety violations in the US alone, the lockout safety routine, one of the most important safety methods in the industry, remains unsafe. This is caused by the limited adherence of companies employees to the preset protocols. Heavy industries primarily focus on the efficiency of their processes and recognise the rising potential of smart product solutions to serve their key safety as efficiency interests. This project aims to meet the demands of the industry by the design a smart lockout use case that enhances the lockout process in terms of safety and efficiency, and that can be adopted by the heavy industry. For the company of TWTG this thesis researches the potential of this product and establishes a digital lockout use case and smart concept design to evaluate the value delivered to the industry.

Through an empirical research study knowledge is gathered on the unknown user behaviour in the lockout process and corresponding lockout materials handlings and methods. This qualitative research study uses protocols reviews, user observations and field studies to provide real-life insight on the manifestation of behavioural routines for a leading industry. Consequently, expertise on lockout routines and smart product innovations in the industry is gathered through consultations with ten industry experts to gather verifiable evidence on unsafety and the potential of smart product solutions in the lockout process.

This research concludes safety in the lockout process is highly dependent on the correct interpretations of the user. A false perception of safety is easily established when activities are not correctly executed. Positively, smart product solutions provide severe potential for the industry to support correct behaviour of operators and identify the life-threatening violations of the lockout procedure. Moreover, interviews with managing and external stakeholders from the industry state a marginal impact on existing industry materials and lockout routines are demanded in order to introduce smart product solutions successfully.

Through a variety of use case evaluations with both managers and operators related to the lockout process, the desired level of disruption to these materials and routines is evaluated for the industry of Royal Vopak. From these insights, a smart lockout use case is established for a sizeable market. The selected smart lockout routine provides pro-active feedback on operators activities and real-time validation of a safe work environment. The ease of implementation is supported by the investigation of compatible solutions with existing materials, low battery power solutions, the LoRa network and wireless communication technologies, allowing to meet the identified context requirements and deliver a feasible product solution.

An appearance model of the smart lockout product is developed to allow the industry to emphasise with the developed concept. The safety and efficiency value of the smart lockout use case is revealed through an objective evaluation with eight respondents representing the majority of directly related employees to the lockout process from three industry locations. Consequently, consultations with the deployment and innovation leaders from the industry advocate the establishment of the smart lockout routine. With this study, the company of TWTG desires to deliver a unique safety product for the global market.

Stakeholders

Stakeholders and department interests

“I-IoT success is defined by the capability to adapt to industries challenges” - TWTG R&D

“We operate safely, or we do not operate at all” - Vopak

TWTG R&D

-Experts in IoT
-Providing (retrofitted) hardware and software solutions

The company TWTG is an ambitious and fast-growing company solving today’s IoT challenges. Products are developed with the companies embedded hardware expertise and insight in real-life business cases. [1] Over the years, they gained the confidence of the industry to deliver long-lasting products. They aim to develop a wide range of collaborating industrial IoT solutions to turn the smart industry into reality. The company TWTG is known to be flexible and disruptive.

In this project, the desire of TWTG is to develop a scalable product for the market of Royal Vopak and other entrepresis in the heavy industry.

The Heavy Industry

- Traditional product storage company located in harbours
- Maintain strict standards on safety in the industry

In this project the heavy industry relates to large organisations providing raw material storage services and related heavy machinery processes. The company of Royal Vopak, playing a significant role in the research of this industry, is world’s largest independent company in this industry. Services of the industry relate to the storage of bulk chemicals, gasses and (natural) oil products and is known for its capital intensive materials and traditional work culture.The industry is perceived as a valuable, large scale customer for TWTG. Rising industrial IoT trends desire digital solutions that are applicable to the existing use cases of their clients. Within the industry three stakeholders have subjected interests during the digitalisation of the industry.

Stakeholders

Subjected stakeholders

1. Management

Desire to improve the output organisation, they focus on financial health, the efficiency and safety of their organisation. In relation to these desires, managers develop protocols and regulations for the industry.

2. Safety supervisors

Maintain the safety, health, environment and quality of the organisation on the industrial work sights (terminals). Concerning these tasks, they verify and evaluate the protocols of the industry.

3. Operators

The main task of the operators is to correctly handle machines, systems and related processes. The exectution of their actions is based on strict industry protocols.

1.1 Introduction

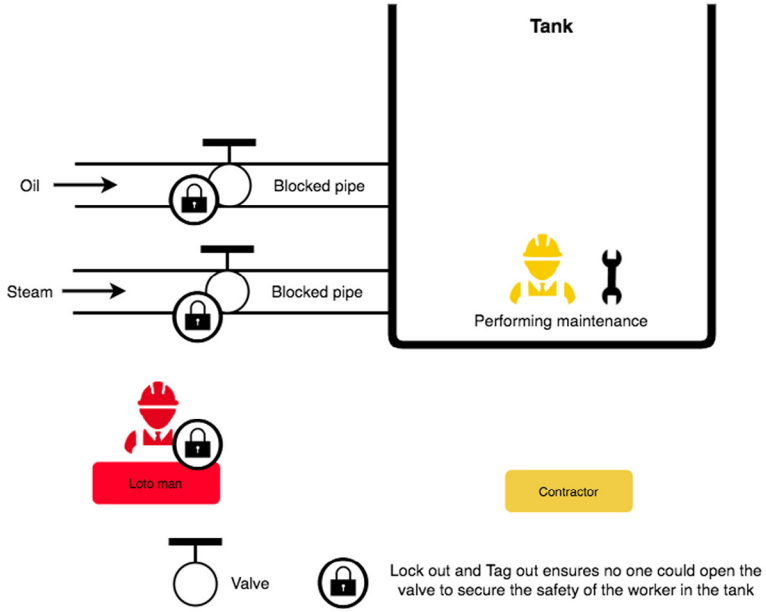
Context
In international harbours like The Port of Rotterdam, sizable ships transporting oil and gas aim to unload their cargo at Vopak Terminals. Filling of the correct reservoirs is regulated by a supervisor who assigns which valves in the piping network should be manually closed or opened.

In this broad field of pipes and valves, specialised operators move across the area to regulate processes and maintain safety by locking out the valves and related processes during the transport of product and maintenance. This lockout prevents hazardous energy (steam, oil, gas, electricity, moving parts) from escaping the system or being released on workers.

Strict safety precautions apply to ensure the absence of (fatal) injuries or serious accidents, e.g. tanks catching fire, befall on the terminal. Hence, all valves and related processes are required to remain closed during a lockout. The lockout method is adopted to achieve this safety status. This method requires all affected operators to individually place lockout materials on hazardous energy sources and related materials.

For the establishment of a lockout conservative materials (regular padlocks, keys, plastic instruction tags and mechanical support materials) are used. Consequently, Loto plans are established based on company protocols to explain who, how, when and where the lockout must be executed. Employers have the flexibility to set up lockout programs that suit the resources of their facilities.

Image 1.1; This illustration is an example of the lockout procedure for the storage tanks of Vopak. By placing mechanical lockout materials on the valves, the Lotoman prevents employees from operating the values. With this solution, hazardous energy (oil, steam) is isolated, ensuring the safety of the worker inside the tank.



Lockout procedure
The lockout procedure is the standard to prevent hazardous energy being released on workers during maintenance and/or services in the heavy industry. In the US, 3.000.000 workers are estimated to prevent 120 fatalities and 50,000 injuries each year with the help of the lockout (Loto) procedure (OSHA, 2019). The Occupational Safety and Health Administration (OSHA) from the United States department on labour, provides extensive regulations and research on this procedure. Though, this procedure is putting pressure on safety programs of the heavy industry and its workers as three issues remain unsolved:

First, the Loto procedure, in general, is not safe. Loto is one of the violated regulations. In 2019, a growing number of 2,975 violations of the Loto standard is reported. Each violation requires workers to spent an average of 24 workdays on recuperation (OSHA, 2019).

Second, compliance of workers with the protocol is not established. Campbell T. (2003), reports that the main issue of the Loto procedure is caused by the inconsistency of operators following the protocols. In the US, 90% of the violations occur as a result of operators being unable to meet lockout procedures (OSHA, 2019). Employees become comfortable working with hazard energy sources resulting in the negligence of meeting the Loto standards provided by the company (Campbell, 2003).

Third, companies top priority is not safety performance. This problem consists of two parts A) An comprehensive safety study on the chemical industry in the Netherlands states signals of potential accidents are weak and indicators for failures remain challenging to observe (Ale, B. 2017). B) Companies purposely neglect implementing safer solutions and focus on the most profitable business models of their organisations; the productivity of their processes in place (Ale, B. 2017).

New technologies provide opportunities to overcome the deep-rooted problems of traditional industry practices. The third industrial revolution speeds up the number of Internet of Things (IoT) technologies and devices adopted by the industry (Gnoni, 2020). So-called smart (IoT) products improve interactions and information

1.1 Introduction

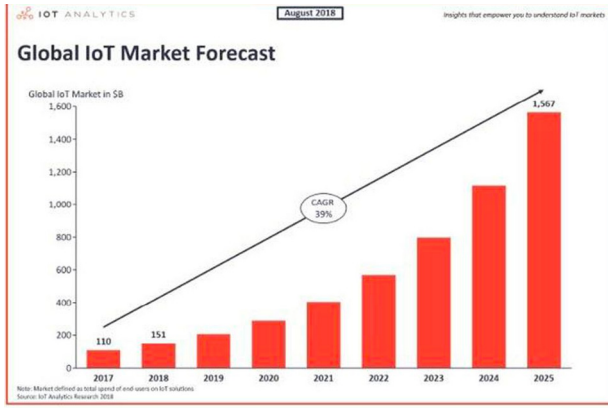


Image 1.2: The market for Industry 4.0 products and services is expected to grow to $310B by 2023 (Forbes, 2018)

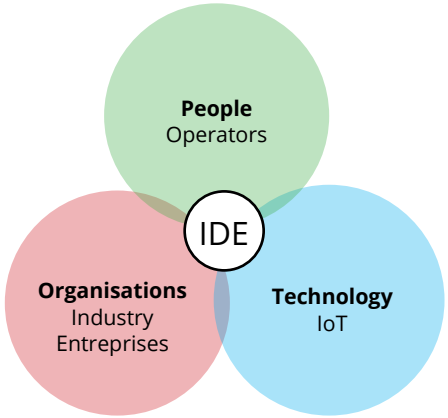


Image 1.3: IDE; Industrial Design & Engineering

transfer with physical commodities. Related technologies have a significant potential in high-risk environments and industries where lives are at stake (Thibaud, 2018). Industrial IoT applications are recognised to offer reliable, efficient and safe solutions due to their competence to engage on a granular information level. Issues related to life loss or prevent severe damage to the environment can be solved, and the performance of processes can be significantly enhanced (Ale, 2017).

Nowadays, occupational health and safety systems desire a broad range of proactive instruments that are not primarily focused on minimising the occupational risk but additionally contribute to the continuous assessment of safety within companies (Robson, 2007).

This research focuses on the potential of a smart lockout use scenario and related concept that solves the stated problems with the support of digital technologies.

ASSIGNMENT

As stated in chapter 1.1, there is a necessity for an improved lockout process. The company of TWTG registers the safety of Loto practices as a difficulty in the safety program of their industry clients. Inspired by the opportunities that IoT technologies deliver, the company of TWTG desires to bring a new smart lockout device on the market. With a Smart Loto product they aim to deliver a product that enhances the safety of the lockout process for Vopak and other clients in the industry. With the resources of TWTG, Vopak and other external parties research will be conducted to determine the feasibility of a smart lockout product to determine the need and satisfaction with this product for the industry.

In terms of safety, this product aims to, a) solve the general problems related to the Loto procedure and b) enhance the compliance of operators with the procedure developed by the employer. In order to be adopted by the industry, the product is required to contribute to productivity.
To contribute to the viable establishment of this product this desired efficiency gain will be part of the research and design development process. Consequently, the adoption of smart solutions must be relevant and achievable for the resources and environment of the industry. Hence, we formulate the following design statement:

Design a smart lockout concept that improves the Loto process in terms of safety and efficiency, and that can be adopted by the heavy industry.

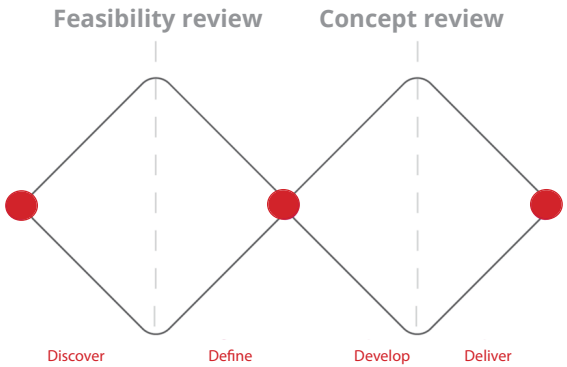
For the execution of a successful design, the answers to the following questions are fundamental:

- How can we improve the safety in the heavy industry with Smart Loto solutions?
- How can we contribute to the efficiency in the heavy industry with Smart Loto solutions?
- What criteria are essential for the heavy industry to adopt smart solutions?

Concerning efficiency, this research concentrates on improving the time required to execute Loto actions. Regarding safety, the focus of this research is on diminishing the chance of accidents occurring in the industry.

1.2 Methodology

In this chapter the project approach and methodology will be explained. Based on the identified problems in literature research questions are formulated to support the design Smart Loto concept.



Double diamond

The design process used in this report is the Double Diamond design approach. The Double Diamond is an iterative process which allows moving back and forth between the four stages of the design process. This process describes four phases: Discover, Define, Develop and Deliver. Roozenburg (1995) list four design principles which are essential to the execution of the process.

- Put people first. Acquire an understanding of people using services, their needs, strengths and aspirations.
- Communicate visually and inclusively. Allow people to achieve a shared understanding of the problems elaborated and the presented ideas.
- Cooperate and co-create. Get activated by what others are doing.
- Iterate frequently. Identify errors in an early stage, avoid risks and transfer confidence when elaborating on ideas.

Discover

In this report, chapter 2 describes the discover phase, and chapter 3 the define phase. In chapter 4, the creative process and concept exploration phase is reported. Chapter 5-8 dedicates to the elaboration and evaluation of the solution in which the last two phases of the design process will be discussed. Based on the problems identified in literature (Chapter 1) three aspects require further investigation in the first phase of the process:

- a) Safety, how to decrease the chance of Loto accidents occurring in the heavy industry with smart Loto solutions?
- b) Productivity, how can a smart Loto product contribute to efficiency in the Loto process?
- c) The industry, what are the criteria for adopting smart product solutions?

For the investigation of these three aspects, five analyses are executed. First, a context study is conducted to identify relevant design factors for the heavy industry.

Second, a trend analysis will be executed to identify smart product applications, how suitable they are for the context of Vopak and what the resources are of Vopak and TWTG to adopt smart product solutions.

Third, a product analysis will be executed to (a) reveal safety limitations of existing Loto materials, (b) to gain insight in opportunities and restrictions of the materials concerning efficiency and (c) acquire knowledge on essential product requirements for future product development.

The fourth analysis, the user study, will be conducted to (a) identify who the user is, what their problems and needs are and what non-compliant behaviour involves concerning safety. In addtion we (b) analyse opportunities for a more efficient Loto process and (c) investigate essential user behaviour limitations and opportunities.

The fifth analysis includes a process analysis of Vopak's Loto process to improve understanding of and focus on the complete product lifecycle.

In parallel to the theory provided by literature and regulations studies, an empirical research study will be conducted to acquire practical information on how the Loto procedure is perceived and executed at terminal locations. The company of Vopak's, key player in the execution of the Lockout process for the tank terminal applications, will be analysed to acquire knowledge on the perception of safety and exectution of this method for the industry.

Knowledge will be gathered from various perspectives. For the implementation of smart product solutions, information will be gathered by consulations with the Loto decision-makers from the industry concerning the introduction of smart product solutions:

Innovation Engagement Leader(V1)
Global Deployment Lead (G1)

In depth knowledge is gathered from interviews with these stakeholders. Key insights will be presented and related to contextual background presented in the appendix of this report to provide a clear understanding of the gathered knowledge. The relations statements and appendix materials are assigned through personal reference codes (e.g (G1) relates to Appendix G1).

Regulations on the Lockout process tend not to reflect to real-life scenario (chapter 1.1). Consequently, practical experiences and information will be extracted through consultations with Vopak employees and external Loto experts of which both are directly involved in the accomplishment of the hazardous energy isolation.

Second operator (V3)
Maintenance Manager (V4)
Safety Health Environment & Quality Officer (V2)
Lockout specialist 1 - Directors Blomsa safety Products (E1)
Lockout specialist 2 - Partner Unique safety products (E2)

To acquire thorough understanding of the rich experiences of industry employees and external experts, interviews will be conducted (E1, G1, V3, V2). To emphasise with the key stakeholders, interviews will be recorded (V3, V2) of which the main insights are documented in Appendix 2, 4, 5 and 7.

A field study at the Vopak Vlaardingen Terminal will be conducted to evaluate literature studies, interview statements, safety protocols of Vopak and esthablish a extensive view of the Lockout process.

To acquire external experience on the requirements for product implementation, inhouse activities at the company of TWTG and thorough consultations with TWTG's managers will be esthablished. This includes meetings with:

Chief Technical Officer - TWTG
Product Owner - TWTG

Additional insights from the industry will be extracted from a meeting with TU Delft Proffessor G.L.L. Reniers (Appendix - 8). With these consultations we aim to acquire insight into the perspective of TWTG concerning product development for the industry and develop understanding of the industry from an academic viewpoint.

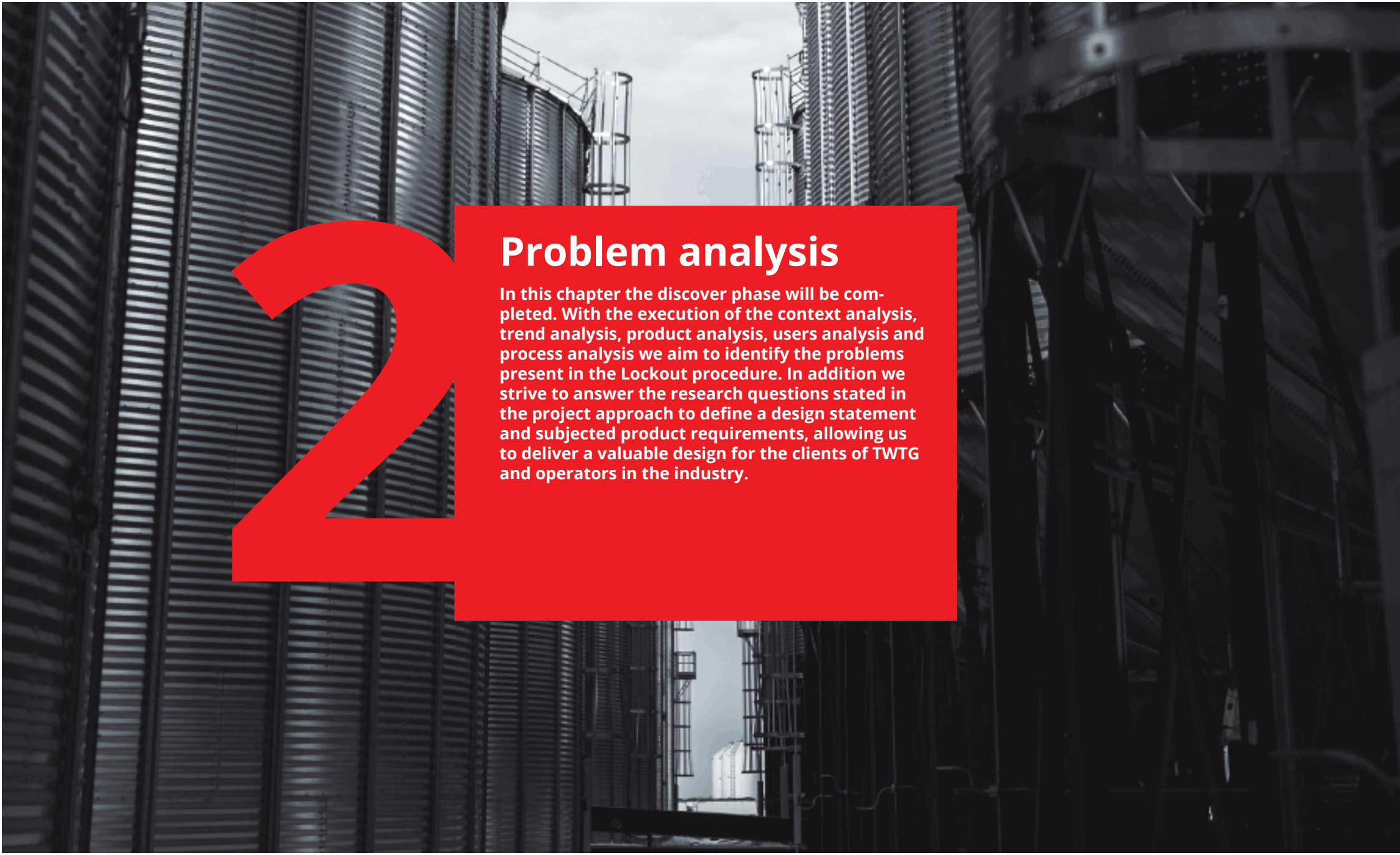
With this approach, we aim to extract a comprehensive variety of experiences and stakeholder viewpoints allowing us to establish an objective view on the Loto process and innovations in the industry.

Define

The result of the first phase of this process will be executed to define the requirements, state the desired user scenario and design challenge for Smart Loto solutions for the industry. These elements, being the fundamentals for the product development process, will be reported in chapter 4.

Develop and Deliver

From the identified requirements, a new Loto scenario and related concept will be developed. The scenario will be evaluated with different stakeholders from managing and operational departments of the Vopak to identify the advantages and limitations of a sizeable and leading market in the industy. The final usecase of the design will be illustrated in the detail to provide the clients of TWTG with understanding of the product solutions its capabilites. An appearance model will be developed to allow the company of TWTG to pursue commercial activities with the developed solution.



2 Problem analysis

In this chapter the discover phase will be completed. With the execution of the context analysis, trend analysis, product analysis, users analysis and process analysis we aim to identify the problems present in the Lockout procedure. In addition we strive to answer the research questions stated in the project approach to define a design statement and subjected product requirements, allowing us to deliver a valuable design for the clients of TWTG and operators in the industry.

2.1 Context analysis

2.1.1 Introduction

The context analysis is conducted to identify relevant design factors for the industry. We investigate the scale of the Loto operations, the related environmental factors and culture the industry by a field study at Vopak Vlaardingen.

External Loto experts, familiar with the context of Vopak, are interviewed to understand the impact and execution of the Loto process within the industry. For a broader analysis of the organisation, the Innovation Engagement Leader and Safety Manager (SHEQ) of Vopak are consulted. In addition, this analysis aims to reveal context aspects that require further investigation.

For this analysis, the field study is executed to review the practices of the industry. With user observations, information on how and where the Loto is used will be extracted.

Vopak Vlaardingen terminal

1KM²
Plant size

293
Tanks

25.000
Loto locations

2.1.2 Field study: Vopak Vlaardingen

At Vopak Vlaardingen cargo is delivered by trucks and sizable ships. A high state of awareness of the operators in the field is required to guide these processes. Vopak offers logistical solutions to various customers by various tank models and tank sizes for storage operations. Operators manually executed valve opening or closing actions at various locations on the terminal. Vopak Vlaardingen is a ninety-year-old Terminal of Vopak BV. Tanks from the 1920's and traditional systems remain in use. For this reason, products used at the terminal location are compatibile with both old-fashioned as new materials and multiple variations of energy isolations equipment (Appendix 1 - Field Study).

7-12 Loto procedures per week

1-30 Lockouts per procedure

500 Loto padlocks in use

Terminal location

Risk involved

The process in place at Vopak's terminals allows products (oil products, chemicals and LPG, biofuels, vegetable oils and LNG) to be stored. These tremendous volumes of products, e.g. heat treatment processes or resulting contaminated area's quickly present hazardous conditions. Operations in the industry incorrectly executed have a significant impact by: potential lethal accidents, the product being lost or damaging the capital intensive equipment.

Scale of Loto

All Vopak's terminals are obligated to execute the Loto method before maintenance can be conducted or goods can be stored. Loto actions include large operations. Unlike the medium-sized terminal of Vlaardingen, Vopak's terminal Europort executes an estimated 20 lockout procedures a week, involving (up to) 90 lockouts per procedure.

Large functional sights

The widely distributed assets on the large terminal sights require to pass great distances to perform all Loto actions in the field. At the terminal, the products and processes are designed to be purely functional and durable* to counteract the heavy impact of industrial material and user scenarios.

Trained employees

Specially assigned operation groups participate in a single Loto procedure. The employees involved in the Loto procedure are specifically trained to execute the process and handle the related materials. Discipline and strict operational behaviour is demanded for the correct execution of the process.

**More information: Appendix 9 -Context requirements*

2.1 Context analysis

“We operate safely, or we do not operate at all”

Global Director Operations
Appendix 10 - Vopak safety standards Loto

2.1.3 Innovation in the industry

Now that we understand the context of the organisation, we further investigate how innovation is approached by the industry.

In consultations with the Innovation Engagemenet Leader of Vopak, we learn the size, the price, complexity and number of processes in place affect the innovation capabilities of the industry. Implementing new products or services in the industry is complicated and not frequently done as processes remain operational for a long period of time. This subjected culture makes the industry stick with what works and adopt technologies that are proven safe (V1).

The safety manager of the Vlaardingen terminal manager explains most employees still prefer registering process inspections on paper.
New products are rarely introduced and new plans take time to be executed. Due to the slow change in business practices, employees with traditional belief systems remain in control of decisions for the industry (V2).

The field study presents a wide variety of old tanks, processes and operational materials. Storage tanks originating from the moment the plant is founded remain in operation. Accordingly, over 50 year old energy isolation valves and systems remain in operation.

The heavy industry of Vopak is supported by the high capital of investments known to result in low transportability of goods. Welfens (2009) states its common for capital intensitive industries in the US and EU to have significant innovations problems due to the low flexibility in their organisation.

We are provided with the insight that a traditional culture and passive innovation practice is present in the industry. This results in resistance to change and traditional methods being maintained diminishing the speed, flexibility and product diversity of organisations. The manifestation of new products must be carefully investigated to be succesfully implemented. This stresses the importance for identifying the suitable implementation for the industries practices.

2.1.4 Short term value and investments

To create a broader understanding of which factors influence the implementations of innovative projects, a global deployment lead of the industry is consulted (Appendix 5 - Global Deployment Lead).

From this consultation is learned, the industry desires to work with demarcated projects. New products are expected to require fast implementation plans while being safe from the moment of implementation. Due to the focus on the core processes and related profits, innovative solutions are often short term cut to create a fast return of investment of the project.

In the industry an the extensive amount of projects run in parallel. Innovation plans not delivering value in mean of profit are underminded by projects who do contribute to a productivity gain in the industry.

2.1.5 Safety protocols of Vopak

To understand how safety is regulated we investigated the presence of safety protocols in the industry. Protocols are designed to support clear communication and safety in the work environment to maintain a safe and efficient workflow (Appendix 10 - Vopak safety standards Loto**)**.

Current developments at Vopak desire to standardise regulations on stating how the Loto procedure must be executed on a global scale for all 66 terminals. Composer of this the Loto blueprint, the Global Deployment Lead, explains these protocols are based on the core values and believes of the industry (G1).

The Loto blueprint, The One Vopak Experience (May, 2020), is established based on standard practices in the industry, organisational perceptions on safety and experiences received from Vopak’s terminals (Appendix 10). Hence, perceived extremely valuable and challenging to change.

2.1 Context analysis

"To establish an effective Loto protocol, industries are required to find a workable balance between efficiency and taking enough safety precautions."

Sander van 't Ent - Director at Blomsma, Specialist Lockout Tagout (E1)

2.1.6 Loto and industry practices

To acquire practical information from experienced Loto advisors, we consult two lockout experts of the heavy industry (Appendix 2, Appendix 3). From these interviews, we learn the Loto procedure is the second most important safety measure of the industry, wearing a helmet is first.

In the current state, safety measures take time to be executed. More safety measures could always be added, yet a workplace saturated with Loto regulations and safety practices leads to unworkable conditions. (E1)

Energy isolations within the industry relate processes being shut down and cause an undesirable drop in productivity. An effective Loto procedure is not only life saving but consequently is effectively and speedily executed. (E2) Negatively, this results in more stress on workers related to the heavy industry.

2.1.7 Loto legislation

Examination of the law and regulations is conducted to understand the room for improvements achievable. European Law explain the adoption of Loto in not Europe. Legistation (EU-lex, 2020) states:

- All work equipment must be fitted with clearly identifiable means to isolate it from all its energy sources.

- Reconnection must be presumed to pose no risk to the workers concerned.

The Loto procedure is a tool to meet the stated conditions providing the ability to design different interpretations of a lockout than the current materials in place (E2).

For more information on Loto legislation review Appendix 9.

2.1.8 Conclusion

An effective lockout tag-out procedure is of significant value to the operations of the heavy industry. An effective Loto process directly relates to the productivity of the main processes in place. This provides opportunities for the industry to enhance the efficiency of their organisations with improved Loto routines.

Traditional cultures and the desires to have fast return of investment diminishes the flexibility of the industry to adopt innovative solutions. Solutions must contribute to short term value and require limited adjustments to capital intensive infrastructure.

The life-threatening dangers present in the industry requires Loto products to be trustworthy, durable, functional and applicable to the large scale of the terminal and Loto operations.

Strict regulations apply for the correct executing of the Loto. Meeting these regulations will decrease the resistance to adopting newly developed Loto products.

Further investigation of the Loto operators is required to understand why their training and strict work ethics do not contribute to the problem stated in literature (chapter 1); poor adherence to the Loto protocol by the operators.

Context:
Lockout applications

This overview is provided to establish a broader understanding on materials identified during the field study. Various materials can be used to isolate hazardous energy sources in the heavy industry. However, to lock the materials equal padlocks are used

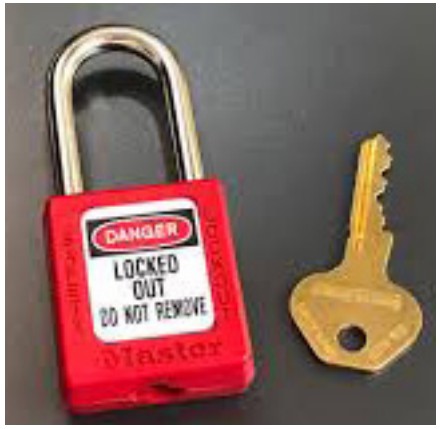
Hazardous energy comes in many different forms, all of which can be potentially harmful to operators in the industry.

Hazardous energy sources relate to (OSHA, 2019):

- **Electrical**
- **Mechanical**
- **hydraulic**
- **Pneumatic**
- **Chemical**
- **Thermal**

Of these energy sources, electrical, mechanical, thermal and hydraulic energy sources are frequently represented at the industry terminals.

Materials



2.2 Risk overview

This paragraph provides an general overview of the risks involved in the heavy industry. Due to the direct relation to safety of the lockout procedure accidents could occur due to the absence correctly executed lockouts. With this overview we stress the importance of the correct execution the procedure.

Risk 1: Postpone maintenance
In the scenario that the lockout method has to be re-executed the safety measure, the procedure functions as a bottleneck preventing workers from starting.

Risk 2: Delay process operations
In the scenario that a delay of the lockout execution or removal is present, this could result in the delay of the start-up of directly, serious cost-related industry, processes, e.g. cargo ship waiting to unload cargo.

Risk 3: Damage to equipment
In the scenario that a lockout is not correctly executed an, the system gets energized, the system can get severely damaged. E.g. millions of litres oil are pumped into an open system.

Risk 4: Injury
Due to the presence of operators and the wide availability of hazardous energy sources, the unexpected start-up of energy systems can harm workers in the industry.

Risk 5: Fatal incident
The magnitude of forces present can result in fatal incidents when released on workers. Logically this incident is of tremendous impact to any organisation, working culture, relatives and company moral.

Risk 6: Catastrophe
The ignorant lockout of control processes to maintain storage conditions or e.g. sprinkler systems, cooling processes or electrical systems can result in a combination of all prescribed high risks involved.

2.3 Trend analysis

2.3.1 Introduction

As stated in chapter 1.1 of this report, TWTG desires to integrate smart solutions in the operations of industry clients. Yet, industrial IoT is not suitable for all industry practices (D. Zhang, 2016). Thus, smart technologies can not be used for all applications or routine improvements.

For this reason, we conduct a more in-depth examination of what the introduction of smart technologies are suitable for the industry terminal practices. We aim to identify if IoT solutions are suitable for storage industry contexts and how TWTG can contribute to the implementation of smart technologies.

First, we investigate the potential of the IoT trend through literature studies and a consultation with the industry expert of the Delft University of Technology. Second, the context of the industry will be evaluated concerning suitable industry characteristics for IoT adoption. Finally, the identified opportunities will be evaluated in relation to the resources of TWTG.

Data drives performance of the industry

Strong digital foundation required

Wireless strengthens automation on a larger scale

2.3.2 The Industry 4.0

From the consultation of Prof. Dr. G. Reniers from the TU Delft (Appendix 8), expert on Performance management science in the industry, is learned a revolution emerges from the embracement of the IoT for safety applications. This causes smart appliances to be widely adopted in the industry. Reniers explains now that the adoption of the internet of things in the industry is broadly accepted there is serious interest to introduce a digital Loto for safer Loto procedures (Appendix 8). This new industrial revolution most often referred to as the industry 4.0 or industry X.

Literature recalls the industrial revolution demands the broad integration of clever software applications, adoption of web-based services and connected (smart) devices (Economist, 2012).

Within this industrial revolution the adoption of IoT devices allows to (Thibaud, 2018):

1. **Cooperate between different departments and employees**
2. **Real-time evaluate of assets**
3. **Monitor defects and errors**

From the company of Ericsson (2020), experts on the implementation of the industry 4.0, we extract the following points of interest; transformation changes the way goods and processes are produced, delivered and monitored. Industries participating in the industrial Internet of Things are able to become more flexible and efficient and acquire competitive advantage. By the adoption of wireless network solutions, the level of insight and automation is strengthened on a larger scale. A strong digital foundation allows to increase productivity and performance. This requires the industry to look beyond what problems should be solved today and additionally focus on how a digital data-driven work could enhance future processes.

Regarding this project, this feeds the desire to deliver a wireless solution which can contribute to a digital work flow.

2.3 Trend analysis

2.3.3 IoT - context characteristics

Increased performance of the Loto process is of serious interest to the industry in means of safety and efficiency (chapter 1.1).

We investigate if the context characteristics of other industries, which proved to contribute to the successful adoption of IoT solutions, suit the context of the heavy industry. We do this to identify if its valuable to pursue IoT solutions for TWTG's industry clients.

The identified context characteristics interesting for adopting IoT applications in the heavy industry are gathered through literature studies and are evaluated with the insights from the context analysis.

We learn the desired characteristics for a satisfactory adoption of smart products suit the identified context characteristics of the industry for the aspects 1,2,3,5. Consequently, we conclude pursuing IoT solutions is suitable for the tank storage terminal context.
In addition, we identify potential for the improvement of data collecting systems (6). To identify the value that can extracted, further investigation on the existing data collecting systems of Vopak is required (Chapter 2.4 - Product analysis).

Listed on the right: Literature study - Internet of Things (IoT) in high-risk Environment, Health and Safety (EHS) industries: A comprehensive review (S. Piramuthuc, 2018).

1) Various employees are involved in the production or processes at the facility.

2) Facilities operations are numerous. Large sites and great distances need to be covered.

3) Large variety of operations relating to different use cases.

4) Interests in cloud computing for resource exploration.

5) Safety concerns related to the damage of equipment and loss of life.

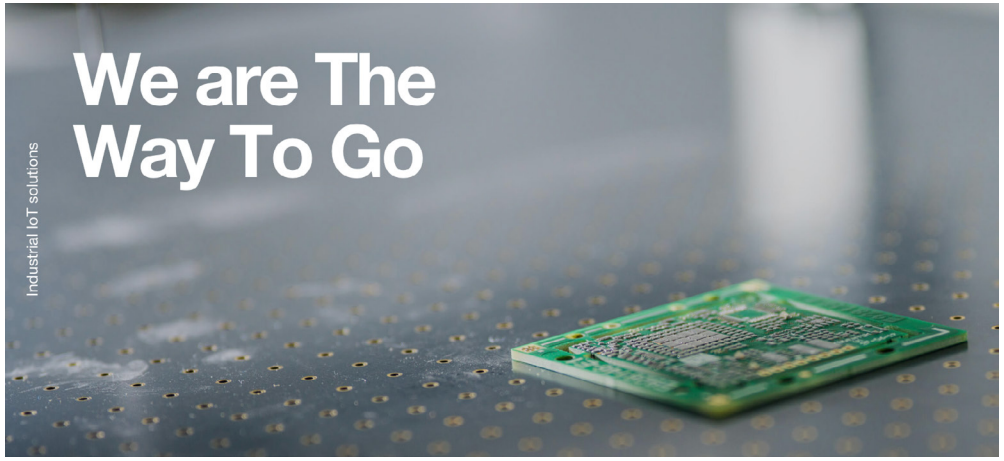
6) Inaccurately collected data related to manual control of processes.

7) Absence of uniform information platforms isolating data.

2.3 Trend analysis

“Industries shouldn't place bandages for every small problem they encounter”

Chieft Technical officer - TWTG



2.3.4 Implementation of the industry 4.0

The opportunities and relevance of the context for the industry to adopt IoT technologies is perceived valuable. Yet, how improvements with these technologies can be achieved in the traditional business operations remains of key interest for this research.

Aheleroff (2020) reports it is essential for the introduction of smart technologies in the industry to make minimal adjustments with the least negative impact on established processes.

J. Tilleman, CTO of TWTG, explains companies must adopt the IoT foundation from an early stage (quote above).

Early adoption allows the industry to embrace more advanced processes in the future resulting in less cost on the long term. Tilleman states: *“Industries shouldn’t place bandages for every small problem they encounter. Long term solutions are present and very profitable. Hence, we must inspire and educate the industry on the potential of these technologies.”*

For these statements we learn, concerning the short return of investment desire of the industry, solutions must pursue both short term as long term in order to be effectively implemented. This could require to implement technologies which are not favourable short term, but do provide long term value or vice versa.

2.3.5 TWTG & IoT product development

The company of TWTG provides R&D services for various enterprises in the heavy industry. With the collaboration established, Vopak and other industries can obtain of the industrial revolution value through TWTG’s resources.

From the inhouse visit at TWTG, we learn the expertise of TWTG primarily relates to embedded software and hardware practices. With their resources, the company of TWTG can significantly contribute to the Industry 4.0 in means of delivering the wireless network and IoT hardware devices. Besides, their company provides services for the integration of their hardware output into existing systems of industrial companies.

With their resources, end-to-end products can not be delivered. Development abilities exclude widely implementable solutions regarding web servicing, big data analysis and cloud computing. The business model of TWTG’s demands the development of new products. Hence, for the design of digital Loto, this feeds the desire for TWTG to deliver a scalable product solution.

However, the identified market size of Vopak’s (Loto) processes and the opportunity to deliver a large scale of connected products and IoT networks, feeds the desire to strengthen ties with Vopak and related industries to deliver tailored product solutions for the entrepresis specific market needs.

2.3.6 Conclusion trend analysis

The rising acceptance towards smart technologies in the industry provide great potential for the adoption of the Smart Loto product. The context characteristics of the tank storage context suit the integration of IoT solutions. With these solutions, opportunities for regarding both safety and efficiency performance can be achieved.

Further investigation of the Loto process is required to identify how monitoring defects, evaluating Loto actions and the cooperations between employees can improve the performance of the Loto process.

From the growing market of Industrial IoT and identified limited adoption of smart applications in the industry, emerge valuable business opportunities for TWTG. To ease the adoption of the product, new product solutions are desired to be tailored to the needs of the industry. This could require to incorporate functions less relevant short or long term.

Due to the enclosed IoT expertise of TWTG, industry entreprises are expected to use supporting web service technologies. The abilities of the industry to adopt these IoT solutions must be further investigated to identify how a digital workflow can effectively be established (chapter 2.5).

The opportunity to solve problems related to manually collected data motivates to conduct further research on the current documentation systems of the industry (chapter 2.3).

2.4 Product analysis

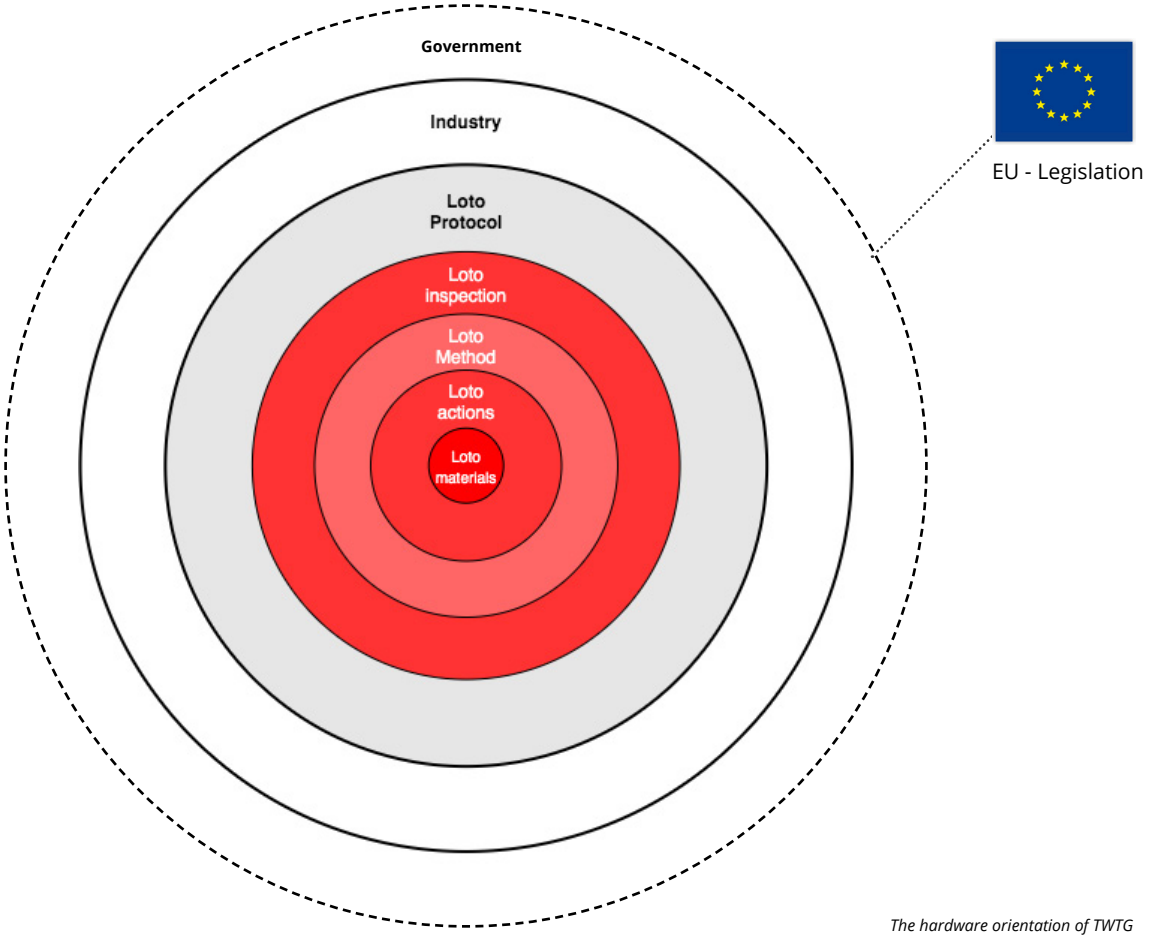
2.4.1 Introduction

This analysis aims to identify safety problems in the Loto procedure (chapter 1.1.) concerning the Loto materials and what actions are related.

Now we understand how IoT technologies contribute to the context of the industry (chapter 2.3) deeper understanding of the problems is present in the lockout routine required to identify where and how smart technologies can deliver value. Due to the absence of Lockout behaviour data we investigate what Loto actions could be enhanced and what problems are present in the Loto process through material studies and related user behaviour.

To understand where in the Loto process materials are used and what actions related to the materials, we first investigate the Loto process and related safety measures. Subsequently, we investigate the restrictions of the materials concerning efficiency to identify opportunities for improvement.

To broaden our view, we interview two experts regarding the materials applications. We study the Loto materials present by field observations and the execution of a functional analysis (Appendix 12 - Function analysis), we review papers on materials applications and consult employees of Vopak related to the Loto procedure.

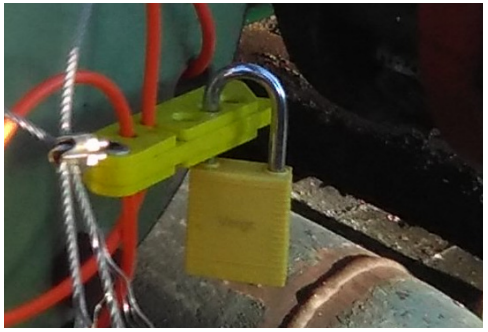


The hardware orientation of TWTG requires a focus on the red illustrated area.

Government
Provide guidelines and regulations.
Industry
Determines what type of lockout should be executed based on materials, employees, software, communication resources available.
Loto Procotol
Document explains how Loto should be executed at terminal location.
Loto plan
Document explaining how, by who, where and when the Loto procedure must be executed.
Loto procedure
The execution of the Loto plans, also referred to as Loto process.
Loto method
Way of locking out assets and ensuring safety among affected employees by the lockout.
Loto Materials
Materials required to prevent and assest from moving.

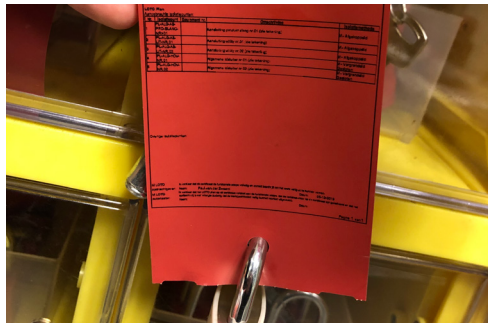
2.4.1 Material overview

Lockboxes at Vopak Vlaardingen



Padlock in field with support materials

Executed lockout out for pipe replacement



Loto tags providing procedure information in field and on the Loto box

Group lockout

Dense valve environment

2.4.1 Materials design factors

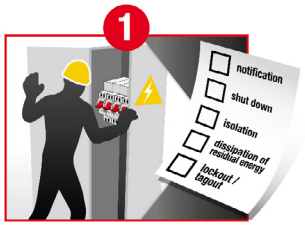
The regulations stated by Occupational Safety and Health Administration (OSHA, chapter 1.1) are not Law in Europe. Yet, they provide guidelines embraced by all industries.

These guidelines explain how Loto materials must be used and what aspects should be present in their design. The described scenario on the following page (step 1-7) are the advised Loto steps by global distributor of Loto materials (Masterlock, 2018, OSHA 2019)

These steps are further investigated in relation to Vopak's Loto procedure to understand how materials meet the safety regulations of Vopak. At the terminals of Vopak, this process is executed a few hours to half a day before maintenance or servicing will be executed. To prevent maintenance being postponed an effective execution of the process is required.

For a full and systametic overview of all actions it's advised to study the process overview. (chapter 2.6) A more indept overview of the practical actions related to this procedure is presented in Appendix 11 of this report.

2.4.2 The group Loto method



Set up Loto plan

Update all people involved

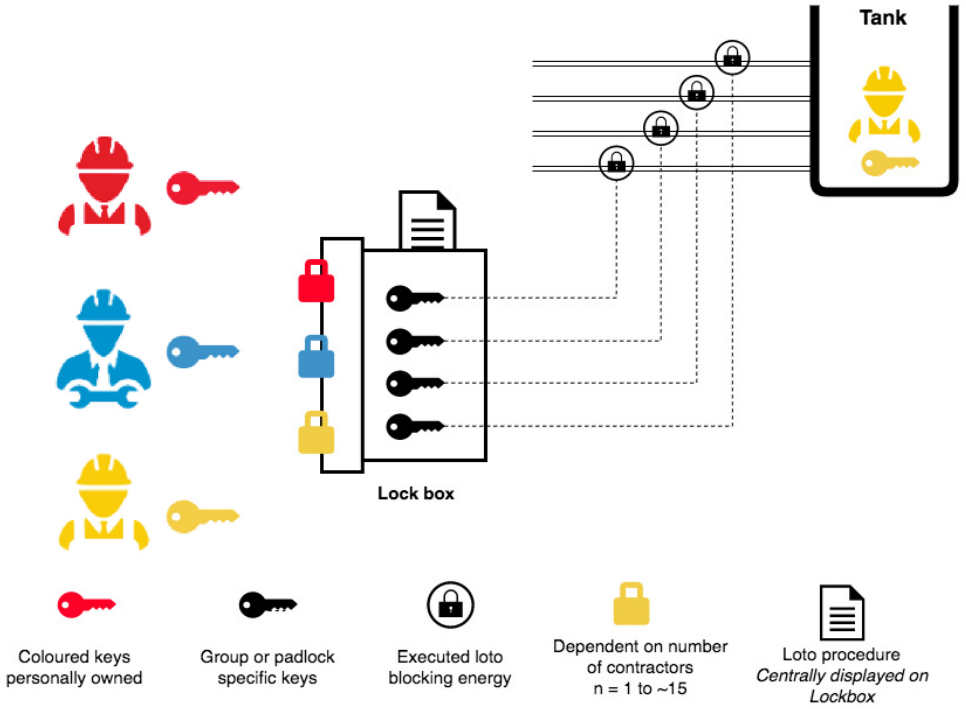
Shut down of equipment

Isolation of system

Execute tagout Lockout

Release of remaining energy

Inspection of isolation 1 & 2



Purpose of the method
The Loto method ensures affected workers are in control of their personal safety while an energy isolation is executed (Red, Blue, Yellow worker.

Vopak Loto Method explained
Placement
- The Loto operator locks out energy control sources (valves on piping network) connected to the tank with **Loto padlocks** and support materials.
- The Loto operator places the **keys** related to Loto padlocks in the assigned lockbox
- The Loto operator locks the lock box with a **personal padlock** (red lock)

Result: Loto operator physically obstructs the removal padlocks in field.

Inspection
- Inspection 1 (step 7): "4-eyes inspection" With the Inspection is validated if padlocks are correctly placed.

If correctly placed **personal padlocks** (yellow, blue lock) are applied to the lockbox.

- Inspection 2 (step 7): Required to be daily executed by a supervisor and contractor to verify if the padlocks remain, thus a safe work environment is maintained.

Release
- Release (step 8): To release the lockout, all the contractors and supervisor need to remove their personal padlocks on the Lotobox.

Hence, the supervisor and contractor are in control of the lockout procedure and their own safety. From this analysis, we learn Loto materials interact with different users in different steps of the process. The behaviour of these will be further investigated in the user behaviour analysis (Chapter 2.4).

We register the Loto materials (padlocks, tags, keys) participate in a bigger system. This system requires the use of a lockbox, personal online Loto operational systems and strict behavioural guidelines.

2.4.3 Summary functional analysis

In the functional analysis (Appendix 12 - functional analysis) we evaluate the functions of the observed Loto products. In addition the Loto managing software systems are are reviewed to identify opportunities for the integration smart product solutions.

In this secition the five main insights from this material study and related communications are explained.

