TU Delft

Ethical task tracking of operators in agile manufacturing

APPENDICES

Sarath Surendranadha Panicker
MSc Integrated Product Design
TU Delft

TABLE OF APPENDICES

DESIGN FOR our future

A - PROJECT BRIEF

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name	Surendranadha Panicker 4840
initials	S given name Sarath
student number	5104858
street & no.	
zipcode & city	
country	
phone	
email	

Your master programme (only select the options that apply to you):

IDE master(s):	★ IPD ○ DfI ○ SPD
2nd non-IDE master:	
individual programme:	- - (give date of approval)
honours programme:	○ Honours Programme Master
specialisation / annotation:	○ Medisign ○ Tech. in Sustainable Design ○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair	Zoltan Rusák	dept. / section:	SDE/ IoT
** mentor	Magdalena Chmarra	dept. / section:	HCD/ AED
2nd mentor	Barnabas Kiss / Peter Slot		
	organisation: Diversey BV		
	city: Utrecht	country:	The Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Zoltan Rusák date 01 - 03 - 2020 signature Zoltan Rusak Digitally signed by Zoltan Rusak Date: 2021.03.15 19:23:24 +01'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: NVT EC

Of which, taking the conditional requirements into account, can be part of the exam programme NVT EC

List of electives obtained before the third semester without approval of the BoE

( ) YES all 1st year master courses passed

(★) NO missing 1st year master courses are:

ID4170 Advanced Concept Design (21,0)

name J. J. de Bruin date 18 - 03 - 2021 signature J. J. de Bruin, SPA Digitally signed by J. J. de Bruin, SPA Date: 2021.03.18 11:51:37 +01'00'

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (★) APPROVED ( ) NOT APPROVED

Procedure: (★) APPROVED ( ) NOT APPROVED

MVE stud.are allowed to start without ACD beingcompleted (it is in their 2nd MSc year), but if the possible addition is not successful, ACD can only be resited from September, and green light can only be given once all courses have been completed,therefore graduation takes unneces.longer

comments

name Monique von Morgen date 29 - 03 - 2021 signature

Initials & Name S Surendranadha Panicker 4840 Student number 5104858

Title of Project Ethical task tracking of operators in agile manufacturing

Ethical task tracking of operators in agile manufacturing — 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 22 - 02 - 2021 — 09 - 08 - 2021 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, ...).

Agile manufacturing has set forth the challenges of adapting quickly to the demand of users in order to configure multiple production lines to manufacturing different products. This activity involves the tedious task of manually configuring of the machines of production line. Expert knowledge in the configurations is essential for efficient and faultless setting of the assembly line. One production line typically produces 10 tons of product 'A' within 20-25 minutes and then it is reconfigured for producing product 'B'. Reconfiguration takes approximately 20 - 25 minutes in case of a simple changeover, while complex changeovers can last up to 2 hours. Changeover times consume around 40-45% of the total production time on average.

The stoppages and faults exceeding 3 minutes are only documented and the tacit knowledge applied by the production line managers in smaller stoppages below 3 minutes goes undocumented. These undocumented data are a missed opportunity in transferring the extensive knowledge of the experienced production line managers to the novice operators in setting up and configuring the assembly line for the corresponding product. Currently the data are captured manually by recording the fault/reconfiguration manually by the person who performed the action.

H2020-COALA project aims to capture, formalize and contextualize tacit knowledge of product line managers about setup, reconfiguration, running, and maintenance of production lines for producing a given product. Through this method, Diversey BV plans to continuously optimize the process of reconfiguration in production lines by capturing the best practices and standardizing them for the respective events happening in the production lines.

The scope of my graduation project is to design a service that is able to ethically capture activities and task of operators and visualize these into meaningful representations. The needs and concerns of the operators as well as other stakeholders need to be researched and relevant data for capturing need to be identified. These collected data of each operator can be converted into meaningful representations for the respective operators to reflect and improve their work.

This graduation project is a part of COALA project of which the major stakeholders relevant here are Diversey BV (client), the novice operators, production line managers, TU Delft, the research scholars associated with the COALA project and partnering universities/organizations of COALA project. The outcome of the project is planned to be implemented for improving the efficiency and best practices in the detergent assembly lines of Diversey Netherlands Production BV in Enschede and Diversey Italy Productions BV.

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introduction (continued): space for images

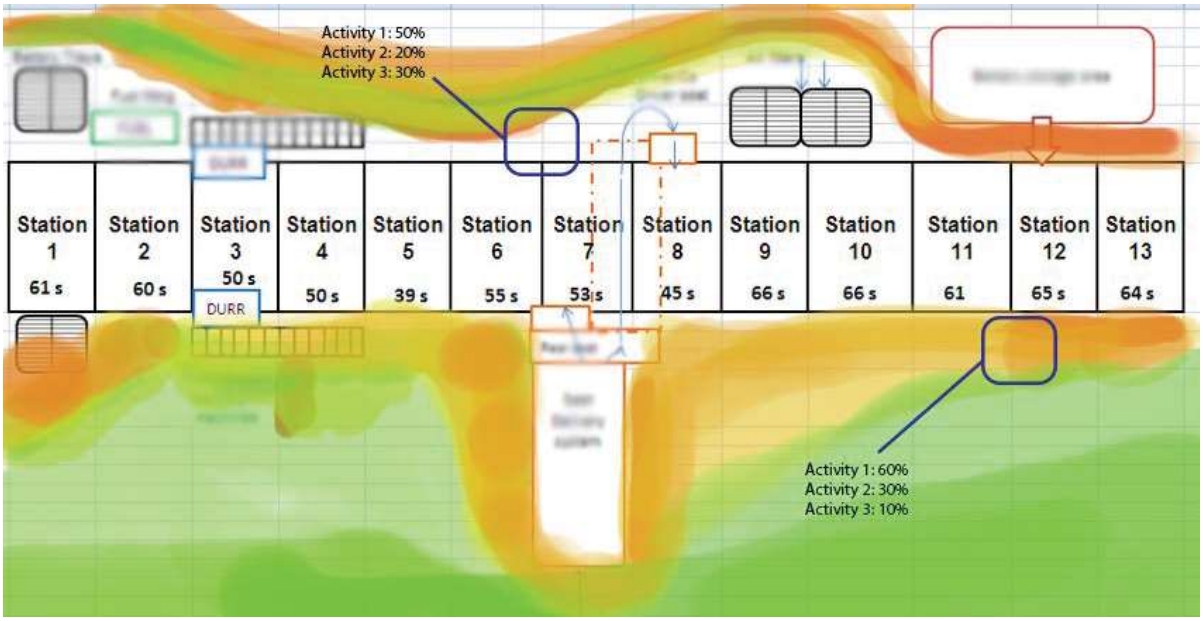


image / figure 1: Heatmap and activity map of operators

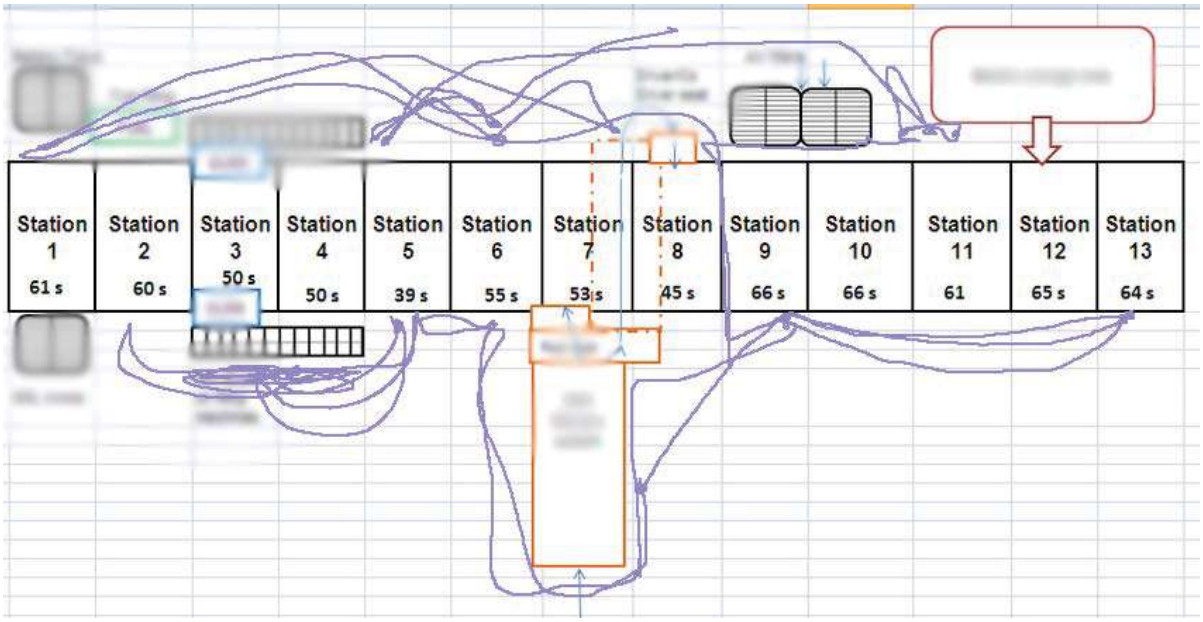


image / figure 2: Sample spaghetti diagram

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.

The focus of this project is the location and activity tracking of operators in manufacturing industry. There is a good potential for a system that captures the best practices of the experts, gained through their years of experience. The design challenge here is to implement a system that collects sufficient data to capture best practices of the operators with an ethical perspective in mind. To tackle this challenge, the following research questions have been formulated:
• What data need to be collected to provide sufficient insights into best practices of operating production line?
• Which are the privacy issues arising from monitoring operator's activities?
• What insights are required by different stakeholders using the captured data?
• How to interpret the captured data into more intuitive representations?

The ethical usage plan is to apply the principles of Value Sensitive Design (VSD) taking into considerations the values and impacts of the technology on direct and indirect stakeholders. This set of VSD cards will be applied on the solution to find how this design can impact the stakeholders, its impact over time and how changes can occur if this technology becomes pervasive. The solution space of the problem deals with how the operator activity can be tracked using Zed2 camera without violating the ethical and privacy issues, and representing this data into meaningful forms for the respective operators. Zed2 camera tracks the skeleton and location data of the person with respect to XYZ coordinate. The collected operator data need to be converted into meaningful representations such as spaghetti diagrams to provide meaningful insights to various stakeholders.