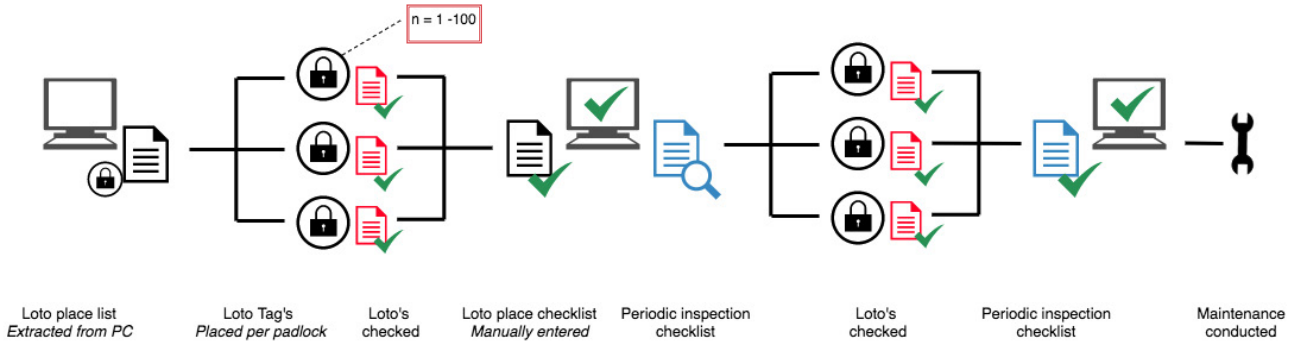


Image: Overview of the time consuming and inconvenient information flow at Vopak.

"Double registering notes is time-consuming and lowers the level of detail and quality of my notes."

2nd Operator

1. Communications

Communication of procedure information and actions

The communication flow related to the Loto materials is investigated during the field observations and consultations with the Loto operators of Vopak Vlaardingen. An inaccurate and inefficient flow of information is experienced. The illustration overview of communications displays how information is required to go back and forth from digital to physical.

Tag and Loto checklist is printed, the point of interest are manually registered on the checklist and later entered in the software system. On a daily basis, this same process is executed by the supervisor for inspection (Chapter 2.4.2.)

2. Software

Registration of Loto actions

Vopak's operators are required to register their Loto actions in the online operation systems. Actions include placement/release and inspections of the Loto. This adaptable and comprehensive software, globally used in various industries, provides options for the integration of smart product solutions data input and output (Infor, 2020), i.e. Dashboards for the in or output of the Smart Loto devices do no have to be developed to operate the smart product.

3. Work permit

Prevent unsafe work conditions

Within the operational software, all steps required to establish a safe work environment are documented. The establishment of a safe Loto is necessary to release a work permit. Operators can not start their work when work permits are not released. Yet, in reality, this level of safety is not maintained (chapter 2.4.3).

4. Padlocks

Strong perception of safety

Include a high level of substantially to prevent accidental or unauthorised removal. Key operations allow to personally in control of the operation. However, protocols states; in the scenario to padlocks can not be placed a tag suffice.

5. Tags

Provide detailed information in field

Provide insight into the Loto procedure regarding: the release date, responsible employees method in place and Lockout location. Loto tag's are not essential for operation. However, their presence in field is perceived essential to maintain clear communications to all stakeholders involved.

2.4.4 Material problems

As stated in chapter 1.1, flaws are present in the Lockout procedure. This paragraph elaborates on the main in the lockout procedure problems related to the materials.

Through extensive user evaluations knowledge is extracted from managers, operators and safety experts from inside and outside the company of Vopak. Interviewed partcipants (chapter 1.2) are questioned to elaborate on the use of materials and the related safety and effiency influencing factors. Through the various experiences and objective view and common thread in problems is be identified. This was done through a qualtive research studies to thoroughly understand the problems and their manifestations.

This paragraph elaborates on the main problems identified by the vast majority of stakeholders. Background information is provided by quotation codes presenting stakeholders elaborating on the essence of problem. All listed identified problems can be reviewed in the appendix 13 - Listed problems.

Plastic lockout support materials

"If people have the intention to open the lockout, they can easily do so, that's not difficult at all"

Safety, Health, Environment & Quality manager - Vopak

Material problems

Safety
From these analyses and consultations, the following problems are revealed concerning Loto safety in the industry:

1. **Locks are cut when keys are lost (E1)**

2. **Substantially is undermined effect due to support materials (V2)**

Plastic mechanical support are used (top image) and master keys shared to various employees (V3).

The substantiality of the lock is a problem. The lockout safety expert (E1) explains: In the scenario that locks need to be opened, people lose their keys or operators are not present at the terminal location, padlocks are being cut. E.g. for the reason moving parts need to change position to prevent life-threatening accidents. (E1) This results in incomplete material sets and a lack of overview for the operators resulting inconvenient operations (V3).

The plastic support material can easily be removed (V2). The key substantiality of the Loto padlocks get undermined by weak support materials and related user behaviour. *(more info user behaviour analysis)*

Subjected problems (identified by the author)
- key operations can not be traced back to the person related to the lockout.
- The unauthorised removal of locks is not registered.

These subjected problems result in industry operators performing actions based on their own perception of safety. This aspect will be further elaborated in the behavioural analysis (Chapter 2.3.3).

2.4.4 Material problems

Companies state; “when locks are cut operators are fired”. However, in this scenario the lock is already cut and registering if the lock is cut remains impossible. - Locks being cut is never the intention, but it always happens.

Sander van ‘t Ent - Director at Blomsma Safety Components and Specialist Lockout Tagout

Efficiency
Consequently, the following problems are revealed in relation to efficiency:

1. Absence of keys at location (V2)
Workers lose their keys or take keys home while locks must be removed.

2. Acquiring the right keys is time-consuming (V3)
- A long authorisation process is required to acquire master keys.
- Acquiring Loto materials is inconvenient; printing, assigning labels managing and key operations is a time-consuming process.

2.4.5 Product analysis conclusion

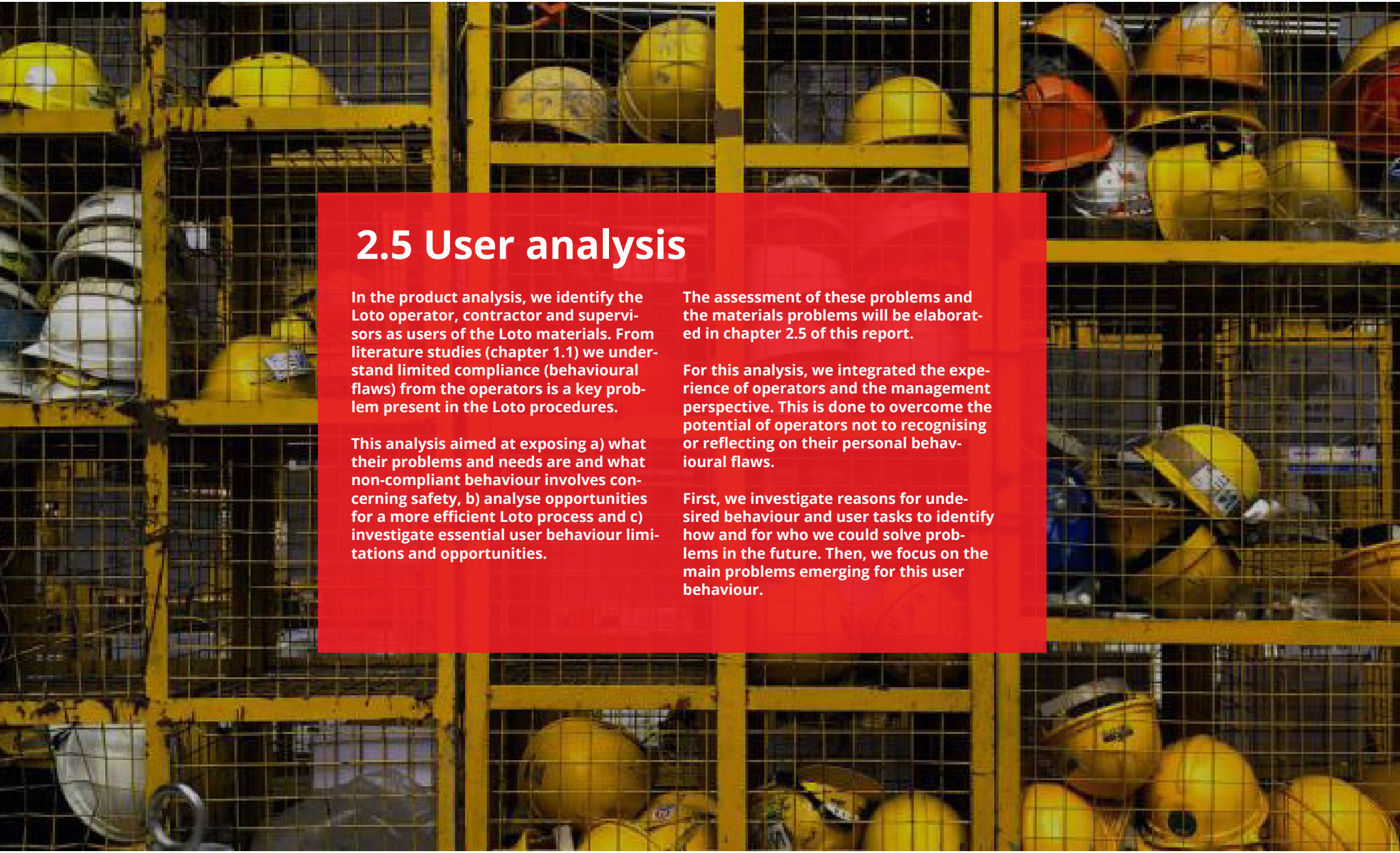
The materials used in the Loto process have a significant impact on maintaining safety in the heavy industry. Yet, the materials used in the Loto process contribute to a false perception of safety.

The relevance of solid Loto materials is eliminated by the ease of locks being cut, master key by-pass actions and weak support materials in place. As a result, the symbolic value of the materials is of much greater importance than the physical locking abilities. In addition, no means are in place to register if a padlock is released unauthorized. These factors heavily undermine the intention of the procedure: deliver personal safety to employees.

Time could be saved in the Loto process by establishing a more efficient key authorisation process. By transforming the communication flow from physical to digital documentation solutions, it is perceived a more efficient and accurate documentation system could be established.

Concerning the adoption of materials; the ease to integrate new materials in the Loto processes can be enhanced by meeting the requirements for operational software of Vopak (suitable for smart product adoption) standardized dimensions of support materials and providing an identifiable appearance.

From this analysis, we conclude that improvements must be achieved on a materials level to maintain a safe and efficient work environment in the future. As a result the product development phase of the project will focus on overcoming the identified problems.



2.5 User analysis

In the product analysis, we identify the Loto operator, contractor and supervisors as users of the Loto materials. From literature studies (chapter 1.1) we understand limited compliance (behavioural flaws) from the operators is a key problem present in the Loto procedures.

This analysis aimed at exposing a) what their problems and needs are and what non-compliant behaviour involves concerning safety, b) analyse opportunities for a more efficient Loto process and c) investigate essential user behaviour limitations and opportunities.

The assessment of these problems and the materials problems will be elaborated in chapter 2.5 of this report.

For this analysis, we integrated the experience of operators and the management perspective. This is done to overcome the potential of operators not to recognising or reflecting on their personal behavioural flaws.

First, we investigate reasons for undesired behaviour and user tasks to identify how and for who we could solve problems in the future. Then, we focus on the main problems emerging for this user behaviour.

2.5.1 Behaviour analysis

In this overview we discuss the four main identified arguments for the limited adherence to the regulations provided by the industry.

This behaviour analysis is elaborated from an operators perspective and based on the Loto user and managing consultations. The identified issues are not directly related to the protocol and training of Vopak's operators and therefore perceived applicable to various industries using the lockout method.

"In some cases we must handle too many things at the same time and we are just too busy. In these scenario's it happens locks are not correctly placed or released"

2nd Operator

"Operators are pragmatic guys, they think they do the best thing for the company but they don't. Personal tasks are first"

Global Deployment Manager

1. Wrong perception of correct actions

Operators are perceived to have the best intentions concerning their performance. However, experiences difficulties in understanding the consequences of their actions for the company. A sizeable ship required to unload cargo or short term maintenance is recognised more important than meeting Loto regulations. When they execute these actions, they believe it's of the companies interest. Yet, an unsafe work environment is strictly prohibited from an organisational level (Appendix 5 - Global Deployment Manager).

2. Pressure on operators

The Loto procedure relates to an excessive productivity drop (Chapter 2.1.3). The faster a Loto is released or placed, the smaller the impact on the company's profits. The related culture established puts enormous pressure on the Loto operator to work fast. When operators are required to work fast, mistakes have much higher potential to befall (E1, V3, V2).

3. Negative conditioning

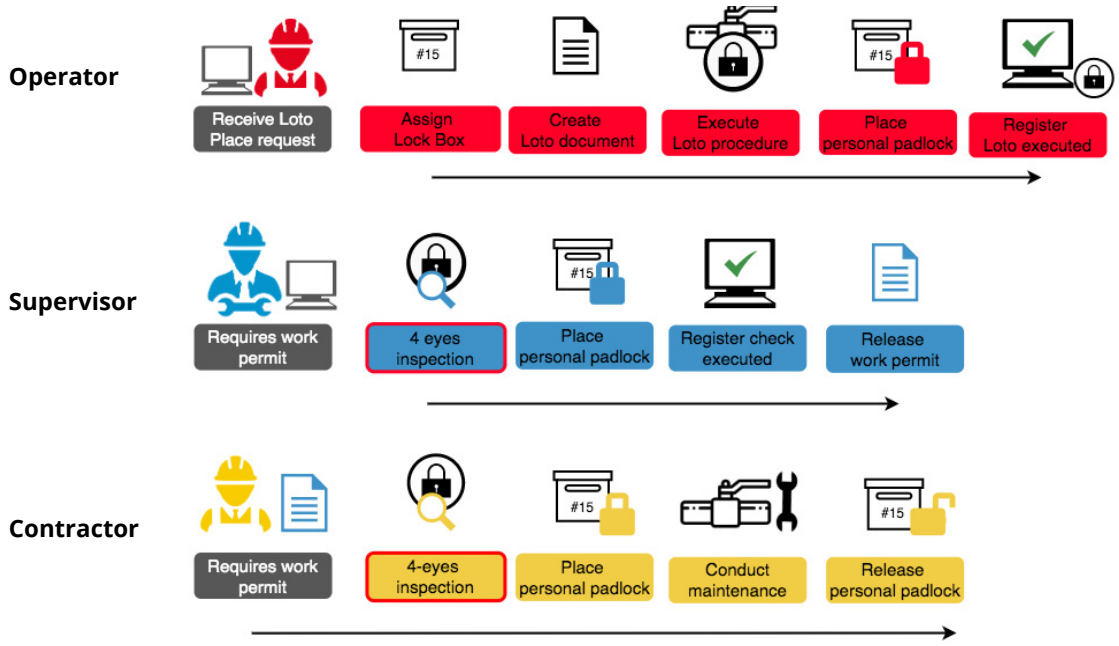
Operators get used to working with hazardous energy sources. Time-related to establish the safety procedure is perceived inconvenient when small tasks are required, e.g. In the scenario that forgotten tools in the work area or minor adjustments must be made, operators enter hazardous areas unauthorised. The absence of accidents results in repeating these negative actions until problems occur (E2, V2, V3)..

4. Invalid safety assumptions

Operators act based on their personal perception of safety. Due to the minimal changes to a Loto system, operators assume assets remain correctly isolated over time, e.g. Long term Loto's can be in place for multiple years without any chances. Yet, new procedures could result in a sudden release of the lock. Besides, operators put their trust in the craftmanship of other employees. This result in operators making safety assumptions instead of validating the level of safety themselves (V3, V1).

2.5.2 Task analysis

In this paragraph, we take a deeper look at the tasks related to the operators. We execute this analysis to identify how the studied behaviour impact the tasks and thus safety in the Loto process. Subsequently, we aim to discover which user has the most significant problems and at what time in the process. The full task analysis (Appendix 14 -User tasks) allows us to emphasise with the user behaviour, prioritise risks involved and identify room for improvement.



The Loto operator

The Loto operator experiences most pressure on performance in Loto procedure. This operator must work fast and accurate to maintain an efficient workflow on the terminal. The Loto operator is part of the support operations group, thus required to handle various processes on the terminal. Besides his daily tasks he is personally responsible for 5-7 lockouts per week, this includes the handling of an average of 12 locks per lockout, excluding the release actions.

Main tasks

- Control the Loto Process
- Place & release all Loto materials

The supervisor

The supervisor must verify if all Loto actions are correctly executed. Validating if all checks are executed is a daily obligated task which demands great effort and time in execution. This task should be executed with contractors affected by the lockout procedure. The supervisor is end responsible for ensuring a safe work environment.

Main tasks

- Perform (daily) inspection
- Releases work permits allowing the contractors to conduct work

The contractor

The contractor executes maintenance at the terminal. The companies Loto regulations are primarily established to secure this worker. The faster the contractor can start his work, the faster his job is done, the more value is perceived from his operations.

Main tasks

- Performs periodic inspection with the supervisor
- Conduct maintenance (requires work permit)

2.5.3 Behavourial problem analysis

Introduction

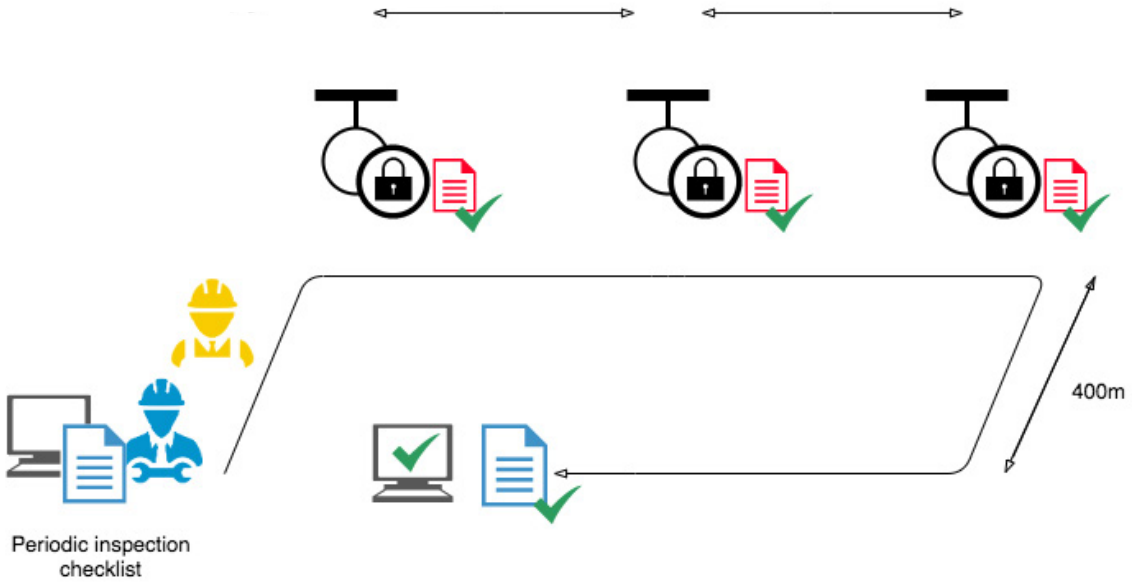
In the this paragraph we elaborate on the main problems present in relation to the user behaviour.

From full extensive task analysis and user consultations with employees difficulties for maintaining a safe and efficient Loto process in the industry are revealed. With this analysis we are able to identify who has the problem, why the problems are present and at what moment the problems occur.

We elaborate on these problems by focussing on safety and efficiency.

The main problems identified relate to:
1. (Neglected) Loto safety inspections
2. Inaccurate Loto place & release actions
3. A false perception of safety

For a more elaborate version of the subproblems, related risks and background can be found in Appendix 13 - Listed problems.



1. (Neglected) inspections

A) Downtime of operators: Time-consuming inspections
A substantial amount of padlocks (up to 90 at Vopak Europort) is widely distributed in the Lockout process. These locks are required to be inspected. This task requires 3-4 workers to spend a minimum of 30 minutes of work per day. The status of the locks (open/closed) is rarely altered. Yet, the correct placement of the lock must be daily validated to ensure safety (G1, V2, V1).

B) Neglected work preparation inspections
The supervisor assumes no adjustments to lockouts are made and a safe workplace is maintained. Hence, the daily inspection is frequently neglected due to the time and effort involved in execution (V2, V1).

Causes
- Time-consuming inspection process due to the large plant size.
- Does not feel the need to inspect locks that rarely change status
- Operators act based on their own perception of safety in order to safe time (V1,V2).

2.5.3 Behavourial problem analysis

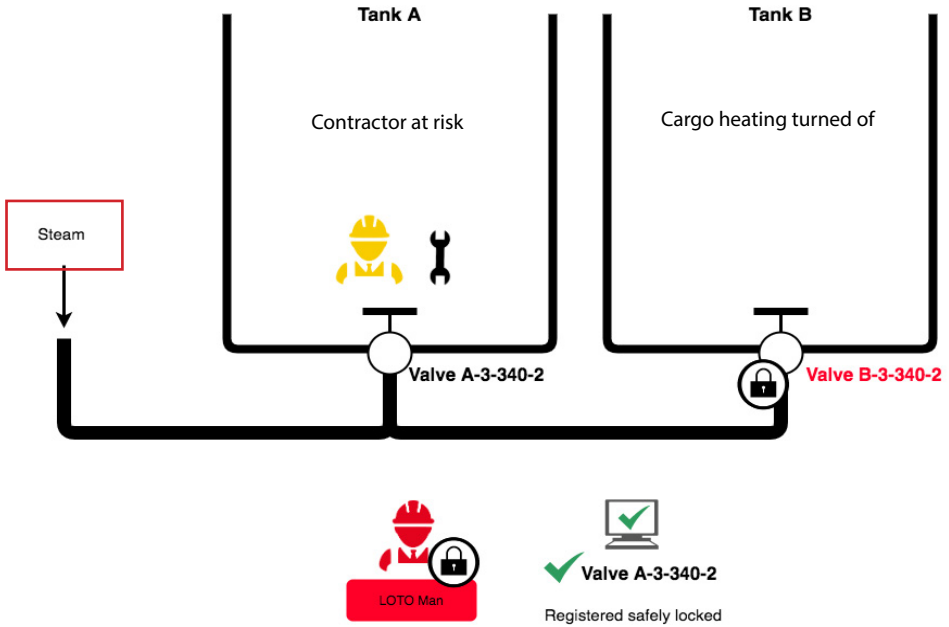


Illustration:
This image illustrates an example scenario of a Loto being executed at the wrong location. Thereby endangering the work environment of the contractor inside tank A.

This problem is intertwined with the invalid registration problem (problem 3). The manifestation of this problems has potential to result in life loss or product and materials being lost damaged. E.g. unintentional cargo heating (steam) being turned on.

Consequently, Loto's being released from the incorrect location can result in obstructing the start-up of regulation processes negatively affecting safety. E.g. control process (sprinkler system) remaining isolated.

2. Inaccuate Loto place & release actions

Background

At large enterprises in the heavy industry, multiple Loto operations run in parallel. Unintended mistakes are being made in the correct execution of the Loto procedure by the potential of human inaccuracy. Overview difficulties are supported by incomplete materials, various similarly looking location codes and detailed handlings required.

Insight in these problems are provided by the field research and consultations of the Loto operators (V3) and Safety Manager (V2), Appendix 7 and Appendix 4.

Problems explained

<u>Release/placement of a Loto is not executed</u>

- Operators forget to execute their actions.

- Operators do not look accurately at the place/release information presented.

- Operators do not have clear insight in the to be placed/released Loto's.

<u>A Loto is placed/released at the location</u>

- Operators do not accurately verify the correct location of the lock. Resulting in the release Loto location being misinterpreted.

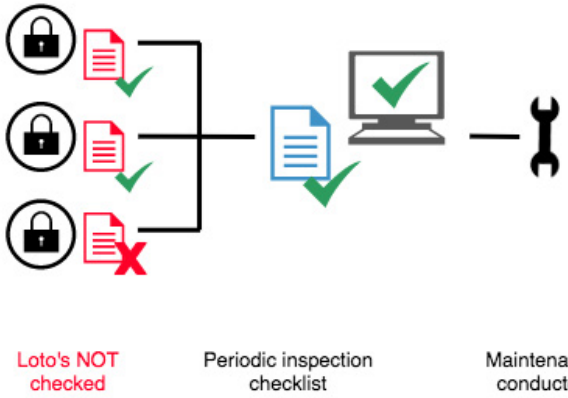
- Detailed information on the correct location is not clearly presented.

- Loto operators are not provided with feedback on the correct execution of their actions.

- Loto's not participating in the designated lockout procedure can be released with multiple keys.

- Terminal location codes are misinterpreted with other locations.

2.5.3 Behavourial problem analysis



3. Invalidated Loto registrations

Background
From the product analysis (Chapter 2.3) is learned documentation systems are used to monitor the actions executed in the Loto procedure. By registering placement and inspection tasks work permits can be released allowing workers to enter hazardous energy affected areas safely. However, false perception of safety is represented in this system due to the earlier identified potential of misinterpreted actions.

Problem
The status of the lock in the system does not reflect the real-life scenario.

Elaboration
The consultations in this problem analysis reveal the possibility of locks being incorrectly placed/release or not inspected (Behavioural problem analysis - problem 1,2).

Yet, maintenance can be conducted if the supervisor or Loto operator marks the actions as executed in the documentation systems. If these actions are not correctly executed this results in the scenario that the industry terminals believes the lockout is safely executed, while in fact a safe environment is not established. Thereby, resulting in the stated false perception of safety.

These problems are represented by two scenario's:

<u>Unintentional mis-use:</u>
Locks are not correctly placed/released, while their are registered correctly placed/released Subjected to misinterpretations of problem 2.

<u>Intentional mis-use:</u>
Daily inspection is neglected, inspection is registered executed.

The intentional misuse is almost routine at Vopak Vlaardingen. Daily work inspections are frequently neglected, yet registered executed. Diminishing the safety of the system and effec-

2.5.4 Conclusion

Within these lockout routines a serious room for error is represented. These problems relate to the tasks executed by the industry employees, thereby underlining the earlier statement in literature (Chapter 1.2); the main problems of the Loto process relate to human factors in the lockout process. With this analysis we identified these unknown factors.

Operators are unaware of their incorrect handlings, operators assume safety is maintained instead of validating safety and inaccurate registrations of actions are performed. A great improvement on awareness and the safety registration systems is required to achieve a secure work environment at terminals performing lockout routines.

The potential of workers making mistakes in relation to risks emerging from these mistakes is unacceptable. Human flaws present will never be truly solved by the craftmanship of the operators due to the significant dependency on human handlings. Preventing the chance of these mistakes from occurring must be done by providing more guidance on the tasks of the operators. In addition, more control factors must be placed to raise the awareness of mistakes being made to various people on the terminal.

Providing a higher level of awarenes supports the effect of an efficiency increase as the current time spent on solving low risk problems will be decreased. For both safety as efficiency reasons limiting the time spent on inspections is desired. Consequently, this will contribute to the adoption of our product as significant productivity gain can be achieved by decreasing the downtime of the maintenance workers.

2.6 Process analysis overview

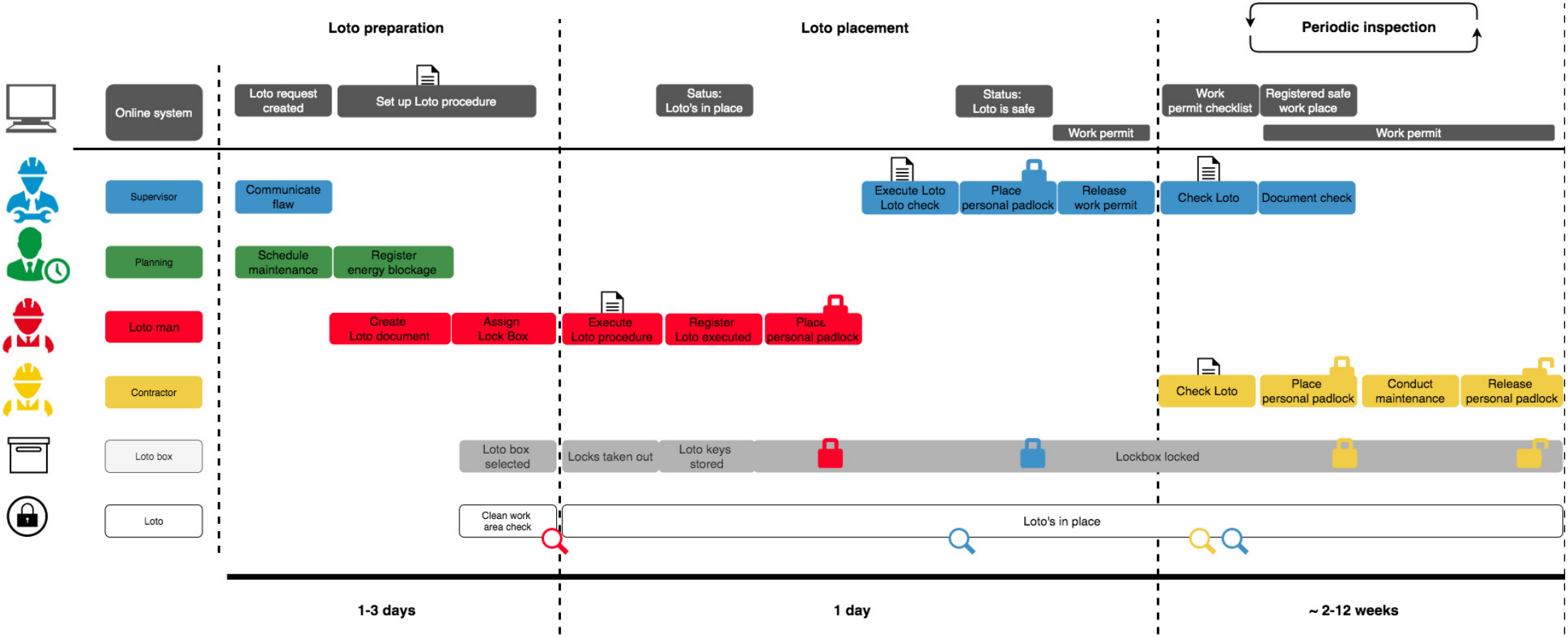
This two page overview provides a structured representation of the Loto process presented in the industry. This overview can be perceived as an extensive summary of the product and user analysis executed at Vopak. With this, we focus on the whole product life cycle.

The process overview:
- Distinguishes the digital and physical communications to identify how the real-life scenario is monitored.

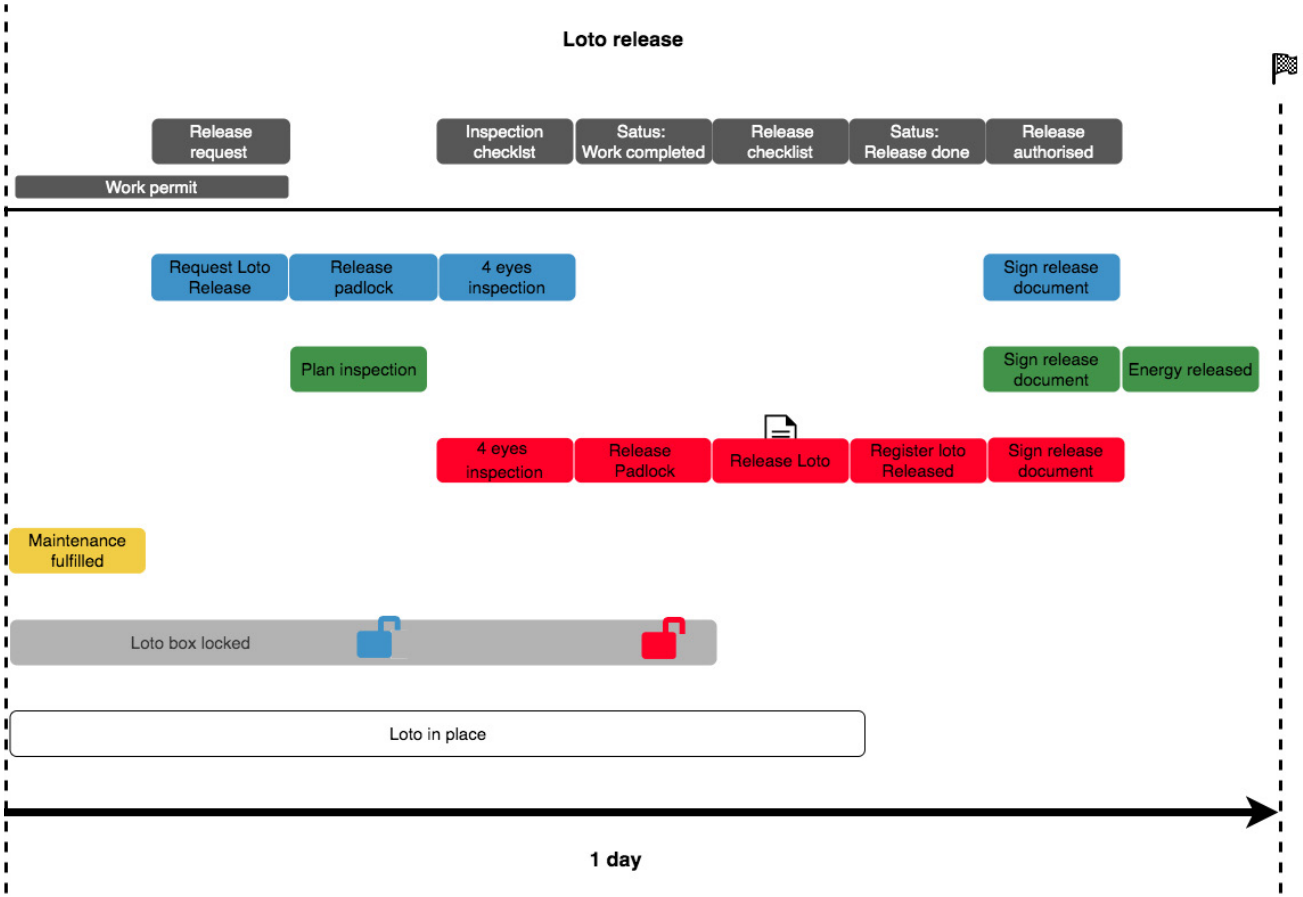
- Provides clear insight into how the padlock materials are used to ensure personal safety in relation to time.

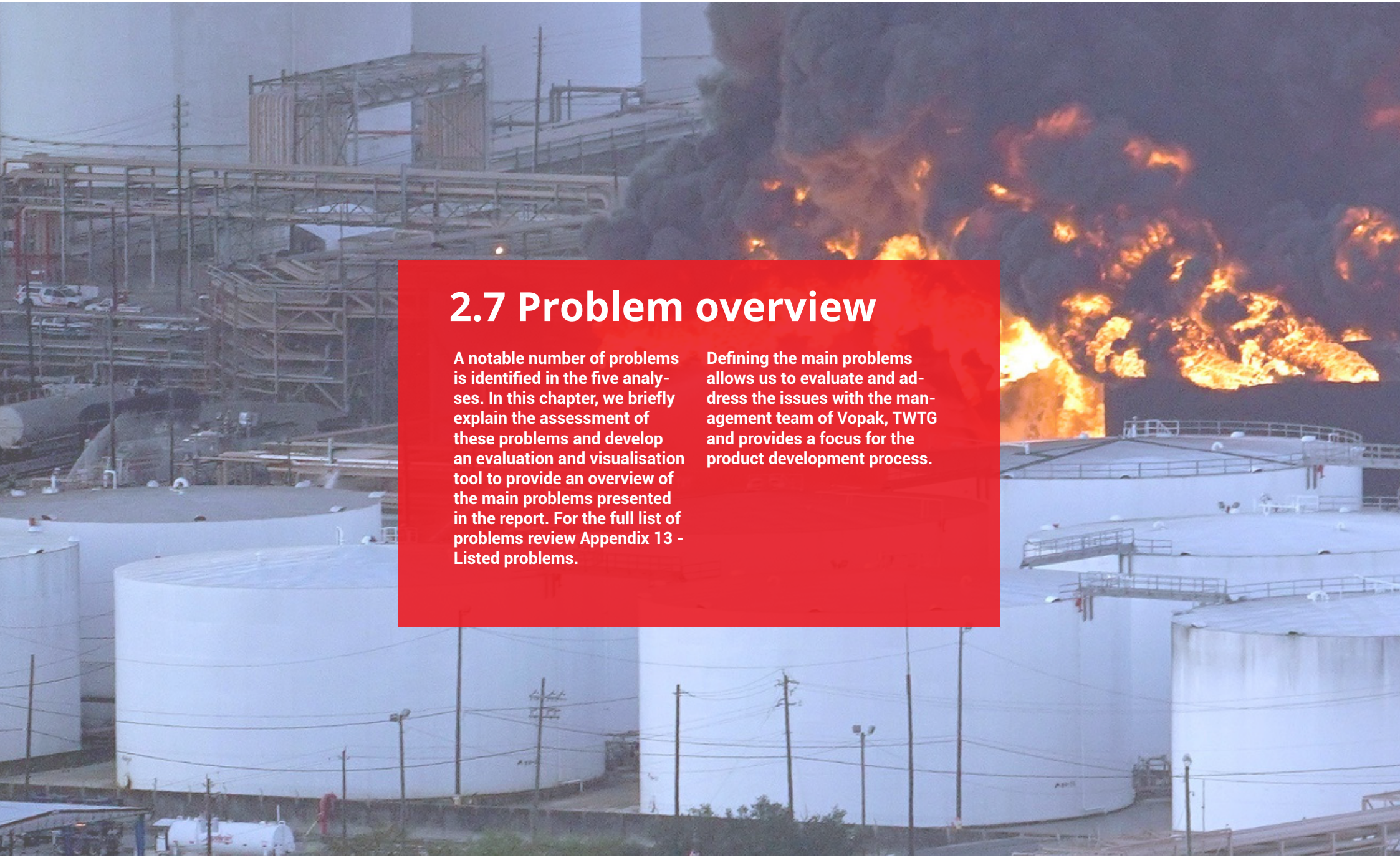
- Provides insight into how the work permit is used as a safety barrier and how the (un)authorised release results in contractors working in unsafe environments.

- Reveals the duration and actions involved in the time-consuming safety inspection.



2.6 Process analysis overview



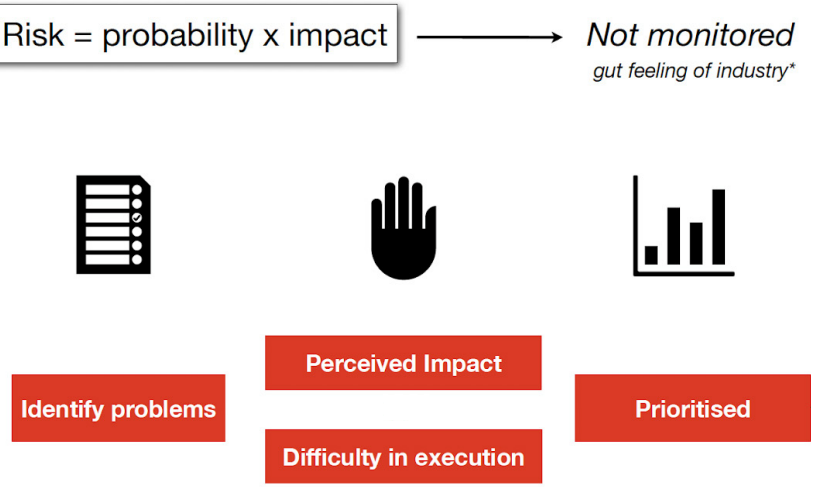


2.7 Problem overview

A notable number of problems is identified in the five analyses. In this chapter, we briefly explain the assessment of these problems and develop an evaluation and visualisation tool to provide an overview of the main problems presented in the report. For the full list of problems review Appendix 13 - Listed problems.

Defining the main problems allows us to evaluate and address the issues with the management team of Vopak, TWTG and provides a focus for the product development process.

2.7.1 Problem assessment



Placeholder image

Background assessment

From the consulation with Prof. Dr. G. Reniers from the TU Delft, we learn efficiency and value-driven economic or analysis models are only rarely consulted by the industry. Problems solving abilities tend to be based on “gut feeling” from the industry managers.

The absence of data on the flaws and issues in the Lockout process suggests the industry does not have a clear understanding of the main problems present in their lockout routines. Thereby providing difficulties in the assesment of the problems present in the lockout routine.

To identify the weight of the recognised problems, theory of the risk assessment formula, aimed at preventing risks in the future (Rausand, 2013) is used as an guideline to assess the identified problems. This risk equation is commonly known to the industry and points out risk in two variables: probability and impact, in which:

*Risk = probability * impact.*

Problem overview

Due to the current absence of data on (near miss) accidents, the true impact can not be quantified with this formula. With the extraction of Loto data, this could be executed in the future. Yet, because of the absence of data, we set up alternative indicators for the probability and impact variables to deliver the overview of chapter 2.6.2.

- For probability, we look at the difficulty in execution of actions in the lockout process. As we learned the more difficult a task is the easier mistakes are made in the Loto process.

- In terms of impact, we look at the different levels of accidents that could emerge from mistakes being made.

Note; a significant problem not displayed in the presented timeline of required Loto actions (horizontal axis) covers the unauthorised release of a Loto.

Conclusion assessment

In the Lockout process three serious risk areas are identified. The greatest chance of risks originates from the Loto placement and inspection actions not being correctly executed. The greatest inconvenience in the execution of the Loto process relates to the four eyes inspection being executed. Hence, safety does not fundamentally relate to the inconvenience of materials, materials related handlings or documentation steps not being understood.

We learn the problems mainly emerge from inaccurateness in placing and releasing the Loto. This relates to an overarching problem: A high level of dependency on the correct interpretation of the operators of Loto actions. Taken away inconvenience in these steps is desired to flatten the peaks of the diagram for both ends.

2.7.2 Problem overview

Abstract overview: Impact of Loto actions in relation to inconvenience and safety

On the horizontal axis the main actions of the Loto users red: Lotoman actions, Blue: Supervisor actions, Yellow: contractor actions

2.8 Review research questions

The synthesis of our five analyses allows us to dedicate this paragraph to the main insights regarding the research questions (Chapter 1.2.

The insights from these analysis are the fundamentals for our product development process. From these insight product requirements will be esthablished to provide guidance in the product development process.

a) Safety, how to decrease the chance of Loto accidents occuring in the heavy industry with Smart Loto solutions?

Serious problems are present in the heavy industry regarding the safety of their Loto process. The dependency on human tasks and potential for inaccurate handlings results in the unsafe placement, release and inspection of lockouts. A false perception of safety is established by incorrect Loto activities being registered correctly executed.

In the current scenario, Vopak's operators are not provided with feedback on their activities. Hence, operators are unaware of their inaccurate behaviour resulting in mistakes being made.

Supervisors, aimed at identifying these problems, do not meet the safety protocol as they neglect inspection activities. This for a reason great inconvenience is experienced in the time and effort related to these actions.

With smart solutions, the user behaviour defects in the Loto procedure can be revealed. Insight on lock breaks and wrong user behaviour can be provided.

Smart technologies can contribute to overcoming the problems identified by:

- Providing proactive feedback to Vopak's users to raise awareness on their actions and prevent inaccurate placement and release activities.
- Provide insight on defects to control departments and employees to identify:
  Are the safety regulations met?
  Who is responsible for the incorrect activity?
  Where do we need to intervene?
- Monitoring activities to register placement or release flaws and eliminate personal intrepretations on safety.

With the support of these smart technologies the identified safety problems can be overcome. Control over the Loto process can be established and the false perception of safety can be eliminated.

2.8 Review research questions

b) Productivity, how can Smart Loto solutions contribute to the efficiency of the Loto process?

The execution of the daily work inspection in the lockout process is a time consuming task. Dependent on the size of the terminals this inspection could require an average of four people to spent 60 minutes on inspecting (up to) 90 lockout locations per day.

A significant value gain can be achieved by decreasing the time spent on these inspections. This can be done by the realtime monitoring abilities of IoT technology solutions. Direct insight into the status of these locks enables workers to start their routine fasters and will improve productivity.

Key operations are a time consuming process. Digital key operations and pursuing symbolic value of the lock provides great potential to increase the efficiency of key operations.
This will eliminate the chance of keys getting lost, time consuming authorisation processes and desire to cut locks. Thereby additionally contributing to the safety of the process.

Fully digitalising this process requires to push the boundaries of the digital authorisation process. A culture shift in perception of safety related to key operations is required.

Further research must be conducted to understand to what extent this boundary can be shifted (Chapter 5.2 - Concept exploration).

Synthesis reflection
In the current state of the Loto process adding safety layers is perceived to negatively influence efficiency. Yet, this research reveals the adoption of realtime monitoring actions and significantly contributes to safety and efficiency.

By targeting both these factors, the adoption and therefore viability of the future product is strongly enhanced. With this solution, the industry can step away from its difficulties in balancing safety and efficiency regarding the Loto process.

c) The industry, what are the criteria for adopting smart product solutions?

In the heavy industry fast returns of investments do not primarily relate to material investments. Hence, for the implementation of smart product solutions at sizeable industries like Vopak it is of the utmost importance to deliver solutions that can be integrated in the strong routines present at Vopak's. Investment factors additionally concern management of chance factors being:

- (Re-)training of employees
- Replacement of systems
- Capital involved in existing systems
- Digital orientation of existing systems
- Perception of safety (culture)
- Innovation readiness of the stakeholders

All of which influence the acceptance level of the industry to adopt Smart Loto solutions.

Solutions must address all these factors in order to cross the interval from invention to innovation. The weight of these factors is complex to identify and out of the scope of this project.

However, on a product level, these factors must be taken into account to improve the ease of implementation of smart products. For this reason it is of priority to deliver a Loto product that marginally adjust the routines and materials in place.

A balance must be found between the delivering value and reaching an accepted level of disruption with new products and technologies. Simplification and/or elimination actions in the Loto process must be pursued to improve on short-term efficiency and safety.

On a software and material level, the success rate for implementation can be enhanced by delivering solutions that can be directly integrated with the webservices of Vopak and meet the standard dimensions and the materials in place.

Finally, meeting the companies protocol will enable to select the path with the least resistance. Yet, this protocol can be challenged through different interpretations of safety.

3

Define

In this chapter, we translate the insights from our discover phase into concrete design requirements. These requirements are perceived as the cornerstones of our product development process. The set requirements will be assessed during the concept exploration and final evaluation of our future concept.

A desired scenario is established as an inspiration tool to overcome the problems stated in the materials and product analysis.

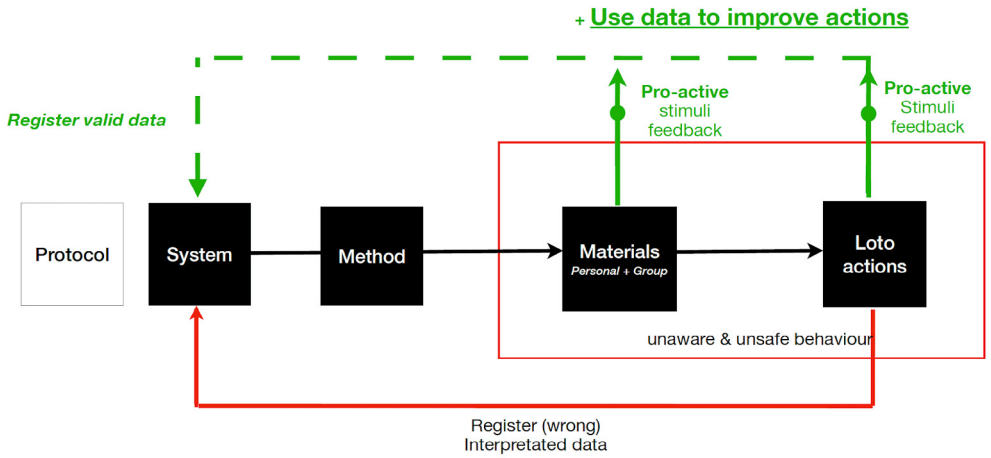
A design challenge will be formulated to provide focus in our product development process.

3.1 Product requirements

Safety & Efficiency	- The product provides feedback to validate if Loto actions are correctly executed - The product provides insight (stimuli) to improve the accuracy of Loto actions
Safety	- The product enhances safety by supporting adherence to the protocol - The product is able to identify the (un)authorised release of a lockout
Efficiency	- The product improves the efficiency of the inspection process - The product improves the efficiency of key operations
Other	- The product does not have to be destroyed to remove the product under stress - The product is suitable for to the heavy industry environment
Implementation	- The product limits the impacts on the existing routines of the Loto operator - The product can be implemented in the exisiting operations of Vopak

3.2 Desired user scenario

The desired user scenario is established as tool to define where the most weight of our product solutions must be placed in order to overcome the problems present in Loto process.



3.2.1 Elaboration desired user scenario

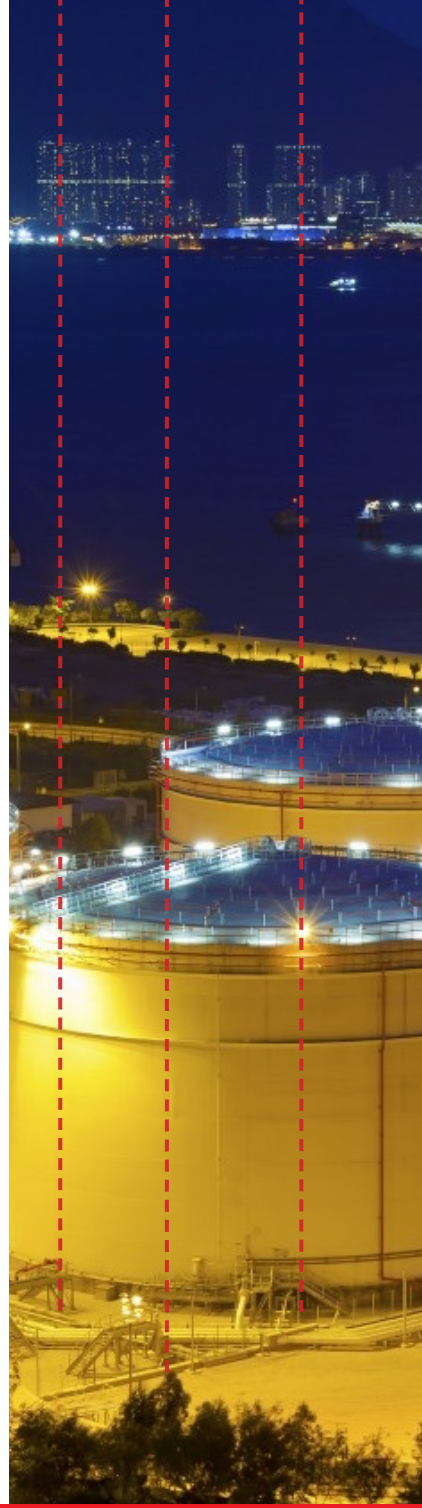
Problems with the current Loto materials and related Loto actions are perceived too dependent on the accurate behaviour and correct interpretation of the Loto operators.

The flaws in the behavioural problems are not documented. More insight in these flaws is desired to improve the control of and safety of the Loto process at Vopak. Smart technologies provide solutions to both monitor and prevent these problems.

To achieve a more convenient Loto procedure clear communication and pro-active stimuli and feedback, currently no present in the Loto procedure, are desired. As a result, monitoring is not perceived to stop the behavioural flaws from emerging.

By providing pro-active stimuli and feedback to the user we can to effectively target the right behaviour of the user and focus on early prevention instead of late detection of the problems. In this desired scenario monitoring the flaws is used to support the validation of the correct actions. Hence, neglecting behaviour is effortlessly revealed.

Operators are able to always be aware of what to do, where to do it and if they correctly executed their actions. By this scenario the pressure on the operators decreases and lockout activities become more efficient due to accurate execution. Thereby, allowing to maintain a validated safe work environment.



3.3 Design vision

With the implementation of an accessible data and hard-ware-driven solution, we strive to deliver a product which pro-actively makes operators aware of their required Loto actions to avert negligent or inappropriate behaviour.

To achieve the desired scenario, we acquire a clear guideline for our product development process. We do this by defining a design vision. This statement is used to accelerate the project and allow to share the design direction of our future product with the stakeholders involved.

In addition, this vision allows to allign our stake-holders interest and activate for change in the traditional orientated industry. This vision is dis-cussed during the concept exploration (chapter 5) and perceived most valuable to pursue.

3.4 Design focus

In relation to our design vision, we further define our statement.

Loto actions:
Focused on the Loto place, (un)authorised re-lease and inspections activities with the aim to

To overcome unsafe actions we focus on the decrease of misintrepretation incidents on the workplace.

To overcome inefficient actions we focus on the decrease the amount of time-consuming ac-tions in the key and inspection process.

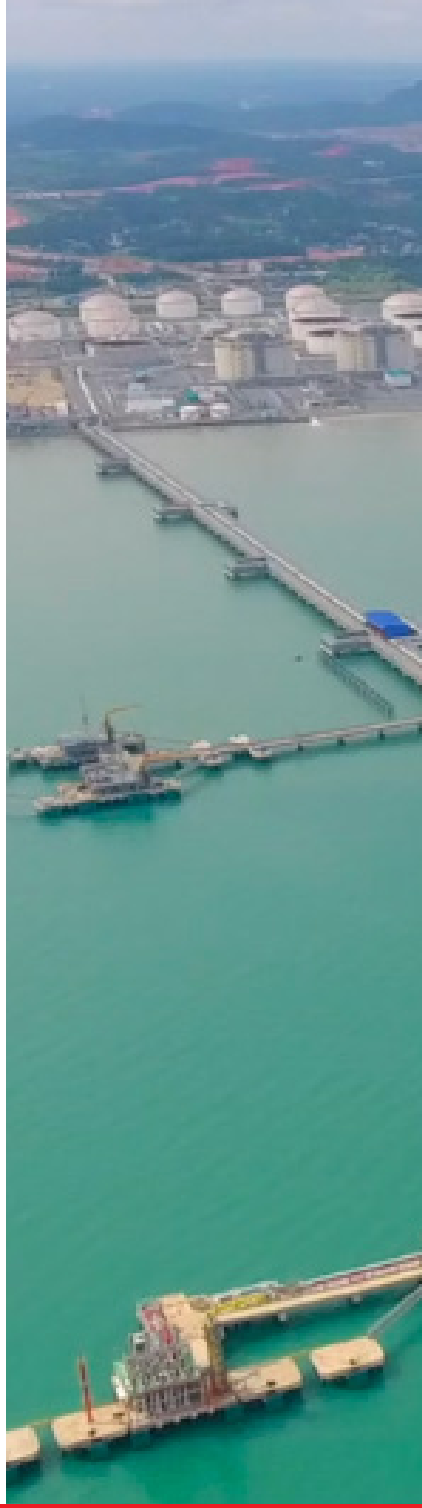
Accessible:
Fits existing practices of the terminal and therefore does not require industries to make radical changes to their existing Loto resources (hardware, software, employees involved).

Avert negligent or inappropriate behaviour:
Behavioural problems related to the poor place-ment/release, inspection and documentation of actions.

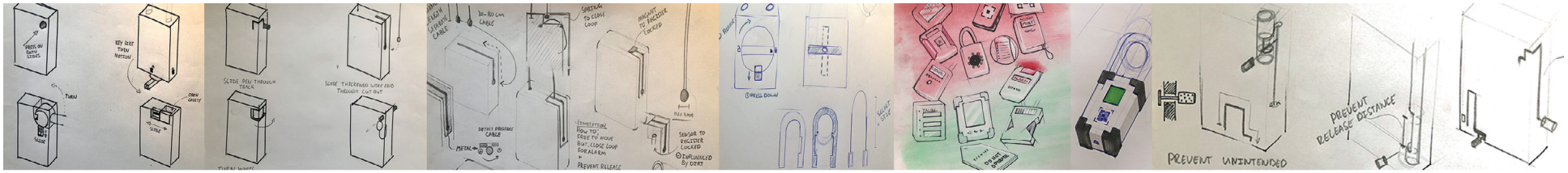
Operators:
Safety and efficiency of the Loto protocol comes down to user handlings and execution of the Loto process. For this reason, we primairly focus on improving the actions of the end-user of the product being the: the Loto operator.

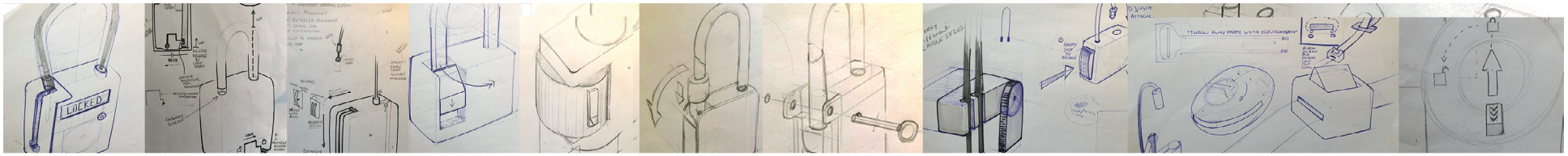
Pro-actively:
- Provide product stimuli on to-be executed Loto actions.
- Provide feedback on executed Loto actions.

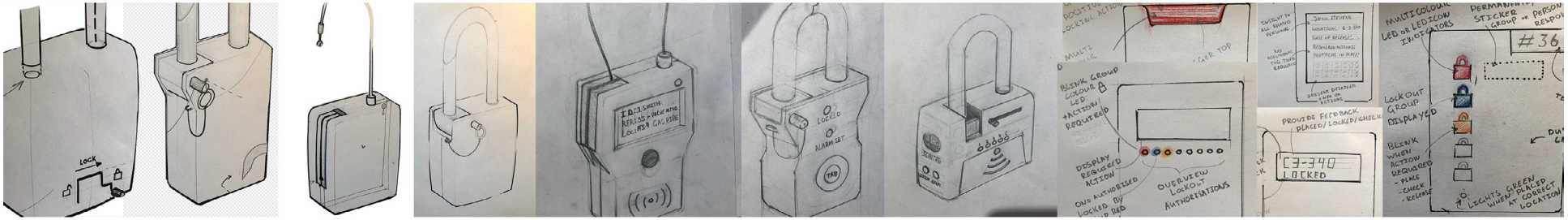
Target market (customer):
In this product development proces we pri-mairly focus on the interest of Royal Vopak. This client desires safe and efficient solutions which can be easily implemented. This defines our customer to sizeable terminals, like Vopak Vlaardingen, dealing with inspection intensive Loto protocols, digital authorisation systems and tag information being present in the field.

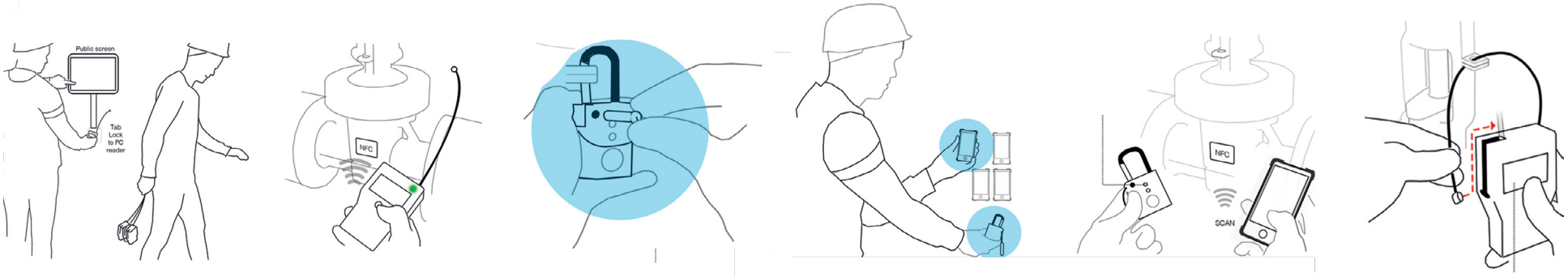


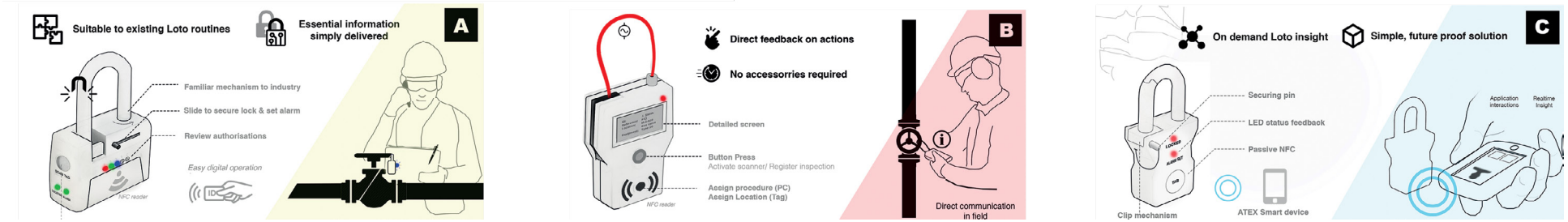
4. Creative process











5 Concept exploration

For the product development process we select the company of Vopak as the future customer of the digital lockout routine. With the focus on enhancing Vopak's Loto routine with smart product solutions, we study how the proposed product manifestations affect real life processes. This allows us to identify the weight of decision making complexities present in the sizeable markets with leading company in the industry. A successful outcome of this product development process would provide opportunities to provide similar large scale industries with the established product solutions.

With the evaluation of a variety of user scenarios this chapter, the concept exploration, aims to identify the most valuable, yet acceptable implementation of a digital lockout routines and related smart lockout product.

This evaluation of presented product functionalities will be conducted with the presented user group (next page). This user group includes a range of Vopak employees related to the identified stakeholders in the lockout process (chapter 2.4.2) and provides us with the opportunity to gather various, real life perspectives on limitations and opportunities of digital lockout routines. Moreover, the multiple angle expertise allows to extract safety, efficiency or implementation factors from both end-users as decisions makers in the Loto process.

User group

The concept exploration is executed with industry experts in the lockout process of which the daily tasks are directly related to placement/release, inspection and safe execution of maintenance in the field.

- Supervisor (V2)
- Loto operator (V3)
- Maintenance Manager (V3)
Representive of the contractor's in the industry

Consequently, employees of Vopak acquainted with the implementation of inventions in their industry are consulted:

- Global Deployment Manager (G1)
Responsible for the implementation of products in products in the industry
- Innovation Engagement Leader (V1)
Responsible for selecting the most valuable innovations for the industry of Vopak

Both managers (V1,G1) have additional experience on plant operations due to their background as operational managers.

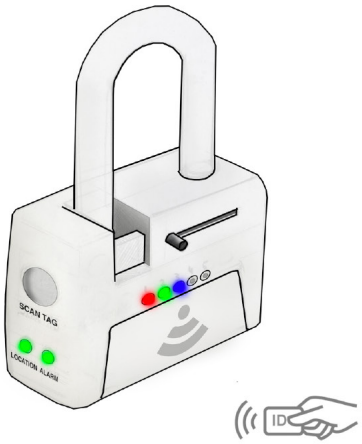
Inhouse visits with TWTG allow to evaluate the production critera for the designed product architecture.

5.2 Exploration of concepts

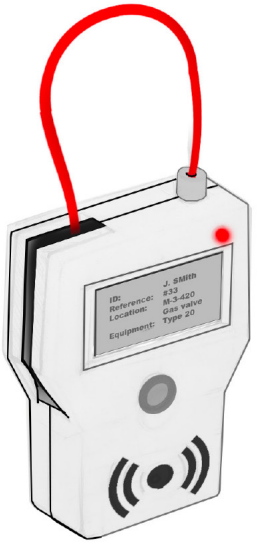
In this paragraph, the developed concepts, concept functions and selection of the concept is elaborated.

The described user group is provided with different concepts and subjected concept functions to identify the most desirable product manifestation for a digital lockout routine. To select the most viable product solution for Vopak concept selection criteria relate to the impact on safety, efficiency and ease of implementation.

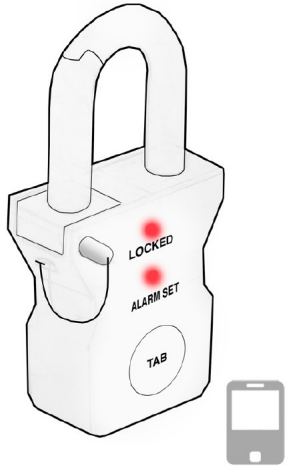
To selected the most desirable product solution for TWTG product development design requirements are extracted from inhouse R&D department consulations. We use these and user group input to selected the most desireable mechanism. We focus on this particular product functions additionally from TWTG viewpoint as it has the most significant impact on the product architecture, thus production capabilities of TWTG.



Concept A



Concept B



Concept C

5.2.1 Method

The concepts presented are established based on the product requirements of chapter 3.1 and are evaluated with the help of the detailed, step by step, use cases of appendix 15 - Concept exploration.

In this evaluation, we evaluate the influence on the lockout routine with the proposed concepts. This new way of routine evaluation is executed to achieve a high level of understanding from the user group and allows to clarify the differences in desirability of the concepts. Accordingly, presenting the required context alterations allows us to receive valuable knowledge on the desire to make alterations to their existing materials and routines in place.

In this exploration, the user group is asked to read through the developed use case materials and concept presentation to evaluate later the potential, limitations of the concepts through skype meetings.

For this evaluation we evaluate the three main product functions of the Smart Loto:

- Locking out energy sources *(mechanism)*
- Transfer of procedure information *(communications)*
- Opening and closing the lock *(key operations)*

5.2.2 Completion of concepts

The concept functions are established based on logical combinations of digital interfaces and digital communication interactions.
With the establishment of different concepts, different use scenario emerge, and different solutions to improve upon safety and efficiency levels are presented. With this approach, we can identify the best product manifestation suitable for industry practices.

For a more indepth view on the market value and limitations identified with the presented concepts review Appendix 11 - Concept exploration.

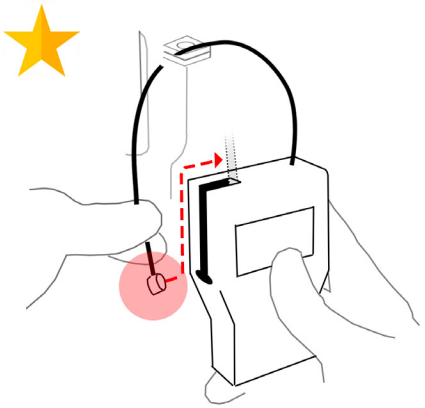
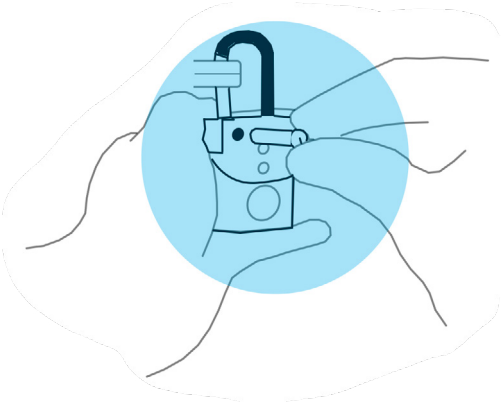
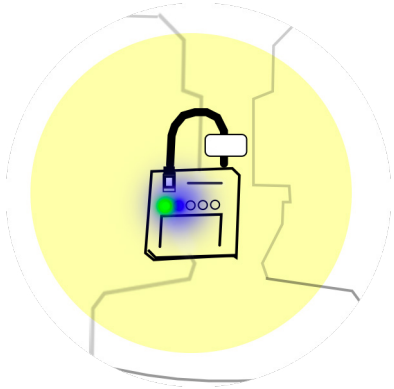
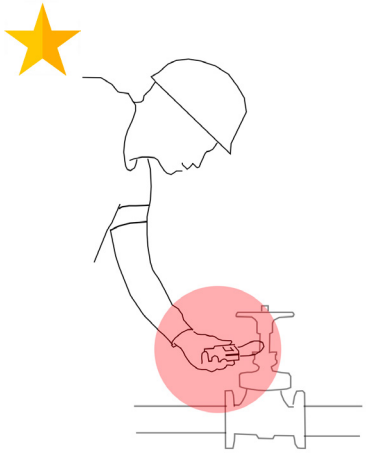
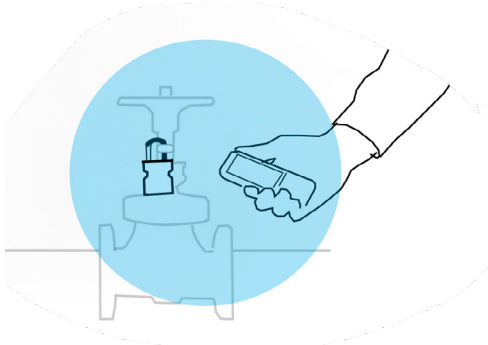
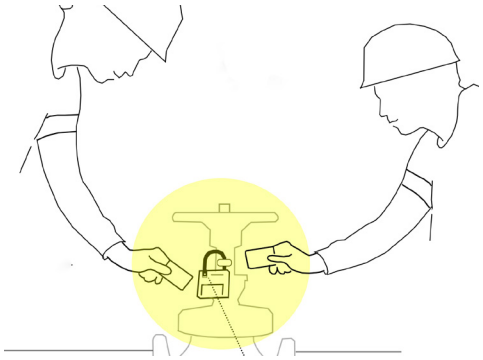
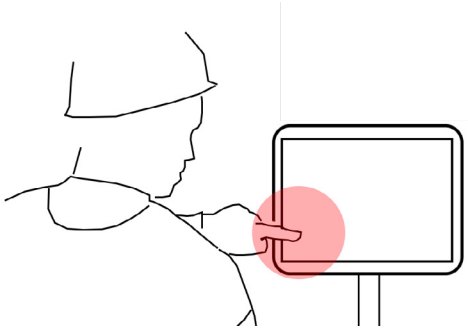
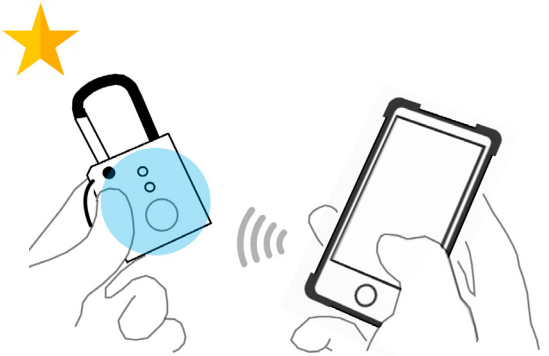
5.2.4 Evaluation of concept functions

An overview of the evaluated concepts and selected functions (star marked) is provided in chapter 5.3.

An abstract overview of the stated success factors and/or limiting factors is presented on the following page.

During this evaluation, the desire for an cross over between the concept's functions of the concepts B and C is identified.

5.3 Concept function evaluation

	CONCEPT A	CONCEPT B	CONCEPT C
Mechanism	 **SHACKLE SLIDE & LOCK** Value gain on safety perception does not outweight the cost price of the mechanism	 **WIRE SLIDE*** Most cost effective solution	 **CLIP HOOK & PEN** Value gain on safety does not outweight the cost price
information of tag information	 **INFORMATION BY LED & TAG** Limited ease of use of additional tag materials not desired	 **INFORMATION BY SCREEN*** Absence of screen is to big of an impact on accesibility of information to all operators	 **INFORMATION BY SMART CONTROL DEVICE** Smart devices will not be available to all terminal members in the future
operation accessorries	 **DIGITAL KEY CARD** Too much negative impact on user tasks: key operation problem not fully solved	 **PERSONAL ACCOUNT KEY** Industry desires smart device over stand alone (No accessories required) solution	 **SMART DEVICE KEY*** Valuable long term solution, yet smart device not are currently not available for every operator. Thus, in field tag information is required.

5.4 Overview concept exploration

5.4.1 Overview

All concepts meet most of the product requirements of chapter 3.1. As a results, new concept critera are set-up to make a more weighted decision for the selection of our future concept.

In this overview, each circle represents the positive (red circle) or negative impact (black circle) on the product criteria.

The product criteria are assigned in their relation to safety and efficiency and extracted from the earlier defined product requirement.

This overview is used as an evaluation tool to provide an easy overview and visual representation of the collected perception on safety, efficiency and ease of implementation from the user group evaluations.

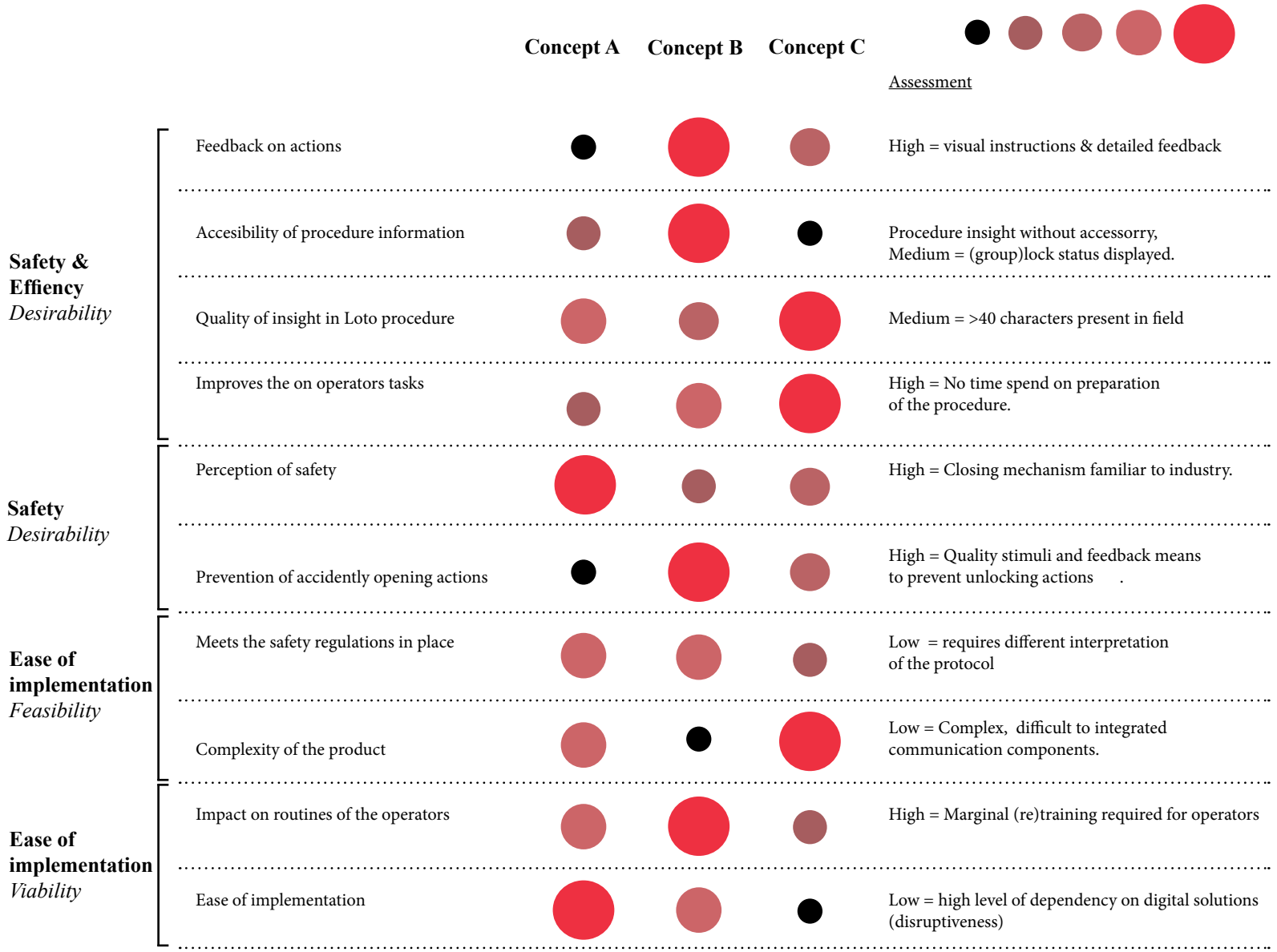
5.4.2 Evaluation overview

From this evaluation is learned Concept B is the most desirable concept for the industry of Vopak. However, the concept scores significantly low on the complexity of the product, thereby increasing the cost price of the product and increasing the impact on the ease of implementation of the product. Thus, negatively influencing the return of investment (Chapter 2.2). For this reason, the participants were additionally questioned on the ability to eliminate the tag information function. However, eliminating this function is not accepted (further elaborated in chapter 7.4) and not desired to be replaced by the traditional tag function or smart control device.

Unexpected positive responses were received on the introduction of the smart control device, and it's capabilities to enhance the safety and efficiency in the lockout process.Providing improved documentation features and a high level of insight in the lockout procedure.

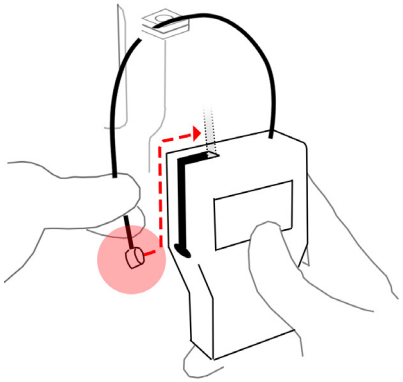
5.4.3 Remarks overview

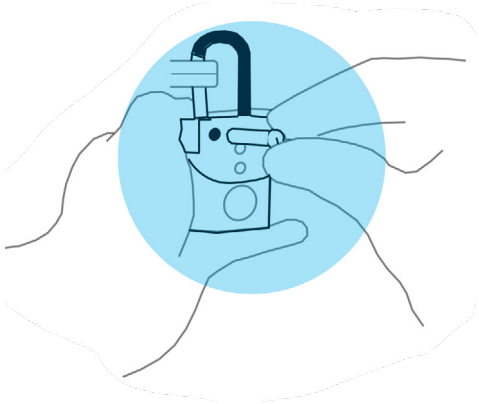
Moving operation accessory benefits of concept C to the use case of concept B allows strengthening the concept in means of safety and efficiency. Subsequently, with these combined functionalities, the high dependency on digital solutions of concept C can be eliminated.



This evalution tool is extracted from McKinsey - Center for Business and Environment and expanded with the identified viability conditions.

5.5 Concept exploration: Mechanism selection





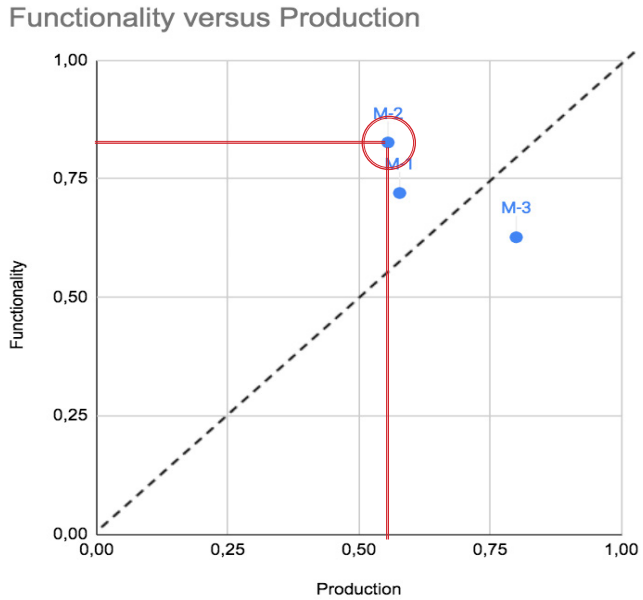


Image: Kesselring method for mechanism selection

5.5.1 Mechanism Evaluation 2

From the evaluations with the operators and managers of Vopak the value in terms of perceived functionality in relation to mechanism can be extracted.

Yet, insight in the production desires of TWTG is required to select the most valuable solution both for TWTG as Vopak's practices.

A new interpretation of the kesselring evaluation method was addressed to evaluate production value from different stakeholders. Production value by TWTG consultations and functional value by Vopak consultations.

The identified production critera are weighted and assest based on the meetings the CTO and Product owner of TWTG (Appendix 16 - Concept Assessment).

From the kesselring analysis mechanism 2 is the most valuable solution as the highest level of functionality for the least production effort is achieved.

(More information on the functions of the mechanisms in appendix 11 - concept exploration)

6.5.6 Conclusion

From the concept exploration concept B is selected as the most valuable and implementable solution for Vopak. Yet, the value of the smart device to improve the quality of information in field was desired to be additionally integrated in the use case of concept B. Based on these insight, we adjust our concept and establish the best market fit for our future concept based on the integration of a tablet routine to the use case of concept B

From this is evaluation is learned that the company of Vopak (management) is willing to pay higher price for a more complex product with screen functions and is open to adopt smart devices in their Loto routine.

6 Final concept

Based on the insights from the concept exploration, the most desirable use scenario and concept is selected for both Vopak's and TWTG's resources.

In this chapter, the final concept and related use case is presented. The presented concept will be used to motivate the industry clients of TWTG to adopt the digital lockout concept. For this reason, the company of TWTG desires a concept presentation which presents a realistic view on product's architecture to acquire more interest in the product, thus benefits commercial activities (product proposal meetings with clients). Accordingly, the presented appearance model presentation is satisfied in the brochure style of TWTG.

In addition, the concept operations elaborate on the establishment of safer and more efficient processes in the workplace.

A more elaborate description of the product's functionailities is presented in the concept elaboration of this report (Chapter 7).

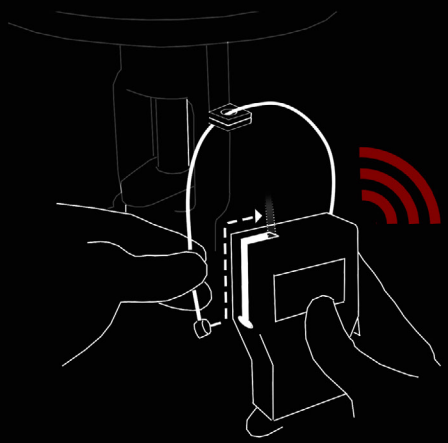
SMART Lockout Device

Realtime evaluation of safety

>4 Years of battery life

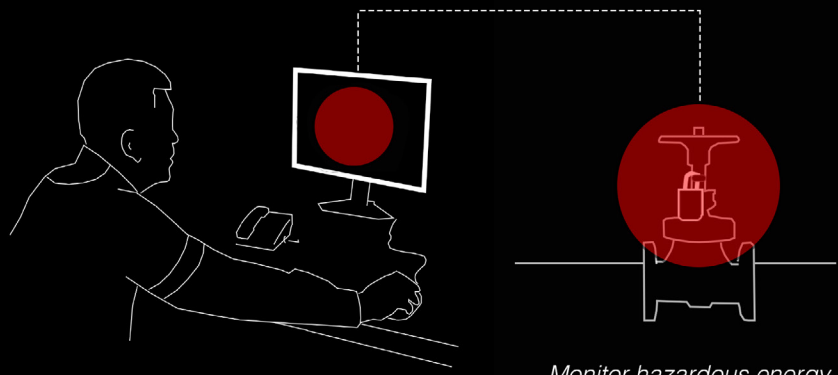
E-Ink Display
Detailed in field information

NFC Communication
ID registration of Loto actions



Placement & release detection
Alarm operators in the heavy industry

Feedback on correct placement
Smart control device operations



Monitor hazardous energy isolation status

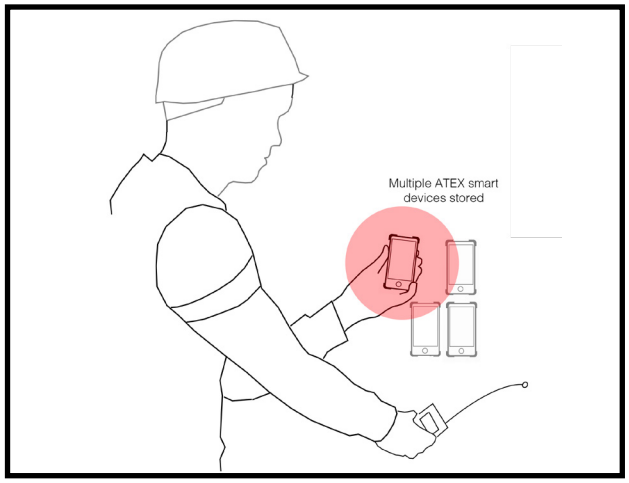
Wireless (LoRaWAN) Safety Validation
The Smart Loto product enhances safety in the industry by monitoring defects in the isolation of hazardous energy sources. This connected device provides realtime inisght in the correct execution of the required Loto regulations and actions.

By providing pro-active feedback, the Smart Loto eliminates flaws in human behaviour and stimulates the accuracy of placement, release and inspection activities in the Loto procedure.

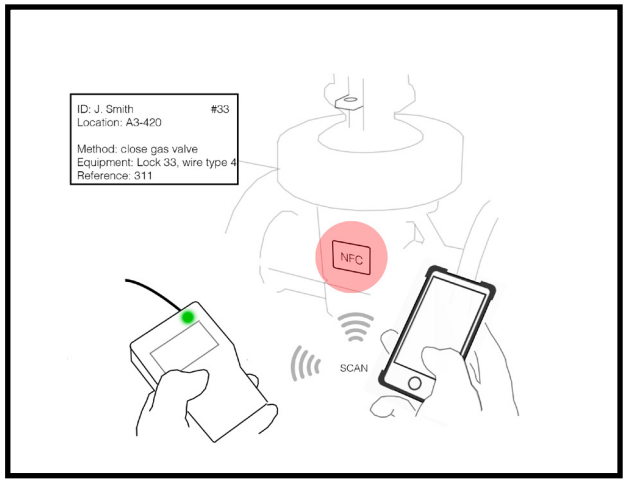
This connected device establishes a validated safe work environment while improving the productivity of the organisation by eliminating manual documentation, daily inspections and manual key operations.

Compatible
with existing materials and Lockout routines

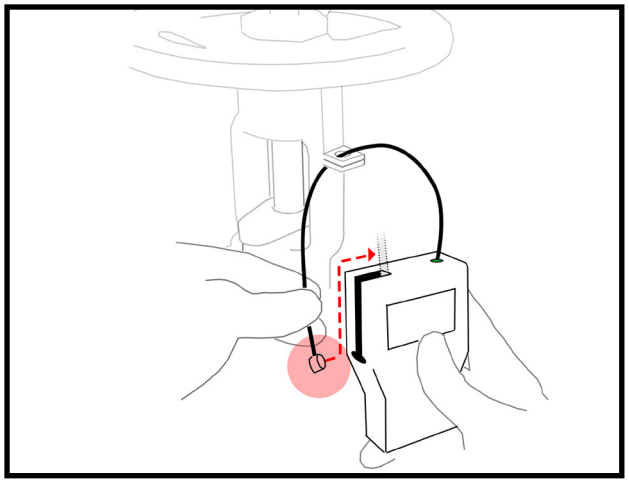
6.2 Smart lockout use case



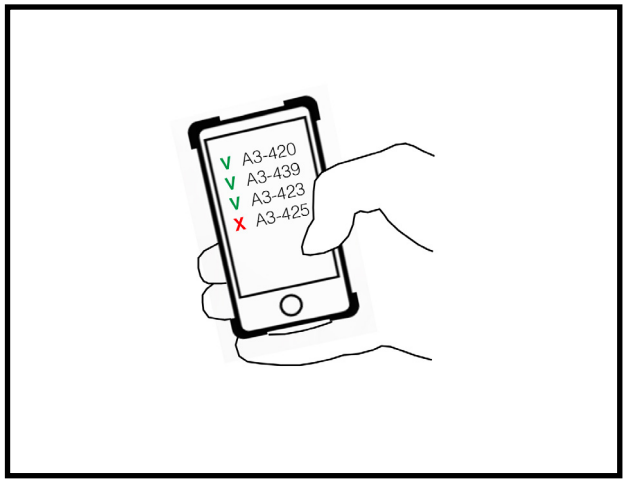
Simply acquire Materials
- Personal account login of operators in existing operational software
- Insight in Loto actions is provided by the smart device



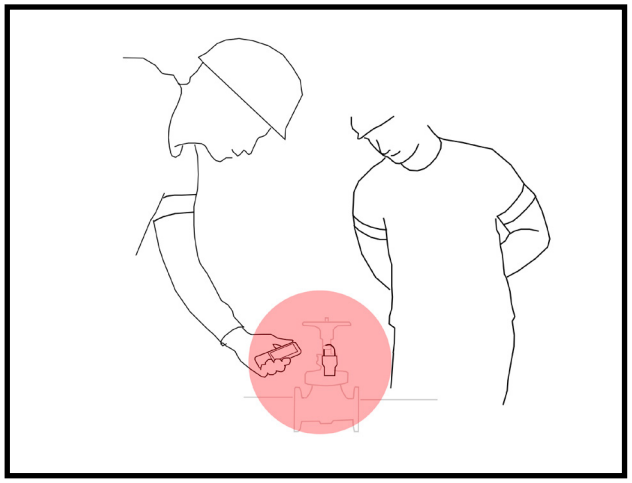
Verify correct location
- Verify the correct location by scanning the location tag
- Procedure information is provided by the Smart Loto screen when the correct location is scanned.



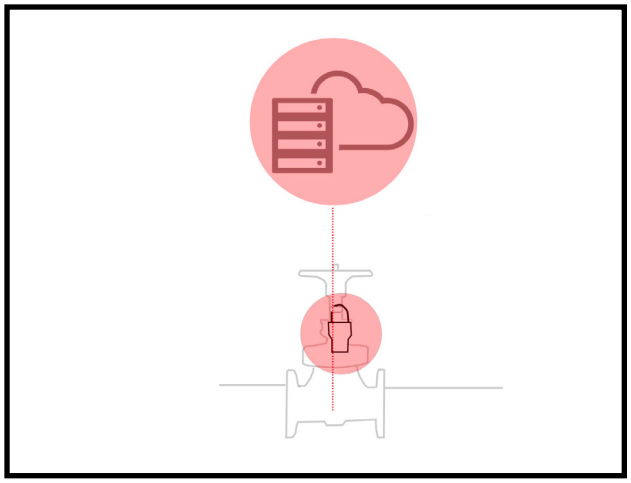
Convenient and secure placement
- The cable can be easily placed through lockout support materials.
- The alarm is set when the cable is secured.



Acquire insight in performance
- Operator receives detailed instructions on how the Loto materials should be placed
- The operator is able to review all (to-be) executed Loto actions on the smart control device



Digitally register inspection
- Supervisors digitally register their work preparation inspection
- Points of interest can be directly documented with the smart control device



Review status of the lock in system
- Operators can review if a safe work enviroment is maintained.
- Insight in the presence of locks at the location and executed inspection(s) is provided.

7

Concept Elaboration

In this chapter, we elaborate on the functions implemented in the digital lockout routine, and related investigations conducted to support the design decisions in of established digital lockout routine.

In this concept elaboration, we focus on the ability of the industry of Vopak to meet the desired scenario and company of TWTG to deliver the lockout routine.

We will elaborate on the most critical aspects of the design by following the following objectives:

a) How does the functionality relate safety and/or efficiency and how is this value delivered to the stakeholders involved?

b) Are the main functions relevant for Vopak's existing practices and/or developments in the future?

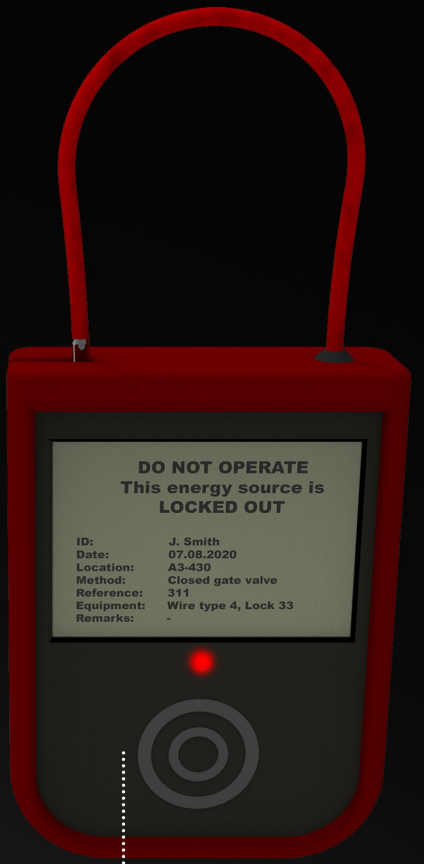
c) How does the functionality relate to the ease of implementation for the context of Vopak or TWTG?

To understand the alterations required we first further elaborated the funtionalities and interactions of the smart lockout product.

Smart Loto interactions

2. Place cable

3. Validate closed status



5. Set alarm

1. Scan location tag

NFC

4. Scan Loto

NFC

7.1 Function elaboration

In this paragraph, we provide insight in the key functions of the Smart Loto concerning the product interactions, safety, efficiency and ease of implementation.

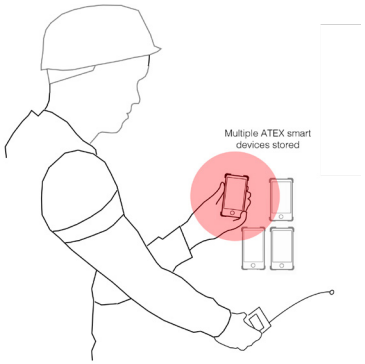
We explain the ease of implementation by elaborating on the adjustments in equipment and routines of the operators.

We elaborate on efficiency by focussing on the impact on the operator's routines and elimination of existing time-consuming routines

The evaluation of safety focusses on the prevention of accidents in the Loto process.

In the following product elaboration paragraphs the key aspects for the establishment these functions will be elaborated.

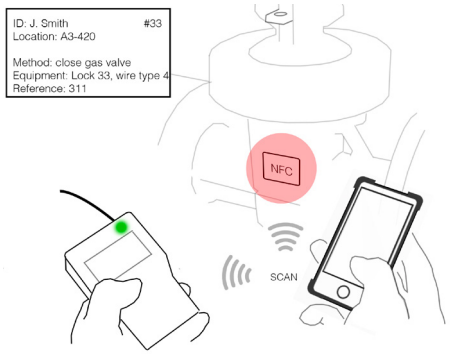
7.1.1 Storage



Implementation
To allow operators to perform equal tasks with fewer handlings smart control devices are stored in the public Lockout area. With this solution key operations and checklist related activities are replaced by a single tablet routine.

Efficiency
Charging of the Smart Loto device is not required due to the long-lasting battery life of the product.

7.1.2 Scan location tag



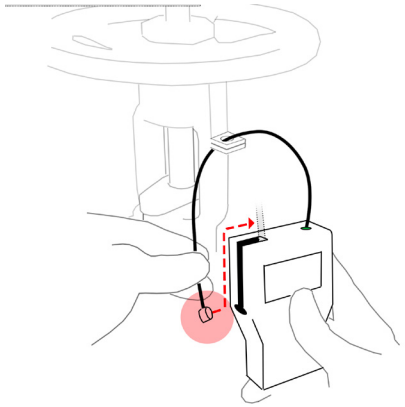
Safety
The correct location must be verified by scanning the location tag. Hence, operators are prevented to place Loto's at the wrong locations and establish an unsafe work environment.

Efficiency
With the digital screen, procedure information is digitally controlled. This eliminates the need for time-consuming tag handling activities including the printing of materials and replacement of the tag's in field.

Implementation
A NFC tag solution is implemented to digitalise, register and validate the location of Vopak assests. This solutions can be retrofitted to industry equipment (Chapter 7.5) Thus, prevents cost intensive adjustments to existing systems.

7.1 Evaluation - functions

7.1.3 Symbolic Lockout function



Safety
The opening and closing mechanism of the product is digitally registered to provide insight in the executed actions of the operators. The establishment of dangerous work areas are directly identified when the product is released unauthorised as an alarm will notify the user and the operators in the control room.

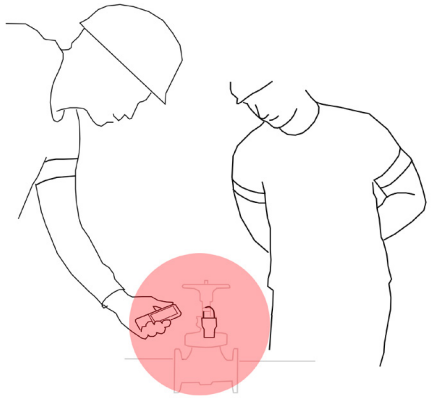
Efficiency
To save time for the operators the time consuming key operations are replaced by smart device operations. This allows the operators to easily access their Loto's while preventing keys to get lost.

7.1.4 Smart device operation

Efficiency
To prevent operators from re-doing their placement tasks feedback is provided by the smart control device. This feedback includes insight in (to-be) executed actions. Compared to paper checklist solutions the smart device operations allows to directly register Loto points of interest.

Implementation
The change towards smart device routines is desired by Loto executive and managing parties (Chapter 7.3.1).

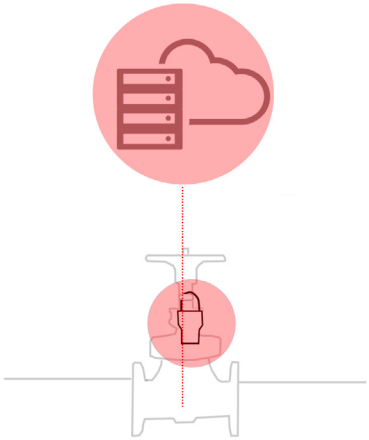
7.1.5 Inspection: Scan location tag



Safety
With the ability of digitally registering Loto inspections supervisors and the organisation of Vopak can validate if all required Loto inspection are executed. Supervisors are prevented from registering an unsafe working environment as safe. As as result, the false perception of safety is eliminated.

Efficiency
Time consuming registrational tasks are eliminated with the support of the smart device. Inspections and the documentation of points of interest are directly documented on the smart device.

7.1.6 Monitoring of actions



Safety
The status of locks is realtime monitored. When lock are not placed or inspected work permits are prevented from being release. Subsequently, workers can not start their work in unsafe environments (Chapter 7.3.4).
.

Efficiency
In the current scenario, an average of four workers is required to inspect the presence of the Loto materials (Vopak Vlaarding's terminal). Time can be saved for the supervisors by distantly monitoring if the locks are in place. allowing this daily routine to be eliminated.

Implementation
With the use of Vopak's personal (Loto) managing accounts the data output of the Smart Loto can be directly displayed on the operational system in place.

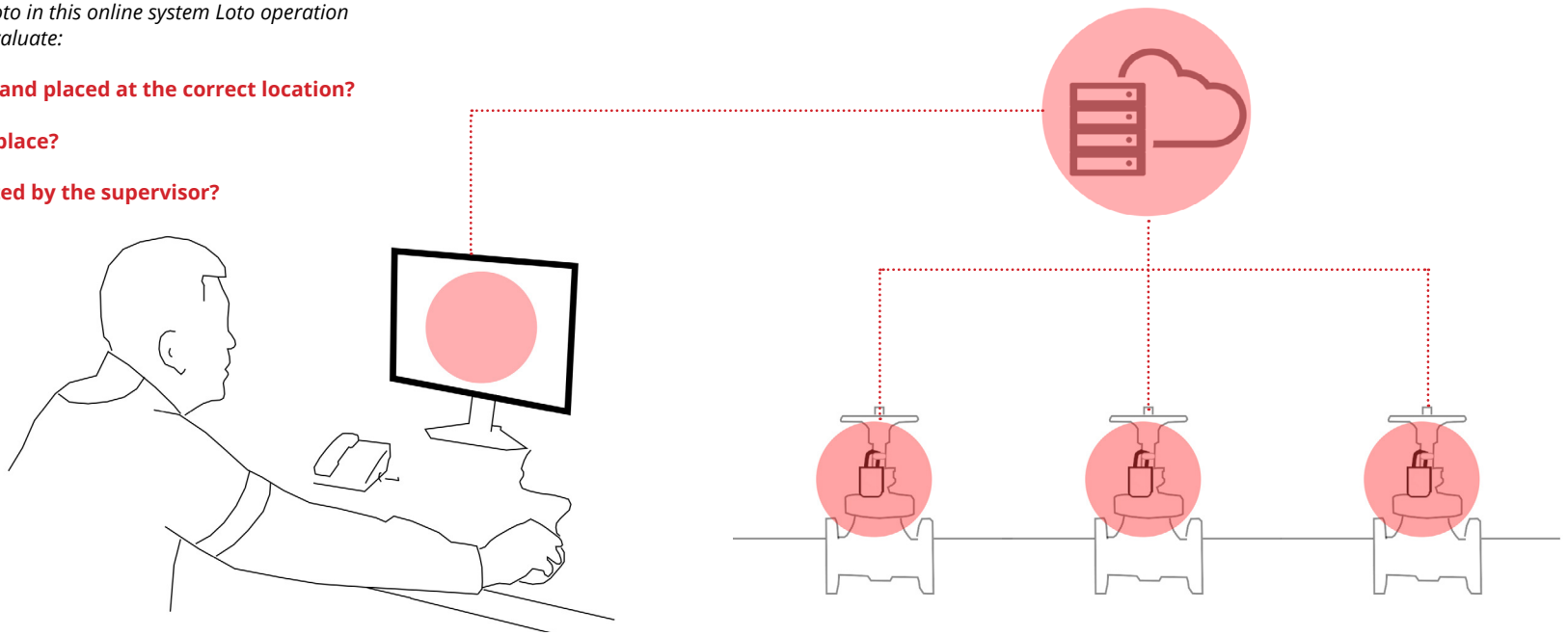
7.2 System verification

Integration of the Smart Loto in this online system Loto operation allows to autonomously evaluate:

Are all Loto's placed and placed at the correct location?

Are all Loto's still in place?

Are all Loto's inspected by the supervisor?



7.2.1 Context & investigation
In the current industry the registration of Loto activities do not directly reflect the real-life scenario (Chapter 1.2). Human inaccurateness provides false answers to questions stated in the image above, providing a false perception of safety. Yet, work permits are released while the work environment is not correctly locked out, not inspected and potentially not safe. I.e. Safety regulations are not met, yet workers can start their work. With the integration of the Smart Loto in the Lockout management system we aim to prevent this scenario.

In this paragraph, we elaborate on the value that is provided by integrating the Smart Loto in the existing documentation systems of the industry. Additionally, we clarify the benefits of a digital workflow in the Loto procedure.
The capabilities of the registration in place system is investigated through consultations with the maintenance manager of and Innovation manager of Vopak. They respectively have expertise in the requirements for a safe work environment and possibilities of smart product introductions in the industry. In addition, desktop research is conducted on the operational management system of Vopak; Infor.

7.2.1 Web services insights
From this investigation is learned the management software Infor, globally used by 6.800 sizeable industry locations, allows to guide the industrial revolution (Infor, 2020). Web and operational services like Infor solutions support industries in transforming their business processes and easily unlock smart innovation. This is done by providing a platform in which the data of smart products can be simply integrated. These platforms support API (application programming interface) integration, allowing two applications (smart device and platform) to talk to each other to perform joint functions. System integration allows to control the device from a remote server, send data requests or return data on Smart Loto interactions.

The Infor platform allows to display and evaluate data gathered from the Smart Loto to the affected operators. The Innovation Manager and Maintenance manager collaboratively agree the Smart Loto integration is the most desirable feature of the Smart Loto in the future. Yet, full adoption of the Smart Loto must be achieved before a full dependency on this flatform can be achieved.