The phases of the project would be to research on what and how to capture data, understanding the stakeholder needs, formulating an ethics plan, filtering relevant data and creating meaningful representations.

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.

This project aims to develop a product service system to ethically track the activities performed by the operators in complex production lines. In order to track these activities, the solution should facilitate the capture of data without direct or indirect identification of the person yet enabling meaningful insights for the stakeholders.

The project will consist of following stages:
1. Research: This phase focuses on understanding the stakeholder needs, privacy concerns and ethical issues in AI through stakeholder interviews and literature research.
2. Analysis: The insights from user interviews and stakeholder analysis will be processed to identify the relevant data that is required for creating the data representations. This will be followed by creation of list of requirement and drawing up an ethics plan for the data tracking. experimenting the way to implement the state-of-the-art activity tracking in industry.
3. Ideation: The ideation stage will be about experimenting the way to visualize the tracking data in industry
4. Conceptualization: Machine learning algorithms and data analytics will be conceptualized to identify the locations, activities and postures of the operators with respect to the stations in the production line. From the data, concepts for data visualization into meaningful forms will be evaluated.
5. Implementation: The final stage is about python implementation for data analytics, off-site testing for data collection, on-site data collection followed by validation of the outcome with the stakeholders.

The final outcome of the project is expected to be a strategy to track the operator activity using Zed 2 cameras and provide the collected data into meaningful and intuitive representations for analysis of efficient operator practices.

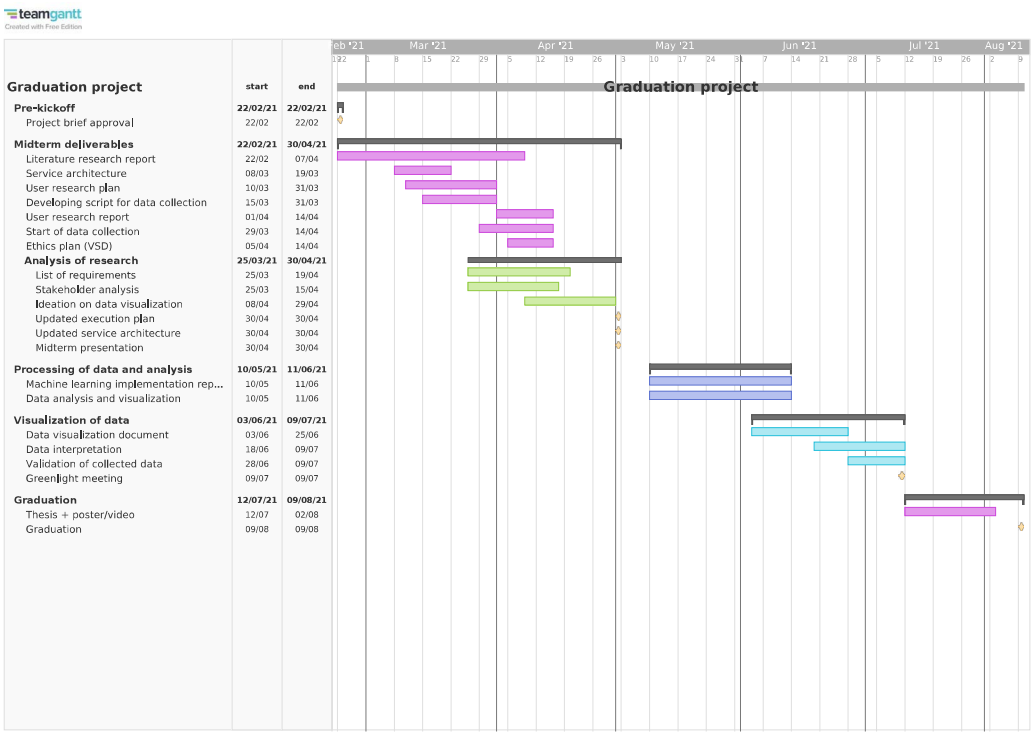
Initials & Name S Surendranadha Panicker 4840 Student number 5104858

Title of Project Ethical task tracking of operators in agile manufacturing

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 22 - 2 - 2021 9 - 8 - 2021 end date



1 day a week will be spend on another course during the month of March.
After the Midterm presentations, a week will be given for break.

Initials & Name S Surendranadha Panicker 4840 Student number 5104858

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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.

This project offers a great deal of perspective in latest Industry 4.0 and Artificial Intelligence trends in manufacturing sector. I have previously worked in an engineering consultancy for 3 years where I had gained extensive knowledge in industry operations and layouts but never got opportunity to implement automation and Industry 4.0 solutions in these projects. Through this graduation project, I aspire to widen my knowledge of manufacturing industries.
My personal ambitions for this project are:
- Developing good skill in Python
- Adding skills to my portfolio - Data Analysis and Artificial Intelligence
- Application of Value Sensitive Design in managing the ethical concerns of the technology
- Understanding the latest manufacturing industry trends
- Working with an international client, mainly the perspectives about data in different countries

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name S Surendranadha Panicker 4840 Student number 5104858

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B - Interview with Quality department personnel

1. Could you explain a bit about your role?
    - Works in quality
    - Checking the cross contamination between products
    - Swab test - checking microgrowth
    - Very important for microsensitive materials
2. I saw that the operators were taking random sample from nozzles before the next product run. How is that done?
    - Rinse the line, take the sample, check if it is foaming
    - The test is done very quickly
    - Checks the pH. It happens parallel while the production line is being set for next run
    - That is the initial testing. There is also another test after the production. One sample of bottle is taken out from the line and tested for reflection index.
3. What are the various activities performed by operators at various stations and do they have a checklist of activities?
    - They should have, but not sure if they do it properly
    - They need to decide with previous shifts what they need to do
4. How often do you observe the activities? Once in a shift, once a week or so?
    - I don't think anyone is observing. But they do have a list of things to do before running the next product. The checklist is on the PC and they do the activities before running it - clean the line, quality, batch no. etc.
    - 4 eyes (another person from a different line) check to be done while running the first product of the shift.
5. Some examples of activities which needed expert operator knowledge?
    - As seen today with the sleeve machine
    - Lot based on experience
    - They do not interrogate, but just adjust

Data -

I read that the performance improvement is done through SMED analysis.