With a combination of a network connection, data visualisation and processing platform, the Loto data can be used to prevent work permits from being released while Loto's are not inspected, correctly placed or removed, i.e. the long list of pre-set workpermit security measures can be autonomously be evaluated in the Infor systems and do not have to be registered by hand. This allows to improve on efficiency an validated safe work environment.

The Innovation Engagement Leader explains Infor will also be integration on the smart control devices. This allows to provide real-time insight into the (to-be) executed Loto actions and supports effiency in the process by saving time on the approval of the work permit as Loto actions are directly documented.

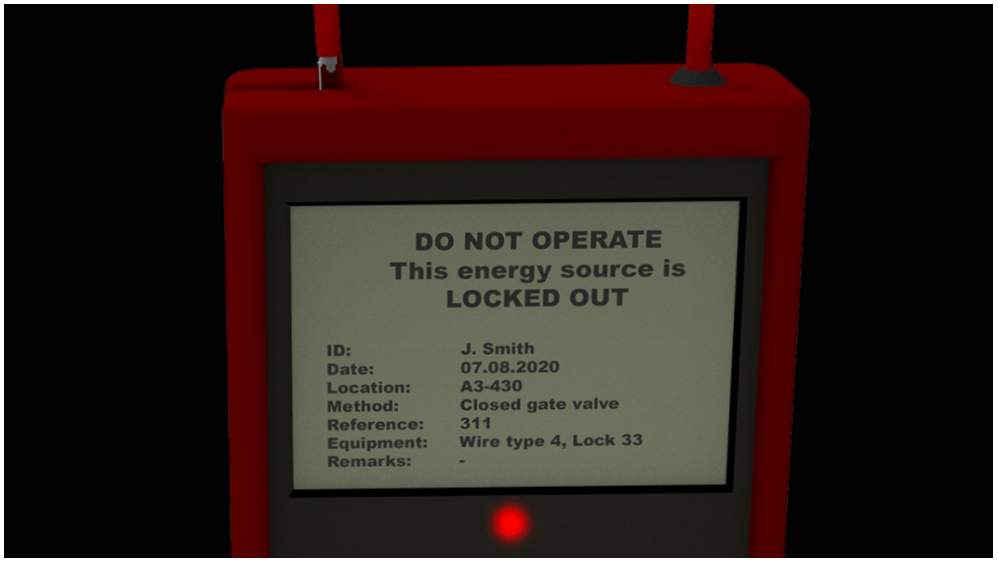
7.2.1 Conclusion
By establishing this digital workflow operators
- are provided with a clear overview of the (to-be) executed actions
- Can evaluation of the correct placement, release and inspection of materials
- Can ensure the safe release of the work permit

With the establishment of this digital workflow, the chance of inaccurate Loto performance is dimin–ished, enabling the industry to improve the awareness of the operators by providing on-demand insight into the Loto procedure.

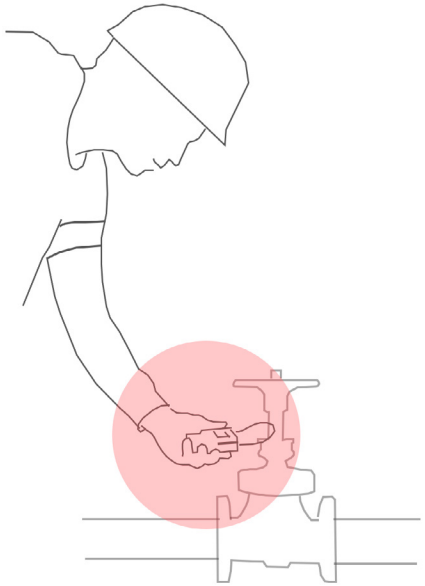
7.3 Screen functionality

"Making the Loto digital is quite some disruption already. Perceptions on safety do not easily change. If we present a Loto without the tag information this product will not get through the board."

Innovation Engagement Leader
Questioned on: "why not eliminate the screen for financial benefits?"



Screen information Smart Loto concept



7.3.1 Relevance of screen function

The screen function fulfils the communication of the tag information (chapter 2.3.3) in the existing tag lockout procedure. The relevance of this functionality is investigated for three reasons:

- a) The price of the product is most heavily affected by the screen; eliminating the feature could increase the market value in the future.
- b) The rise of the smart control device in the industry could diminish the relevance of the screen in the future.
- c) Research on the Loto process reveals tag information is not necessary for product operations

In the concept exploration phase of chapter 5.2, alternative are functionalities supporting the elimination of the screen are evaluated. From the problem analysis and this evaluation is learned the existing tag procedure too time-consuming to maintain. On the other hand, the replacement tag information through tablet operations is perceived to deliver a too high dependency on smart control device operations.

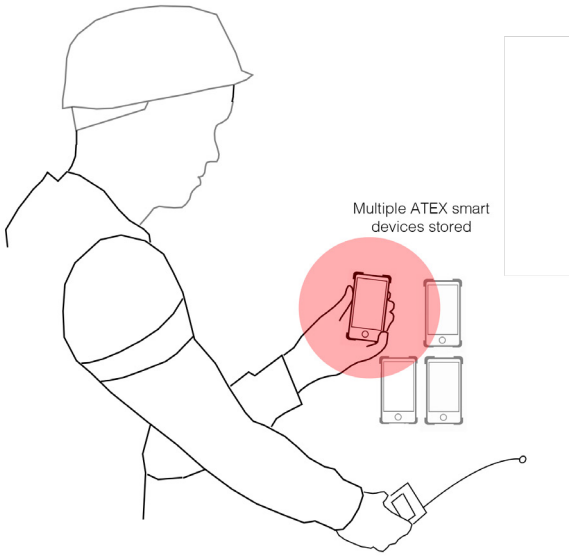
From the user group evaluations is learned the tag information is of great importance to the industry and a very traditional safety measure.
The tag information is perceived as an unnecessary safety measurement due to the communication systems already in place. Yet, all stakeholders in the concept evaluation demand the presence of the tag information for added convenience and simply meeting the requirements of the traditional lockout products.

Positively, the implementation of the screen function allows to digitalise the communications, while maintaining the key function of presenting tag information in the field. During the concept exploration, the logic behind this desire is clearly from an innovation management point of view and explaining replacing traditional functions with digital means smoothens the adoption of smart devices in the industry and improves the level of acceptance of the future product.

As stated in chapter 5.4 of this report, protocols are not desired to be altered for the introduction of new products. The recently released standard on Loto, additionally globally adopted (OSHA, 2019), supports the interest to provide tag information in the field. Regulations state; *"Each isolation point should have its own tag to inform persons in the field that the asset is in Loto. Each tag must include detailed information on the lockout procedure."*

This standard is established to offer global guidelines for Vopak's lockout operations for the coming 5 to 10 years. Hence, does not have to be altered with the implementation of this screen functionality, thereby positively affecting the ease of implementation. (G1).

7.4 Smart device adoption



"Carrying a tablet to the work ground is just as easy as carrying a checklist. Yet, I don't have to perform print or manual documentation actions."

Loto Operator

"Moving towards a tablet routine now, is more valuable than adopting short term alternative solutions"

Global Deployment Manager

7.4.1 Background

The adoption of smart devices in the workplace has great potential in the industry. Experts recall; industrial tablet technology is critical for the employees in the industry in the future. A rigid ATEX (explosion-proof quality mark) tablet or smart device allows workers to receive notifications directly, analyse data, connect to assets and sensor devices (SECO, 2020).

However, from the context analysis presented in chapter 2.1 of this report we learn innovations are not easily adopted by the heavy industry. For this reason, we investigate the desire of the industry to adopt these smart control devices and current use of the smart control devices in to justify the use of the control device for Lockout documentation, inspection and Loto operations purposes.

7.4.2 Investigation of users

By the consultation of our selected user group (chapter 7.1) we orientated ourselves on the current use of the smart control device in the industry and evaluate the perception of Vopak on smart device adoption for lockout applications.

7.4.3 Perception on the smart device

In these consultations, the safety manager (V2) explains that smart devices are currently marginally used for inspections and process analyses. However, smart operations are positively perceived as the ease of work is enhanced in means of documentation and in the field access to data.

The maintenance manager believes the mart device is too cost-intensive to implement. Explaining he does not put much trust in the broad adoption of tablet routines and perceives more value from solutions that are already present (V2).

The process and Loto operator of Vopak explains tablets are highly desired in both their general routine as the Loto routine. Spending less time on acquiring Lockout key and documentation materials will make his job more manageable. Requests for more Smart control device for process analysis purposes have been made by the operator, but were neglected to be delivered by the managing departments. (V3)

Vopak Global Deployment Lead recalls; "Moving towards a tablet routine now is more valuable than adopting short term alternative solutions." Consequently, this delegate states not to believe in alternatives that won't last long term. (G1)

The Innovation Engagement Leader of Vopak underlines smart control devices will meet signifcantly more applications in the near future and part of the digital revolution their industry is in. For this reason the implementation of the smart device for Lockout operations should not be arguable. (V1)

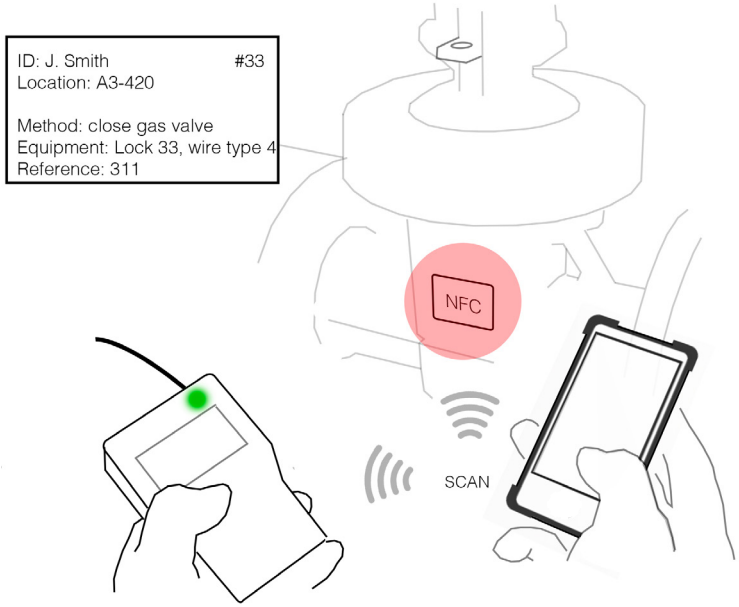
7.4.4 Conclusion

Although limited experiences could be gathered, this evaluation provides various perspective on the potential of smart devices and suggests a desirable solution for both managers and operators interests. Most trust in the wide adoption of the smart control device is experienced from a high organisational level. Yet, the adoption of the smart control device is perceived to be slow. Based on the expontial growth of Industrial IoT and related adoption of smart devices (Forbes, 2018), as user evaluations, it's perceived the industry desires to significantly implement more smart control devices, making the adoption of the smart device viable product function.

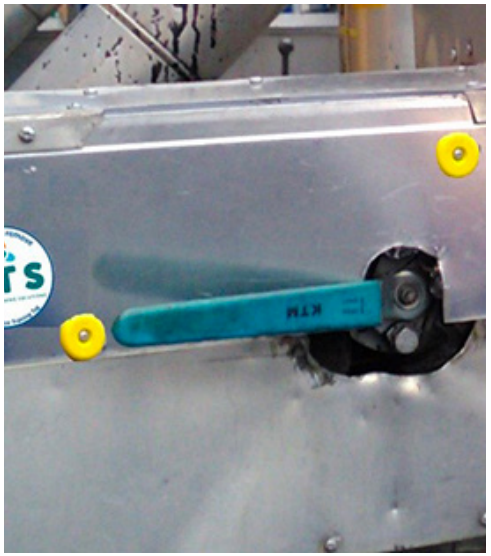
7.4.5 Scale elaboration

In the review of the existing lockout routine, three smart control devices will satisfy 135 Loto's being operated. (Vopak Vlaardingen use case) Thereby lowering the threshold for adoption of smart devices and gradually introducing the smart control device in the heavy industry. The storage of the tablets in the public lockout room allows acquiring the device in an equal routine of the currently executed key operations.

7.5 Communication technology



ATEX NFC Tag for the industry (Mobatex, 2020)



NFC tags use in the industry (Mobatex, 2020)

7.5.1 Context & conditions
The established use case describes the operation of the smart lockout product with a smart control device. For these operations, a personal area network between the smart control device and Smart Loto is required. Communications must be established to collect data on actions to verify the placement, release and inspection of the Loto. Moreover, communications with isolation equipment must set up to identify to correct location for placement

The wireless communication system of the lockout device and smart control device enables to transfer and evaluate the extracted or received data with the online operational system.

The adoption of the smart control device-provides the potential to select a variety of communication options to extract information from the energy isolation equipment (e.g. valves) and establish the communications with the smart lockout product. Due to the minimal amount of data required to execute the identification of actions, a single string (line) data can be sent. This allows to selected temporary established communications technologies not demanding more battery intensive continues data streams to be established.

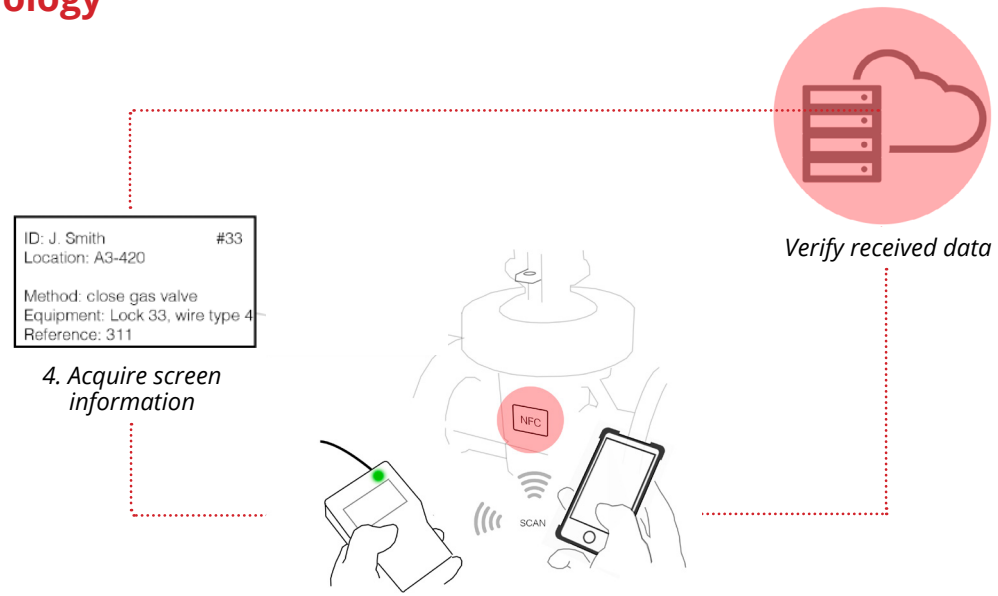
7.5.2 Evaluation of technologies -1
For the investigation of the to be implemented technologies, we review the technologies presented in the smart control device and select the most reliable and battery efficiency communication system to ensure safety in the lockout process. Through the evaluation of context requirements, desktop research and evaluations with the Innovation Engagement Leader and TWTG's R&D department, we evaluate the feasibility of the selected technology. The industries currently used smart control devices, being equipped with NFC, bluetooth, GPS and camera technologies provide four mature communications technologies for the location and device operations.

For location identification, the GPS data of the smart control device offers a logical option. However, the dense environment of valves and limited accuracy of this technology (1,5m) do not provide an accurate enough identification of locations to ensure the selection of the correct valve. Asset-specific location identification is required. Consequently, a low power solution of the Loto device is desired, thereby eliminating the adoption of the intensive power consumption of Bluetooth technology.

The placement of QR codes and NFC tags, linked to the assets in the operations systems, provide opportunities to implement solution not demanding power to be consumed from the Loto device for communication. Data can be extracted by the control device by the use of the camera to reading the QR code and NFC reader to extract information from the Smart Lockout product or isolation asset.

The use of QR codes provide the most cost-effective solutions as a simple, yet durable sticker is required to be printed. However, the dust, oil and dirt present in the industry context do not provide convenient and reliable working conditions for both the camera functionality and visual capabilities of the QR code in place.

7.5 Communication technology



7.5.2 Evaluation of technologies - 2
Research on NFC technologies in the heavy industry explains the use of the radio frequency identifications, of which NFC is part, and the wireless network are fundamental pillars of the Internet of Things being widely adopted (Landaluce, H. 2020). With the use of RFID applications, devices can be tracked and identified. Additional research on this technology describes the ability of NFC tags (ATEX tag image) to provide solutions which require no adjustments to the infrastructure present, no wires involved and no adaptations in existing pieces of hardware. Subsequently, this technology is easily scalable and safe to use in the industry environment (Mobatex, 2020). Thereby adding significant value to the ease of implementation to the existing large scale operations of the industry.

Nonetheless, the NFC technology demands the industry of Vopak to place tags on their numerous isolation equipment. For this reason, the Innovation Engagement Leader is questioned on the ability of Vopak to adopt this to this location tracing solution. From this consultation is learned the industry is making plans to monitor assets with smart control devices for various applications and perceive NFC tags as a feasible solution.

Accordingly, the integration of a low-cost (±30 cents) passive NFC chip in the smart lockout product allows identifying the Smart Loto with the control device. However, Bluetooth and active NFC technologies to provide feedback on the executed actions from the Smart Loto, thereby enabling a double redundancy in communications to be established. This allows to be less dependent on the established network for the execution of actions. However, consultations with the R&D department of TWTG explain significant trust is put the network capabilities TWTG to avoid the negative influence of these technologies on battery power.

7.5.2 Conclusion & additional benefits
The implementation of NFC technologies is the most feasible and low-cost solution for personal area communication with both the asset as the smart lockout product for the context of the heavy industry.

Yet, the full adoption of this project will require up to 25.000 location tag's to be placed at a medium-sized terminal to manage all assets in the industry. For this reason, it's beneficial Vopak and other industries are already pursuing solutions to the implementation of asset managing technologies.

This demand reveals the added benefits for the company of TWTG to deliver a large scale of NFC tag as an essential support material for their Smart Loto product. With this solution, TWTG can target the implementation of a new product with a low production cost and a relatively high product price (±7,00EU - ATEX shop, 2020)

7.6 Registration of Loto status

Conditions
- Dirt or extreme wheater conditions do not influence the digital registration capabilities of the product

- The product does not include open connectors (ATEX) or sensors

- The tamper detection enables to register the break of the materials

- Wire end detection to register employees with the desire to open the product unauthorised

The selected mechanism allows TWTG to differentiate in the market and Vopak to meet their lockout protocol.

7.6.1 Context mechanism

Earlier mechanism evaluations (Chapter 5.5) selected the wire mechanism as the most desirable mechanism for operation and production of the Smart Loto concept. This mechanism requires to read out the closed or opened status of the digital lockout product and thus digitally register the presence of the cable end.

By implementing this function, the Smart Loto is able to register the closing and (un) authorised release of the smart lock. We focus on this particular product function as a reliable validation of the lock status is critical for the establishment of a safe work environment. A cost-effective solution and solution in line with their product development expertise is desired.

In addition, the discover phase revealed the industry desires the lockout product to be operational in case of emergency. The managing department of TWTG additionally shares this interest.

7.6.2 Investigation

For the registration of the cable end desktop researched is conducted on mechanical, light sensors and magnetic sensors. The possibilities for cable end registration are evaluated with the user context of the lockout process. From this is learned the context of the heavy industry involves too much dirt interfering with the infrared light to reliable register the cable end. Mechanical registration solutions are more reliable, however require moving components to be integrated. This potentially diminishes the durability of the device and increases the cost price of the product. Moreover, ice, snow, dust or oil in the industry context negatively affect the working conditions of small components moving parts.

Through mechanism investigations is concluded an integrated magnet and magnetic sensor is the most feasible option to register the cable end. Hence, consultations with the R&D department of TWTG on the feasibility of magnetic sensor solution and their product development abilities expertise are further investigated. From inhouse consultations is learned, TWTG has the internal (development) and external (production) resources to deliver high-quality injection moulded products, including the integration of advanced hardware components.

7.6.3 Conclusion

With the integration of an embedded magnetic sensor, the selected mechanism design allows overcoming difficulties regarding environmental requirements. Accordingly, this solution allows to meet the ATEX (explosive prevention) requirements and context characteristics of the industry. This requirement can not be met with the integration of a connector set up as open connectors are not allowed in gaseous industry environments.

7.6.4 Elaboration

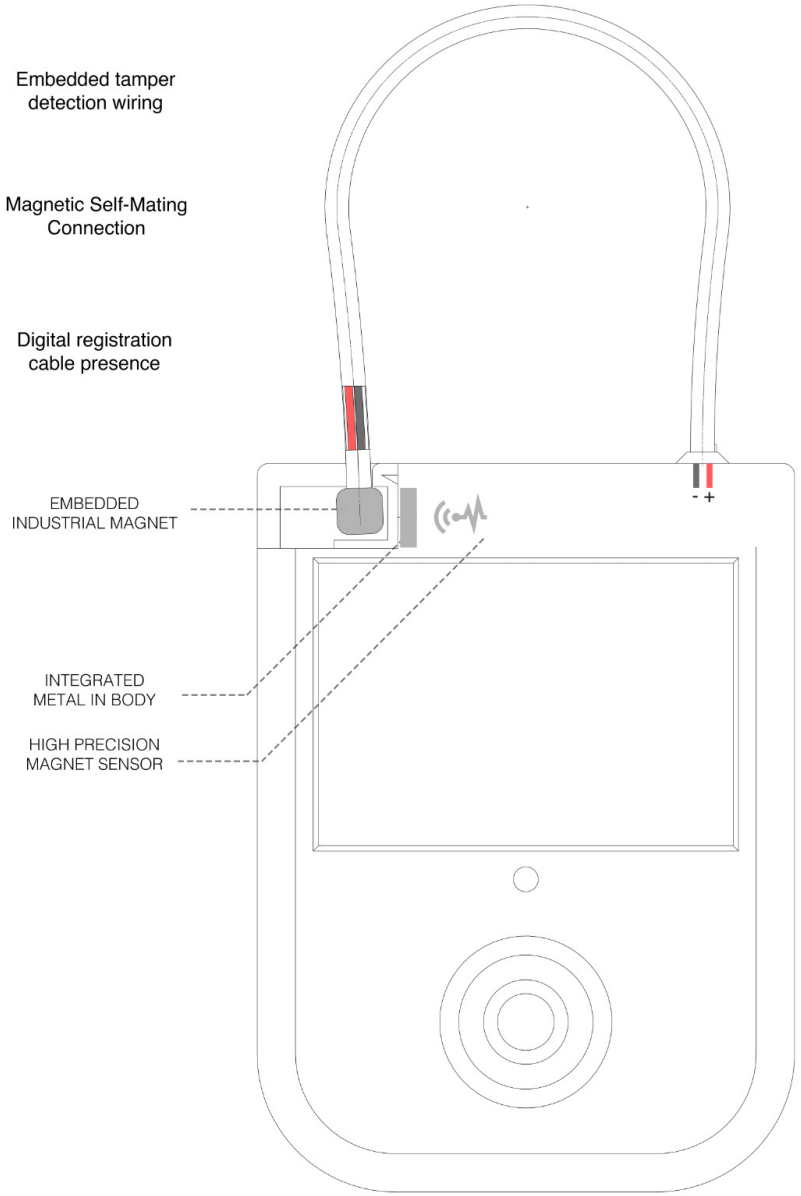
This symbolic lockout solution allows the mechanism to be operated in case of an emergency without the need to destroy the product. As a result the presented solution remains fully operational when:

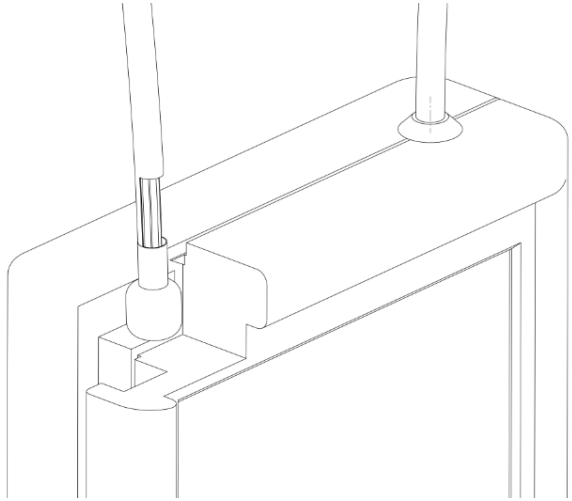
1. The battery is out
2. The network is unavailable.

By eliminating the desire to cut Loto's complete Loto sets can be maintained. Safety issue can be determined as the release of the padlock can be registered. Yet, the placement of low battery Loto devices must be prevented through the online read out of battery life in order to maintain the registration of a safe lockout status.

With the implementation of this mechanism, a unique smart lock is developed particularly for the use case of the Lockout procedure. This allows TWTG to deliver new market value and differentiate in the current lockout market.

7.6 Registration of Loto status





7.6.5 The functioning of the mechanism

To sense the presence of the cable end, the thickened part is embedded with an industrial magnet. The accurate magnetic sensor (Appendix 18 - Component datasheets), allows registering the presence of the strong magnet with high precision. This sensor is selected by the R&D department of TWTG based on the presented product dimenions and required operations.

A self mating interaction is established by the integration of a metal component in the body and the magnet. Besides the mechanical connection established through the cut out on the side of the product and the wider cable end, this mating system supports the cable end in maintaining its lockout position. With the digital readout of the cable ends presence, the smart devices LED will be triggered to provide feedback on the correct placement of the cable end.

The selected sensor consumes minimal power and functions as a button by registering if the cable end is present: Present / Not present. In the scenario that the digital Loto is locked out with the control device, the alarm is set. Disruption of the magnetic self mating system will be registered, resulting in an alarm sent to the control room and local display of the unauthorised action.

With the sensor integrated into the body of the product, a rigid and durable solution can be achieved. Hence, a product resistant against the various user and environmental impacts can be developed. Furthermore, the mechanism design allows to integrated the components directly on the power control board (PCB), thereby reducing the manufacturing costs of the product and eliminate the integration of fragile sensoring components.

A wire is placed inside the outer shell of the cable. By running the wiring through the cable and connecting this to the PCB, an electric circuit is maintained. By the break of the cable, interrupting the closed-loop, cable break is detected and lock obstructions to be detected.

The mechanism set up is presented and reviewed by the R&D department of TWTG. From this consultation is learned the mechanism and complementary technologies are an advanced, yet practical application of technologies familiar to their expertise. With their expertise in magnetic applications, the R&D department is convinced that a reliable registration of cable detection can be achieved.

7.7 Battery life: LoRa Network

In this section, we elaborate on the design decisions in relation to the battery life of the product, related investigations and selection of components. In order for this product to be desireable a long battery life is required for two reasons.

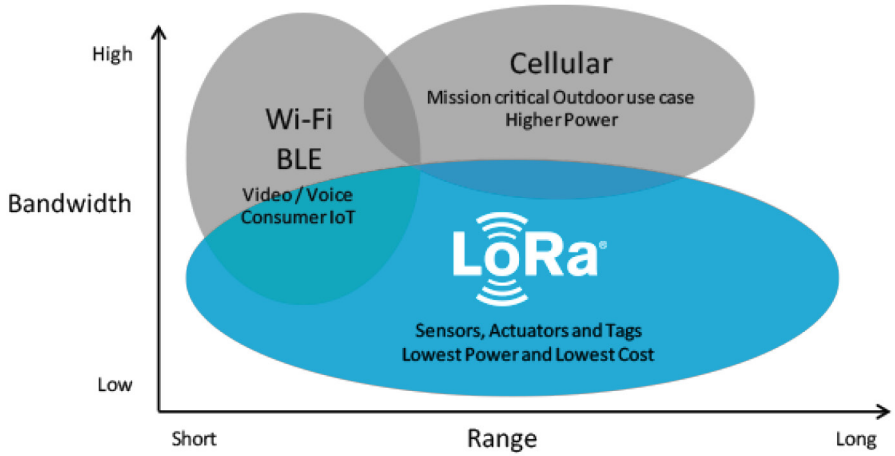
1. Smart wireless products are known for their fast battery discharge. When designing smart products battery life is one of the main difficulties to overcome (C. Chen, 2012).

2. We desire to minimise the operations required to maintain the product

Frequent battery charging or replacement activities would heavily affect the routine of the operators diminishing the ease of implementation of our future product. Subsequently, we desire to overcome the fast discharge problems. For this investigation we focus on the aspects recognised for their significant impact on power consumption.

Wireless network
The screen
The Battery

By selecting these functionalities, the battery life of the Smart Loto can be determined, this allows us to evaluate if a desirable digital lockout scenario can be met.



Bandwidth in relation to range, network overview Semtech (2020)

7.7.1 Contex & conditions network

Compared to e.g. household appliances connected to the Wi-Fi network the Smart Loto demands a large number (>500) of wirelessly connected devices (nodes) to the network of Vopak. Consequently, a low power network is desired.

The Industry 4.0 wireless applications typically need burst communications and use a small amount of data per node. In the case of the Smart Loto device, data needs to be transferred over sizeable terminals, yet minimal amount of data needs to be transferred (screen info, Lock status, inspection executed).

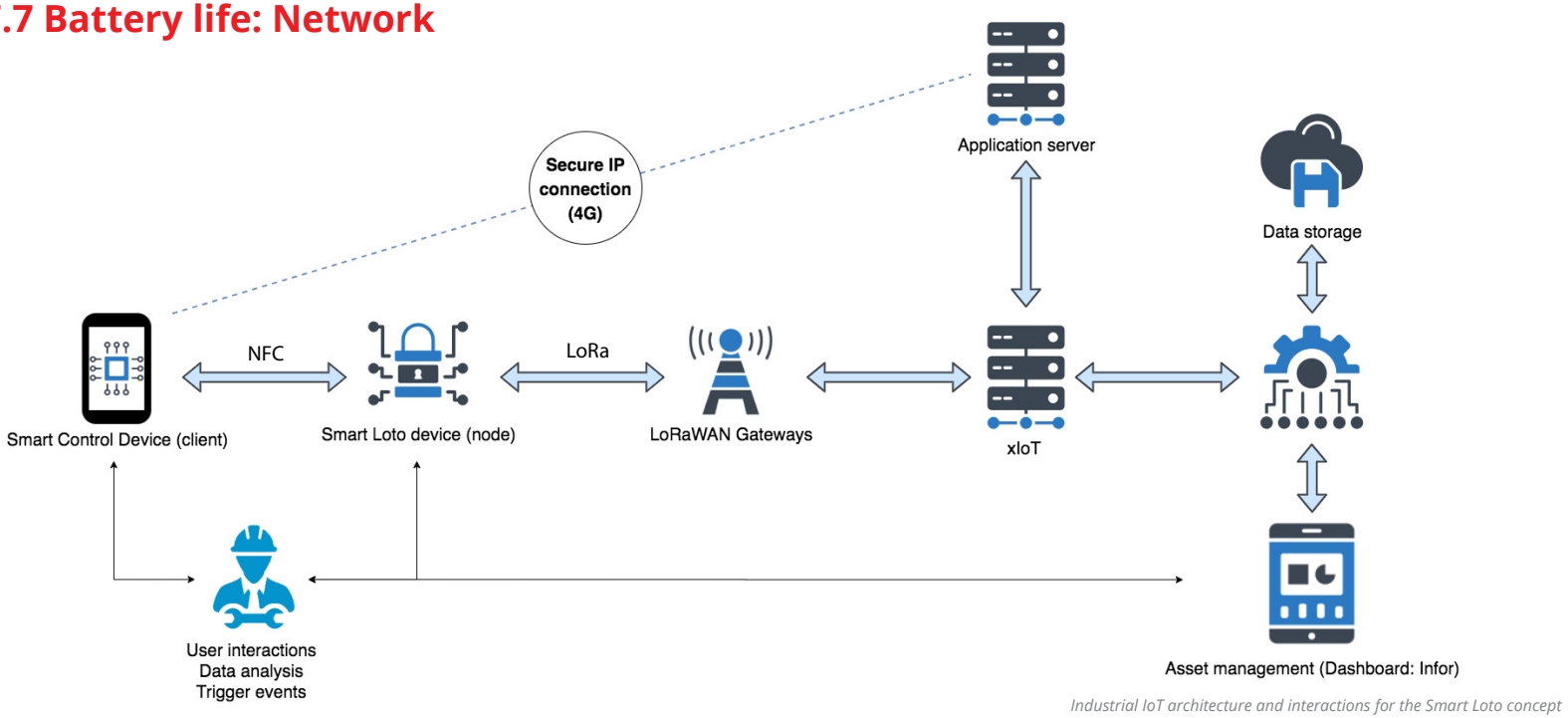
For the implementation of wireless network reliability, availability, the ability to track real-time behaviour (failure or status of the nodes) are key performance indicators to meet the industry environment demands (Khan, A 2016). The company of TWTG R&D are recognised experts on delivering wireless and compatible LoRaWAN (Long range, Low Power - Wide Area Network) solutions on a global scale for various industrial applications.

7.7.2 Investigation of LoRa capabilities

To objectively identify the feasibility and desirability of this network, we investigated the LoRa network in relation to our context and evaluated potential to adopt this network with the R&D department of TWTG.

The Lora alliance, an open non-profit association leading the global standard for IoT connectivity addresses benefits for the context of the Loto product. The alliance states a network of LoRa sensors provides workers with real-time data via the cloud and is a powerful tool to strengthen industry processes (LoRaAlliance, 2020). With this solution, the LoRaWAN technology is specifically suitable for industrial work environments as it allows to monitor the safety and security of personnel and assets, while additionally providing insight on the battery power level of the product.

7.7 Battery life: Network



Industrial IoT architecture and interactions for the Smart Loto concept

An objective research study on the use of LoRa for enhancing industry 4.0 in relation to the industry environment concludes LoRa and LoRaWAN meet the requirements of industrial environments. In particular, when the application scenario requires a large number of nodes (Rizzi, 2017).

Farnell Technology (2020) states the key features of LoRa is it able to cover a long range of 15-20 Kms, Consequently, LoRa can connect to endless of nodes and can achieve up to 10 yeras of battery life for long lasting battery life simple sensor applications.

However, The LoRa network is limited by the amount of that data that can be transferred and specific communication protocol required (actively) send data. This specific message protocol requires messages to be transferred on set time intervals or with the support of trigger events.

In the scenario of the Smart Loto product, suitable trigger events relate the actions being executed or data being received. For the use scenario of the Smart Loto device, wire-end movement triggering the magnetic sensor and the NFC chip being scanned can be used as trigger events. For this reason, the LoRa protocol does not limit the operations of the Smart Loto. In review with the R&D department of TWTG we learn these interactions are valued and suitable interactions to register and transfer data on (dangerous) Loto actions.

Messages bundled in these operations and transferred on set intervals allow monitoring the remaining battery power of the product's status in the field over time.

7.7.3 Other solutions

Continuous data streams with a higher bandwidth (Wi-Fi, BLE), are not feasible for the Loto use case due to the limited and frequency of data to be sent. Semtech (2020), a leading supplier of mixed-signal conductors, state: LoRaWAN fills the technology gap of Cellular and Wi-Fi/BLE based networks that require either high bandwidth or high power (image FIXME1).

For none urgent messages, like the information the battery capacity, the LoRa message protocol can be altered to send weak messages, thereby limiting the battery power of the product.

7.7.4 Conclusion LoRa

Limitations of the LoRa network do not affect the desired use case of the Smart Loto product. The long-range, low power solution and reliability of the LoRa network deliver a feasible and desirable solution for terminal characteristics.

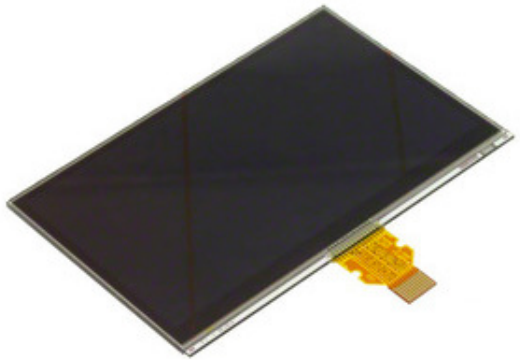
7.7.5 Reliable LoRa applications

To address the viability of network, the R&D department of TWTG is questioned on their ability to deliver safety and an implementable solution. From this investigation is learned the company of TWTG is able to deliver a private LoRaWAN network allowing industries to prevent unknown parties from interfering with the operations executed in the industry. For this establishment, LoRa gateways must be installed at the client's industry.

Reliable connections are of key importance to always be aware of flaws in the Loto systems. Loto actions can be detected by ensuring that every node is connected to a minimum of three gateways. This allows messages to be send secure and fast. Clients value the implementation of the LoRa network due to the low amount of gateways to be installed and the ability of LoRa to be easily and cost-effectively be integrated on top of existing network infrastructures. In case of their clients being existing applications servers handling the received data and xIoT platforms (industrialised secured IoT platforms) for the management of assets. The Things Industries (2020) support these arguments by stating the LoRa network helps to control costs and speeds up the time-to-market.

For the Smart Loto use case the LoRa network technology allows TWTG to significantly contribute to a safer work environment in the industry.

7.8 Battery life: Screen



Low power selected E-Ink component; LCD Display Module - Monochrome Serial 2.7"

7.8.1 Context & screen conditions
Stated in chapter 7.2, the screen functionality is essential for the operation of the Smart Loto device. Additionally, the industry demands screen information to be accessible at all times. Nonetheless, screen operations are known to have a significant negative impact on power consumption resulting in difficulties to maintain long term battery solutions in wireless devices. As a result, it's the desire to select a screen or use scenario demanding minimal power consumption while meeting the desire user interaction for our future product.

In the current scenario, a single tag, displaying 130 characters, is sufficient for the entire duration of the Lockout. We take this excessive amount of characters as a guideline for the to be displayed screen information.

7.8.2 Low power E-Ink screen solution
Desktop research on low power screens solutions identifies the potential of low power E-ink screen solutions.

With the integration of an E-ink screen, minimal battery consumption is required. Compared to light-emitting screens, E-ink screens do not demand continuous energy consumption.

The E-ink screen sets the particles of the screen to deliver the desired information layout with a single stint. This allows providing detailed information for the full Loto use cycle with the use of marginal power consumption. Due to the minimal frequency of screen changes (2-3 times per Lockout) the use of the E-ink screen is an excellent application for the Smart Loto use-case.

Consequently, the ATEX expert from the R&D department is questioned on the ATEX limitations of the screen (explosion prevention). From this is learned E-ink screens are perfectly suitable for industrial environments due to their low power consumption.

In this investigation, the R&D department of TWTG is perceived as the most knowledgeable in the selection of digital product components. For the selection of the component, we provide the department with the desired dimensions of the screen and required amount characters to be displayed. Moreover, to improve the resistance to fall damage, a small screen surface, yet detailed screen is desired. In addition, extreme environmental resistance, low power consumption and durable component are present criteria for the screen selection. Accordingly, we decide to lower in relation to the outer boundaries of the product, to enhance the resistance to fall damage and improve the durability of the product.

7.8.3 Evaluation screen component
The E-ink screen is the most suitable solution for low power applications. In review of the presented product requirements, a 2.7-inch (diagonal) memory LCD screen is selected. (Appendix 18 - Datasheet) This screen is known for its rich content and allows to display over 130 detailed characters. Further analysis of the components reveals the selected screen components is operational within the set temperature boundaries of existing Loto materials (minus 20 to plus 70 degrees Celcius), suitable for wet environments (fishing applications), known for its durability and extremely low power consumption. The R&D department of TWTG explains a 20mA for 2 seconds will be used as a criterion for changes to the screens display.

7.8.4 Supplementary screen benefits
A efficiency gain is achieved by the screen implementation and ability to distantly update screen information with the use of a LoRa Network. This function allows eliminating the work routine related to updating tags in the field , e.g. in the scenario that lockouts take longer than expected or new maintenance issues are identified. In the current scenario, this would require to replace all Loto padlocks and renew the Lockout related tag's.

7.9 Battery life: Use case

Use case	Power consumption per action
50 LoRa messages per lockout 25 Lockouts per year 4 years 1 Place/ 5 inspection / 1 release action(s) pw	0 80mA for 250 ms Engergy usage per bite (criterion): (0,3 Joul per message)
2 screen E-ink interactions (Load and remove screen information)	3 mA for 2 sec.
30 LED blinks of 3 seconds per lockout	neglectable
Cable end registration	neglectable

3600 mAh, AA size

4 Years battery life

Safe for industry

Selected battery for Smart Loto concept

For the context of the industry, it is of key interest to prevent the battery from catching fire in e.g. gaseous envrionemtns (ATEX requirement). For this reason a Lithium Thionyl Chloride battery with a medium energy density selected. Power sources with a high energy density, like several lithium-ion batteries, are not allowed in these environments.

7.9.1 Battery use case & investigation
With the components selected, the power consumption of screen operations, cable end registration and communication protocol can be determined. From the field study, we extracted the number of interactions required with the Lockout product.

For this investigation, the high amount of 7 interactions per week per Loto device are translated in an excessive use case of 25 lockouts per year per Loto product.

The required message protocol to validate a safe work environment, thus review the lock status, is set at three messages per day on set time intervals. The messages sent are required to correspond with the time schedule of the three work shifts present at the terminals of Vopak. The control room will be alarmed when Loto's are removed. Yet, this safety measure allows operators and contractors to validate the Loto's presence at the beginning of their shifts.

The battery life is significantly influenced by temperature and minimum and maximum power demands over the lifetime of the Loto product. As a result, the battery life is complicated to predict. Yet, with the presented use case, desired communications and selected components, the R&D department of TWTG is enabled to define the battery life of the Smart Loto device. These battery calculations involve complex algorithms based on earlier battery tests executed at TWTG's research facilities.

An abstract overview of the impact on battery life and performance is presented in the datasheet in Appendix - 18. Consequently, expertise on battery selection is extracted from the R&D department of TWTG to select the desired user scenario of the smart lockout product.

7.9.2 Inhouse battery insights
The excessive use case of 25 lockouts per year per product presents the Smart Loto as a not actively used product. With the implementation of the selected components, the smart Lockout product has the potential to reach long term battery life.

In the understanding that non-rechargeable batteries drain significantly less fast (1% per year) and estimated life expectancy of the four years can be met. Rechargeable batteries are estimated at 3% drainage per year and battery life of 3-4 weeks. Through this tremendous battery performance, we allow the operators in the industry to save time and prevent new routines from being established for battery charging activities. In particular, for the non-rechargeable batteries use case.

Positively, the implementation of non-rechargeable batteries eliminates the implementation of charging supporting functions and the adoption of charging by the industry. Thereby improving the ease of implementation for the industry and lowering the cost price of the product. Negatively, it limits the lifetime of the product to four years. On the other hand, the lifetime of the product can be extended by industries internal or external (TWTG) refurbish services. Existing product solutions and clients of TWTG use this service to replace batteries and thereby double the lifetime of the product.

7.9.3 Battery usecase selection
From this investigation, we conclude favoured to deliver products with a four years life expectancy compared to implementing rechargeable battery solutions. We make this claim based on the high dependency on the performance of the product, significant impact on the routine of operators for battery charging solutions and expected disability of operators to find the time to replace lockout materials, i.e. the ease of implementation requirement is met to a much greater extent.

Based on the defined use case, battery calculations and context of the Smart Loto product the R&D department of TWTG is enabled to select an AA sized, industrial graded 3600 mAh battery as a feasible solution to meet the highly desired use scenario. With this solution and selected components, outstanding numbers in means of battery life can be achieved. Thereby eliminating the adoption of Loto charging routines and delivering a feasible, long term product solution to the industry.

8 Concept evaluation

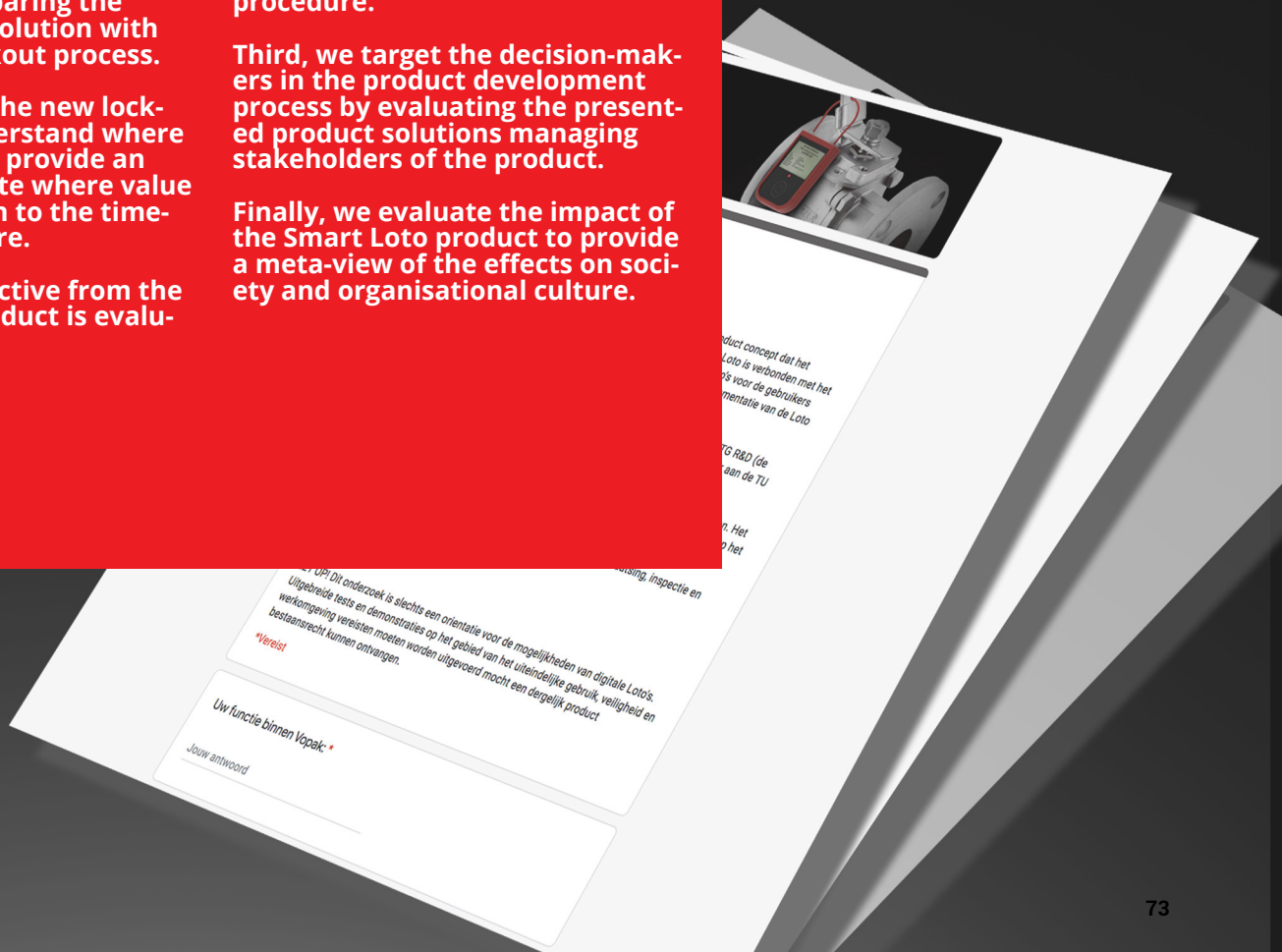
In this chapter, we evaluated the Smart Loto use case and concept. We do this by comparing the newly introduced solution with the traditional lockout process.

First, we evaluate the new lockout process to understand where value is gained. We provide an overview to evaluate where value is gained in relation to the timeline in the procedure.

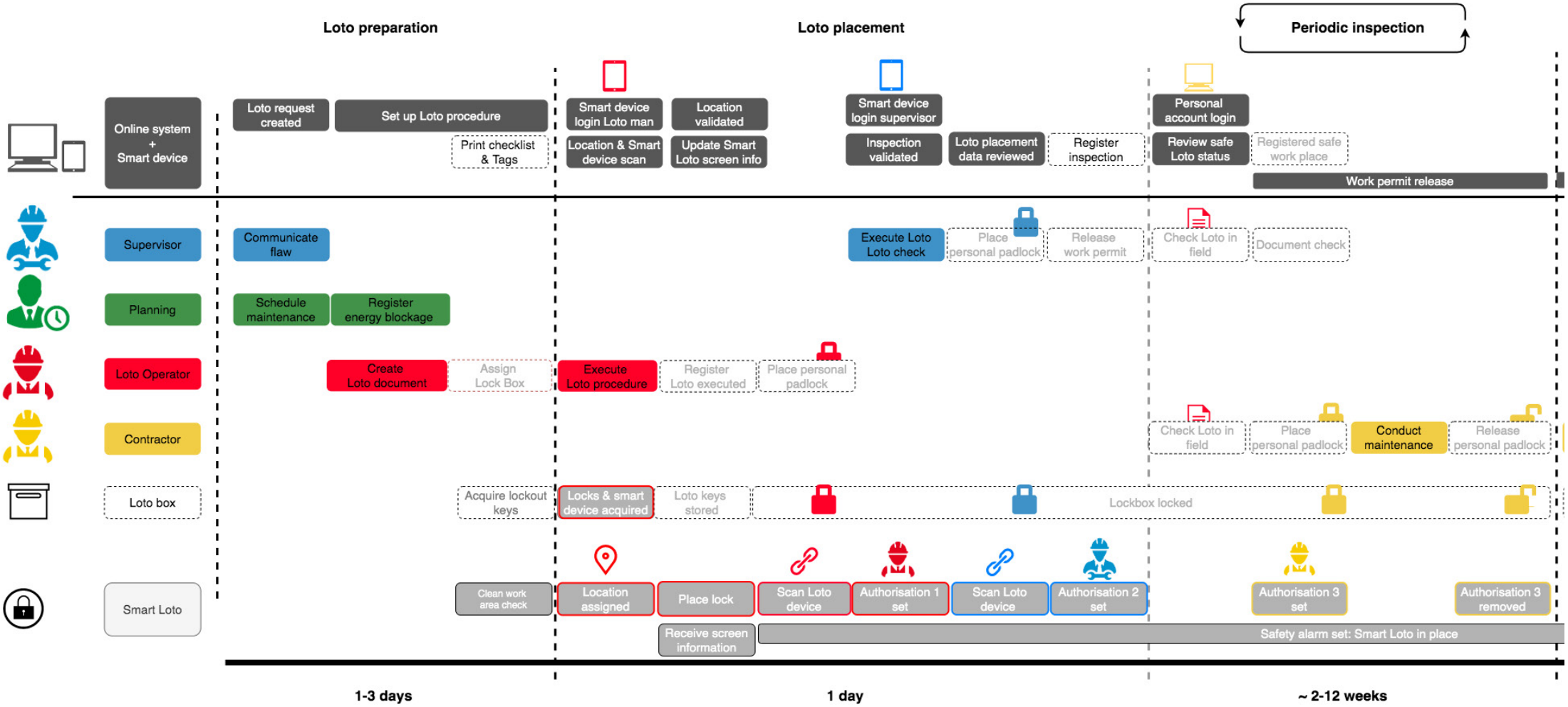
Second, the perspective from the end-user of the product is evaluated to extract practical expertise on the value gain in the lockout procedure.

Third, we target the decision-makers in the product development process by evaluating the presented product solutions managing stakeholders of the product.

Finally, we evaluate the impact of the Smart Loto product to provide a meta-view of the effects on society and organisational culture.



8.1 Comparison lockout process



8.1.1 Comparison old vs. new use case
In the overview on this and following page we compare the current Loto process with the newly introduced Smart Loto routine. This new process overview includes the steps to meet the Smart Loto usecase.