1. Are there any other ways you try to improve the performance apart from SMED?
    - Process lead knows. They have a project on improvement

- I tried to implement the six sigma on the line but was unsuccessful as the data collection was challenging - like how often error occurs? Root cause of the error/ Why?

Representations -

1. What data analysis or representations do you currently use?
    - Data required for root cause analysis. This time this was the issue; next time it can be different issue
    - Camera can identify same issue on same place, then root cause analysis to be triggered
    - Invest by quality and performance
    - If the line stops more than 3minutes, record. Record only symptoms
    - Root cause should be based on data
2. How is the root cause analysis done now?
    - Sitting in a room and doing the root cause analysis
    - If camera is implemented, focus on issue zones

C- Interview with Process Improvement lead

S: What is a normal day as a performance lead? Could you explain a bit about your role?

P: Normal day starts at 8 o'clock, when I arrive at the company. What i will do is calculate and gather the production numbers;numbers from each line; performance for the last 24 hours. 3 shifts from last 24 hours;review for last 24 hours. So these numbers go on a sheet and go on the wall in the smart room.I don't know if you have seen the smart room before. It's actually a lean room, called more like a ror room, for more lean transfer to us is called a smart room. Meaning there are white boards starting with safety, quality, performance for the last 24 hours, issue board, planning board, technical dept. board and one white board for special projects. Actually what we discuss is for the last 24 hours how the production went. If it is okay, actually there are no issues, if not okay there is a sticker on the board. And the sticker is more or less kind of addressing the issue and the issue will be spoken about and will be assigned to who is gonna pick up this problem and would do that. And that goes for production, safety and...the onus of the whiteboard will be available this morning and will be appointed. If it is a small issue, it can be solved within the day and if it is complex it will be done in a kind of project.

S: These issues that occur at site, is that being referred to you when you come back the next day?

P: No, not to me. It is reported to the group. I am a facilitator in all the departments but I am a chairman and I will do the talking. I will guide the group and more and less.. Like in conversational wise and asking critical questions and asking for solutions and when the solutions are done when it is ready and I would like to have feedback and all kinds of..

S: When these operators are doing various activities at the stations, do you keep track of the activities that they are doing?

P: So, what I will do is to make the numbers visible by printing the numbers and I will go by each and every operator and ask if this has happened in the last 24 hours. What did you see out of perspective, out of the operatorview and ask ok, its... it's… high over for a scope and I will ask them across this was the problem for the last 24 hours in your line, in the morning for instance and what is the issue with machines. I will go more in depth, trying to define the core problem in more detail.

S: It's more like manually approaching the operators and asking them what happened?

P: It's more like an interview. I will say Good morning how are you and chit chat about normal life and after 5 minutes, i will go into detail about.. I will show him the numbers and if he is getting the target, yes and no . If he is getting the target, no action no issue and then we talk about our

daily life. What is an issue that occurs in the row room..then if he has more than a stop for half an hour or an hour or something, i will ask him in a short interview, so what happened, what did you do, what was the problem was maintenance involved and things like that. I actually try to analyse what happened with the machine the day before.

S: So.. I know that you are implementing the methods to understand the activity performance. So how often do you implement this? Like once in a week, once in a day, shift, etc.?

P: The implementation is if it's like, normally these issues are small issues or 15 mins or half an hour and the problems about the sensor, the adjustments of the machine while there is a changeover, then you adjust which went well , so there is no action taken for the performance. The sensor that is out is like good aligned then there is no action taken. The action taken when it has gone fast behind and if it is not the technical issue, the technical issue is not solved by the maintenance and then it gets complex and then you get a project like Kaizen or 5 why,... all kinds of lean tools to get to the root cause for analysing.

S: something to do about the operators, do they have a list of activities; something they should look into when they do this. Do they have a sequence or so?

P: In the right protocol, they have a sequence called SWI. It is a standard work construction but they're so ...most operators are that skilled that they do it by heart. They have done so many times and so yeah.. Small mistakes.. Normally it doesn't matter. That skilled normally wise it is not a problem.