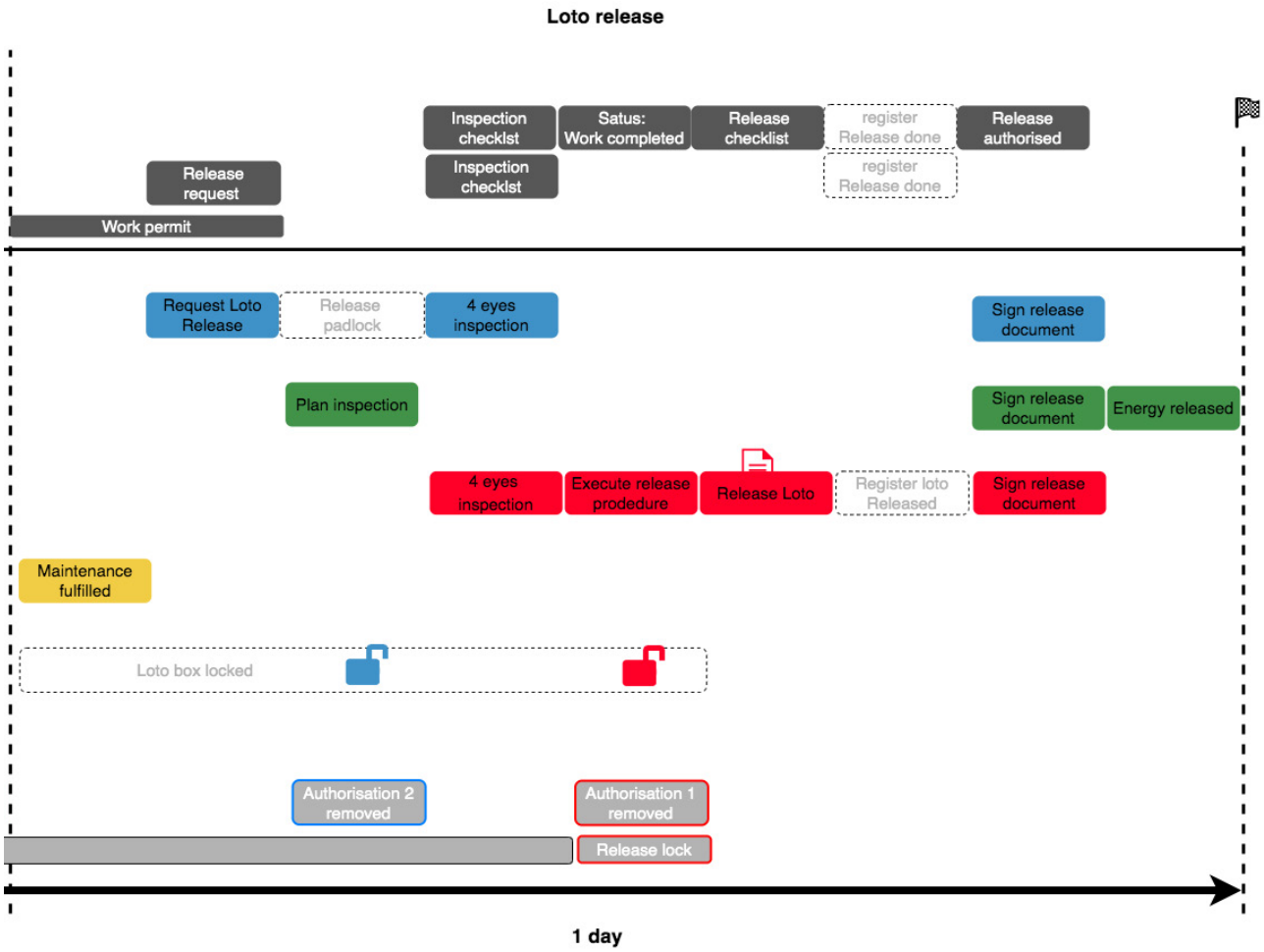
Additionally, we provide insight in the eliminated steps of the traditional lockout routine by displaying the white boxes of the process overview (Chapter 2.6). We do this on an abstract level to provide a clear overview of the differences in the Smart Loto routine.

Placement
- A tablet operation routine replaces the key routine, thus time spent on acquiring the right keys is eliminated.
- Tag preparation and placement routines are eliminated.
- Instructions provided by the checklist are replaced by updated and detailed instructions from the smart control device.
- Correct location placement feedback by inspection is replaced by the direct of placement feedback from the smart control device.
- Time spend on manually gathered registering data in the computer is eliminated.

Inspection (Loto check)
- Inspections, currently not validated, are identified through the personal ID registered from the smart control device operators.
- Personal insight in the currently executed inspections is displayed.

General
- The function of the Loto box is replaced by the smart control device.

8.1 Comparision lockout process



Work prepartion (periodic) inspection
- The daily routine, of an average of four operators, performing work preparation inspections can be eliminated. Thus, an average group of four contractors can directly start their work routine.

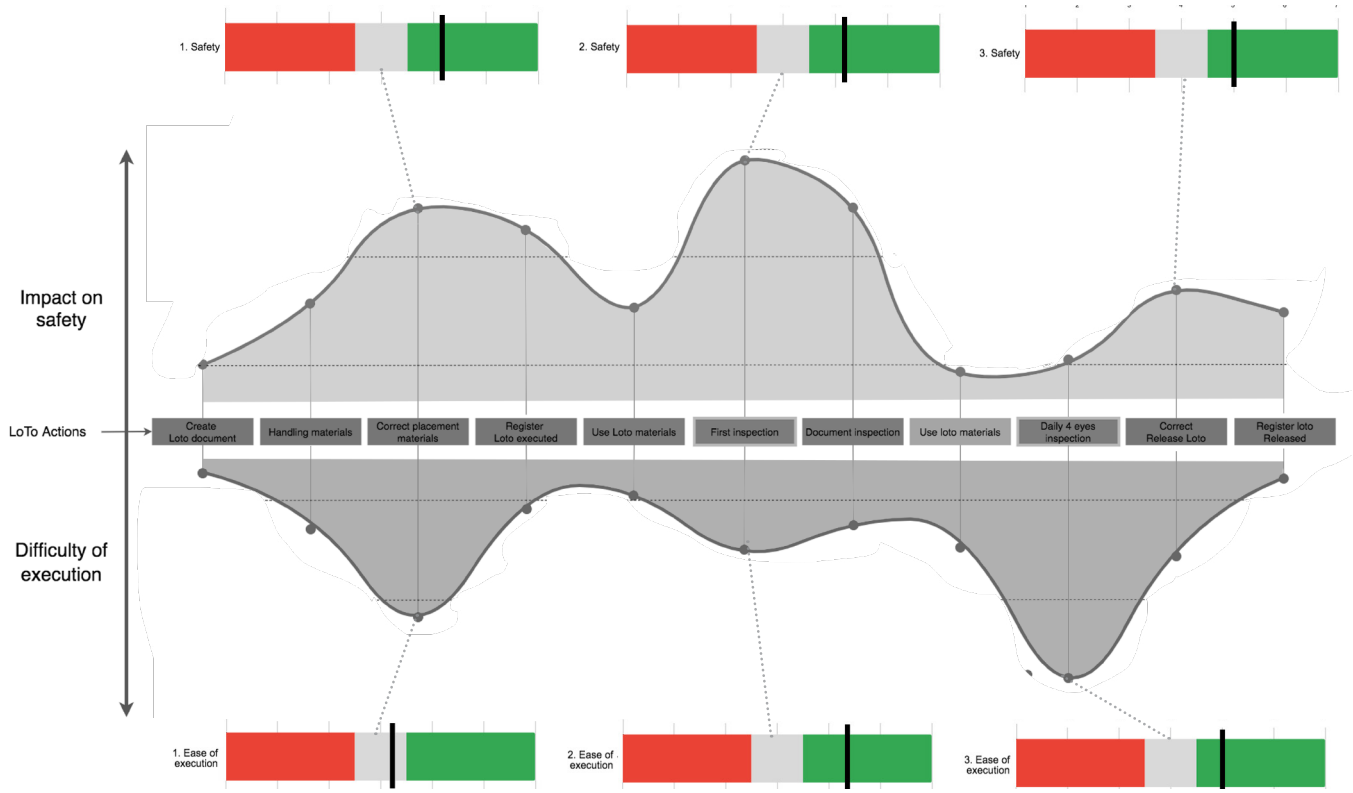
Release of the Loto
- Release of the Smart Loto is directly registered
- Release of the Smart Loto from the wrong location is prevented.

8.2 End-user evaluation

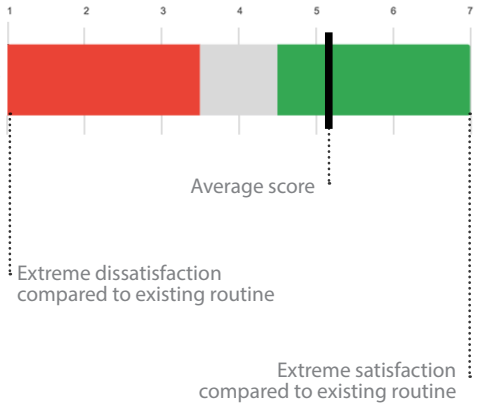
The process evaluation describes the potential of the digital lockout solution. Yet, the theory is desired to be evaluated with practical experiences from the industry to identify if and to what extent the desired scenario can contribute to the safety and efficiency of the end-users in the lockout process.

In this paragraph, we evaluate the improvement of key activities by comparing the existing Loto routine with the newly introduced digital Lockout routine. We do this by evaluating the key activities in the lockout process, causing safety and efficiency issues to emerge.

Perspectives from end-users of the lockout routine are extracted to acquire the rich experiences of operators, dealing with the lockout process on a daily basis. Delivering a higher level of value to these users would ease the implementation of the digital lockout use case as the operator's perception is of key importance for the effective implementation of new product solutions.



Visualisation of data



8.2.1 User evaluation method

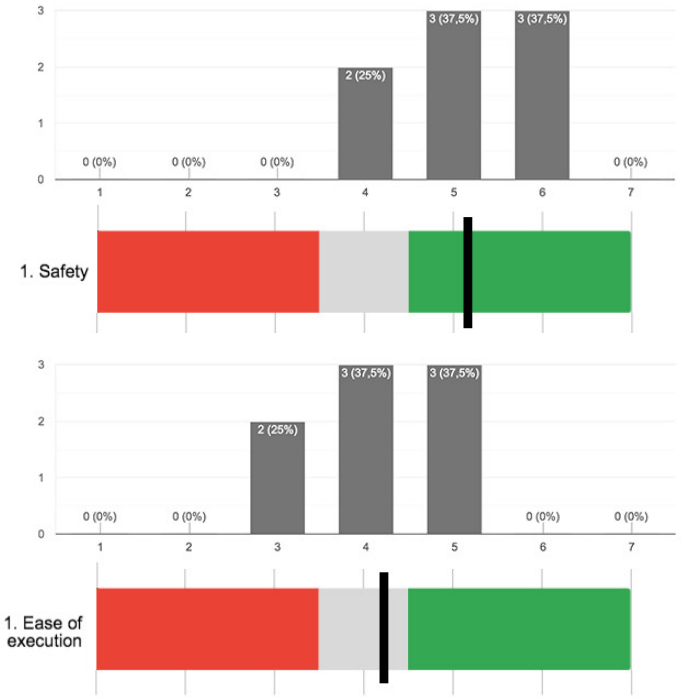
For this evaluation, a group of eight respondents are selected. With an average of three directly related Loto employees per terminal, this evaluation represents the collective experience of a significant number of Loto personal from three leading terminals in the heavy industry. These respondents have the highest level of practical experience in the execution of the lockout process.

A simple to understand 7-point satisfactory evaluation format is presented to the respondents to execute an objective evaluation and make a clear distinction between the perceived value on the evaluated activities. To provide the respondents with a thorough understanding of the influences of the digital lockout routine on their work activities, the online presented evaluation form (Appendix 19) includes illustrations. Consequently, the evaluation form elaborates on the differences between the newly introduced and currently executed lockout activities. With the 7 point scale respondents are enabled to accurately rate the influence on safety and ease of execution from extremely negative to extremely positive. Accordingly, respondents are provided with the opportunity to select a neutral standpoint and elaborate on their selected satisfactory rate. In the end, to provide a general understanding of how the lockout safety is perceived, respondents are questioned on their general perception of digital Lockout in means of safety and ease of maintaining safety. With the limited users presented in the lockout process, we followed a qualitative research design, which does not generate enough data to draw strong conclusions. This for a reason, we know qualitiative designs are not indicative for the total population.

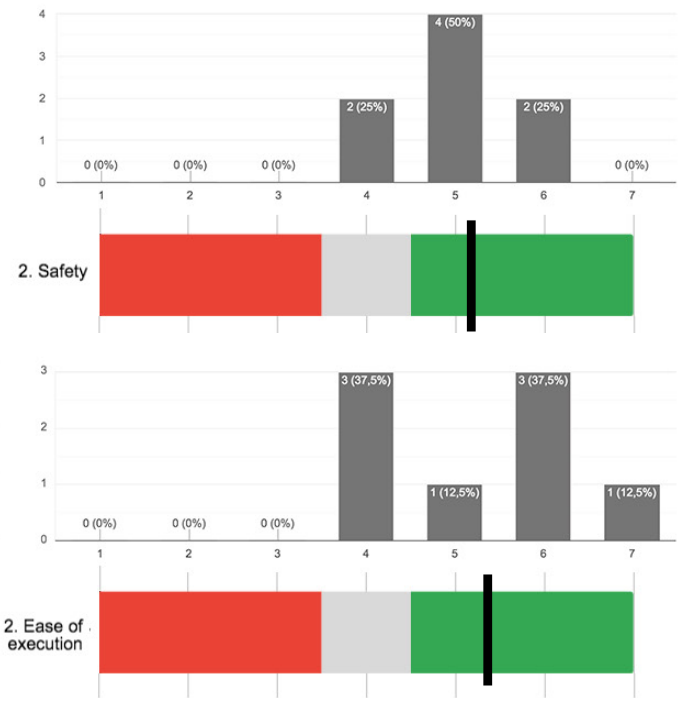
Yet, this evaluation can be used to acquire objective evaluation data, support the value statements of the presented design and provide an end-user perspective on the potential of the digital lockout routine.

8.2 End-user evaluation

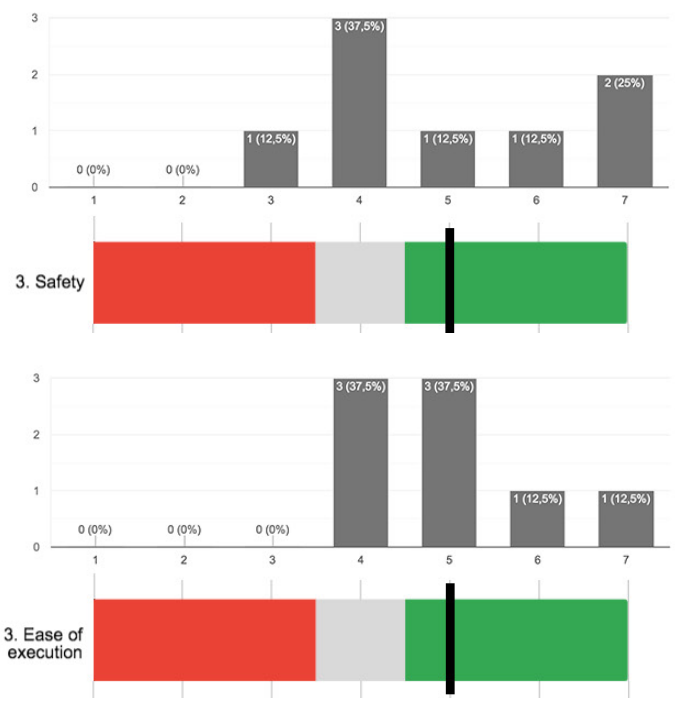
1. Placement



2. Inspection



3. Work preparation routine



Compared to the exisiting Lockout scenario the presented digital Lockout scenario of the [placement/inspection/work preparation] activity is:
Safety: Very unsafe 1 2 3 4 5 6 7 Very easy, Ease of execution: Very difficult 1 2 3 4 5 6 7 Very easy

8.2.2 User evaluation results - 1
Regarding the evaluation of safety, the calculated average and distribution of rates present an overall positive perceived impact on safety for all the evaluated Loto activities. Except for a single negative rating for the safety of the work preparation routine, no negative influences of the digital Lockout routine regarding safety are identified. For the safety of the placement inspection and work preparation routine, a vast majority of respondents identifies the digital lockout routine as an improvement of safety compared to the existing lockout routine.

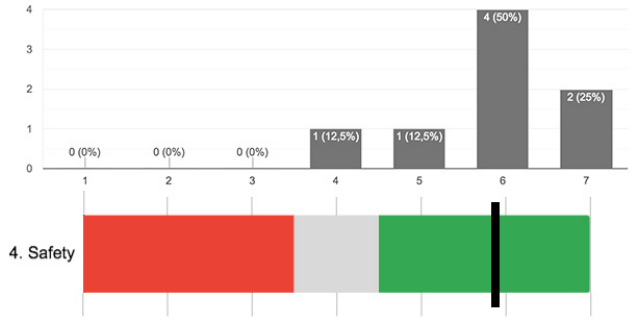
Limited improvements are identified for the ease of execution for the placement of digital Loto materials. The main identified argument of three respondents is related to the limited change in routine from using the tablet operation instead of the key function. For the inspection and work preparation routine, a positive impact on the ease of execution is perceived. From the participants, two out of the eight respondents recall that Loto materials are required to meet chemical products requirements in order to maintain this ease of execution in the lockout process.

8.2.3 Evaluation Insights - 1
The expected traditionally oriented operators from the industry and value gain for all routine alterations in relation to safety and 2 out of 3 activities for ease of execution, making the digital Loto routine and improvement to the existing scenario. For 1 of the 6 alterations evaluated a neutral standpoint is identified for the ease of execution of Loto placement.

Yet, an improvement of safety is perceived from the implementation of the placement activity supporting the desire to implement the routine from a material placement viewpoint. Potential influences of chemicals could limit the ease of execution of the placement process. Hence, further research must be conducted to support the ease of execution in chemical environments (one out of the three evaluated terminals).

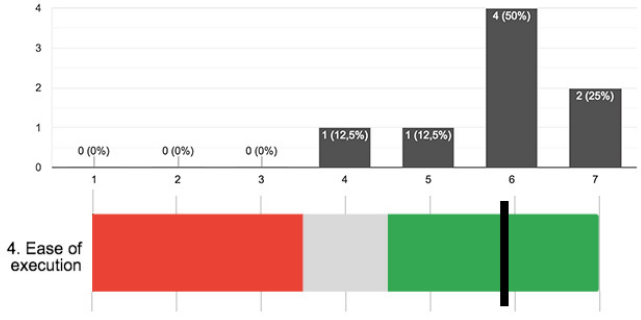
8.2 End-user evaluation

4. General perception on safety



With the new lockout scenario the Lockout becomes: Very unsafe 1-7 very safe

5. General perception on ease of execution



With the new lockout scenario maintaining a safe work environment becomes: Very difficult 1-7 Very easy

8.2.4 User evaluation results - 2
From the eight respondents, seven respondents perceive the digital lockout routine as an improvement on general safety in the lockout procedure. Zero negative perceptions of the influence of safety are received. Coincidently an equal distribution is received for the ease of execution of maintaining this safe work environment. An perceived high average on general safety and ease of maintaining safety is received.

8.2.5 User evaluation main insight - 2
With the new lockout routine, and thus abilitity to distantly monitor safety, the safety level in the lockout is perceived to signifantly improve.

In addition the ease of maintaining th safety is in the lockout routine is perceived much easier to executed than in the current lockout routine. Thereby eliminating the earlier identified trade-off (chapter 2.2) of implementing new safety layers and maintaining workable conditions.

Remarkeable in this general evaluation of safety and ease of execution is that the average level is, postively, much high compared to the evaluation of individual lockout activites . This could be contributed to the fact that the continous monitoring of safety is not assest in three Loto activities of the operators.

8.2.6 User evaluation conclusion
This evaluation strongly suggests the desire to monitor safety flaws and implement the Smart lockout routine in means of safety and efficiency. It suggests a severe positive impact on the workflow of the operators in means of safety and ease of execution of tasks. The affected Loto employees, experts on the execution of the lockout process, do not recall issues regarding the safety and efficiency affecting the establishment of this lockout use case, suggesting the digital lockout routine is highly relevant for the establishment of a more efficient and safer work environment.

Although a high level of understanding is received from the respondents, a true evaluation of ease of execution must be executed through physical product evaluation and extensive user testing. This study provides the relevance to conducting user tests for his use case through physical models and usability evaluations operators from the industry.

8.3 Evaluation management

In order for the presented use case to become viable, the presented use case materials of the final concept operations are presented to two prominent figures from both the industry as TWTG. A video conference meeting is set up in which respectively, the implementation and further development of the smart lockout product is discussed. The key insights from these evaluation will be elaborated in this paragraph.

The first delegate from the industry includes the Innovation Engagement Leader, which is selected due to his responsibilities concerning the selection of the most valuable product innovations for the industry. Secondly, the Global Deployment Lead responsible for the implementation and evaluation of new innovations is consulted. Subsequently, this managing stakeholder is known for his expertise on lockout improvements in the industry. In this evaluation, both stakeholders were questioned on their perception of the presented digital Lockout use case of chapter 6 (Concept presentation) and required steps and adjustments to meet the desired scenario.

From the company of TWTG product evaluations are conducted with the CTO, responsible for the introduction, management and persuasion of innovations and Product Manager, responsible for the establishment and feasibility evaluation of products. From these discussions the managing perception is shared.

"Our innovative thinking is based on how they are raise by the industry, limiting the ability to think outside the box. This solution allows to be disruptive and thereby adds value in terms of safety and efficiency to our industry, while suiting our global Loto blueprint"

Innovation Engagement Leader

Image : Headquaters Vopak Rotterdam

8.3.1 Management industry

The Global Deployment Manager is critical, however positive on the implementation of the Smart Loto. He underlines the Loto procedure will be marginally impacted to meet smart Loto concept, thereby allowing to meet the pre-set Loto regulations. On the other hand, effort to maintain the tag network and data quality is expected. The Deployment Manager is critical towards the implementation of the Loto for less digital advanced terminals and flexibility of the system when alterations are made. A disciplined workflow involving re-training of the operators must be established to safely manage this scenario.

Yet, the Deployment Manager perceived value form the use case and is eager to dig deeper in to the cost influencing factors of the product. He states the capabilities of the Smart Lockout concept is highly desirable for its the efficiency features. Especially for large size locations, Like Vopak Europort. These terminals will significantly benefit in productivity by a new work inspection routine resulting in fewer inspections. Consequently, he addresses technology advanced industries will allow to adopt the solutions fastest. Accordingly, he states, with this use case in place, further safety tests are desired to be executed.

With the further development of the Infor systems, implementation will be possible in the future. With this system and the Smart Loto device the Deployment Manager is convinced effective support to the operators can be delivered to improve their actions and reduce misinterpretations of safety.

The Innovation Engagement Leader of Vopak declares the Smart Loto solution is highly desired for both its cost reduction abilities as it's enhanced safety performance. From his experience in the industry, he believes the current lockout must be significantly improved with the proposed concept. He explains the product functionalities are disruptive, yet suitable for implementable solution (quote top page).

The Innovation Engagement Leader foresees a great challenge in the industry to implement the solution and states a shift in mindset on what safety is, is required. The Engagement Leader is sincerely willing to contribute to this change in mindset and states, with a relevant product manifestation identified, demonstration models are required to display value to the practical mindest of industry managers and operators. Finally, the Innovation Engagement Leader recalls that there is a strong desire to acquire data on the lockout actions executed from a managing perspective, supporting the ease of implementation of the product.

8.3.2 Management TWTG

With the establishment of this report, TWTG identifies the relevance for the development of the Smart Loto product. Based on the interest extracted from the industry and ongoing events during this research, the management of TWTG pursues the development of the product for industry clients and aims to make a significant impact with this product. Additional interest is recognised for implementation of the tag functions to monitor industry assets and support the placement of the Smart Lockout device. This system and the interest received from the industry delivers valuable business case for future product development.

8.4 Evaluation: Impact

8.5.1 Operators

Operators in the heavy industry do not have an easy job. Their direct relation to the productivity of the organisation puts pressure on their performance. They must work fast accurate, while mistakes can rapidly translate into cost-intensive material damage or (lethal) injuries.

The Smart Loto concept delivers a solution to reduce the stress on the performance by eliminating the insecurities on (to-be) executed actions and improving the ease of execution. In addition, supervisors are relieved from the anxiety of not daily performing their time-consuming inspections.

The higher level of terminal safety significantly reduces the chance of operators being affected by hazardous energy sources or being responsible for (un)intended inaccurate registrations.

Verification of their actions allow operators always to be aware of the correct placement and release of their Loto materials, also when stressful or a low level of concentration diminishes the accuracy of handlings. This allows to built trust in the Loto process. Subsequently can productivity interests of the organisation not take over control of the personal health and safety of the operators as actions will always be evaluated.

8.5.2 The industry

A smooth landing for a disruptive product is identified through the implementation of traditional tag functions, allowing the industry to take on the false perception of Loto safety present in their industry. With the Smart Loto industry entreprises can counteract the lack of control on human actions and overcome the traditional deep routed problem of decreasing efficiency with new safety regulations.

A new practice, in which assets are validated safe instead of relying on human interpretations of safety, adds value to the organization on a social level. The trustworthiness of the system allows organizations to establish clear communication on safety. By digitally monitoring if regulations are met, different interpretations of meeting the protocol can be controlled top-down and eliminated.

With the data provided by the Smart Loto a transparent safety practice can be established, making Vopak less dependent on personal desires not to report safety flaws. This transparency through data allows Vopak to deliver a new safety culture in which; the Loto process is significantly more safe, terminals not meeting Loto regulations can be targeted and improved and neglecting adherence to the protocol can be revealed for everyones best interest.

8.5.3 TWTG R&D

The company of TWTG is provided with the opportunity to deliver a breakthrough in the industry with smart safety technologies. With the Smart Loto product, the traditional, widely adopted, padlocks materials in the industry can be effectively replaced in Vopak's Global practices.

With the safety and efficiency gain and relevance for implementation identified the Smart Loto product is stated to be highly relevant for the market of Vopak. The forthcoming desire of Vopak to adopt this solution provides the engagement TWTG desired to start the implementation phase with this product. By building on the product development expertise of TWTG this product can be short term realised.

This unique product in the market allows us to differentiate in the market and address new market value. With the support of the Smart Loto the transformation from traditionally orientated terminals to smart technology-oriented terminals can be accelerated. This provides TWTG with the opportunity to deliver supporting IoT foundations and a broad scale of IoT applications to (Vopak's) terminals in the future.

Chapter 9: Conclusion

From the research study and use case evaluation presented in this report is concluded that the traditional lockout routines can significantly be enhanced through the implementation of digital technologies. As described in the literature, the identified flaws in this procedure relate to the execution of the Loto process and not to the described Loto protocol itself. The developed Smart Loto use case allows to prevent, detect and monitor these key executionals flaws in this lockout process, allowing to ensure a safer and more productive work environment.

The presented use case allows the industry to solve the identified lockout problem from an operators perspective. This allows operators to a) review the correct execution of Loto placement/release/inspection activities, b) support operators work more accurately, c) make operators jobs less stressful. The objectively evaluated use case with these stakeholders strongly suggests the digital lockout solution does not primarily enable safety flaws to be monitored, but consequently provides pro-active supports with the operators to meet a safer and easier to execute Lockout process.

Through management consultations, the need to monitor (near-miss) accidents and support of safety adherence in their Loto protocol is identified. To deliver a product that is accepted by the industry, the company of TWTG is provided with a smart lockout routine that, a) limits the impact on the routines and materials in place, b) provides data for risk assessment purposes and c) increases returns on investment by a significant value in means of efficiency.

A feasible product solution, accepted by the industry leader Vopak, is established through the integration of in-field communication instruments, being the LoRa network, NFC communications, screen component and control device operations. With this product manifestation, a desirable lockout routine can be met for the industry of Vopak, both adressing new value, as maintain traditional lockout functions. Yet, thorough understanding of the product's its capabilities in a real life scenario is required. Demanding product demonstrations and secure software protocols to be established.

To effectively introduce Smart Loto solutions, TWTG must pay attention to the complex trade-off of industries related to the investments in (re-)training of employees, replacement of capital intensive systems, the digital orientation of existing systems, view on safety and innovation culture. As additionally represented in the design of the digital lockout use case, this necessitates being open for the develop the less disruptive or complex products in order to cross the interval from invention to innovation.

The development of this smart lockout routine stresses the importance of efficiency and a limited alteration to existing Lockout practices for the introduction of safety-oriented smart product solutions in the heavy industry.

The context characteristics of the industry, problems present in their Loto routines and technology expertise of TWTG provide a valuable business case for TWTG to disrupt the traditional lockout process with their hardware and software expertise. The significant value gain in efficiency and safety of the lockout provides valuable opportunities for TWTG to become the leading supplier of the digital transformation of the lockout process and increase the dependency on TWTG's network services.

10. Recommendations

This chapter elaborates on the recommended steps the company of TWTG R&D can take to further develop the Smart Loto concept. Consequently, critical insight for the product implementation and introduction product are described. During the time available in this research a smart lockout concept is designed up to the level were the digital Loto use case is defined and accepted by the industry. From the use case evaluation insights for the continuation of the product development process and desire for a prototyping phase are extracted. These elements are required to be thoroughly tested and evaluated with the different stakeholders addressed in this project.

10.1 Product testing

The Loto product, being a serious safety measure in the heavy industry, requires an extensive evaluation of safety in the industry. Before taking steps towards the broader distribution of the new lockout product, long term testing is advised with various user types to understand how the new behaviour developed with this product affects the safety and efficiency in a real-life scenario.

A designated area on the terminal, preferably a full terminal tank section, adopts the Smart Loto product for the lockout method. In the ideal scenario the construction of a new section, like section 3000 on pilot location Vopak Vlaardingen, allows to directly integrate valve tags and link the location to the system, to support the ease of implementation. By targeting a section, the Lockout pilot can run in parallel to the existing Lockout process, preventing interference with existing Loto processes.

10.2 Target market

By gradually introducing product functionalities in the Loto process, the threshold to adopt the Smart Loto concept can be lowered. To reduce the impact on management of change, the effecitive client to target are the ones that are already in the digital transition and adopted the LoRa network and/or tablet routine. For Vopak this would relate to Vlaardingen, Europoort and Botlek.

10.3 Introduction of functionalities

Besides the implementation of the LoRa network, minimal alterations are required to be made to the systems in place in order to establish the placement and release validation function. The company of TWTG is advised to investigate the potential of inhouse applications development to provide a low threshold in assets management. The establishment of an application would allow delivering an end to end solution improving the ease adoption for usage, test and potential full integration purposes.

More significant alterations,related to the placements of location tags to all isolation equipment. To support the ease of implementation of this function, supporting the validation of Loto placement at the correct location, its advised wait until the use of the digital use case is widely established.

Accordingly, the functionality of tablet instructions, demanding the integration of the online Loto system with Loto activities, can be postponed. Later, with all functionalities established the full integration of the Loto data in the asset management system would prevent unsafe work permits to be released.

Presenting all the functionalities at the same time might result in too much disruption at the moment of implementation. This would requires drastic re-training and safety perception changes of the operators. A routine change not properly managed could create unsafe conditions or a dependency on digital systems while not having a clear understanding of the product's output.

10.4 Points of interest for model evaluation

The full product use flow must be evaluated with a physical model of the presented design proposal and evaluate the perceived improvement of safety and efficiency through extensive usability testing and interaction prototypes.

For the establishment of this prototype, special attention must be dedicated to the operation of the handlings related to the usage of a smart control device with chemical resistant gloves in stressful conditions. Tablet operations are executed in these scenario's, yet it's advised to make the operation as simple as possible to improve upon safety. Operators must execute actions with clear and minimal (potentially zero) smart device interactions in the field.

The mechanism is required to evaluated be in the industry context to validate the usability of the mechanism. Moreover, the perceived resistance against the unintended opening of the product must be investigated. Although the R&D department of TWTG perceives a high level of reliability, yet excessive use case scenarios must be evaluated to validate safety in the work environment.

10. Recommendations

The relevance of the tamper detection in the wire mechanism must be investigated further in relation to the cost price of the product and commercial benefits. Compared to a traditional padlock solution, the symbolic lockout eliminates the desire to cut the padlock. Although the tamper detection provides full insight in the lock status, the new scenario could result in zero padlocks being cut, eliminating the relevance of this product functionality.

In the industry, Loto products are carelessly handled and experience great environmental impact and extreme use cases. A durable product must be established to ensure a long product lifetime. This demands the resistance to chemical exposure in the scenario that the product is desired to be implemented at terminals dealing with these resources.

10.5 Limited battery life routine interference
Early identification of battery life product must be established to prevent operators from removing Smart Loto products from the field. Algorithms must be developed to early identify products low on battery and must be tailored in relation to the maximum lockout duration of a terminal.

10.6 Prevention of safety abuse
Misinterpretation of the distantly monitoring of lock status could result in operators neglecting the in-person inspection of the lockout product. In-person executed inspections must remain monitored and executed on set time intervals, in particular when changes to systems are made.

10.7 Addressing product value
Current Loto products meet the desired criteria of the industry. Research reveals they do not ensure a safe work environment. Evaluation of the digital lockout product based on the existing criteria will not reveal added value in means of safety maintenance. Therefore different perspective from the industry on safety is required.

The introduction of a new product must clearly point out the problems solved to enable the industry to think beyond the status quo and understand the value a Smart Loto concept delivers. This could require to educate the industry on the false perception of safety present in their routine. Marketing statements, discussions with innovation and deployment managers must elaborate on the new value delivered by lowering the dependency on human handlings, providing data on safety and eliminating the room for misinterpretation. Delivering new value and awaking new interests requires to introduce a new product. Dependent on the type of stakeholder, it could help to address either efficiency or safety functions.

10.8 Different market segments
The lockout process is widely adopted in the heavy industry. This provides great potential to introduce the Smart Loto product to markets outside the industry of Vopak. To provide these clients with a wide understanding of the product's capabilities, its strongly advised elaborating on the detailed use cases presented in this report. This with the aim to identify the critical elements in the implementation process. Accordingly, the deepley routed mindset of the heavy industry is not perceived ease to change. To enhance and evaluate the desire for product adoption the company of TWTG could use more visual means in terms of use cases, videos or product demonstrations to evaluate the potential of future products before fully developing product solutions.

This could ease the implementation of future products and provide a more lean approach in the product development process and could allow to identifying even more highly favourable IoT product solutions.

11. Reflection

11.1 Project drive
Starting this project with zero understanding of the context of the heavy industry, let alone the lockout process, resulted in the great challenge to reach a high level of understanding of the industry within the set time frame. The desire to thoroughly understand what drives the industry was motivated by the identified potential of smart product solutions in the industry and later recognised the urgency of this product to become a reality. Personal conversations with industry stakeholders supported this motivation. This drive enabled to tackle the doubts related to the magnitude of this assignment and led to the personal desire to discover the undefined user behaviour in the lockout process.

11.2 Project management
After the first weeks of field observations and user consultations, the project objective was altered. New insights from the research objectives shifted the initial project objective from the request to simply monitor safety flaws towards a product development processes aimed at preventing undesirable behaviour, delivering new challenges along the way. Consequently, a change in the project approach was required due to the execution of this thesis during the COVID-19 lockdown. User evaluations were required to be digitally executed, resulting in the establishment of evaluation formats and digitally shared smart product routines. Translating the use cases into real-life scenario's would have allowed to provide a more in depth understanding on the impact on efficiency and safety. Reaching a high level of detail in these use cases was challening, yet the results allowed to efficiently executed user evaluations.

Project adjustments and unforeseen design factors related to Loto Law, the various Loto applications, extensive and overcomplex Loto procedure, Loto materials resulted in the great challenge to maintain a structural research approach and to report clear narrative presenting the most relevant information. Independently dealing with this project complexity from my home office, while aiming to deliver fundamental research and the relevance for the product put severe pressure on both my analytical skills and project managing abilities.

11.3 Project approach
By gradually extracting knowledge from various perspectives from the industry, I learned to establish an objective and analytical view in the research process. Yet, due to the unknown variables of the heavy industry, this research was conducted in a very hands-on approach. New discoveries fed the desire to dig deeper into industry practices than initially intended. This continues iteration of acquiring new information diminished the efficiency, focus and depth in this research. Positively, this contributed to the documentation of a large number of valuable industry experiences, providing the company of TWTG with a solid basis and wide understanding of the context for further product development. Negatively, the focus on acquiring as much knowledge as possible didn't allow to structurally break down efficiency and safety in variables other than time-consumption, difficulty in of execution and prevention of incidents. More fundamental research on these specific aspects for the existing and future Loto products would have allowed to the select more conditions to improve the establishment of a demonstration model and digital lockout routine in the future.

11.4 Personal project learnings
The greatest learning and challenge of this project does not originate from one of my pre-set project ambitions, but relates to dealing with a large number of project uncertainties and maintaining manageable stress levels during this project. These project management factors were additionally influenced by the life-threatening problems in the lockout routine, stressing the importance of a truly safer, yet desirable product solution. Thereby also addressing my responsibility as a researcher and product developer.

In this project, my ambition to help businesses accelerate through the implementation of smart technologies is achieved to a much greater extent than expected. My desire to make smart innovations commercially attractive resulted in a further understanding of how IoT product innovations are perceived by managing departments and how products can be tailored accordingly.

The desire to co-create with TWTG's engineers was fulfilled with great enthusiasm. By acquiring and streamlining information from industry experts to dedicated R&D engineers to end-users provided me with more clarity on the importance of being a product design engineering. The real-life playing field and managing organisational, people's and technologies interests truly strengthed my capabilities as a product developer. In the future is strive to continue in this line of work and deliver social impact through smart technologies solutions.

Looking back, I can fairly say I'm proud of managing these stakeholders interests to deliver a clearly defined use case design contributing to the safety of humans in hazardous environments.

12. Acknowledgement

After I finished my three years bachelor degree in Industrial Design Engineering, I was encouraged to take on more progressive challenges in the business environment and step out of my faculty comfort zone. For a year, I was fortunate to participate as a board member in the Forze Hydrogen Racing Dream Team striving to push the adoption of hydrogen technology in the mobility sector. As a follow-up, I joined the flight case team to execute design consultancy practices with foreign enterprises in Japan. During my Masters, Intergraded Product Design at the Delft University of Technology, I strived to build research skills and smart product development expertise. This proudly presented report is established with the gathered know-how, newly gathered experiences and six months of hard work, with which I proudly conclude this study. However, in both stressful and enjoyable times, this initial individual project would have been impossible to execute without the support of the following people.

First, I would like to thank my supervisor team from the Delft University of Technology. Throughout this Master thesis project, my research approach has been supported and critically reviewed. My design decisions have always been respected, while enjoyable and exciting conversations were naturally established and highly appreciated. In times were almost all communications were online, and exceptional pressure on the educational system was present, great emphasises with my project was experienced. Jacky Bourgeois and Martien Bakker, your invaluable support and feedback truly supported me to take the project and my personal skillset to the next level.

Secondly, I wish to express my gratitude towards my company mentor, Joost Peters. Your experiences and extensive knowledge on project management enabled me to further develop my skills as a product developer. Our meetings provided me with the confidence to continue the challenging research and product development objective and provided me with an understanding of TWTG's innovative design approach for smart product solutions. Your support, flexibility in project adjustments due to the COVID-19 scenario and trust provided me with the ability to work with great freedom and run internal investigations with the support of TWTG's resources. I can honestly say the TWTG is a great company for a graduation project.

Third, I would like to thank all the anonymously involved employees of Vopak for delivering a significant contribution to understanding the industries practices and providing valuable industry insights. This project could not have been completed without your high standards on safety, flexibility in communications, openness in conversations and endless drive to improve companies processes.

During the past six months, I must admit a person feeling the urgency to adopt an unhealthy work intensity is not always the most social and desirable boyfriend, friend, UFO roommate or family member. However, your trust, listening ears at all times and tremendous support encouraged me to start, continue and walk the extra mile to proudly finish this Masters.

Lastly, thanks to the reader for the interest in this thesis. I wish to have inspired you to push the boundaries of (smart) product innovations even in contexts where the realisation of innovations are perceived challenging.

With gratitude,

Karsten Bakker

Literature

Aheleroff, S., Xu, X., Lu, Y., Aristizabal, M.m Velásquez, J.B., Joa, B., & Valencia, Y. (2020). IoT-enabled smart appliances under industry 4.0: A case study. Advanced Engineering Informatics, 43, 1-14. https://doi.org/10.1016/j.aei.2020.101043

Ale, B.J.M., Kluin, M.H.A., & Koopmans, I.M. (2017). Safety in the Dutch chemical industry 40 years after Seveso. Journal of Loss Prevention in the Process Industries, 49, 61-67. https://doi.org/10.1016/j.jlp.2017.04.010

ATEX. (2020). Atex Zone 1/21 Certified 34 MM TEC PU NFC TAG. Retrieved Month day, 2020, from https://www.atexshop.com/atex-zone-1-21-certified-34-mm-tec-pu-nfc-tag.html

Campbell, T. (2003). Loto Remains Problematic. Professional Safety, 48(3), 48-51.
Ericsson. (2020). Industry 4.0. Retrieved May 14, 2020, from https://www.ericsson.com/en/internet-of-things/industry4-0?gclid=EAIaIQobChMIlq-ahPGh6QIV2ON3Ch3jhg9cEAAYASAAEgIhiPD_BwE&gclsrc=aw.ds

Forbes. (2018). 2018 Roundup Of Internet Of Things Forecasts And Market Estimates. Retrieved Month day, 2020, from https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#231553707d83

Gnoni, M.G., Bragatto, P.A., Milazzo, M.F., & Setola, R. (2020). Integrating IoT technologies for an “intelligent” safety management in the process industry. Procedia Manufacturing, 42, 511-515. https://doi.org/10.1016/j.promfg.2020.02.040

Farnell. (2020). Wireless LoRa Technology. Retrieved Month day, year, from https://nl.farnell.com/wireless-lora-technology

Inhand Electronics. (2020). Why a Rugged Tablet Must Have An IP67 Rating. Retrieved May 23, 2020, from https://www.inhand.com/why-a-rugged-tablet-must-have-an-ip67-rating/

Landaluce, H., Arjona, L., Perallos, A., Falcone, F., Angulo, I., & Muralter, F. (2020) A Review of IoT Sensing Applications and Challenges Using RFID and Wireless Sensor Networks. Sensors, 20(9), 1-18. Doi:10.3390/s20092495

Mobatec. (2020). Field Solutions. Retrieved May 23, 2020, from https://www.mobatec.nl/web/products/field-solutions/

Osha. (2019). Lockout/Tagout. Retrieved May 14, 2020, from https://www.osha.gov/dts/osta/Lototraining/tutorial/materials.html

Puisis, E. (2020). The Best Subscription Boxes For Every Need, From Drinks To Dog Food. Forbes. https://www.forbes.com/sites/forbes-personal-shopper/2020/07/09/best-subscription-boxes-for-every-need/#71ad39959932

Robson, L.S., Stephenson, C.M., Schulte, P.A., Amick III, B.C., Irvin, E.L., Eggerth, D.E., omission sign Grubb, P.L. (2012). A Systematic review of the effectiveness of occupational health and safety training. Scandinavian Journal Work, Environment & Health, 38(3), 193-208. doi:10.5271/sjweh.3259

Rizzi, M., Ferrari, P., Flammini, A., Sisinni, E., & Gidlund, M. (2017). Using LoRa for industrial wireless networks.

Roozenburg, N. & Eekels, J. (1995). Delft Design Guide. Retrieved from https://arl.human.cornell.edu/PAGES_Delft/Delft_Design_Guide.pdf

Ryder, B. (2012, April 21). The third industrial revolution. The Economist. Retrieved from https://www.economist.com/leaders/2012/04/21/the-third-industrial-revolution

Semtech. (2020). Why LoRa?. Retrieved Month day, 2020, from https://www.semtech.com/lora/why-lora

Thibaud, M., Chi, H., Zhou, W., & Piramuthu, S. (2018). Internet of Things (IoT) in high-risk Environment, Health and Safety (EHS) Industries: A comprehensive review. Decision Support Systems, 108, 79-95. https://doi.org/10.1016/j.dss.2018.02.005

The Things Industries. (2020). LoRaWAN™ Network Server Provider. Retrieved MONTH DAY, YEAR, from https://www.thethingsindustries.com/

TWTG. (2020). Capabilities. Retrieved Month day, 2020, from https://www.twtg.io/capabilities/

Vopak. (2020). Tank Terminals. Retrieved Month day, 2020, from https://www.vopak.com/tank-terminals

Welfens, P.J.J., & Addison, J.T. (2009). Innovation, Employment and Growth Policy Issues in the EU and the US. doi:10.1007/978-3-642-00631-9

Zhang, D. (2016). Industrial IoT Technologies and Applications. Springer Nature. https://doi.org/10.1007/978-3-319-44350-8

CONTEXT:
Institute for Standardization. (year). Standard title standard number in italics. City, State or Country: Author.

Nederlands Normalisatie Instituut. (2011). Water Potentiometrische bepaling van het totale gehalte aan totaal

Literature

fluoride NEN 6578:2011. Delft, The Netherlands: Author.

Vopak. (2020). Council Directive

Vopak Safety Document

(EU-lex, 2020)
https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A31989L0655

Used in literature:
Ale, B. (2017).
https://www.sciencedirect.com/science/article/pii/S0950423017303716

Campbell, T. (2003)
https://search.proquest.com/openview/e3aa843468edeb6d5968857c2d6b60b8/1?pq-origsite=gscholar&cbl=47267

(Thibaud, M. 2018)
https://www.sciencedirect.com/science/article/pii/S0167923618300344

(Gnoni, M. 2020)
https://www.sciencedirect.com/science/article/pii/S2351978920305898#cebibsec1
(Robson et al., 2007)
https://www.researchgate.net/publication/51763208_A_systematic_review_of_the_effectiveness_of_occupational_health_and_safety_training

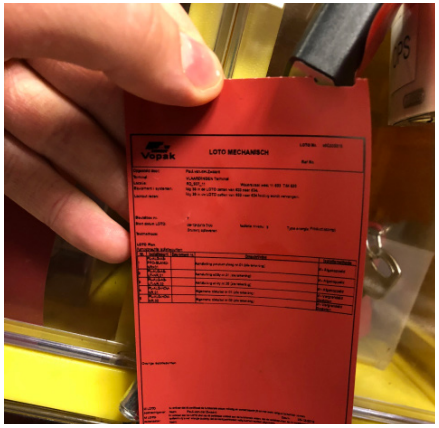
Welfens, J. 2009. https://books.google.nl/books?id=_qistEQt_BsC&pg=PA236&lpg=PA236&dq=high+capital+intensive++slow+innovation&source=bl&ots=3kH9VfmMMw&sig=ACfU3U2NF_P6yGPkvhlycn7cKrZCLpfO6Q&hl=nl&sa=X&ved=2ahUKEwiau8ShxfLpAhUEDewKHYjtBllQ6AEwC3oECAwQAQ#v=onepage&q=high%20capital%20intensive%20%20slow%20innovation&f=false

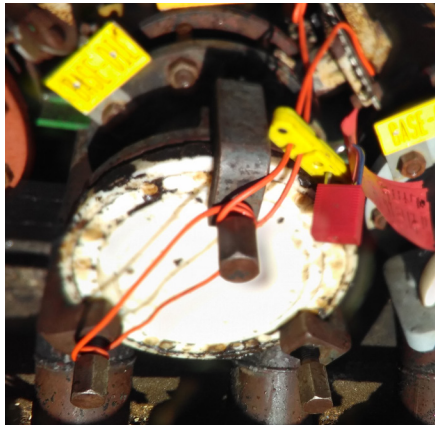
Author, A. A., & Author, B. (year). Book title in italics. City, State or Country: Publisher.

Appendix 1

FIELD STUDY

VOPAK VLAARDINGEN



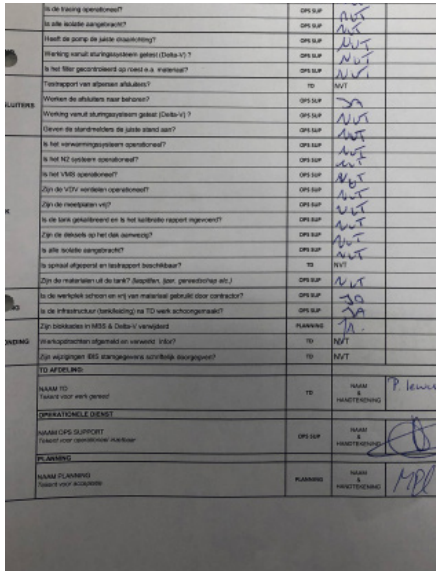


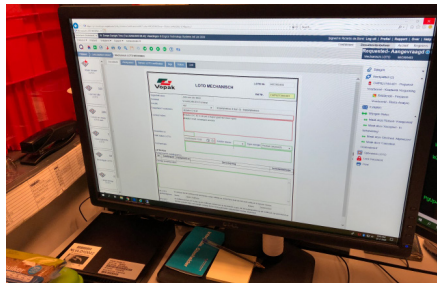
Meeting

During this field study a team of 5 Loto operators where questioned

During this field study a guide across the terminal was provid-edby Loto operator [redacted] - 2nd Operator at Vopak Vlaardingen and head of Loto execution

Due to the ATEX regulations no high quality camera's were allowed on sight.





Appendix 2 - Lockout specialist (E1)

https://blomsma-safetycomponents.nl/contact/
Sander van 't Ent - Director at Blomsma Safety Components / Specialist Lockout Tagout

Main qoute:
"Ze zeggen, wanneer iemand een slot door knip, dan staat hij op straat. Maar dan heeft hij het slot al doorgeknipt en hoe kom je daar achter? Het is niet de bedoeling maar het gebeurd natuurlijk altijd - Sander van 't Ent - Director at Blomsma Safety ComponentsSpecialist Lockout Tagout"

Main qoute (ENG)
Padlocks are cut when people lose their keys or e.g. moving parts need to change position to prevent life threatening accidents.
S. van 't ent - Director Blosmsa Safety component, Specialist Lockout Tag Out

Main takeways (ENG)

Due to the strict chemical (ATEX) related regulations Loto businesses are reserved on implementing new technologies.

Loto procedure is a trade-off between safety and productivity

After wearing a helment the Loto is one of the most important safety regulations.

Companies will always look for bypassing regulations, until accidents occur.

Padlocks are cut when people lose their keys or e.g. moving parts need to change position to prevent life threatening accidents.

How the locks are stored plays a center role in the Loto procedure

Pressure on operators to release a industrial energy source result in mistakes being made.

To overcome issues with the complexity of the Loto procedure operators need to be able to use simple equipment which they can place easily.

Ziet u dat gebruikers in de praktijk hun sloten toepassen zoals door u of regulaties voorgeschreven?
Procedure is de energiebron afspraak is afhankelijk en verschilt per bedrijf. Wij leveren oa. masterlock padlocks - mechanisch slot met sleutel. In de sloten markt is digitale vergrendeling erg opkomend, toch blijft het probleem bij al de chemiebedrijven dat je iets ATEX gecertificeerd moet zijn voordat het ergens in business komt. Bedrijven zijn hier terughoudend in.

Het principe is altijd 1 man 1 slot 1 sleutel - sloten moet je fysiek zien en ophangen, zo kun je beter je je procedure nalopen. Er kunnen ook masterkeys gebruikt worden maar dan ga je telkens verder van dit systeem. Het is afhankelijk per organisatie hoe je hier mee om wilt gaan.

Ervaren klanten wel een problemen in het gebruik van uw producten?
Bij lockout tagout procedure zit je altijd in een spagaat. Aan de ene kant wil je zoveel mogelijk veiligheid garanderen, maar toch moet het ook werkbaar blijven. Om grote gebieden gemakkelijk voor meerdere mensen af te kunnen sluiten kun je dan bijvoorbeeld een lockbox gebruiken. Je hebt dan aanzienlijk minder sloten nodig.

Slimme jongens binnen de bedrijven vinden altijd wel weer een manier om om de lockout procedure van het bedrijf heen te gaan wanneer dat echt moet. In 9/10 gevallen gaat het goed, maar op een gegeven moment pakken ze toch weer de knipschaar er om een slot door te knippen. Pas wanneer dan iemand vinger weer ergens terug komt wordt het opgelost.

Wanneer wordt er niet voldaan aan de Loto procedure en om welke reden?
Ze zeggen, wanneer iemand een slot door knip, dan staat hij op straat. Maar dan heeft hij het slot al doorgeknipt en hoe kom je daar achter? Het is niet de bedoeling maar het gebeurd natuurlijk altijd. Het kan zijn dat iemand zijn sleutel kwijt is, dan is het knippen wel onder begeleiding. Loto is altijd om een energiebron buiten werking te stellen. Wanneer deze nodig is om een deel van de machine toch te laten draaien of en klep af te sluiten om iemand in veiligheid te stellen dan moet er een slot worden doorgeknipt wanneer de procedure te lang duurt.

Welke zaken worden vaak vergeten in het Loto process?
Belangrijke stap die vaak in het Loto process wordt vergeten is de try-out. Hierbij hoort een 4-eyes controle die er voor zorgt dat iemand hem niet zomaar in zijn eentje kan vrijgeven.

Waarom denkt u dat er zulke conventionele methode worden gebruikt bij het plaatsen van tagout lock-out systemen?
Lock-out, tag-out is een tijdloos verhaal. Onderdeel van de procedure is, waar berg je het allemaal weer op? Je kunt het heel ingewikkeld maken met allemaal schema's hoe het beter kan, maar uiteindelijk moet het duidelijk zijn voor de jongens die het uit moeten voeren. Zij moeten het snel kunnen begrijpen en toepassen. Stel je voor dat er bij jongens bij TATA steel moeten een systeem vrij gegeven, dan komt er wel flinke werkdruk op te liggen. Hierdoor gaan dingen fout. Ze hebben iets nodig wat snel of eenvoudig werkt en moeilijk verkeerd uitgevoerd kan worden.

Hoe staat u tegenover alternatieven op de Loto procedure?
Elektronisch of digitaal uitlezen zou handig kunnen zijn, daar doen ze bij deze bedrijven op dit moment niets mee. Wanneer je plek zou hebben waar je dit inzichtelijk zou kunnen maken voor iedereen zou dat waarde kunnen hebben.

Sander van 't Ent - Director at Blomsma Safety Components / Specialist Lockout Tagout

Appendix 3 - Lockout specialist 2

Rob Voorendag was contact through mail communcations. The questions stated in this overview are deliberately answered.

Rob Voordendag
Partner Unique safety products
Retailer & specialist in Machine and Lock-outagout materials

Additionally sharing Lockout Tagout essentail seminar materials: Appendix

- Hoe ziet u dat gebruikers in de praktijk hun sloten anders toepassen dan volgens de regulaties voorgeschreven?
Allereest moet je begrijpen dat Loto opzich geen wetgeving is, zoals dit bijvoorbeeld in de USA wel is (volgens OSHA). Wel hebben wij in Europa vastgelegd dat er veilig en spanningsloos aan installatie gewerkt moet worden, Loto is hier een methode voor. Vaak wordt er in plaats van hoofstroom enkel de stuurstroom mee geïsoleerd, dit is dus geen Loto maar valt onder de Machinerichtlijn. Daarnaast worden veiligheidssloten veel gebruikt voor het voorkomen van insluiting in besloten ruimtes of robotcellen, ook dit is geen Loto maar wordt vaak zo genoemd. Het niet over verkeerd markeren van energiebronnen is ook een vaak gezien probleem (oplossing zou een KKS systeem kunnen zijn)

- Welke problemen ervaren klanten het met meest met het gebruik van padlock tagout Lockout systemen?
Het is een blijft procedureel en hierbij worden fouten gemaakt. Meestal doordat de regels van de procedures niet goed vastgelegd zijn of dat machinespecifieke procedures niet overeenkomen met de werkelijkheid. Dit komt meestal omdat de P&ID, elektrische aanpassingen of machine samenbouw niet worden meegenomen in dit procedureblad. Met andere woorden MOC (management of chance) is altijd problematisch bij Loto.

- Hoe uit menselijk falen zich het meest ten opzichte van het uitvoeren van het Loto process?
Het niet plaatsen van sloten, het plaatsen van sloten op de verkeerde energiebronnen of het vergrendelen van energiebronnen in de verkeerde positie.

Human behavioural flaws primairly relate to locking out wrong locations, forgetting the Lockout and lockout out assests in the wrong position.

- Worden sloten wel eens verbroken en om welke reden?
Ja met name bij het werk in ploegendiensten of bij werkzaamheden van contractors. Een goede procedure voorziet hierin.

Locks are most frequently cut when contractors are performing work and groups of people are involved

- Hoe staat u tegen over alternatieven op de Loto procedure?
Voor kritische processen raden we altijd aan gebruik te maken van trapped key interlocks ipv Loto omdat dit een fail safe systeem is waarbij het niet mogelijk iets fout te doen. De aanschafkosten voor een trapped key systeem liggen echter veel hoger dan voor Loto.

- Denkt u dat er manieren zijn waarop de Loto nog veiliger of efficienter kan?
Er bestaan meerder digitale proceduresystemen voor Loto die je begeleiden in het opstellen en onderhouden van een procedure. Daarnaast gaan we binnenkort producten zien die op basis van GPS en RFID plaatsing van Loto producten kunnen gaan controleren.

- Hoe staat u tegenover digitale slot oplossingen met het gebruik van codes of verbonden online services?
Op het moment zijn er nog geen producten die efficient en robuust genoeg zijn om in industriële omgevingen gebruikt te worden.
Denk hierbij een chemische blootstelling, ondergrondse ruimten, buitengebruik.

Until this moment there are not Loto's which are efficienctly and robust enough to be used in outdoor environments

- Waarom denkt u dat er zulke conventionele methode worden gebruikt bij het plaatsen van tagout lock-out systemen?
Het is beproefde methode die onderhoudsgevoelig is. Het op een andere wijze aanpassen van installaties om deze spanningsloos of drukloos te vergrendelen is veel kostbaarder.

Appendix 4 - Interview *SHEQ OFFICER (V2)*

This consultation consists of two parts.
1. Acquiring background on the Loto procedure at Vopak
2. Evaluation of concepts

For part 1 an open interview is conducted at the Vopak Vlaardingen Terminal

For part 2 the concept exploration materials were studied by the SHEQ officer an evaluated through an online meeting.

Function
SHEQ manager Vopak
(Safety, Health, Environment & Quality)

Job description:
Safety strategy and operations supervisor at Vopak Vlaardingen

Role in Loto process:
Intervene when problems occur.

Tasks:
-Inspect if people adhere to safety protocols of Loto
-Intervenes in process when operators lack Loto safety Procotol
-Sample wise inspects in field Loto materials.
-Walks round the terminal to validate if all desired working conditions are met.
-Reports (Loto related) incidents

Background
Safety inspection role at multiple large Enterprises like;
DSM, Rail Terminal Chemelot, Shell Asmterdam, Dow Chemical Terneuzen
At all these locations Loto was an issue.

Main takeways:

Why Loto:
Tanks are put in Loto to ensure the safety of the contractor inside a tank

Inspection Loto:
Another operator (this may be from the same department) checks this correct placement of Loto materials of the Loto man

Daily inspection for workpermit release

A permit must be released in order for a contractor to conduct maintenance.

To release this permit Vopak shift leader (supervisor) and contractor need execute an 4-eyes inspection
Perform inspection with Loto form at the isolated assets
This makes it complete since it is assumed that it has been checked correctly before.

- Goal is to investigate if the contractor can work safely on his part.
-This inspection must take place daily
- A checklist to inspect the related Loto's and tags
- SHEQ managers aim to monitor if employees go outside with their A3 checklist form
- SHEQ managers perform random sample inspections to ensure the quality of the process.

Neglected inspection:
Contractor do not take the inspections role seriously as they assume it has already been secured by the company.

Contractors work at the same tank every morning
They walk an extra 100m for an outlying Loto.
When they register the Loto's at the entrance of the tank, they just approve it.

The same assets need to be checked each day, therefore it an option that operators say:
I do not go out for this resulting in a check being neglected.

At multiple Loto locations where [redacted] worked in the past Loto methods were poorly executed. This required extra inspection from [redacted] in order to maintain safety.

Reasons for this neglecting behaviour are:
-Operators are not aware of their tasks
-Operators perceive something will be OK based on earlier inspections.
-Operators assumed that someone else would perform their action.

Lack of manpower
Its difficult to validate if all materials are inspected due to the lack of manpower of the SHEQ managers.

Absence of contractor personal locks
At Vopak Vlaardingen no personal padlocks are available for contractors.
This is done to ease of communication and operations and allow adjustments to be made to the Loto without the need for the contractor

Reason for this is: In the past, people lost their keys or took them home.

Limitations of Loto procedure
The procedure is too often possible for multiple interpretations.
Understanding the procedure is difficult due to details and terminology.

Incidents have never occurred with trained Loto people at Vopak.
However, early interventions were required to obstruct things from going wrong.

E.g valves were left open, allowing gas to come out of a pipe, perceived very dangerous when grinding.

(Unauthorized) release
Supervisor, being Vopak's employees have no insight in in the Lotomans Loto releases.

Risk of Forgetting to remove Loto
It sometimes happens that a Loto is registered released for two months but is still in Loto.

Example of misinterpretation:
Tank A: Loto must be off tonight they will pump in
Tank B: Loto off, everything just goes down the street

Lotoman has registered a pipeline is released, yet no product can pass.
-product of the customer is lost because no e.g. nitrogen is supplied.
-Take out tank because millions of liters of oil are trapped here.

Colour codes of locks
Color codes make it easy to distinguish locks quickly and easily.

Update of tag
When new servicing is required on the same asset the Loto form must be adjusted. Therefore the Loto procedure should officially be performed again.

Human check
Problems can always be related to humans checks. Also when it is monitored on a screen things can be misinterpreted.

Conventional industry & documentation
At Vopak Vlaadringen al lot of employee are 60+ years of each
This affacts the procedures ande documentation in place.
Older people decide to work out and stroe executed Loto actions on paper.
However, Vopak's digital registration system provides an clear overview of all the executed Loto actions.

Padlocks - symbolic value
If people have the intention to remove it, they can easily do this.
The materials added to the pad lock are not that strong and easy to remove. Just a label actually already be sufficient. However, when people do this need to have a very good reason or get fired.

Required Tag information at Vopak
In field at a isolated assest no inisght in the entire procedure is provide. This is online done by accessisng the online system.

At this location the Tag includes:
Name operator
Date placement
Method
To control asset

Appendix 4 - Interview *SHEQ OFFICER (V2)*

Number 1: isolation point
Number 2: equipment type used
Number 3: isolation type

Tablets use
For process inspection at Vopak Vlaarding are tablets being used.
Differenttype of operators share 3 tablets around the work place.
This allows to directly document results online and inspect KPI's

Effect of digital Loto
An alarming Loto would force people to do their checks
This would counteract deciding their too busy for their checks
They could enable them to be less physical present at the locks

Implementation smart devices
Smart devices cost more time and money to implement.
The ease of a Loto box is, you can directly start after buying it.
Ease of implementation could be improved by keeping the product very simple. E.g. online providing a barcode scanner to identify location and if check is executed.
Other related information (Dutch)

Permit system
Elke aannemer heeft een vergunning
-Project wordt geregistreerd in de industrie
-Techniek benodigd voor onderhoud wordt weergegeeven.
-constructie afdeling voor projecten
-Ops support, maakt leiding schoon
-onderaannemer in dit geval inigma, moet me een papiertje naar buiten om onderhoud uit te mogen voeren

Planning of Loto request
Een werkvoorbereider van Vopak, Technische dienst of constructie, zal altijd de vergunning maken.
Afhankelijk aan waar de aannemer aan moet werken zal de Loto gezet worden.

Deze aannemers werken obv specifieke opdrachten zoals:
-Leiding aansluiten op die tank voor een schip.
-Spiraal van een tank moet vervangen worden maar aan deze tank zitten leidingen
In deze leidingen kan product zitten , stoom, gas of elektrische tijd. Om te voorkomen dat de aannemer risico loopt zetten ze de tank in Loto. Op basis van deze opdracht komt er een aanvraag binnen bij de Loto man die vraagt of de tank in Loto gezet kan worden.

Inspection of operators & SHEQ
Als [redacted]controle doet buiten doet hij dat aan de hand van het Loto formulier. Hierbij controleert hij visueel en fysiek of alles overeenkomt met het formulier. Voornamelijk visueel moet matchen met formulier.

Niet elke Loto die de Loto man uitvoert wordt door SHEQ gecontroleerd. Er wordt door SHEQ managers enkel steekproefsgewijs gecheckt.
Voor een goede plaatsing is de Loto man zelf verantwoordelijk. Een andere operator (deze mag van dezelfde afdeling zijn) controleert deze correcte plaatsing. Wanneer de Loto fout is wordt de Loto man verantwoordelijk gehouden.
"Een persoon mag niet zijn eigen vlees keuren"

Neglected checks
Doordat ze elke dag opnieuw de checks moeten doen is het een optie is dat ze zeggen, hiervoor gaan ze niet naar buiten.
Dan valt er al een check af.

Daily checks & Workpermit
Een vergunning om te mogen werken wordt een speciale werknemer van Vopak in de morgen uitgegeven.
-Dagelijks moet deze inspectie plaatsvinden
-Er moet worden uitgezocht of de contractor veilig aan het onderdeel kan werken.
-Met behulp van een Loto controlelijst worden de Loto's en tag gecontroleerd.

Richard en zijn SHEQ collega's lopen steekproef geweest rond om te kijken of mensen wel met zn formulier naar buiten gaan.
Externe werknemers teken voor het ontvangen van de werkvergunning en die bewaren ze.
De vergunning wordt in de morgen geprint en vrijgegeven door de wacht chef. Afhankelijk van wat er wel of niet in Loto staat kunnen er zich grote problemen voordoen wanneer checks

Problems with Loto placement
"Op de locaties waar ik vandaan kwam controleerde ik vele malen vaker de Loto's omdat ze daar vaak gewoon niet goed waren" Hier was de vergunning wel goed gekeurd en maar stonden bepaalde delen toch open in plaats van dicht.
Het formulier moet kloppen met buiten, daarbij moet het formulier ook correct zijn.
Hierbij is het voornamelijk te probleem dat mensen zich niet bewust zijn van hun taken en er vanuit ging dat iemand anders een actie zou uitvoeren

Aannemer neemt het controle aspect niet zo serieus gewoon mee aangezien hij denkt, het is door het bedrijf al veilig gesteld.
Wanneer er zich dan opeens druk vrijkomt, dan zit je als organisatie in de problemen.

Waarom plaatsen contractors bij Vopak geen persoonlijke sloten?
Contractors zijn vanuit hun werk verplicht zichzelf in veiligheid te stellen, plaatsen hier geen pad lock, wat is daar de reden voor?

Het niet plaatsen van persoonlijke sloten door de contractor is deels gemakzucht.
Op deze manier kunnen er aanpassingen gemaakt te worden aan de Loto zonder dat de contractor hier voor nodig is
In het verleden raakten men de sleutel kwijt geraakt of namen hem mee. Dat gaat nog wel eens mis

Bij andere locaties doen contractors het wel, maar Vopak blijft in controle van zijn sleutel.

Differences per industry and locations.
De Loto procedures die Richard gezien heeft vind niet op 1 niveau plaats.
Tijdens het werken met DTR, Amsterdam, Vlaardingen ging de procedure overal anders.

Perception on limitations of the Loto procedure
De procedure is voornamelijk vaak voor meerdere interpretaties mogelijk.
Een leek moet het kunnen lezen. Begrijpelijk maken van de procedure blijft lastig.

Dingen buiten niet goed kunnen lezen of lastig terminologie maakt het uitvoeren lastig.
Flowcharts worden gemaakt om het begrijpelijker en daardoor veiliger te maken.

De Lotoman zorgt voor het plaatsen en het uiteindelijk weer in werking stellen.
Wanneer Loto niet goed verwijdert zitten ze product in te pompen tegen een dichte afsluiten en hebben ze lekkage.
Incidenten zijn voor deze personen nog nooit een probleem geweest.
Wel heeft het zich voorgedaan dat ze konden ingrijpen voordat het fout ging.
Afsluiters stonden dan per ongeluk nog open, hierdoor kwam er nog gas uit een leiding.
Bij slijpen is dit zeer gevaarlijk.

ATEX
Vopak vlaardingen, ookal is het geen atex zone, regels die er gelden zijn vrijwel gelijk.

Alternative lockout approach
Er zijn ook bedrijven die er voor kiezen er voor alles in Loto te hebben en alleen wanneer het gebruikt wordt buiten Loto te stellen. Voor deze terminal doen we dat niet door diversiteit van Loto processen. Plaatsing & Goedkeuring duurt hierdoor te lang. Er zijn hier duizende afsluiters; stikstof, lucht, stoom, per tank kun je al 15 afsluiters hebben.
Dit zou bij Vopak Vlaardingen voor onwerkbare situaties leiding.

Colourcodes
Kleur codes maken het gemakkelijk sloten snel en eenvoudig te onderscheiden. Op Vopak worden er in het veld twee kleur codes toegepast. We hebben een schoonmaak Loto (blauw) Deze mag alleen maar door compotente Vopak schoonmaak bedrijf gebruikt worden Deze maken geen onderdeel uit van de groeplockout en dus lockbox. Die plaatsen binnen de afdeling van de Lotoman hun tijdelijke Loto's en checken deze. Wanneer blauw Loto verwijdert is kan er de rode Loto groep lockout in het veld geplaatst worden (mechanische Lockout)

Appendix 4 - Interview *SHEQ OFFICER (V2)*

en eenvoudig te onderscheiden. Op Vopak worden er in het veld twee kleur codes toegepast. We hebben een schoonmaak Loto (blauw) Deze mag alleen maar door compotente Vopak schoonmaak bedrijf gebruikt worden Deze maken geen onderdeel uit van de groeplockout en dus lockbox. Die plaatsen binnen de afdeling van de Lotoman hun tijdelijke Loto's en checken deze. Wanneer blauw Loto verwijdert is kan er de rode Loto groep lockout in het veld geplaatst worden (mechanische Lockout)

Loto esthablishment at vopak
-Een werkvergunning wordt aangemaakt.
-Lotoman wordt verzocht Loto materialen in het veld te plaatsen.
- De Lotoman plaatst de Loto materialen
-Deze worden controleert en goedkeurt door een collega
-Loto formulier wordt goedgekeurd
-Werkzaamheden worden ingepland
Shiftleadder
Keurt in de morgen de vergunning goed. Controleert Loto formulier aan aan de afsluiting. Dit maakt het volledig aangezien er van wordt uit gegaan dat het al eerder correct gecheckt is. Supervisor gaat naar buiten met de aannemer (bv. Firma Jan de Jonge) Loto formulier wordt samen doorgelopen Beide partijen tekenen het is druk vrij. Elke dag dienen deze checks uitgevoerd te worden mbv van een A4

Neglectence of daily inspections
De dagelijkse inspectie wordt niet altijd uitgevoerd. Wanneer een Loto er niet af is gehaald kan er niks gebeuren. Maar dit weet je nooit zeker.
Als aannemer kun je niet weten of sloten zijn weggehaald wanneer je ze niet controleert. En de supervisor, ook al is die van Vopak, heeft geen inzicht of de Lotoman zijn materialen al heeft weggehaald.

Vaak controleren ze alleen de Loto's die naar hun inzicht belangrijk zijn. Bijvoorbeeld. Die zitten naast het gat waar je ook de tank in gaat. Waar de energie vandaan komt, bv de pompkamer, die zit 100m verder op, daar zullen ze niet helemaal heen lopen. Wanneer een werknemer de hele maand aan dezelfde tank bezig is gaat hij niet elke ochtend de hele Loto weer nalopen. Normaal gebeurt het dat ze het zomaar goedkeuren

Richard houd controle op of dit gebeurt, echter is dit pas sinds kort ingevoerd. Hier is voor gekozen omdat de aannemer zich niet altijd houdt aan vergunning. Vopak moet dit meer doen dan anderen omdat zij voornamelijk in gesloten ruimtes werken.

Achterhalen of de dagelijkse controles zijn uitgevoerd is lastig door het gebrek aan mankracht. Er is maar 1 iemand loopt van 7.00 -16.00 buiten om dit te checken.

Contractors zijn net zo schuldig wanneer ze toch aan het werk gaan. Zij mogen niks doen tot dat de controle in de ochtend is uitgevoerd.

Interm tests
Testen zoals toxiteit meting moet uitgevoerd worden.
Wanneer een aannemer een vergunning mee kreeg ging hij simpelweg aan het werk.
Dan ging de aannemer in een tank terwijl er bijvoorbeeld niet genoeg ventilatie was.
In dit geval zou een werknemer van Vopak naar buiten moeten gaan om te controleren en te zorgen dat alles open staat.

Unauthorised release
Wanneer je twee tanks hebt die beide leeg zijn en er moet product in worden gedaan kan het voorkomen dat er een Loto onrechtmatig wordt verwijdert.
Tank A: Loto er af moet klaar staan vannacht gaan ze er in pompen
Tank B: Loto er af, alles loopt gewoon zo over straat

De Lotoman voert geen controle uit of het werk goed is of niet. Hij verneemt van de Technische dienst of de Loto er af kan en geeft na het verwijderen van de materialen de tank terug aan locatie planning

In het geval dat er meer onderhoud is dan verwacht
Wordt een nieuwe werkvergunning wordt vrijgelaten of werkvergunning wordt aangepast.
Aan een Loto voor een tank kunnen meerdere werkvergunningen hangen.
Zolang de Loto geldig is en goed voor de werkzaamheden levert dit geen problemen op.

Een uitzondering is dat de tank in Loto staat en de Loto niet goed is dat de leiding ook in Loto moet.
Dan moet het Loto formulier worden aangepast.
En de procedure opnieuw uitgevoerd worden.

Risk of Forgetting to remove Loto
-Registreert een leiding is vrij gegeven toch kan er geen product door
-product van de klant gaat verloren doordat er geen stikstof wordt toegevoerd.
-Tank eruit halen want miljoenen liters olie zitten hier in vast.

Menselijke checken bijft altijd aanwezig. Wanneer iemand iets met een muisklik kan openen moet dit ook altijd geverifieerd worden. Dit wordt op een beeldscherm gecheckt maar kan ook fout gaan.

Authorised release
Het doet zich ook wel eens voor dat een Loto al twee maanden is vrijgegeven maar nog steeds in Loto staat. Aan het openmaken van het slot gebeurd door van slot gaat een lange procedure aan vooraf. Dit gebeurd door de operationele dienst. Er wordt gecontroleerd of het klopt dat een tank nog een Loto staat. Wanneer uit het systeem blijkt dat dit niet het geval is maar hij al vrijgegeven zou moeten zijn meldt de accountmanager, we gaan in tank A inpompen. Hiervoor dient de Loto handmatig weggehaald tot worden De Loto man krijgt hier een mail over.

Appendix 4 - Evaluation *SHEQ OFFICER (V2)*

Main takeways Part 2:

Hoeveel SHEQ operators zijn bezig met de eerste-controle van de Loto?
1 manager 1 officer

Hoelang vaak bezig met checken of iets er nog moet hangen?
We kijken of de Loto overeenkomt met wat er staat met formulier en de werkelijkheid

Hoeveel tijd zijn supervisors kwijt met het controleren van de Loto?
Vergunning en Loto punten moet elke ochtend nagelopen worden
Hier zijn ze voor werk dan wel even mee bezig
Aan het begin doen ze dat wel maar daarna nemen ze het voor lief.

Denk je dat je met een pasjes routine het sleutel probleem kan oplossen?

- Op huidige pas systeem zou handig zijn.
- Huidige passysteem is poort registeratie. Daarmee kan kantoor binnen en terminal

- Denk je dat er veel moet veranderen om dit te implementeren? /pasjes in de toekomst nog nodig zijn.
Hoe meer pasjes hoe meer barierers, mensen gaan wel pasjes uitdelen. Maar je wilt ook niet hebben dat niet iedereen de rechten heeft die er af te halen.

Mensen zouden de pasjes wel kunnen gaan delen wanneer ze niet persoonlijk zijn.
Aannemer kan zijn pas wel registeren, hij moet ook bij de Loto zitten. Die moet ook zijn pas aanbieden. Dan houd je het probleem dat je de Loto er niet af kan halen.
Pas aannemer van firam zou voldoende zijn. Of de voorman.

Gebruiken jullie al eens nfc pasjes voor operaties?

Questioned on: Ease of use
We personally use cards to enter the terminal. Authorisation related to the card must be enabled.
The current Tag routine is working fine for me and should not neccesairly be

Questioned on: Ease of implementation (infrastructure)
The card scenario would be very easy to adopt if applicable to our current nfc pass system. Changes must be made to the authorisation related to the cardbut this can singulary happen in the back-end.

Questioned on: Impact on operators tasks
Releasing a Loto in the system without a personal ID itself is not a problem. It perceived valuable not to be resitrcited by key operation or other accesories to release a lock.

Operators should not have to be retrained to adopt this solution. Currently everyone already has a personal pass. However, still undesirable time must be spend on acquiring relating key materials when people need to open locks . Additionally do people take the card home all time.

Questioned on: Safety of operations
For both the scenario of B C its not perceived codes will get passed. In all the places where I worked if never heard of something happening like this. It does not ease the work flow and it allows reason sharing of codes allows operators to perform actions. Beacuse of this it stricly prohibited personal code this is strictly prohibited. or check their own plans. Compared to the key routine this is purely personal

Mr. Janssen is wondering if the key card routine allign with the protocol. **ID Cards are easily lost and simply replaced.** If you need a master. Additionally pass could easily be passed on in field
You don't want people walking a round someone else his pass to conduct an inspection for someone else. Addiotionally allowing them to have access to various locations on the terminal.

Worden er bij jullie wel eens codes door gegeven om bepaalde handelingen uit te voeren?

Codes werken we niet mee.
Operations with your personal account are strictly personal and never shared.
Handelingen die je nu uitvoerd doe je nooit op andermans account. dat is uit den boze en strafbaar. Verschillende accounts hebben ook verschillende rechten. Je kunt dan je eigen autorhisaties door zetten.

Wat vind je er van dat informatie op de Loto zelf digitaal beschikbaar is?
Je zult een grote slot moeten hebben en een duurder systeem. Per slot zul je een grotere slot moeten hebben.

Per slot moet je ook geregisteered hebben waar. Alle info daar mee gehad hebt.
Eingelijk worden er nooit meerder tags gehangen aan 1 slot

Wat vind je er dat je sloten met je persoonlijke account in plaats van een sleutel zou beheren?
[redacted] zou dan moeten vrijgeven, een aannamer kan overruled worden door [redacted]Aannemer in het systeem en collega van [redacted]. In geval van nood zou dat nodig moeten zijn, onafhaneklijk iemand nodig. Hij zal ze altijd moeten vrijgeven in het system. Nu hoeft die niet met meerdere sleutels naar buiten. In het huidige systeem kan ook een moeder sleutel gebruikt.

Denk je dat het scherm nog nodig is wanneer smart device meer geïntegreerd zijn op de werkplek?
Te veel mensen met een tablet of telefoon uithangen. Altijd mensen correct controleren of hij correct in het systeem hangt.
Telefoons aan meerder menesen met telefoons wordt meer als last ervaren. Eerder neigen naar een pas systeem. Je kunt het dan niet uitlezen.

Is de tag informatie nodig voor de arbeids inspectie?
Arbeids inspectie wil meer kijken of het overeen komt met jullie protocol.
Ze gaan protocol controleren wanneer er een fout is.
De verschillende aannemers die aan het systeem werken.
In princiepe lopen die al een rondje, maar we hebben ook Lotos die niet elke dag gecheckt.
Aannemer wil toch altijd checken.
Eigen procedures

Gebruik je momenteel al smart devices voor je routine?
Zeker gebruik smart devices, EX tablet.
Je zou het goed kunnen gebruiken voor hett Loto process

Wat is je ervaring van veranderingen met een tablet?
Het is niet wenselijk dat ze altijd met een tablet moeten lopen. Het is de verandering van de technologie.
Dat gaat rap en daar moet men aan wennen.
Nu gaan ze makkelijker met pen en papier naar buiten dan het overtypen. Wij zijn een terminal die met veel producten werkt die vettig zijn.
Daardoor worden dingen smerig. Tablet kan kapot. Hufter proof maken is belangrijk.

Hoe vaak hebben we nu echt incidenten met Loto's. Hoe vaak komt dat voor?
Bij veel bedrijfven zal dat laag liggen.
Maar, waarde van de digitale blijft zeker aanwezig, het kost alleen nogal wat.
De tablet technologie kan voor meerdere standaard zaken ingezet worden

Appendix 5 - Global Deployment Lead (G1)

Meeting with:
[redacted] | Global Deployment Lead

Background
Worked for 14 years in the industry as operational managers

[redacted] **is the writer of the global blueprint of Loto and states new product solutions are expected to meet these guidelines provided. This just recently realed document is not perceived to shirt drastically within the coming 5-10 years.**

[redacted]
Belangrijk is om het volgende mee te nemen wanneer je een digitale Loto ontwerpt:

1) wat is de tijdsbesparing (en daarmee) kostenbesparing die kan worden gerealiseerd door gebruik te maken van electrical Loto padlocks. Tijdsbesparing weggezet tegen de benodigde investering;

2) wat levert het op wat betreft een veiliger Loto systeem (welke risico's die nu aanwezig zijn worden verminderd)

3) zijn er risico's die met dit Loto systeem worden geïntroduceerd.

4) wat zijn de voorwaarden waaraan een terminal moet voldoen (technisch/ procesmatig) om hier gebruik van te kunnen maken.

Heel veel mensen die echt in de operatie zitten die focussen zich echt op de operationele activiteit en veel minder op andere innovaties.

Adaptatie van een nieuwe verandering is lastig. Het moet echt helpen. Zij moeten minder hoeven doen. .dan pas zullen ze het omarmen. Meer inzicht creëren is niet perse minder werk hebben.

Proof of concept, dat moet worden uitgevoerd met een pilot. Dan wordt er gekeken is het interessant ja of nee.
Is dat voor de industry een interessante bedrijge.
Welke dingen gaan kwalitatief beter worden.

Het vieren ogen principe van de Loto efficienter uitvoeren is waar het meest waarde zit. Daar voegt de digitale Loto het meest waarde toe op implemenatie gebied Bij europoort kan het nalopen van 90 sloten met een grote groep erg lang duren

Daarbij is het nadeel van huidige het huidige syteem is:
Niet weten wie hem heeft verwijderd
Niet weten waar hij is verwijderd.

Dat zou je op een andere manier kunnen inrichten, daar kun je efficiency halen. Je zou wel altijd nog de eerste keer fysiek naar buiten moeten

Bij europoort zijn is het uitvoere van isolatie plannen voor 90 isolatie punten zeer tijd intensief. Die moeten allemaal na gelopen worden. Deze registarties uitvoeren kost erg veel tijd

Text below explains: "We work with short demarcated projectthis demands fast returns of investments"

Hoe wordt innovatie bij jullie benadert?
Bij Vopak wordt er altijd eerst gekeken naar de mogelijke returns of investments
Innovatie moet ons altijd wat opleveren op kosten. Ook opkosten gebied. Anders worden andere oplossingen gekozen. We werken met afbakende korte projecten. Dit betekend dat kosten snel terug verdiend moeten worden. Hier worden innovaties vaak op gesneden Ze kunnen daarmee de investering halen. Opbrengst word er naast gelegd. Dan is de investering sneller terug verdiend.

Hoe implementeer je oplossingen?
Veiligshied oplossingen moeten ook echt kunnen worden toe gepast. Wanneer mensen er niet naar handelen heeft het geen waarden.
Je moet mensen dwingen om volgens nieuwe standaarden te werken ze moeten he zelf ook willen.

Protocolen
Wanneer we iets denken denken te kunnen doen dan schrijven we dat op. Mogelijkheid tot wijziging is wel lasting.

Operators make wrong decisions with their believes what's best for the company:
Operators proberen zich altijd aan de protocollen te houden maar soms vinden ze dingen die echt op dat moment moeten gebeuren belangrijker. Wanneer er bijvoor product ingepompt moet worden en er hangt een Loto waar van ze weten dat hij al enige tijd is geplaatst. Dan denken ze dat het voor het bedrijf belangrijker is dat het product gelost kan worden, dan dat het een probleem is dat die Loto blijft hangen. Ergens is dit natuurlijk zo, maar volgens de protocollen mag dit niet. En het brengt grote veiligheids risicos met zich mee.

Operators zijn pragmatsiche jongens

"Die denken goed te doen voor het bedrijf, maar weten dat helemaal niet"

Die denken aan hun boot en hun klusjes.

Ik knip dat ding er van af.

Is er veel gebrek aan displine van mensen?

Je hebt eenvoudige controle middelen nodig om te verifieren of de discipline bij mensen op orde is.

Daar zitten de grootste risico's
Ik moet naar buiten toe om te kijken hoe mensen hun werk doen. Het toezicht voeren daar helpt erg bij.
Infor is het systeem wat door Vopak wereld wijd gebruikt gaat worden. Dit systeem is toepasbaar op alle tablets en online programma's. Het werken met korte termijn oplossingen is daarom niet relevant. Tablets zijn de toekomst en daar moeten we op mikken, daar ben ik van overtuigd.

Wanneer je geen fysieke bariere creeert: dan is de drempel om het uiteindelijk te doen is kleiner. Bij een operators moet je altijd een drempel opwerken om het te doen. Dat zijn bariers. Hij krijgt op zijn flikkers

Appendix 6 - Innovation Engagement Leader (V1)

This consultation consists of two parts.
1. Acquiring background on the Loto procedure at Vopak
2. Evaluation of concepts

For part 1 an open interview is conducted at the Vopak Vlaardingen Terminal

For part 2 the concept exploration materials were studied by the SHEQ officer an evaluated through an online meeting. The innovation manager highly favoured concept B due to the intergation of the screen. Hence, this concept was primairly discussed.

Part 1:
Other solutions
Mr. [redacted] searched for other smart lock solutions but didn't find a solution suitable to the market needs of Vopak.
Dhr. [redacted] heeft gezocht naar andere "smart lock" mogelijkheden voor Vopak's markt maar die zijn niet aanwezig, daarom heb hij TWTG gevraagd om specifiek een slimme Loto te onderwerpen. Ze er echter nog niet uit hoe deze er uit moet zien. Oplossingen die Dhr. [redacted] nu gezien heb werken op basis van batterijen. Het zijn gewoon normale sloten maar niet speciaal ontwikkeld voor de Loto usecase. **Voor innovaties is het van belang dat we met materialen werken die duurzaam zijn en lang mee gaan.** Wanneer je met gevaarlijke stoffen werk kan er niet zomaar iets stoppen met werken.

Het gebruik van sleutel kan oplopen tot 80 steutels voor een enkele Loto, dan weer drie sleutel op de sleutel box. Dit maakt het hele systeem erg onoverzichtelijk. Als - nood breekt wet - dan toch word er toch voor gekozen het slot door te knippen. Deze fouten mogen niet voorkomen, maar het gebeurd altijd de werk druk of onzorgvuldig heeft van de werknemers.

Dhr. [redacted] is bekend met de bedrijf processen aanzien hij zelf op de terminals gewerkt heeft. Om sloten te vervangen
Is het belangrijk wie mag het weg halen, wie gaat de werkzaamheden aanvfragen, wie regelt de schoonmaken, wie gaat de checks uitvoeren en hoe wordt dit geauthoriseerd

Er zitten altijd twee kanten aan het process: het authoriseren en uitvoeren. Hier doen zich nu problemen bij voor.
Het is onduidelijk waar Loto's bij horen.
Sommige Loto's hangen 3-6 jaar jaar in het veld. Dit maakt de controle op het Loto process erg lastig.
Het moet beheerbaar zijn anders heeft het geen zin.
Mensen moeten weten dat ze op de Loto kunnen vertrouwen. Er worden alleen maar meer man uren opgezet om dit vertrouwen omhoog te halen. Dat zorgt voor omstandigheden die nergens meer opslaan. Bij zn sleutel discipline komen harstikke veel man-uren kijken. Het nalopen ook, alleen dit gebeurd niet eens elke dag. Omdat het simpel weg te veel tijd kost en ze van uit gaan dat het slot dat ze eerder gezien hebbben er nog zal hangen.

Part 2:
General
"Dit actieve slot maakt het mogelijk onze acties te plotten. Met een API kunnen we het slot eenvoudig in onze systemen integreren. We moeten kunnen checken of het slot op de juiste plek hangt. Dit om zo te achterhalen of slot op de juiste plek hangt en goed geplaatst is."

Questioned on: Ease of use of the concept
The current discipline is slowing the workflow on the terminal. A personal login account is therefore perceived more valuable than working with nfc ID tags. **The digitalisation of this solution would allow the work preperation checks to be executed from the desk**, which heavily decreases the amount of time four workers need to spend on their check.

Impact on user task:
Not every operator will have access to the ATEX tablet all the time. External users additionally need to acquire this information of which its not desired they required a tablet to use this. **Currently our operators leave use printed version of the tag, handling these tags costs a lot of time. Concept B will allow to solve this issue directly**. Not having direct access to this information is perceived very difficult to pass the board for the industry of Vopak and chemical industry in general. Other industries don't use tags, Although Mr. [redacted] in not entirely sure a solution not including a digital tag could be interesting.

Questioned on: Safety of the concept
Good safety is simple, therefore allowing a digital solution to take away difficult steps in the Loto procedure is very valuable.
No problems in relation to personal log in is perceived, by ensuring only related employees can operate we can maintain safety.
To include external contractors by a personal log in account is perceived a reasonal option here.

Questioned on: Implementation of the concept
The integration of a smart device should not be part of the case. We aim to implement this routine all around the work place as all processes requires couplings to a digital system. However, the adopted widely yet. People explaining a smart device routine will cost too much of the terminal are too short-sighted. We have valuable business cases for the implementation of smart devices not just for Loto.

Questioned on: Complexity of the concept
If this solution allows to elimanite the daily work checks there is such a value gain in terms of time that the implementation of the screen still justifies the higher price of a product. Additionally for the more expensive use case of the product with screen.

The battery life of the solution must be ensured for a longer periode of time. Though, Loto's shouldn't hang longer than three months and receive low levels of interactions.
Messages send at a few moments a day is perceived to be enough. Communication by a screen or tablet will not happen more than once per day.

I believe a substaintial padlock design should not be the focus of the industry. A shift is needed in the perception from what a Lockout device is. Alarms integrated in your products are eventually way more valuable than having a substaintial design and therefore i would choose the easiest to procedure solution. A pin placed in the lock or cable end in a hole doens't matter for our use case as long as it allows to lockout in a symbolic matter.

Questioned on future adjustment required:
All assests will work with location tags in the near future. Vlaardingen is willing to run a project to achieve this. This smart lock allows us to link our device to the inforb (new plan, actions and monitor software) system in the future. Altough in short notice not everyone ould use ATEX certified device this is the direction where we are headed. Still this would not mean everyone will use a smart device all the time.

Questioned on: the concept in relation to the procotol
With the screen concept you could directly adhered to Loto blueprint protocol making it interesting solutions to present to the final discision makers. For this you would required demonstration models. Our Loto procedures explain the Loto must always be labeled. This enables all stakeholders to have direct insight at the location. This for the reason knowing if the lock is at the correct location is not enough. The users additionally require insight about a asset being correctly locked. Other solutions could meet this as well, although I do personally not perceived enough value from it as it would be too time consuming to get procedure information or is too dependent on a smart device routine.

Based on the exisiting protocol [redacted] does not believe external inspection parties would agree on no labels being used if we still have the presence of tags in our blueprint.
Besides from if this still allows workable conditionsNot using the screen is difficult: Although a screen might be irrelevant for operational purposes, this perception does not easily change. Making the Loto digital is quite some disruption already. We can not additionally explain we are also eliminating one of main traditional functions. This is just difficult to get through the board in the near future.

Questioned on: value of the concept
Vopak innovative thinking is based on how they are raise by the industry, not allowing them to think outside the box. **This solution allows to**

Appendix 7 - Operators Vopak (V3, V2)

[redacted] is the main operator of Vopak Vlaardingen and is met during the Field Research. He is very open about all the problems that are present in the Loto procedure and mistakes he makes himself. This interview was recorded and revealed practical insights on serious safety issues of Vopak. Part 1 of this interview was executed to extract background information on the Loto process. Part 2 reveals the main insights regarding the concept evaluation. (Chapter 6)

The main insight of this open interview are as follows:

Fouten komen voort uit miscommunicatie - soms zijn we perongeluk vergeten druk af te laten
of hebben we de locatie niet goed schoongemaakt, maar hebben we hem toch\ in Loto gezet in het systeem.

”Dan gaan ze de pijp open sleutelen en dan komt er ineens product uit- dat willen we natuurlijk niet.

“Miscommunicatie zoals: niet goed gekeken in systeem of buiten niet goed gekeken of het schoongemaakt is OF Per ongeluk de verkeerde leiding gedaan”

Bij nieuwe werknemers is dit in het begin aan aantal keer In begin aantal keer mis gegaan Allebij de pompen 42 genummerd, maar wisten we niet dat we in sector C zatten in plaatsen van B.

“Het zijn allemaal de zelfde nummers, alleen er zit verschil in sectoren, dus ja - dat moet je wel weten - “ in het begin denk je, je bent nieuw en je voelt druk, ja dat kan wel eens fout - ja Dat kan gebeuren weet je wel”

Wanneer ze werkzaamheden uitvoeren maar ze zien niks hangen dan merken ze dat snel genoeg, kom ze afvragen bij support ops.

“soms ben je gewoon zo druk bezig, dat het fout kan gaan. Wij doen zo veel taken - dan kan het wel eens gebeuren, oh ik ben een slotje vergeten of ik heb er daar een te weinig gezet”
Voornamelijk met het weghalen van het slot wordt vaak vergeten

Er Missen aantal sloten in de Loto box, die zijn gewoon weg, kapot gemaakt, of weggooit door wie dan ook - dat weten we niet.

“Wanneer iemand willekeurig Loto doorknipt dan staat hij op de stoep”

Ontbrekende Loto’s worden pas ontdekt wanneer deze er uitgehaald dient te worden.

Vervolgens komt datum in het systeem erbij wanneer hij goed is gekeurd

Door de status kunnen ze in systeem checken waaner hij is geplaatst

Het aantal sleutel boxen is niet compleet, sleutels/lock raken over tijd kwijt, gaan kapot of worden weg gegooid.
 Op de drive wordt ingevuld hoeveel sloten ze hebben.

Deze moet worden opgeschoon, hier staan allerlij Lotos in die niet meer in gebruik zijn.

Evaluation concepts
Tablets
Wij willen later ook naar tablets toe. Om de Loto punten zelf aan te geven.
Dit maakt het documenteren van taken een stuk makkelijk. Ik hoef mijn checklist niet constant te printen en kan gewoon bij de assets mijn tablet gebruiken om de procedure te bekijken.

Ease of use
Als we naar buiten gaan om een tank in de Loto zetten. Kijken welke equipment er allemaal op zit. Dat kun je meeten in een tablet aanvinken en een Loto plan op te stellen en bepalen we hoeveel sloten we nodig hebben.

Impact on user tasks
Pasjes raak je weer kwijt en aan wie ga je ze allemaal geven. Je krijgt dan heel veel pasjes. Voor een slot heb je dan heel veel pasjes nodig. Dit lijkt [redacted]taal niet handig.
Opladen vindt[redacted]ideaal. Stel je voor dat je in een periode zit en dat het heel druk wordt en je in eens alles moet vervangen dat je in een periode zit dat het heel druk wordt. Daarbij blijven sommige dingen, blijven heel lang in een Loto staan. Dan moet je hem elke keer omwisselen, dat werkt toch niet.

Het maakt voor [redacted] niet uit of hij nou een tablet of een checklist bij zich heeft. Hij heeft zijn handen vol met sloten en toch al van alles bij zich, een tablet maakt hem dan niet veel uit. Hij vermeldt dat het documenteren door het gebruik van een tablet een stuk gemakkelijker zou worden. Nu wordt het toch vaak een rommeltje op je checklist en neem je niet alles over in het systeem.

Wanneer [redacted] gevraagd of het elimineren van de tag werd verteld dat er op pzich is er geen kaartje voor nodig wanneer het er aan zit. **Het gebruik van de tag is echt van hogere hand. Terminal en SHEQ managers willen het inzichtelijk hebben dit is verplicht volgens het hoofdkantoor.**

Hij heeft al eerder gevraagd of een tablet naar buiten kon voor dingen open en dicht.
Dat moet allemaal door Rotterdam goedgekeurd en dat kost geld en zijn ze heel heilig op.

Maintenance manager (V4) - evaluation

[redacted]Maintaince manager at Vopak additionally participated in the evaluation of concepts and states the following:

Tag in product is niet perse nodig, via de portofoon wordt er nagevraagd waarom iets in Loto staat. Deze hebben de werkers altijd bij zich.
Officeel moet er altijd controle op de plaatsing van de Loto’s maar daar komen ze nu niet aan toe. Wanneer je met digitale controles gaat werken zal dit inderdaad minder snel nodig zijn.

Er zal altijd controle uitgevoerd moeten blijven worden maar met de digitale Loto kan dat een stuk minder worden.
Je weet dan er iemand er geweest Je hoeft checks niet meer te doen, want ze weet dat ze het niet meer doen.
Ze voldoen niet aan de procedure. De Smart Loto zal extra veiligheid bieden om en er voor zorgen extra “compliant: te zijn.
Hoe weet je nou dat nou dat er in de tussen tijd niks verandert. Steek proef gewijs, doet SHEQ permit controlles, maar dat doen ze niet bij alle situatiies. Dat gaan ze nooit doen.

Contractors moeten ook hand helds hebben.
Op dit moment moet dat ook op de werkvergunning staan. Op het moment moet er dan [redacted]erkvergunning op de tablet komen. J. Hoefnagel noemt dit het ideale scenario maar denk dat het kosten technisch niet handig is nu al met de smart tablet te werken. Op vlaardingen kun je dat er wel door heen krijgen. Maar vanuit Global moet er een call komen om de veiligheid te vergroten.

Elke contractor krijgt een nu pasje mee voor toegang, Die krijgen bij de poort sowieso al een nfc tag. Met eigenlijk persoonlijke gegevens.

Appendix 8 - TU Delft Expert

In this section a summary of the meeting with Prof.dr.ir. G.L.L. (Genserik) Reniers is provided. In this meeting Dhr. Reniers was enthusiastic about the possibilities of the Smart Loto in the future. He explained the third industrial revolution will contribute to solving the issue's will Loto. Now might be the time for this project to succeed. In addition, he explains that during this project its of importance not to blindly believe what people in the industry say. They tend act more like everything is really thought trhough than it actually is. Often poor analysis are and people are guided on the gut feeling of a few managers.

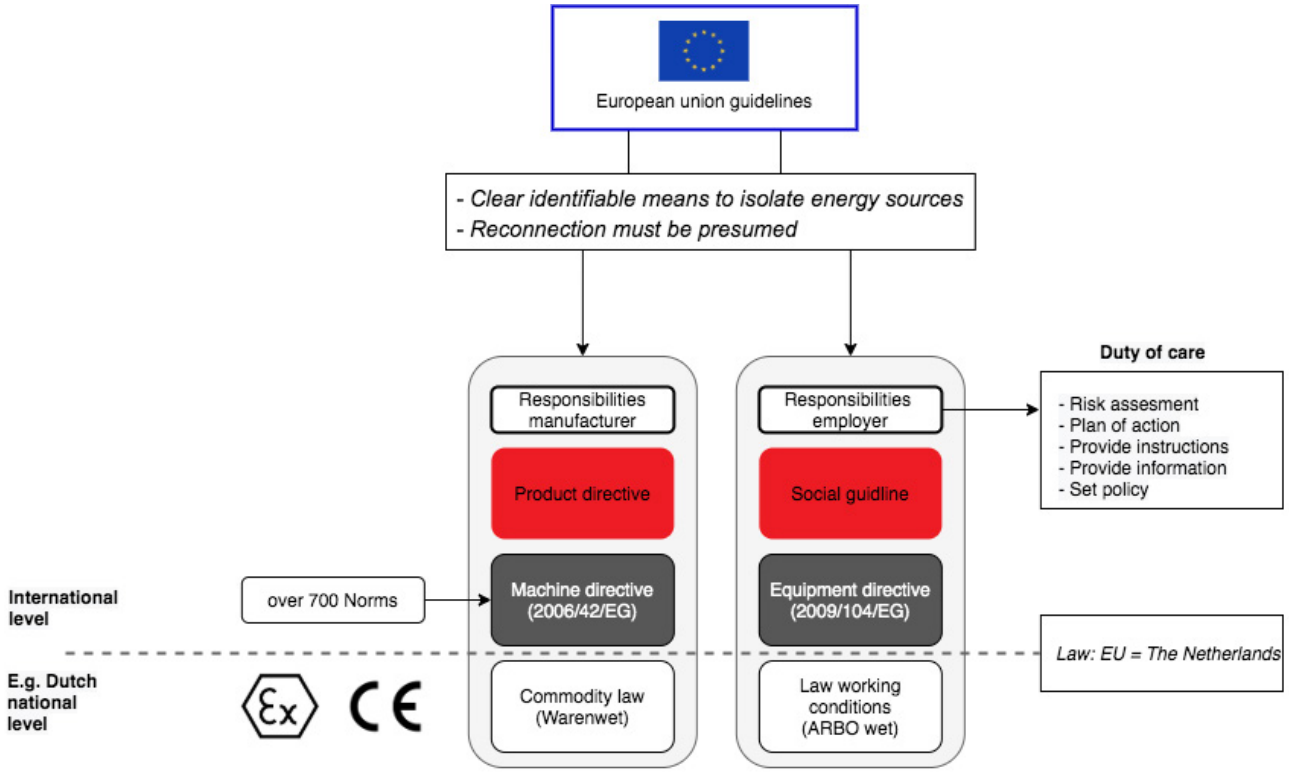
Prof.dr.ir. G.L.L. (Genserik) Reniers
Safety and security integration - expert

Belafspraak samenvatting:
- De Smart Loto is heel levensvatbaar dat ben ik asluit van overtuigd. De introductie blijft lastig maar gezien de huidige ontwikkelingen of het gebied van IoT in de industrie is het zeker mogelijk.
-The Smart Loto is very viable i'm sure about that
- Een andere student van Dhr. Reneirs heeft er ook onderzoek gedaan naar de slimme Loto. Datis een tijd geleden. Toen bleek het nog lastig. meer bereidheid om te innoveren. Ook op het gebied van veiligheid. Een initiatief duurzame veiligheid 2030 eind dit jaar. Omgaang in safety delta nederland. Dit inititief kijk erg naar hoe kan je nog veel meer inzetten op gebied van veiligheid met behulp van technologie
Grot bedrijven zijn hier absoluut mee bezig. Kleine minder zijn bezig. Oplossingen zijn in de richting van: Big data, Assest management, Internet of things

Sinds 20 jaar gaat alles sneller door het internet. Mensen in bbedrijven hebben sneller door wanneer er iets gebeurd. Onder andere zijn werknemers nu mondiger en reputatie van bedrijven belangrijker. Dit zorgt voor een derde veiligeheids revolutie. 1950 gefocust op veiligehid werknemers. De universiteit is hier nu ook veel meer bij betrokken. Toch gaan bedrijven erg uit van een "gut-feeling" ze pakken de projecten aan die het meest aantrekkelijk ogen, maar doen eigenlijk geen analyse of dit ook echt zo is. Er worden weinig modellen gebruikt.Daarbij wordt er nauwelijks gebruik gemaakt van risico analysis. Op micro enomische wordt er slecht gekeken wat veiligheid opbrengt.

Er Laatste jaren is er een kanteling. Er is Veel

Appendix 9 - Context requirements



Established based on seminar Unique safety products

European law

To find out if not issue where overlooked regarding the government stakeholder potentially obstructing the product deployment the regulations concerning the industry and Loto procedure were consulted.

The regulation that applies to the Loto procedure is dependent on the geographic location where the procedure is executed. Although strict obligations apply to the Loto procedure in the USA, the Loto procedure is not obligated in Europe. Loto is therefore perceived as a tool to meet the minimum requirements for the use of work equipment the EU maintains.

The EN 1037 norm explains the employer should assure a safe and secure intervention within a risk-prone area. Stating:

-All work equipment must be fitted with clearly identifiable means to isolate it from all its energy sources.

- Reconnection must be presumed to pose no risk to the workers concerned.

Pilot location Vopak

Unlike other Vopak terminal locations Vopak Vlaardingen does not required to gaseaus nflameable products to be stored. This allows Vopak Vlaardingen to maintain soft rules in relation to ATEX safefty standards and

For this reason Vopak Vlaardingen is suitable pilot location to test new product solutions. Allowing the external R&D company of TWTG to test with new product functions on sight. To test with the digital products solutions of TWTG and improve their operations Vopak Vlaardingen adopted the LoRa wireless network as one of the first terminals Vopak's terminal portofolio.

Strong environmental impact on materials

The Loto method and thereby materials used both indoors as outdoors in extreme and various weather types.
Loto's materials are outdoor for longer periods of time (>3 Months)
Great forces are present in the heavy industry affecting the Loto matierals

Existing Loto solutions aim to meet the following criteria:
Tempertures (-40°C tot +90°C) and chemicals
Protection - cover agianst dust, dirt and contamination prevention
Explosive resistant - Anti sprak materials
housing protects against rust,
Durable aluminum/hardend steel

These requirements were additionally evaluated with industry partners of TWTG (W1 - Total consultation)

Appendix 10 - Vopak safety standards Loto

Two documents are consulted to provide insight on the Loto standards of Vopak to support the design process.
-Vopak Fundamentals on safety (2017)
-Loto Blueprint (2020)

These document are esthablished by Global Operations.

Due to the confidentially of the documents we can singularly share the insights additionally present in literature provide by OSHA and the global lockout distributer of Masterlock.

From these documents is learned strict safetly regulations apply. The known standards for Loto highly relate to operations present at Vopak.No exceptions could be found.

Quote
"We operate safely, or we do not operate at all" - Global Director Operations
(Acquired from the Loto blueprint)

These documents states:
Where more than one person/work site can be effected by the removal of the isolation multiple padlocks should be applied, one for each effected work site.
These standard applly to all existing terminals owned by Vopak and its joint venture companies.

Management of Change process must been completed before changes can happen.

The Vopak Fundamentals on Safety state:
For any isolation of energy systems; mechanical, electrical, process, hydraulic and others, the following must be completed.
o The method of cut-off and discharge of stored energy are agreed and executed by a competent person(s);
o The cut off(s) is/are executed
o Any stored energy is discharged;
o All agreed isolations are in place and a system of locks and tags are in use
o A test is conducted to ensure the isolation is effective;
o Isolation effectiveness is periodically monitored.

The intent of this fundamental is to ensure that when work is to be done on electrical or pipeline systems, that those systems are placed into a safe condition by isolating the area which is to be worked on from the rest of the system such that no unexpected release of energy or pipeline contents occurs.
This fundamental applies

Any isolation of energy systems; mechanical, electrical, process, hydraulic and others, cannot proceed unless:

- The method of cut-off and discharge of stored energy are agreed and executed by a competent person(s);

- Tag-locking results in an isolation of the energy systems

to be written on isolation tag prior to fitting includes:-
-Name of equipment being isolated
-Any available circuit/pipeline reference
-Name of the person carrying out isolation
- Date of isolation
- Maintenance request/permit to work, reference number
- Fit lock and danger tag as part of isolation procedure.
- When isolation is removed, remove and discard danger tags

Reason for tag-locking:
Where equipment has to be removed from a pipeline system or where preparation is being made for confined space entry.

-All agreed isolations are in place and a system of locks and tags are in use

-Where more than one person/work site can be effected by the removal of the isolation multiple padlocks should be applied, one for each effected work site.

-Fit tag detailing why and how isolation has been made. Information required to be written on isolation tag prior to fitting
-Name of equipment being isolated
-using test cocks or drains on pipelines, or circuit testers for electrical equipment.

-Check the integrity of the isolation in the 'correct' direction with regards to the potential source of pressure.

-Isolation effectiveness is periodically monitored.

-checks if isolated section is becoming slowly contaminated or re-pressurised.
2 Effectiveness can be confirmed by repeating the checks detailed above.

-Long term isolations need to be managed and checked from time to time in accordance with local procedures; considering the nature and intent of the isolation.

-When isolation is removed, remove and discard danger tags

Addtional precautions: Blank flange or cap and warning tag to be fitted to any open ends of line where a hose could possibly be connected. System to be disabled in product handling software if applicable.

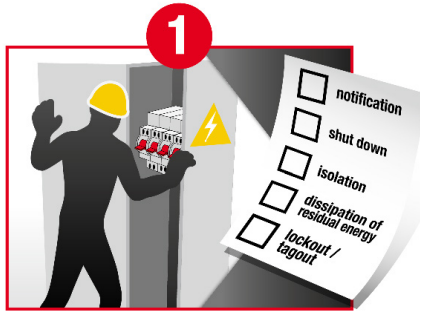
Appendix 11 - Procedure information

Images where extracted from the masterlock material paper (2017)

1. Prepare for Lockout

An authorised employee will determine which power sources are present, must be controlled and determine which control method and regulations apply.

-Executed online with the support ofLoto related software
-Preparation plan for Lockout is reviewed by a supervisor



Close all direct and indirectly linked steam & oil valves and place blind and piping end when maintenance is required in a tank.

No off-switch presented: Explain how the cable should be disconnected and cable end should be secured.

2. Update all people involved

Information related to what, why, by who and for how long the system is locked must be shared to the employees affected by the Loto.

- Obligated by clearly displaying the Loto procedure in a public area
-Loto software provides insight in executed or running Loto procedures.

Loto planning is adjust in software

List of Loto (to-be) executed tasks is represented on online dashboard

3. Shut down equipment

When the system is active it should be done normally be turned off. THis to ensure machines or processes are not damaged and lockout materials can safely be applied

Close valve

Press stop button

Send request to planning for online controlled systems

4. Isolation of system

Add mechanical isolation materials to ensure the dangerous energy could not escape the system.

- Dependent on the type of isolation
- Dependent on the mechanically lock support abilities of the system

Plastic support materials is placed over the valve to prevent operation when cut out holes for padlocks are absent

Plastic support material does not fit
Cable wire is ran through the wheel of the valve

5. Execute tagout Lockout

Multiple padlocks and tag for one Lockout procedure. Small or large scale group Lock-outs are executed

-Operators places padlock to ensure the energy source can not be operated.
-Operators applies Tags to notify people about the procedure being conducted.

-Place padlock-
-Place support materials
-Place tag

6. Release of remaining energy

Identifying all stored flow in cylinders,fly-wheels, springs, pneumatic or hydraulic systems and ensure that it is distributed. Most often referred to as the “Try-out”, to stress these step people rephrase the Loto procedure as the LotoTo procedure.

- Test cocks or drains on pipelines
- Check the integrity of the isolation e.g. valve shut in the ‘correct’ direction
- Test circuit testers for electrical equip-ment
- Test movement of components for heavy machinery

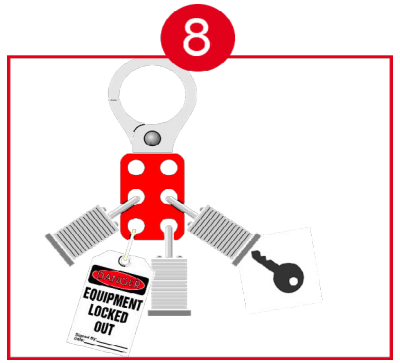
7. Inspection of isolation

A daily review of the Loto must be conduc-ted between the supervisors and contrac-tors executing the maintenance. This often referred to as a 4-eyes inspection. This safety step is executed to achieve mutual agreement about a safe work environment. Periodic inspections are executed to iden-tify if pipes get re-pressurised or areas get contaminated.

Check if Loto’s are (still) in the correct place
Check if materials are still performing a correct Lockout
Check if the right tag detailing is used for the Lockout

8. Release of the Loto

For the release of Loto steps can be per-ceived executed in the opposite direction. Starting with a 4-eyes inspections between the contractor and the supervisor to in-spect if the executed maintaince is fulfilled. Ones agreed upon the execute task a Loto release document allows the Loto executive to:



8.1 Inspected executed work
8.2 Release of remaining energy
8.3 Remove Loto materials
8.4 De-Isolated of system and dangerous energy
8.5 Prepare equipment for start-up

Appendix 12 - Function overview

Tags

Identifiable design
Attract the attention of operators
Warn people from operating an assets

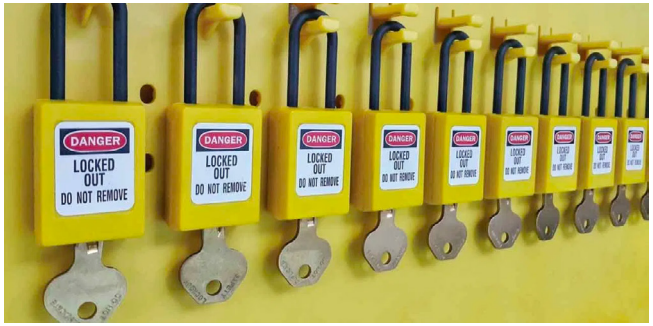
Detailed textual information
Provide in-field information on date of placement, related personal, method in place, location placement

Explain operators and supervisors who is responsible for the execute actions

Explain to operators what and where to fulfill actions

Warn people from operating an assets

Customize options
Tailor information of tag according to lockout method in place as specific location.



Padlocks

Colour codes
Recognise which lock relates to the identified procedure

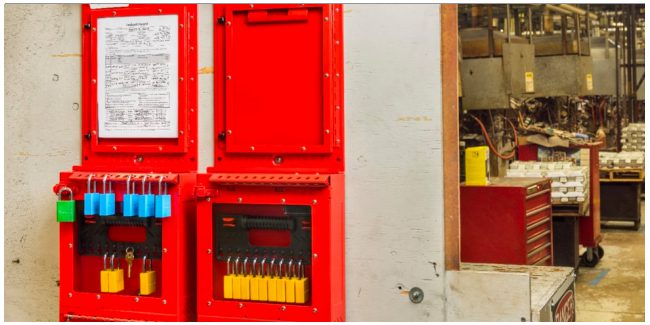
Personal padlock colour
Communicate of group related to group lockout

Key operated
Personally in control of operation

Standardized sized
Padlocks can be applied to all lockout support materials.

Standard design
Simulate clear communication and unity in the work field

Substaintial design
Perceive high level of safety and prevent accidential or unauthorised removal.



Lockbox

Display Loto procedure
Receive information about the procedure in a central area

Attachment for personal locks
Become in control of own safety by a simple handling

Visually communicate involvement in Loto procedure

Prevent use of field lock materials on personal level*

Related checklist
Enable detailed process information on sight

Simple box
Can be easily Implemented in any work scenario.

Appendix 13 - Listed problems

Loto esthablishment at vopak

Intro
The main reason identified why the current Loto protocols in place can not be executed safely is because of human actions being involved making essential mistakes regarding the desired Loto protocol. Based on their locations in the chain of consequences are ranked on the following priority. With the prior aim to solve these problems it's expected the "wants", also related to the efficiency of the process, could additionally be solved.

Problems ordered by priority:

Checking if the Loto is correctly placed is not adhered to

A Loto is online registered as placed could be not in place.
The status of the Loto's is not real-time monitored and therefore does not reflect the real-life scenario
A Loto digitally registered and perceived to be ...
... placed, could be not physically in place.
... placed, could be placed at the wrong location.
... released, could still lock an energy resource.
By being forgotten, unaware of placement or a lack of overview

Loto place or release action is not (correctly) executed

Existing smart solutions are not designed to durable for the industry

The constant shifting between digital and physical communication documents
Digitalizing manually gathered data is time-intensive.
Manually gathering data is time-intensive.

Materials
The constant shifting between digital and physical communication documents. (A)
Tag materials are impractical
Padlock materials are impractical
Existing smart solutions are not designed to substantial for the industry (E, I, L)
Monitoring
A Loto is online registered as placed could be not in place.
/The digital registered status of a Loto could not reflect the real-life scenario

Resulting in "Wants" to solve:

The Loto place or release action is not executed at the right location (subjected to problem #3)
Tag materials are impractical
Employees are unable to remove their personal Loto
Loto's are forced open (V, I)
Padlock materials are impractical
The Loto lock down equipment in the wrong position

Recalled by:
A = Author insight
V= Experts Interviews & Field research industry
E= Experts & advisors of Industry
L= Literature
P = Product analysis, Usability analysis
C = Chief Technical Officer

Behaviour problems

Checking if the Loto is correctly placed is not adhered to
Executing the (daily) Loto checks is time-intensive (A, V)
Loto's on an industrial sight could be far apart (V)
The location where the Loto's are checked in relation to where the registering of the Loto's condition is done is far apart. (A)
The to be checked Loto location is difficult to find.
Executing the (daily) Loto checks cost a big effort (A, V, E)
When the most important Loto's** are registered by the operator the Loto is perceived safe (V, L)
Easy to place Loto's are perceived safe by experienced supervisors (V, L)

-Including both the set-up Loto check as the daily periodic inspection.
-E.g. Loto's visible when entering the tank.

Examples manifestations of problem:

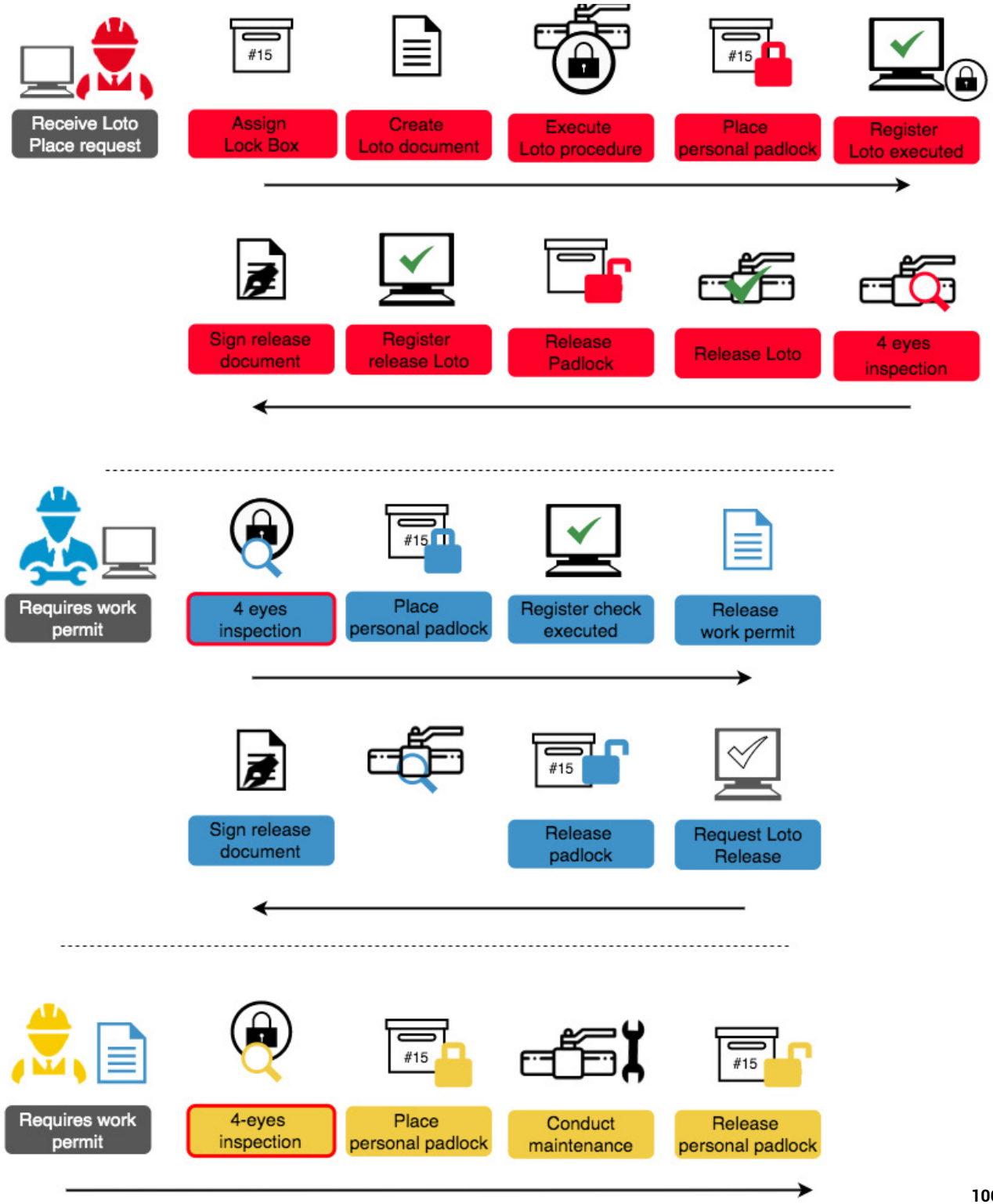
Result: A Loto mistake is not discovered by the supervisor
Risk1: The wrong sprinkler system is locked out

Result: Sight is not prepared for maintenance
Risk2: Contractors need to go home, maintenance is postponed

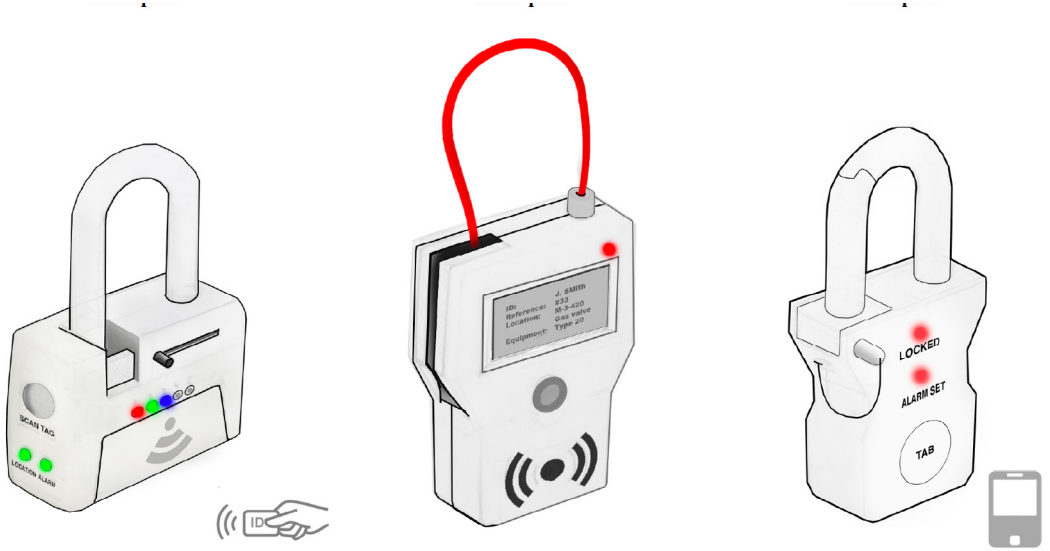
Result: Maintenance of Loto procedure for tank A is fulfilled, Lock 10 related to tank B its Loto procedure is accidentally removed over night.
Risk3: Product is loaded in Tank A while employees are at work

The Loto place or release actions are not (correctly) executed
Loto operators makes human mistakes
Loto operators are under pressure (V, E)
Loto operators lose concentration (V, E, L)
Loto operators neglect validation checks/want to work as fast as possible (V, E, L)
An employer forgets to place or release a Loto (V, E, L)
Employer lacks an overview of the to place/release Loto's (V, E)
The Loto place set is incomplete (V)
Locks are not registered missing (V, L)
The Loto place or release action is not executed at the right location
The operator who places or release the Loto doesn't receive direct feedback on his user actions (A)

Appendix 14 - User tasks



Appendix 15- Concept exploration



Scenario A (appendix - Concept A)
This scenario allows to replace the physical key operation with digital key card operations and adopts the traditional tag function of the existing lockout solution. Hence, requiring marginal alterations to the existing systems in place.

This scenario was dischared as the time spend on the present routine key routine, was perceived as a too limiting factort regarding the improvement of the operators tasks conditions

Scenario B (appendix - Concept B)
Provides direct accessible information by a screen without the need of additional keys or smart device accessories. Tags are replaced by digital screen interactions.

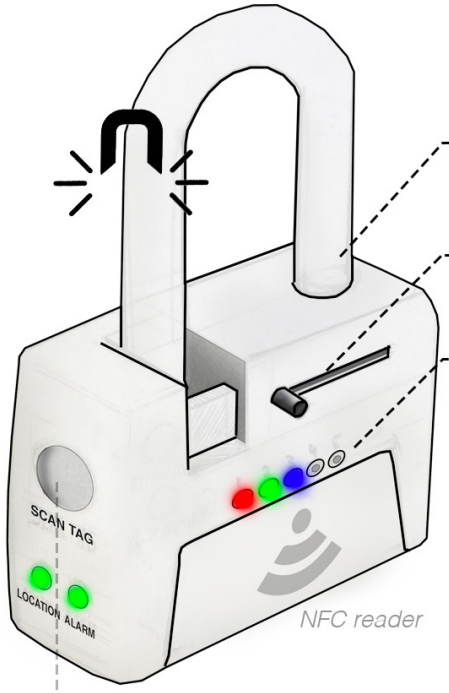
In this scenario the level accessible informion-related to the absence of ID related inspection actions. This factor was perceived too limiting safety factor. The complexity of a screen, raising the cost of this solution, is perceived of essential value.

Scenario C (appendix - Concept C)
To deliver a future proof solution and limit the complexity of the product a scenario was developed which primarily was operated with a smart device. This requires smart devices to be adopted in the routine of the operators.

The dependency of smart devices to deliver protocol information is perceived a too limiting factor to adopt this use scenario. Yet, Vopak explains the adoption of smart device applications is extremely valuable concering the Loto use-case.

Appendix 15 - Concept exploration

Suitable to existing Loto routines



Familiar mechanism to industry

Slide to secure lock & set alarm

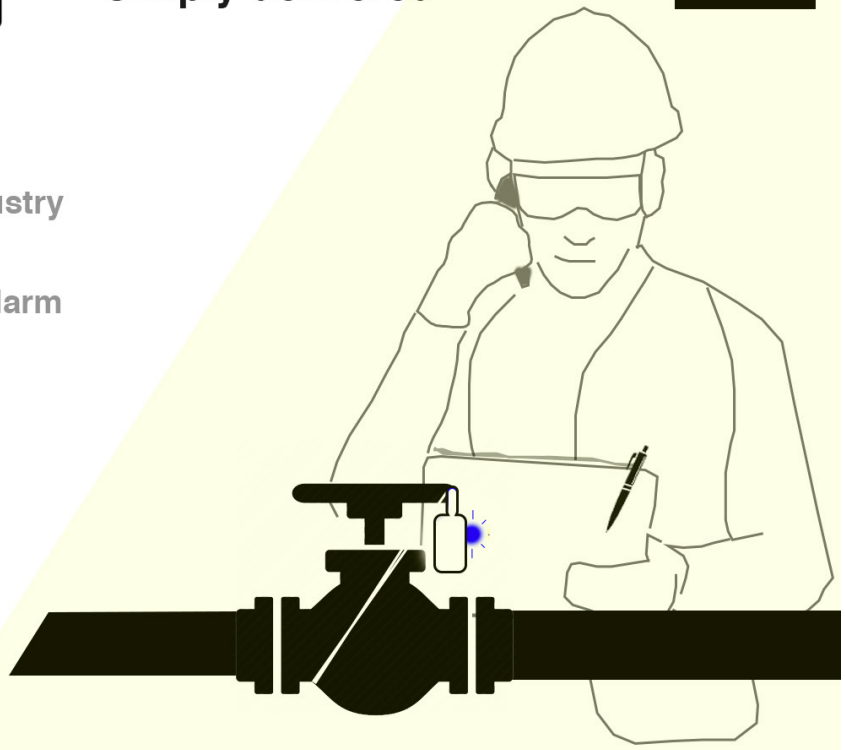
Review authorisations

Press: scan location tag

Easy digital operation

Essential information simply delivered

A

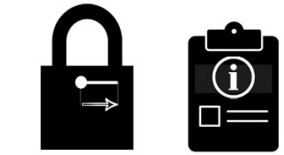


Register group action required

Easily going digital

Lock becomes: E-Lock
Key becomes: Digital key

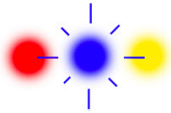
Familiar materials with digital benefits



Shackle & slide *Checklist*

Marginal alteration of materials

Fast insight in group authorisations

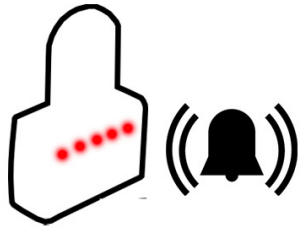


Group related dispalyed by colour code
Action required: Blink led

Insight with minimal management of change

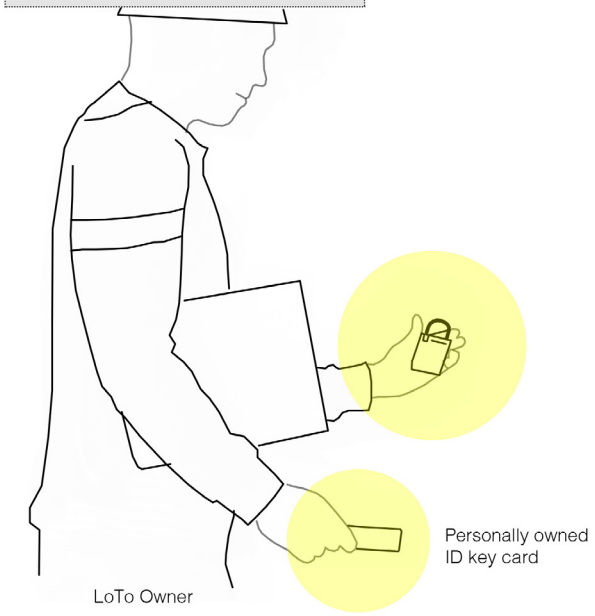
Register inspections and review group Identity

Prevent opening



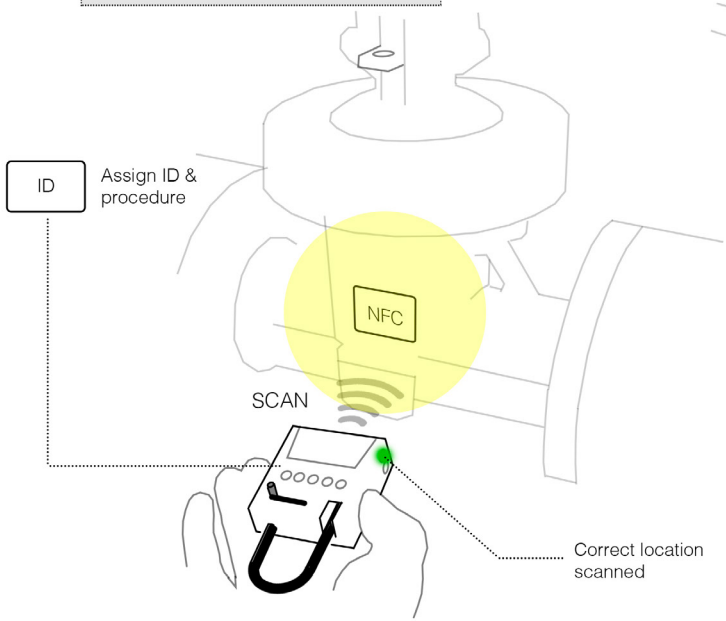
Unauthorised movement of slide registered

Acquire LoTo items



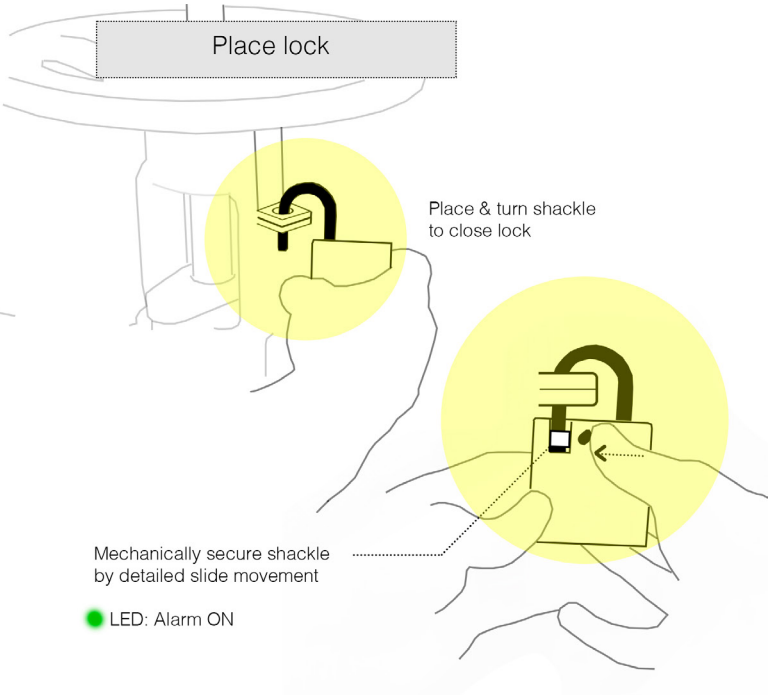
Operator has to execute similar actions
to existing LoTo routine

Scan location tag & lock



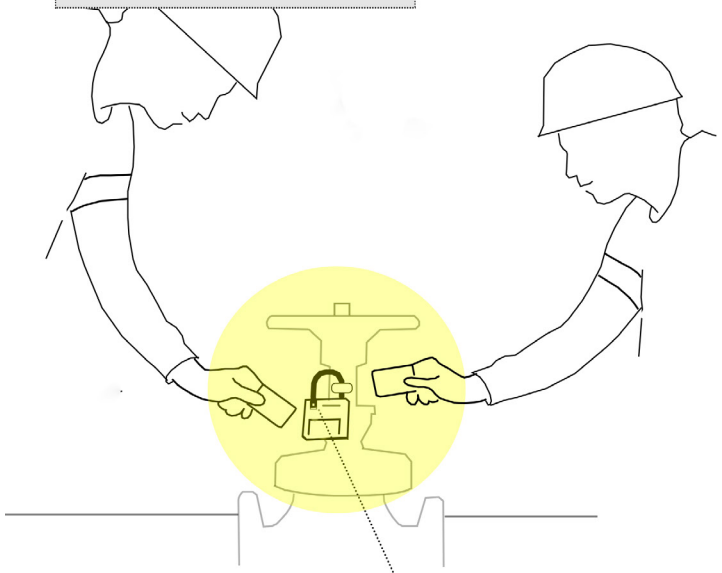
Scan tag to verify location
Scan Lock with personal card

Place lock



Lock placement familiar to industry
Simple enclosing action

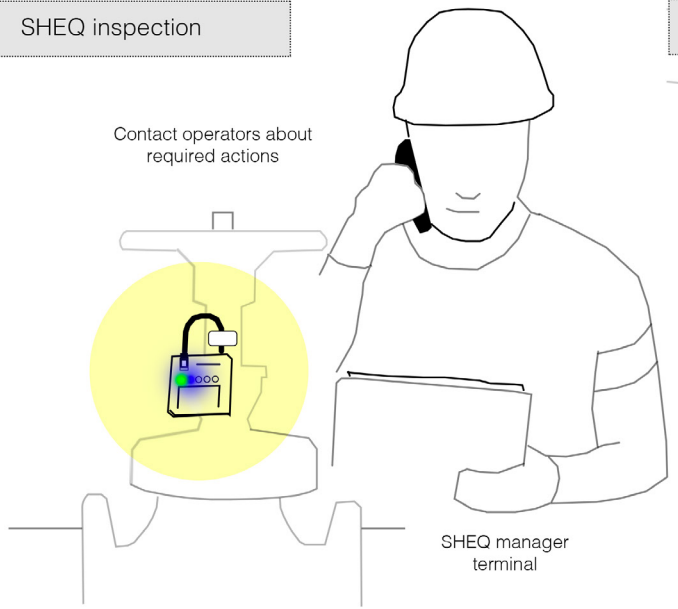
Work preparation check



4-eyes check
ID's registered

LED visually displays
action executed

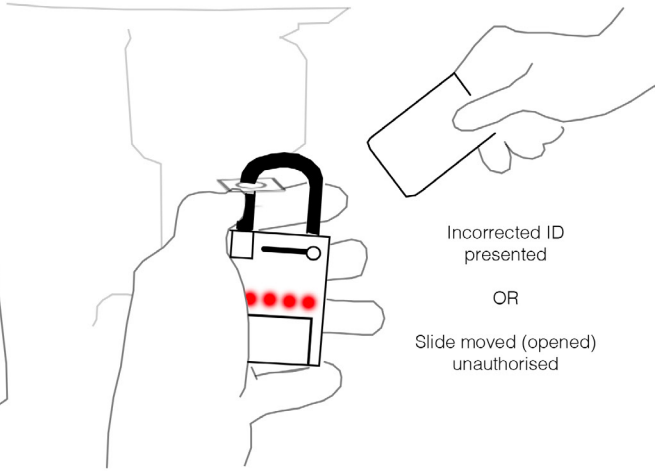
SHEQ inspection



Review group(s) related
to lock procedure

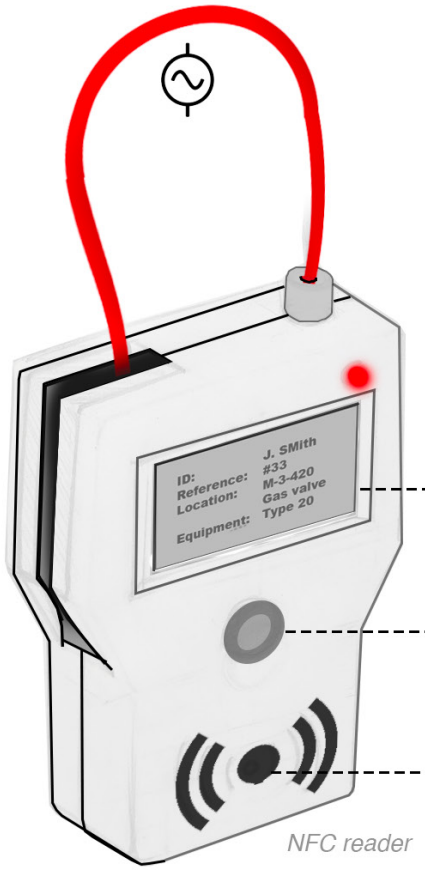
Direct insight in neglect
actions by blink led

Release



Always be aware of who prefroms
(in) correct actions at the lock

Appendix 15 - Concept exploration



NFC reader

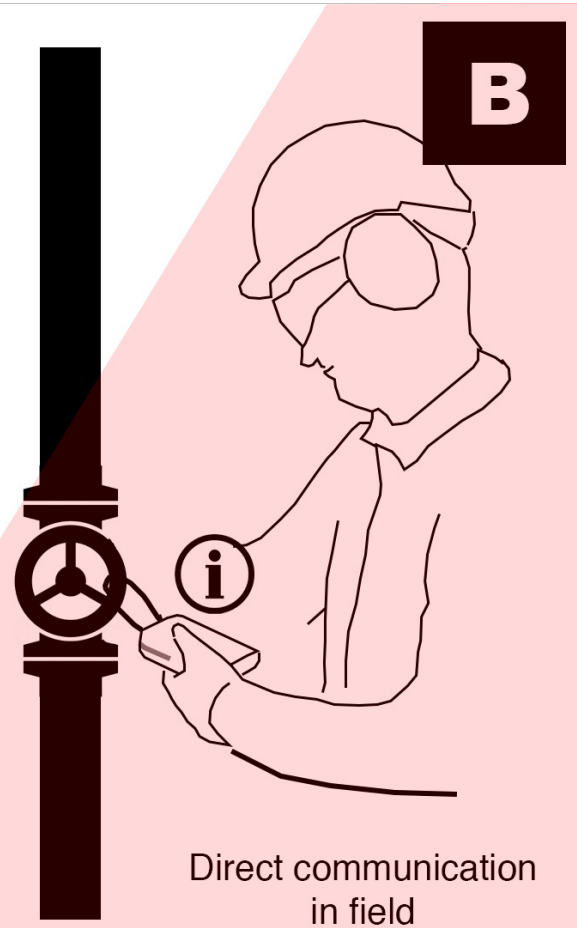
Direct feedback on actions

No accessorries required

Detailed screen

Button Press
Activate scanner/ Register inspection

Assign procedure (PC)
Assign Location (Tag)

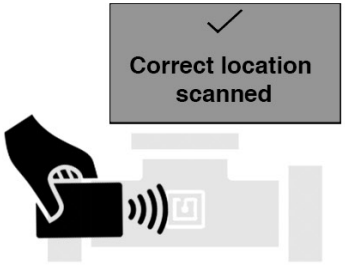


Direct communication in field

Stand alone solution

No time spend on acquiring materials

Prevent inaccurate behaviour

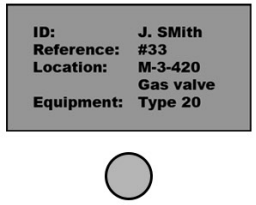


Direct feedback on actions

Simple placement

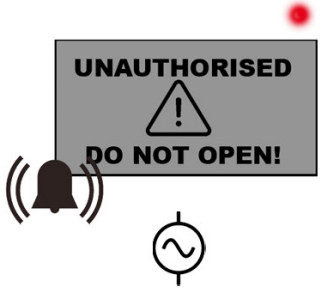
Fast to apply cable
place cable end, slide up

Insight to all operators



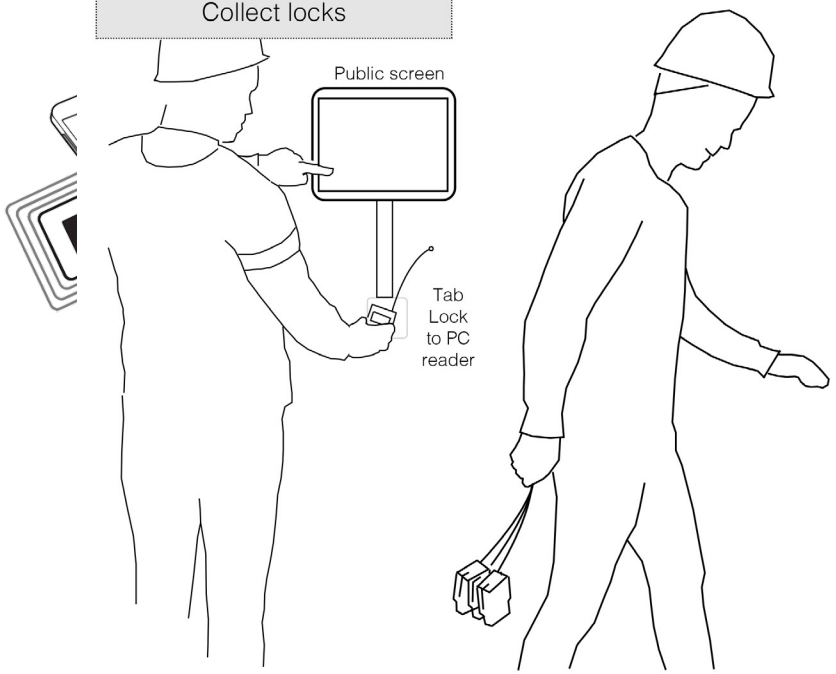
Accessible information detailed information on location

Improve awareness



Tamper detection and
Detailed warnings

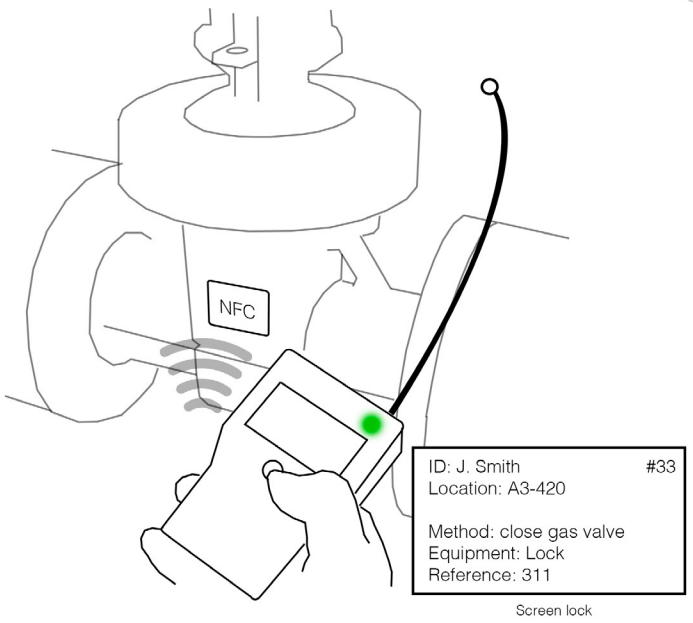
Collect locks



Personal log in
Assign procedure

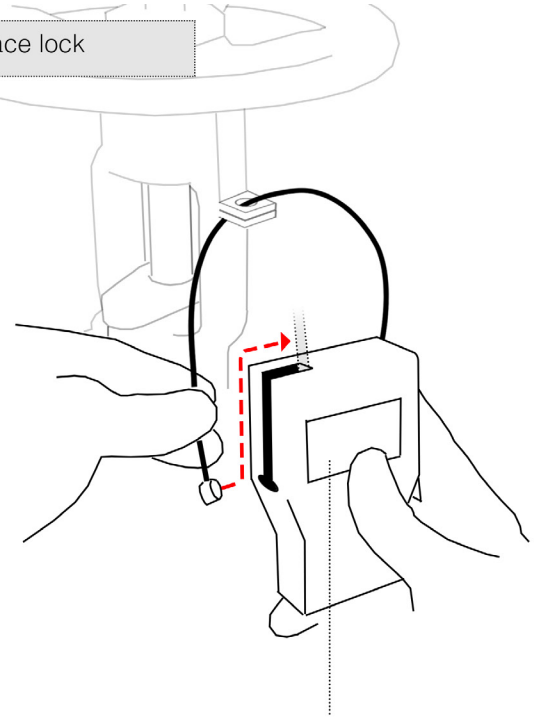
No accessorries required

Scan location



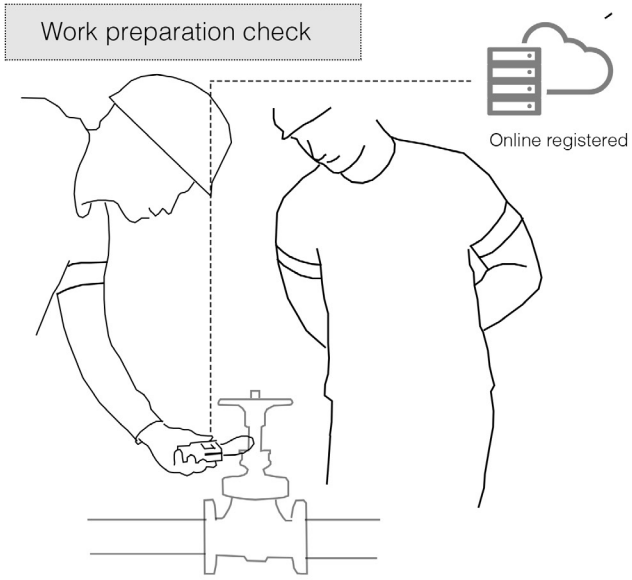
Review and verify correct location
Direct insight in lockout method

Place lock



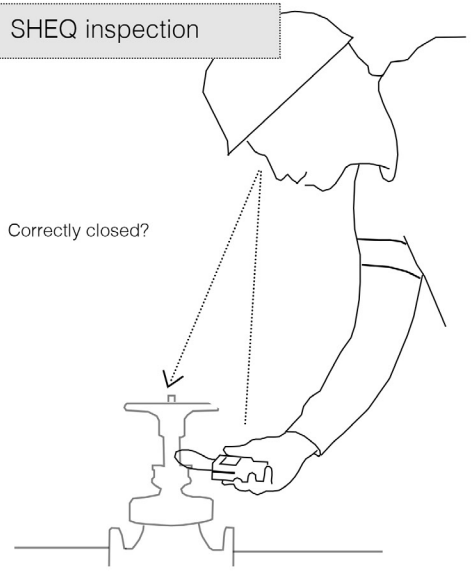
Instructions: Close valve, enclose lock
Feedback: Lock is closed

Work preparation check



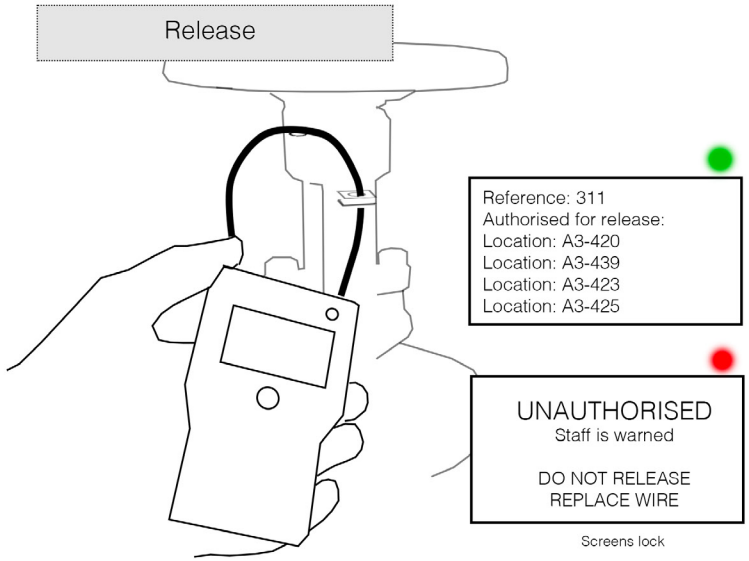
Button press:
Easliy register inspection

SHEQ inspection



Direct in field accesss to detailed Loto information & (not) executed actions

Release



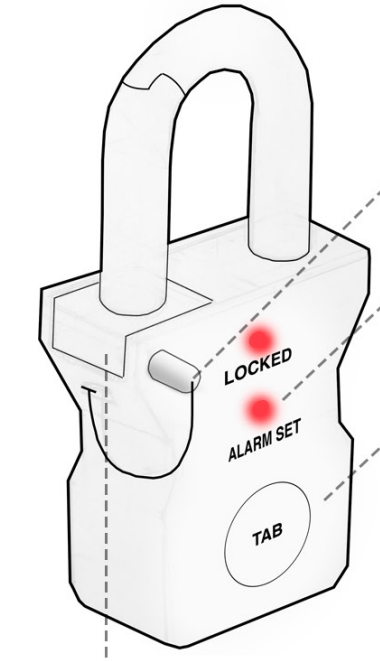
Detailed warnings enable prevent release

Appendix 15 - Concept exploration

C

On demand Loto insight

Simple, future proof solution



Securing pin

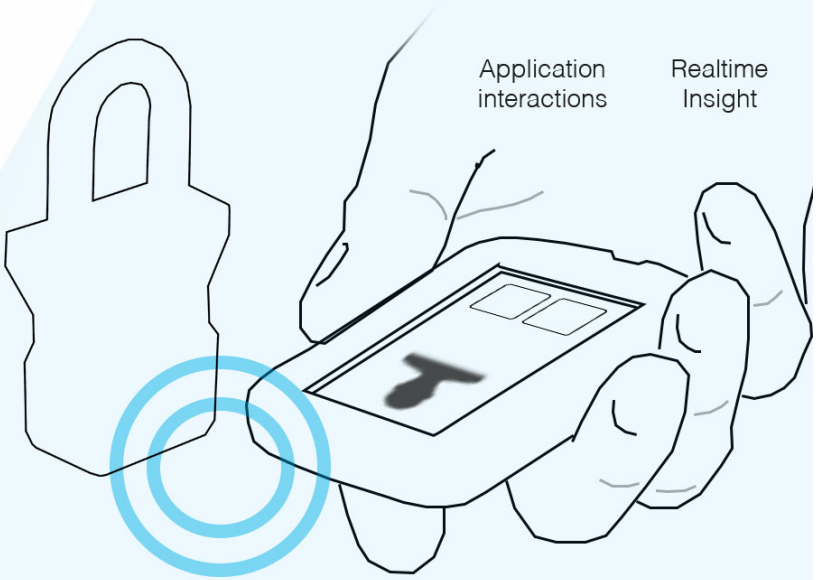
LED status feedback

Passive NFC

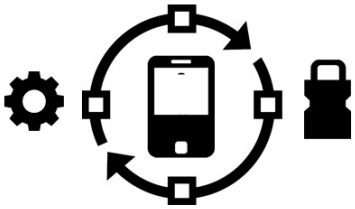
Clip mechanism

Smart device

Place / Release/ Inspect lock



Part of Digital workflow

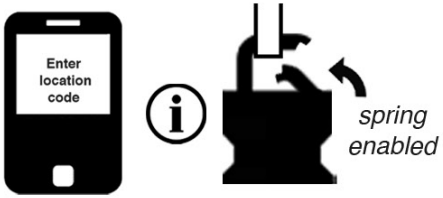


Smart device used for multiple applications

Multiple smart devices in use

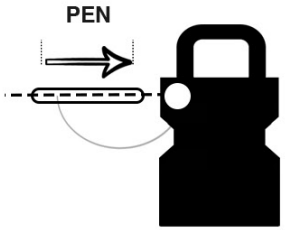
Public storage of ID registering smart devices

Smart Controlling Device



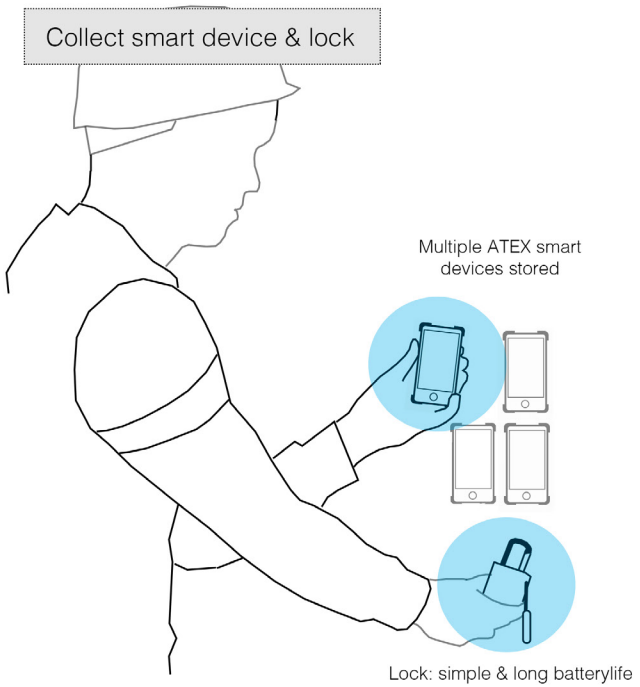
Indept procedure insight, feedback & instructions

Strong safety image



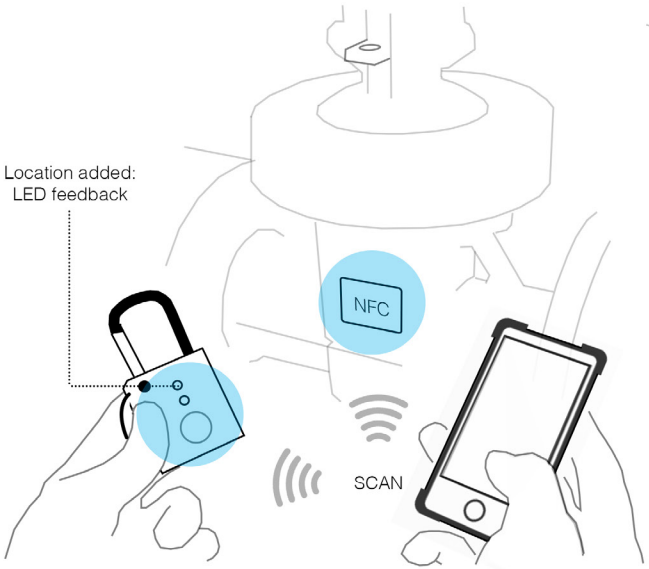
Opening prevention by pin
Pin placed = Alarm set

Collect smart device & lock



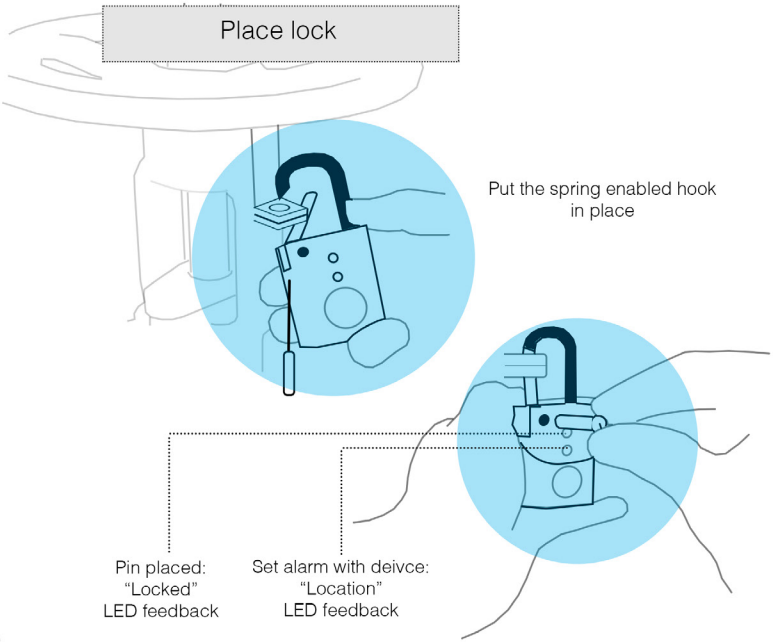
Receive detailed information &
execute actions with the smart device

Scan location tag & lock



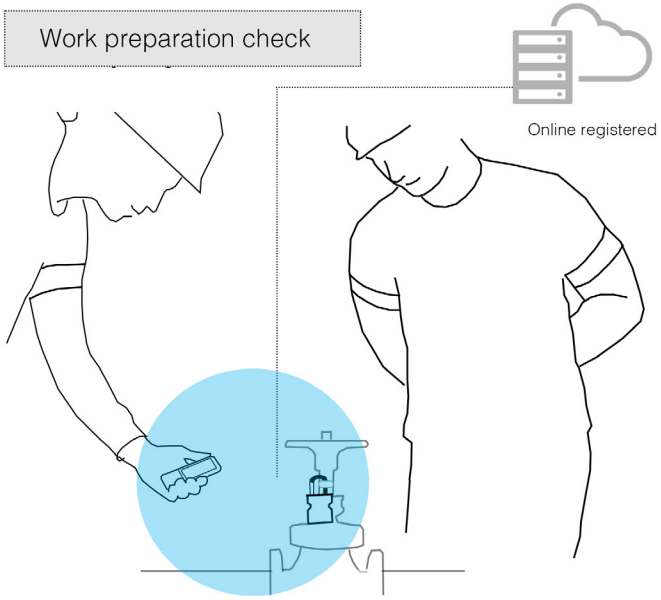
Verify correct location with smart device
Scan Lock: Assign ID & location

Place lock



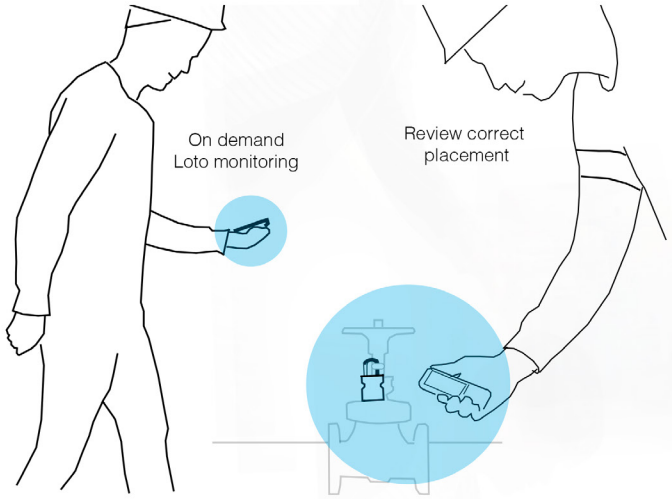
Prevent (accidental) opening
by a strong safety image

Work preparation check



Register inspection with device
No paper & checklist required

SHEQ inspection



Insight in Loto status in field

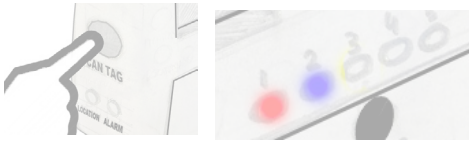
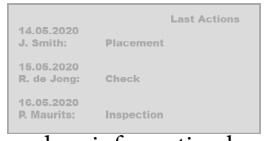
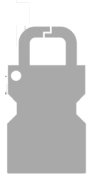
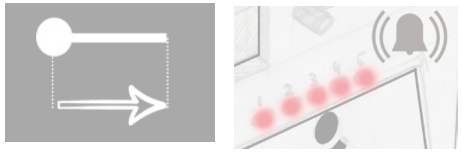
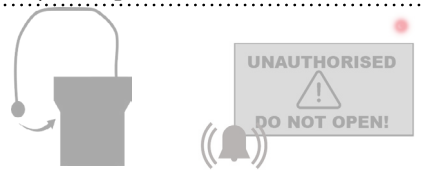
Detailed insight in procedure

Release

Never forget the release of a Loto
with the in field overview

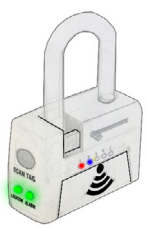
Appendix 16 - Concept assessment

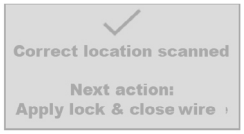
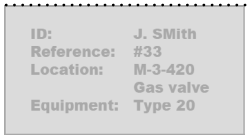
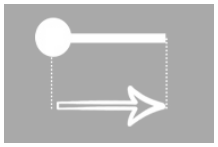
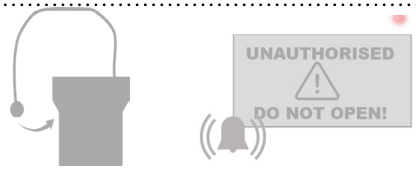
Interaction: Means

ease of use: **Feedback on actions**	 Green/Red Location LED, Alarm on LED, Group authorisation Leds	 Detailed screen for instructions and feedback on actions.	Feedback & instructions from smart device Green led Alarm verification provided by Lock 
Accesibility of protocol information	 Press button in field	 Press button of lock in field	 NFC scan lock with smart device
Quality of insight in Loto procedure	Review "group actions required by colourcodes and led blink Review tag information with Loto checklist 	 Review procedure information by screen Review tasks by screen	Review procedure information with device Review detailed tasks by screen 
Impact on operators tasks	 Place personal digital ID to lock instead of physical key to execute Loto actions	 Connected locks with computer (NFC) to start placement procedure	 Acquire & use smart device to execute Loto tasks
Perception of safety	Shackle in place. Closed slide ensures shackle can not trun 	Cable in place. Cut out in product prevents cable end to accidently leave product 	Closed hook in place. Pen ensures hook remains closed. 
Preventing of unauthorised opening	 Red blink leds and noise when slide moves	 Red led, noise and screen response when cable end moves	 Red blink leds and noise when pen moves out

Appendix 16 - Concept assessment

Interaction: Consequences



Feedback on actions	 Singurly insight in group related authorisations of procedure	 Procedure and tag related details present in field	Feedback & instructions provided by smart device. Alarm verification provided by Lock 
Accesibility of protocol information	 Checklist required for indepth insight Group required to act is quickly identified	 No accessorry required for in field detailed procedure information	 Bring smart device to Loto location.
Quality of insight in Loto procedure	 Checklist provides detailed information on required actions	 Screen provides insight in procedure, required and executed actions. No inspection ID registered	 Smart device provides indepth insight in procedure, required and actions provided
Impact on o perators tasks	 Maginal alterations and MoC required. Checklist routines remain time consuming	 Loto dashboard interactions. NFC enabled computer to assign Loto procedure to lock	 Time consuming implementation understanding smart device routine and applications.
Perception of safety	Buckle familiar to industry Minimal disruption to industry. 	Wire disruptive to existing padlock practices. Full tamper detection, Easy to operate and produce. 	Buckle familiar to industry, pen strong perception of safety 
Preventing of unauthorised opening	 Easy to understand and operate	 Provide detailed commands to overcome lower perception of safety	 Complex rotation mechanism required and lose part required

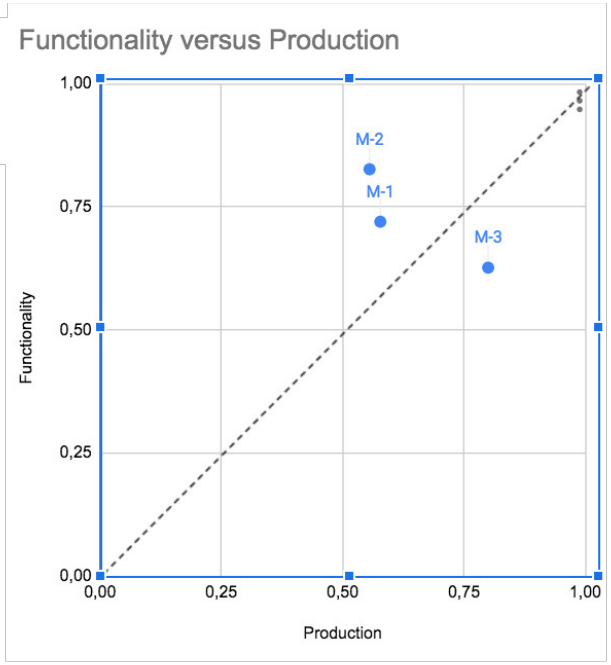
Appendix 16 - Concept assessment

Mechanism selection Kesselring method

Mechanism selection kesselring

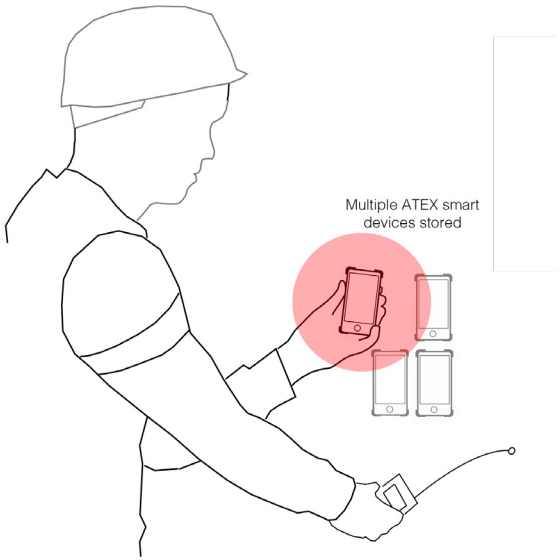
	weight	M-1	M-2	M-3	M-4	-	-
Awareness on required loto actions	3	5	4	2	4	-	-
Feedback on lock status	3	4	4	2	3	-	-
Level of perceived safety	2	2	4	3	4	-	-
Ease of execution	2	3	4	5	2	-	-
Can not be accidently opened	2	4	5	3	5	-	-
Efficiency improvement on process	1	3	4	4	2	-	-
Resistance agianst enviroment	1	3	3	5	3	-	-
	1	3	5	4	3	-	-
Total max score	75	54	62	47	51		
Functionality	1	0,72	0,83	0,63	0,68		
Cost price of the solution	2	2	3	5	3	-	-
Difficulty in assembly	1	4	2	3	1	-	-
Durability of the solution	2	2	4	5	4	-	-
unique parts required	2	4	3	4	2	-	-
Limited amount of parts required	1	3	1	2	3	-	-
Limited amount materials required	1	3	2	3	2	-	-
Total max score	45	26	25	36	24		
Production	1	0,58	0,56	0,80	0,67		

	Production	Functionality
M-1	0,58	0,72
M-2	0,56	0,83
M-3	0,80	0,63

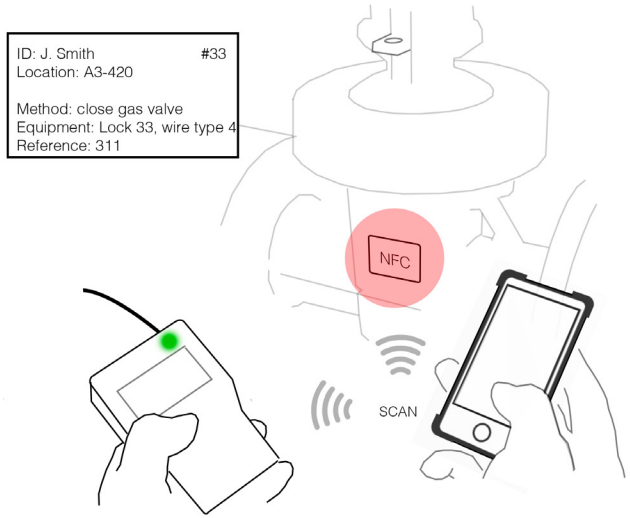


Appendix 17 - Detailed usecase

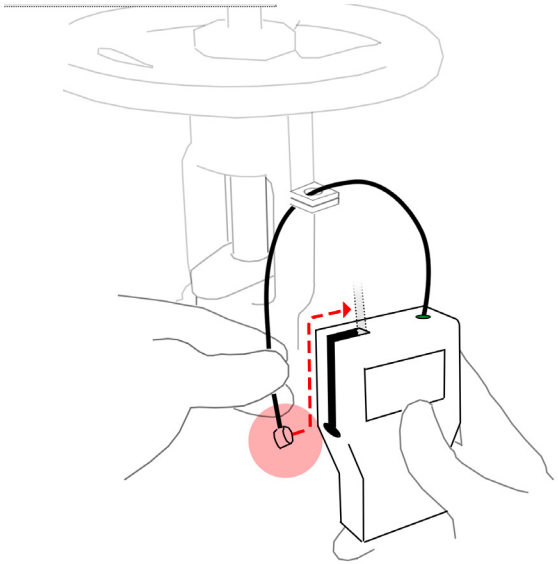
Acquire smart device materials
No keys operations required



Validate correct location
All Loto's removed from and placed at the correct location



Place lock:
No lock required to be cut & always aware of released locks



The Lockout is ready to be executed ...
- The Loto man enters personal credentials and selects procedure on his smart device (tablet)
- Lotoman can simply take required number of padlocks
- Required Loto actions aree provided by the smart device

Feedback:
When moving the product a led blink reveals the operator the digital Loto is functional.

The Loto man arrives at the lockout location ...
- The Loto man can verify the correct location for placement by scanning the valves location tag.
- Tag information is assigned by scanning the digital Loto with the smart device

Feedback:
- Correct location: Display of the digital Loto will reveal procedure required in field communications.
-Incorrect location scaned:

The Lotoman starts his lockout ...
- Easily slide the cable through the lockout support materials. The cutout of the digital Loto registers and secures the cable end
- The alarm is set when the cable is secured.

Feedback
-Operator registers lock correctly closed by LED Feedback
-Unauthorised release: Aarm is set off and registered.

No lost are loss of keys

Save time on acquiring keys for lockout proceddure

Directly assign personal ID to Loto procedure

TEST
Loto's will not be placed at the wrong location, thereby preventing accidents to occur

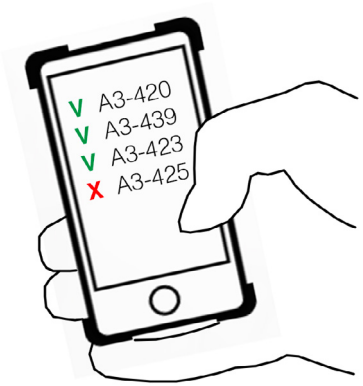
Register real time status of lock being in place enalbes

Ease of use
Direct feedback is provided on the actions lock closing actions prevents:

Safety
registration of unauthorised release actions

Prevention of lock's being destroyed

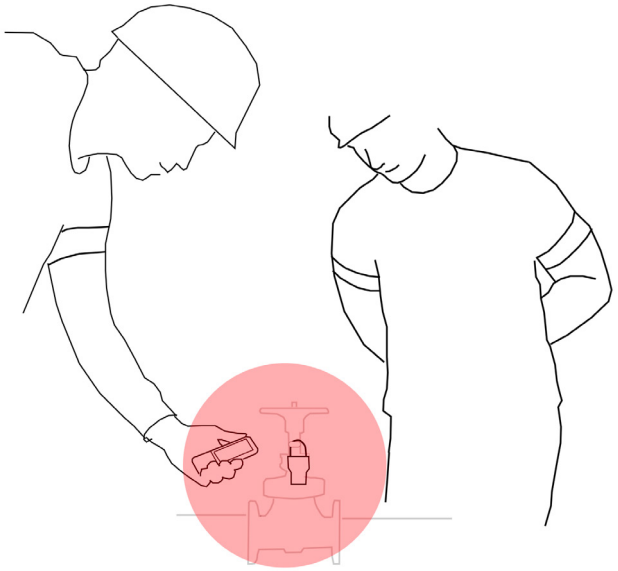
Verify Loto actions
Enhance accurracy and ease of actions



Direct insight on the (to-be) executed actions is provided to the user...
- Operator receives detailed instrucutions on how the Loto materials should be placed
- Operator validates if all Loto's have been placed.

Feedback
- Application: Review Loto's required to be placed/released Receive feedback when Loto locations is forgotten.

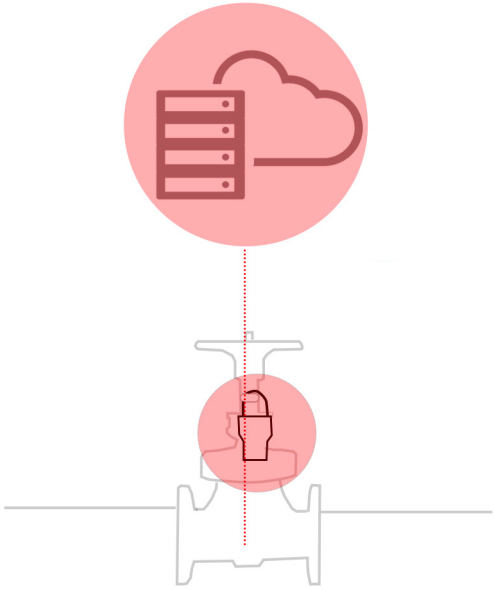
Validate inspection actions
Directed insight in operators (inspection) actions



Work preparation checks can be directly digitally monitored ...
- Register their work prepartion inspection routine.
- Points of interest can be directly digitally registered, no additional registeration required..

Feedback
- Digital Loto provides LED feedback when scanned with the smart device.

Eliminate daily inspection routine
Digitally monitor the status of the



The smart displays the Loto status online ...
The operator can review if a safe work enviroment is maintained.
-Provide insight in if locks are still present at the location and if inspection(s) are adhered to.

Feedback
- System feedback (dashboard): Lock status safe Y/N
- System feedback: Not all Loto's placed, work permit to conduct maintenance can not be released*

Ease of use
Early identification and overview of mistakes: Prevent forgotten Loto place/release actions

Efficiency
Prevents postponing maintenance or redo Loto actions related to inaccurate operator behavior

Safety
Always in control of inspection perfomed due to the digital monitoring of actions

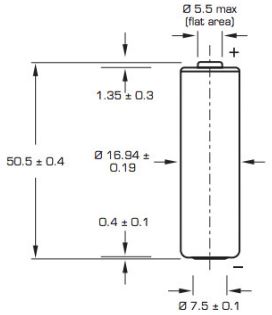
ID of related employees is registered by integration of Loto accounts on smart device.

Safety
No chance of unsafe working conditions due to incorrectly materials handlings

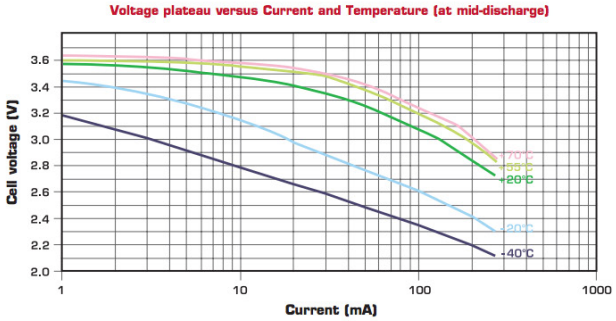
Efficiency
Eliminate daily inspection routine of an avaerage of 4 workers.

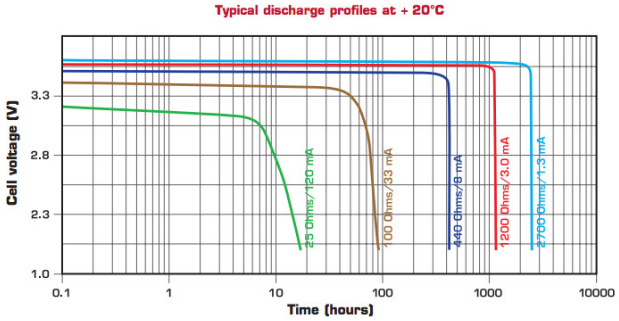
Appendix 18 - Components

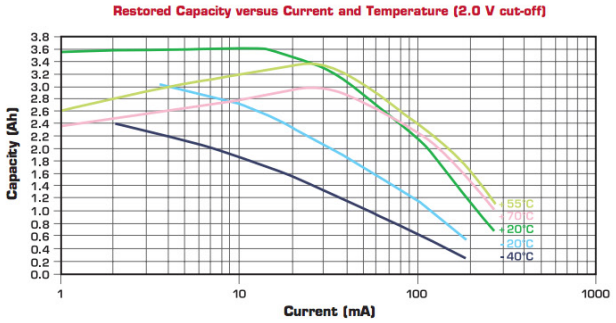
LS 17500



Dimensions in mm.







Storage

- The storage area should be clean, cool *(preferably not exceeding + 30°C)*, dry and ventilated.

Warning

- Fire, explosion and burn hazard.
- Do not recharge, short circuit, crush, disassemble, heat above 100°C *(212°F)*, incinerate, or expose contents to water.
- Do not solder directly to the cell *(use tabbed cell versions instead)*.

Saft
Specialty Battery Group
12, rue Sadi Carnot
93170 Bagnolet - France
Tel.: +33 (0)1 49 93 19 18
Fax: +33 (0)1 49 93 19 69

www.saftbatteries.com

Doc. N° 31029-2-0710

For more details on primary lithium technologies please refer to Primary Lithium Batteries Selector Guide Doc N° 31048-2.
Published by the Communications Department.
Photo credit: Saft
Société anonyme au capital de 31 944 000 €
RCS Bobigny B 383 703 873
Produced by Arthur Associates Limited.

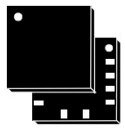
https://nl.rs-online.com/web/p/speciality-size-batteries/4199536/

life.augmented

LIS2MDL

Digital output magnetic sensor:
ultra-low-power, high-performance 3-axis magnetometer

Datasheet - production data



LGA-12 (2.0x2.0x0.7 mm)

Features

- 3 magnetic field channels
- ±50 gauss magnetic dynamic range
- 16-bit data output
- SPI/I²C serial interfaces
- Analog supply voltage 1.71 V to 3.6 V
- Selectable power mode/resolution
- Single measurement mode
- Programmable interrupt generator
- Embedded self-test
- Embedded temperature sensor
- ECOPACK®, RoHS and “Green” compliant

Applications

- Tilt-compensated compasses
- Map rotation
- Intelligent power saving for handheld devices
- Gaming and virtual reality input devices

Description

The LIS2MDL is an ultra-low-power, high-performance 3-axis digital magnetic sensor.

The LIS2MDL has a magnetic field dynamic range of ±50 gauss.

The LIS2MDL includes an I²C serial bus interface that supports standard, fast mode, fast mode plus, and high-speed (100 kHz, 400 kHz, 1 MHz, and 3.4 MHz) and an SPI serial standard interface.

The device can be configured to generate an interrupt signal for magnetic field detection.

The LIS2MDL is available in a plastic land grid array package (LGA) and is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 1. Device summary

Part number	Temp. range [°C]	Package	Packaging
LIS2MDL	-40 to +85	LGA-12	Tray
LIS2MDLTR	-40 to +85	LGA-12	Tape and reel

Appendix 18 - Components

Overview	Power consumption (mAh)
30 send messages per lockout (place, release, inspections) * 20 lockouts per year * 5 years = 3000 messages	1 message: 80mA *250ms = 0,0055 mAh
2 receive messages per lockout (screen info, authorised for release) (neglectable)	Energy usage per bite. (0,3 Joule per message)
Weekly battery status message 52* 5 years = 260 messages Total: ~3300	Total: 3300* 5,52 *10^-3 mAh * = 18,5 mAh
2 screen E-ink actions per lockout * 25 per year* 5 years = 250 actions	3mA * 2s = 0,0016mAh 250* 0,0016 = 2 mAh

Battery dichargell 1-2% per year	Avg. Of 500mAh p
Continues consumption Sensor 1 – 4 µA Screen - 5 µA PCB – 10 µA	19 µA
30 LED blink's per Lockout	neglectable
Lithium Thionyl Chloride .	3600mA

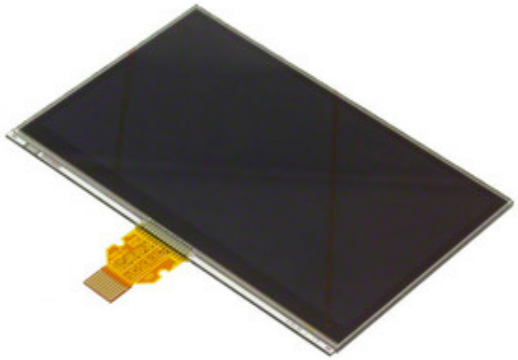
2.7-inch (diagonal) Memory LCD

The new 2.7-inch (diagonal) HR-TFT Transflective model is Sharp's first Transflective Memory LCD. Add a backlight with this display for excellent viewing in dark ambient conditions.

LS027B7DH01A Part Detail Information

See your local Sharp Representative for Specification information

Size	2.7 inch
Pixel Format	400 × 240
Outline Dimension	62.8 × 42.82 × 1.4 mm
Active Area	58.8 × 35.28 mm
Dot Pitch	0.147 × 0.147 mm
Input Voltage	5 V
Interface Type	3 V serial
Reflectance	17.5%



Application Ideas

- Wearable technology
- Mobile phones
- Remote controls
- Performance tracking devices
- Parking meters
- Smart utility meters
- Medical monitoring devices
- Wristwatches
- Fish finders
- White goods
- Retail tags
- Any product with a battery

Sectie 1 van 6

Evaluatie Digital Loto

- 10 minuten
- 8 korte vragen

Met behulp van deze evaluatie vragen we feedback op een product concept dat het digitaliseren van de Loto procedure mogelijk maakt. De Digitale Loto is verbonden met het internet om de lockout status en uitgevoerde inspectie van de Loto's voor de gebruikers inzichtelijk te maken. De bediening, instructies en gerelateerde documentatie van de Loto kan worden uitgevoerd met behulp van een tablet.

Dit evaluatie formulier is onderdeel van een onderzoek voor het bedrijf TWTG R&D (de sensor ontwikkelaar voor Vopak) en wordt afgenomen door een afstudeerder aan de TU Delft.

Het streven van de Digitale Loto is de Loto procedure efficienter en veiliger te maken. Het doel van de evaluatie is de waarde van het digitale Loto concept in kaart te brengen op het gebied van gebruiksgemak en veiligheid.

Middels illustatries en tekst zullen de grootste aanpassingen op plaatsing, inspectie en verwijdering kort worden toegelicht.

Hartelijk dank voor uw tijd.

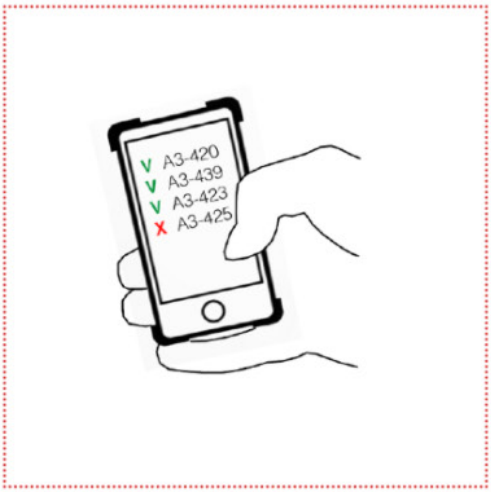
LET OP! Dit onderzoek is slechts een orientatie voor de mogelijkheden van digitale Loto's. Uitgebreide tests en demonstraties op het gebied van het uiteindelijke gebruik, veiligheid en werkomgeving vereisten moeten worden uitgevoerd mocht een dergelijk product bestaansrecht kunnen ontvangen.

Uw functie binnen Vopak: *

Korte antwoordtekst

Afbeeldingstitel

Afbeeldings...



Inzicht in handelingen
- Ontvang persoonlijk informatie over de (on)juist geplaatste sloten
- Documenteer Loto acties op de tablet

Plaatsing

HUIDIGE SCENARIO
1. Feedback op correcte Loto locatie door inspectie
2. Persoonlijke en Loto specifieke sleutel procedure
3. Tag voorbereiding en plaatsing
4. Checklist documentatie & invoeren in de computer

NIEUWE SCENARIO
1. Feedback op correcte Loto locatie door tablet
2. Slot vergrendeling met tablet
3. Tag informatie laadt op scherm van de Smart Lock
4. Documentatie via tablet, authorisatie via het online systeem

DOEL
- Elimineren sleutel routine
- Documentatie door middel van tablet
- Voorkomen van plaatsing Loto's op de verkeerde locatie
- Voorkomen van het vergeten van Loto plaatsing

Door het nieuwe scenario (1) wordt het plaatsen van *

	1	2	3	4	5	6	7	
Veel onveiliger	○	○	○	○	○	○	○	Veel veiliger

Door het nieuwe scenario (1) wordt het plaatsen van *

	1	2	3	4	5	6	7	
Veel moeilijker	○	○	○	○	○	○	○	Veel gemakelijker

Opmerkin

Tekst lang antwoord

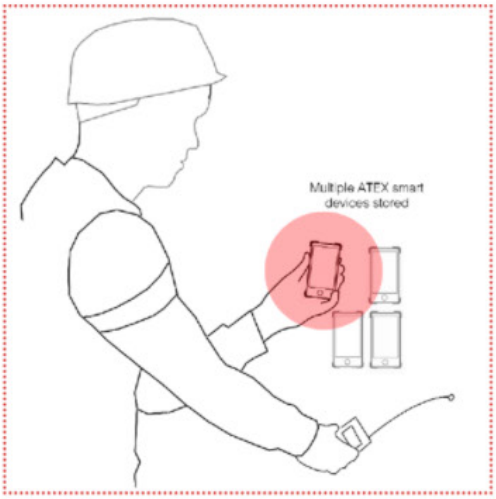
Na sectie 2 Verder naar de volgende sectie

Sectie 2 van 6

1. Plaatsing Digital Loto

Beschrijving (optioneel)

Afbeeldings...



Verzamelen materialen
- Log in op de tablet met het persoonlijk operation account
- Verzamel benodige aantal digitale Loto's
- Ontvang Loto plaatsing instructies op de tablet

Afbeeldings...

Scherm informatie Loto

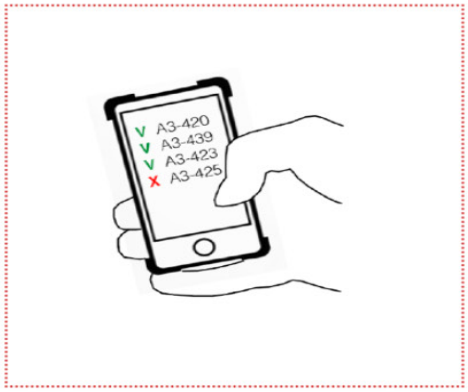
Controleer locatie
- Scan de locatie tag van de valve met de tablet
- Scan de digitale Loto met de tablet om de lockout te bevestigen en het alarm te activeren

Sectie 3 van 6

2. Inspectie Digital Loto plaatsing

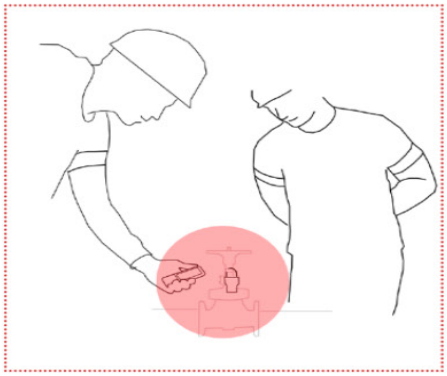
Beschrijving (optioneel)

Afbeeldings...



Inzicht in handelingen
- Ontvang informatie over de benodige inspecties op de tablet
- Documenteer activiteiten en inzichten in de tablet

Afbeeldings...



Inspectie Loto
- Log in op de tablet met het persoonlijke operation account
- Scan de Loto op locatie om de inspectie te bevestigen

Inspectie Loto

HUIDIGE SCENARIO

1. Documentatie inspectie met behulp van checklist
2. Registratie met behulp van computer

NIEUWE SCENARIO

1,2 Documentatie & registratie inspectie in het veld via de tablet

DOEL

- Documentatie met behulp van de tablet
- Stimuleren juiste controle met behulp van tablet instructies
- (Persoonijk) Inzicht of inspecties zijn uitgevoerd
- (Persoonijk) Inzicht of inspecties zijn uitgevoerd op de juiste locatie

Door het nieuwe scenario (2) wordt de Loto inspectie *

	1	2	3	4	5	6	7	
Veel onveiliger	○	○	○	○	○	○	○	Veel veiliger

Door het nieuwe scenario (2) wordt het uitvoeren van de Loto inspectie *

	1	2	3	4	5	6	7	
Veel moeilijker	○	○	○	○	○	○	○	Veel gemakkelijker

Opmerkin

Tekst lang antwoord

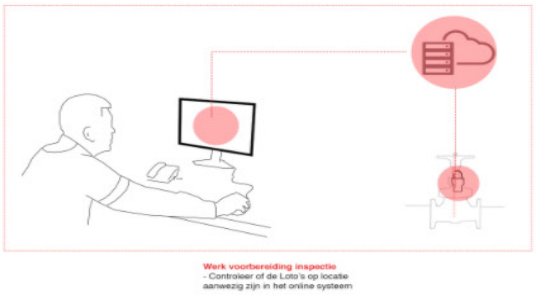
Na sectie 3 Verder naar de volgende sectie -

Sectie 4 van 6

3. Werkvoorbereiding inspectie

Beschrijving (optioneel)

Afbeeldings...



Werkvoorbereiding

HUIDIGE SCENARIO

1. Fysieke inspectie door dagelijks alle Loto's op locatie na te lopen met de werkgroep.

NIEUWE SCENARIO

1. Door het online systeem te raadplegen is de aanwezigheid Loto's op locatie te controleren

DOEL

- Elimineren dagelijkse* fysieke controle van Loto's in het veld
- Vereenvoudige dagelijkse* documentatie voor werk voorbereidingen

Door het nieuwe scenario (3) wordt de *

	1	2	3	4	5	6	7	
Veel onveiliger	○	○	○	○	○	○	○	Veel veiliger

Door het nieuwe scenario (3) wordt het uitvoeren van de *

	1	2	3	4	5	6	7	
Veel moeilijker	○	○	○	○	○	○	○	Veel gemakkelijker

Opmerkin

Tekst lang antwoord

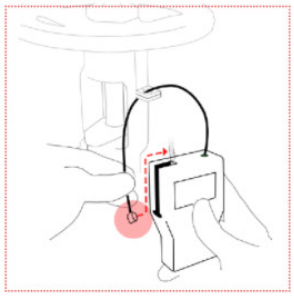
Na sectie 4 Verder naar de volgende sectie -

Sectie 5 van 6

4. Onrechtmatig verwijderen Loto

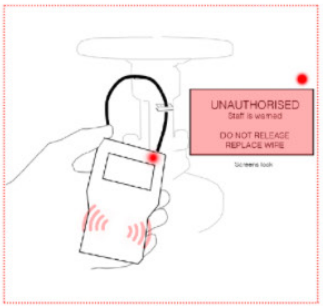
Beschrijving (optioneel)

Afbeeldings...



Registratie verwijdering
- Door de sensor in de Digital Loto wordt geregistreerd of de borging geplaatst is.

Afbeeldings...



Ontgrendel alarmering
-Het onrechtmatig verwijderen of doornkippen van de Loto wordt online geregistreerd.
-Het alarm wordt in werking gezet

Controle op het onrechtmatig verwijderen

HUIDIGE SCENARIO
1. Solide slot
2. Geen registratie onrechtmatige verwijderen slot

NIEUWE SCENARIO
1. Kabel borgings mechanisme
2. Inzicht in Loto's die incorrect worden verwijderd

DOEL
-Tegen gaan van onrechtmatig verwijderen Loto
-Op locatie en in de meldkamer alarmeren wanneer een slot onrechtmatig verwijderd

Door het nieuwe scenario (4) wordt de uitgevoerde *

	1	2	3	4	5	6	7	
Veel onveiliger	○	○	○	○	○	○	○	Veel veiliger

Door het nieuwe scenario (4) is het waarborgen van een veilige *

	1	2	3	4	5	6	7	
Veel moeilijker	○	○	○	○	○	○	○	Veel gemakkelijker

Opmerkin

Korte antwoordtekst

Na sectie 5 Verder naar de volgende sectie

Sectie 6 van 6

EINDE

Vul onderstaande vragen naar uw eigen inzicht in

De implementatie van de digitale Loto routine vraagt van *

	1	2	3	4	5	6	7	
Veel omscholing	○	○	○	○	○	○	○	Weinig omscholing

De digitale Loto routine sluit goed aan op de bestaande Loto

- Waar
- Niet waar

Licht uw antwoord kort *

Tekst lang antwoord

Hartelijk dank voor uw deelname aan deze evaluatie. Mocht u overige opmerkingen hebben aangaande het Digitale Loto concept dan kunt u deze hier onder delen.

Tekst lang antwoord

	A	B
1	Tijdstempel	Uw functie binnen Vopak:
2	1-7-2020 13:00:49	operator OPS Support
3	1-7-2020 17:44:51	Project manager
4	2-7-2020 10:25:29	operators dagdienst
5	2-7-2020 12:50:57	LoTo autorisator.
6	3-7-2020 8:42:04	SHEQ Officer
7	6-7-2020 12:41:50	Assistent Terminal Manager
8	8-7-2020 10:18:41	Cleaning Coördinator
9	8-7-2020 10:29:08	Cleaning Coördinator
10	8-7-2020 11:07:22	Support ops

Participants study

Note: cleaning operators are execute the Loto process and clean the materials as a part of the establishment of a safe work environment.

Appendix 18 - Project Brief

Personal Project Brief - IDE Master Graduation

Design of a smart device to improve tag-locking safety & effiency — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 12 - 02 - 2020 — 08 - 07 - 2020 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

In international harbours, like The Port of Rotterdam, sizable ships transporting oil and gas aim to unload their cargo. By connecting to a piping and storage network of companies such as Vopak and Shell gas and oil can be stored in reservoirs on the mainland. Filling of the correct reservoirs is regulated by a supervisor who assigns which valves should be manually closed or opened.

In this widespread field of pipes and valves, three different stakeholders move across the area to regulate and tag-lock the valves in the piping network. Being the operators; operator X1, operator X2, operator X3.

In case a pipe or valve needs to be replaced strict safety precautions apply to ensure the enormous pressure of dangerous gases can't escape the system. Meaning the direct and indirect valves surrounding the operation remain closed and tagged during the maintenance of pipes and valves. To achieve this all operators are required to individually place a tag-lock on the closed valves, explaining a operator personally authorises the valve being closed. A total of three taglocks, one of each type of operators, allow changes to be made to the system. No locks present allow the valve to be opened.

As flaws in this system could seriously endanger workers on the piping network this so called tag-lock system is used to safely put down heavy machinery. However, the conservativeness of this industry makes this quite an outdated solutions. Making the system smart could reduce human errors, decrease the downtime the valves and create more insight in the process, being a tremendous value gain for the industry. However innovative solutions are not easily tailored to replaced conservative methods. A full redesign of components in heavy industries often asks for expensive processes and new materials. Therefore smart solutions are desired which could be built on existing solutions and allow the interested clients like Vopak and Shell to smarten their industry.

The fast-growing company TWTG, experts in Industrial IoT solutions, aim to smarten the current tag-lock system for these clients. TWTG is able to deliver end-to-end digital R&D solutions to collect, process and handle data for the industry. For the new design of a tag-lock product, TWTG is put to the task to define the required product interactions, functionalities and desired data-collecting technologies and translate these into a concrete product design. To reach this a focus on product design engineering is required to meet their hardware and software expertise.

space available for images / figures on next page

introduction (continued): space for images

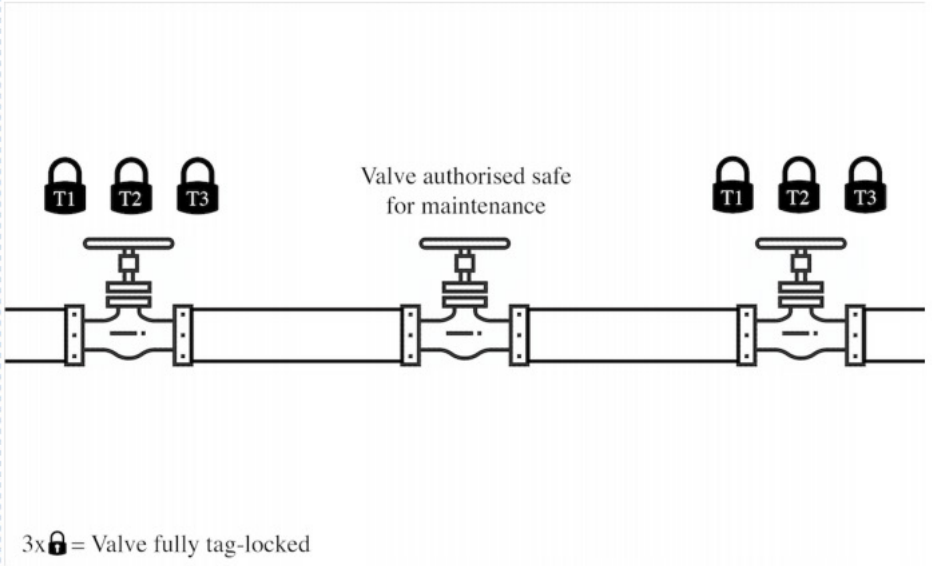


image / figure 1: Tag-lock procedure

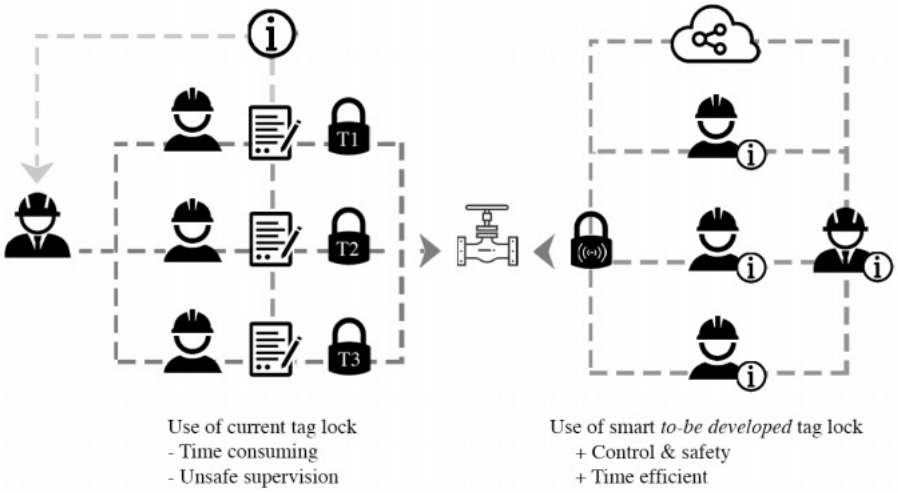


image / figure 2: Tag-lock scenario and to be developed product

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

In collaboration with Vopak, the company TWTG aims to bring a new smart tag-lock to the market. With this product, TWTG wants to enhance the safety and efficiency of tag-locking in the conservative piping industry. Over time, the current tag lock solution has become an overcomplex procedure, invoking various human errors, a lack of overview and being a time-consuming process.

A new smart tag-lock will demand strong tag-lock processes and routines to be replaced. These routines relate to multiple user interactions, different authorisations activities and operators using the tag-lock. Therefore the design of this product should meet safety values and safety regulations of the industry and become able to replace existing routines.

To meet the demands of the industry a list of requirements for the smart-tag lock product should be established. To reach this, the context and processes of the industry will be analysed by field research and consults at Vopak's operational sights. Additionally existing tag-lock regulations, products and processes will be analysed. The goal of these analyses is to identify the nature of the process, the mistakes and the way they happen. During this research, various operators in the industry involved in the lock placing process will be questioned.

With this context and process map, the desired user scenario could be designed for the smart tag-lock product. The desired product functionalities and product interaction will be evaluated with the operators from Vopak. This research will support the generation of a detailed concept design for TWTG, enabling the company to close the gap between the desired user scenario and their IoT embedded hardware and software expertise.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Identify the design requirements for a smart tag-lock device by mapping the process and context of tag-locking valves in the international harbour of Rotterdam. From this generate a smart tag-lock concept enabling the process to become safer and more efficient.

Map the process and context of locking and tagging heavy industry objects in Rotterdam's international harbor. Therefore, identify the design requirements for a smart tag-lock product within the industry and generate a smart tag-lock concept from this.

To support the design of smart tag-lock concept conduct field research at Vopak's piping industry to research current user interactions and related tag-locking processes. With Vopak's resources identify the process of "locking and tagging" an industry object and examine the existing routines present. Document how in this process safety currently is regulated and how this could be improved in the future. Based on these findings establish a list of requirements the smart tag-lock product should include in order to be adopted by the industry and reach a higher level of safety and time efficiency. From this collected data develop a feasible new user scenario to replace the existing tag-locking routine.

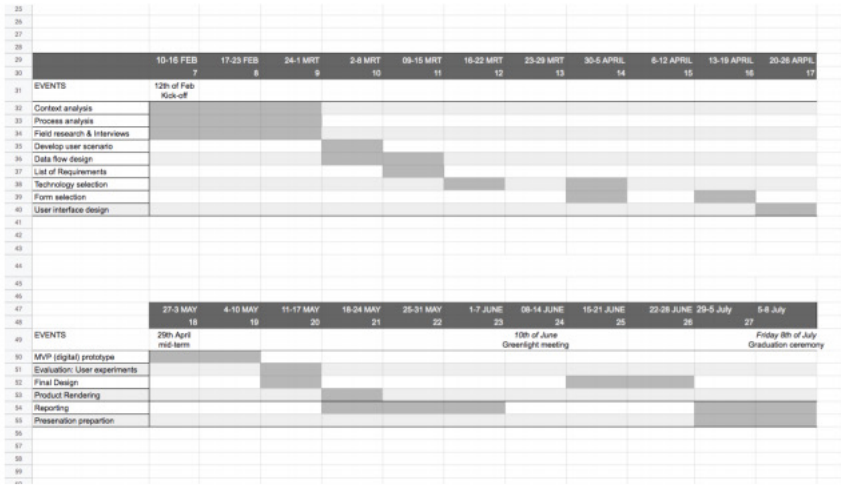
The proposed user interactions and resulting product requirements will be evaluated through users tests with operators from Vopak to support the eventual smart tag-lock concept design. This concept will be generated to demonstrate to the clients of TWTG how this concept functions and enhances the safety and efficiency in the tag-locking industry.

Personal Project Brief - IDE Master Graduation

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date - - - - end date



During this project I wil intensively collaborate with experts and operators related to the smart tag-locking context, being Vopak for the harbour context and TWTG concerning the integrated (IoT) embedded hardware. The goal is the get a thorough understanding of the users their tag-locking activities by consulting different levels of operators, authorities and regulation manuscripts. Communications should be esthablished in an early stage of the project with the innovation manager of Vopak. The network of TWTG can be used for this. Essential design drivers will be extracted from this research to discover the value required to contribute to the tag-lock industry.

With this information, a clear list of product requirements will be developed. These will categorised into different design drivers and back with various point of views from the industry. For the most essential product requirements, qualitative user tests will be conducted to investigate if e.g. the tag-locking functionalities meet the safety demands and regulations of the industry. These findings will support the generation of the concept design. This concept will be established through multiple model iterations, evaluations with Vopak's employees. Meetings with TWTG embedded hardware engineers, Vopak operators and authorisers, as external regulation authorities will be sceduled to design this product along side the interest of the it's users. This to conviences the stakeholders in the industry to break their current routine and adopt a safer and more efficient solution.

Personal Project Brief - IDE Master Graduation

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

My passion is to help businesses reach their maximum potential by implementing innovations and technologies. I aspire to be doing this by making smart innovations commercially attractive and easy to implement in existing practices. In this design project I aim to further develop my IoT product development skills and enable TWTG's clients to adopt smart solutions to improve the safety and efficiency of their current business.

Ambitions
Develop further understanding of design requirements for smart products
Develop further understanding of the product development process for smart products.
Get a feeling for the design of a smart operational model
Co-create with hardware and software engineers
Insight in the potential of the smart industry X and it's solutions

Study related activities
Industrial Design Engineering - Msc. IPD
Advanced Embodiment Design - Smart Jacket Project - 8.5
Prototyping connected products - Data sharing wheelchair Project - 9.1

Extra-curricular activities
Student assistant - TU Delft
Concept development in Japan - Flightcase - Designing Smart solutions for businesses
Board member TU Delft Dreamteam - Forze Hydrogen Racing - Commerizaling Advanced technologies
New Business Development - YEP Tanzania
R&D Engineer - Leapfrog

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name: K.D. Bakker, Karsten
Student number: 4278887
Title of Project: Design of a smart device to improve tag-locking safety & effiency