What you can see is there are less skilled operators, they are well trained with work construction at hand and they are taught by doing. It is not a proper way to do it. What they need to do is… actually especially, when there are new, fresh operators that have not all the skills that needed like fully matured seniority operators .. actually what they need to do is they need to check these boxes they need to check. This is the thing from number 1 to number 50, this will run properly. What you see is what operators that have skills and the ones new at the operators say within a year, they think I know it by heart but still make mistakes. For things that need to be done left to right, they put it in right to left or its front back.. Such kind of things. You will see that once in a while.

S; when you look at the performance improvement, is there any station that came to your notice?

P: My full attention for .. i would say 80-90% is the 5L line, the one where you put the Zed 2 camera.

S: In that line, is there a specific station which has problems?

P: I would say the depalletizer and the cans come from outside… come from a truck and then they get on a conveyor, its a rolling conveyor, like bars and the pallet will be stacked for total for

9 pieces and the mount from the line, one pallet comes inside, one robot, more or less from the line, depalletizes the cans onto the table that feeds the machine.

S: So, that is where you have encountered most errors?

P: That and the filler itself. Sometimes it's the depalletizer, sometimes it's the sleeve machine, sleeves coming from the vendor are too tight. Then sometimes you have an issue. Depalletizer cans falling over, that's an issue. Sometimes spilling actually the fluid…. That will sometimes be an issue. More for the filler. Quality… when the can is dent, it cannot be filled by the filler, then you get a crushed can, the spill...you need to remove the can and clean the spill… sometimes the check weigher does not give feedback to the machine to stop.So.. Sometimes there you got a jam...uhh… if you have a spill on the conveyor belts will be contaminated and eventually will be slippery. Coz in the end towards the stacking tech and onto the pallet, there is a spiral, the conveyor belt will be slippery and cans will be slipping down the spiral. That is the issue. So...yeah.. Here and there and most of them are recurring.

S: How important is the labeller area? Is that an error prone area?

P: Labeller was done last week. The label checker and that checks if there is a label on the can. That has been fixed last week.

S: So as of now the errors are less in the labeller area?

P: Yes. Yes. What the maintenance dept. do is to give some construction on papers like, also like again work construction and once this is done, the action is complete.

S: When a fault is reported, what are the actions you have to take?

P: What will happen is a kind of an escalation model. This escalation model is written and stated that you can fix the problem by yourself and if it's been done within mins. If not, you have to call your PO, the technical assistant who has more knowledge than yourself and he will try to fix it together with the two of you for the next half an hour. If he can't fix it, the POer will call the technical dept.and the maintenance guy will come and try to solve it. He makes a report and he makes a written comment in the system formaintenncce dept and is called Maximo. He writes the registration of time and text what he has done all along he took to solve the problem. This one the maintenance guy will make a report, also the production makes a report. This will be summarized as a report for today and will be spoken at the 9 o'clock meeting next day.

So from all three angles, there is a notification and will be discussed at 9 o' clock and further action to be taken will be addressed whoever is responsible.

S: I read that the performance improvement is done through SMED analysis. Are there any other ways you try to improve the performance apart from SMED?

P: Oh yes. SMED. But also run rate how fast the machine goes. What i will try to do is… It is like a simple product that looks like water and alcohol, it can be fast filled not foaming. If it is still low,

I will ask him to go to maximum and once you reach the maximum without any aviation or flows or mechanical issues, then that will be your new standard. When they are trying to…. last period is that the run, say at 55, I will challenge them to go as fast as possible and once you reach 100% backup a little bit and that your technical wise getting into problems run at 90%. So I will try to, I would say, dare them to enhance boundaries.

S: Are there any factory-specific limitations with SMED data collection? (large area, difficult to integrate data, etc?)

P: Limitations are specific per product. If for instance, let's call it hypochlorite, that's a product which needs to be filled slowly. If the product has very thick filling, filling takes longer than usual alcohol products. So here and there if you can divide it into 4-5 product families, thick thin foaming, unfoaming, hypochlorite, feeding 10L cans by manual, if it's done automatically after this week, this will be done automatically, the time goes up like 100%. Coz now we are depending on the manual labour that takes can from the pallet and puts manually on the conveyor belt.

S: During SMED, where there some specific parameters which were difficult to collect manually? Will automatic collection of data help you in specific parameters. Could you give some examples.

P: What would be nice is have .. like… standard protocol stand or recipe that says if you are running this product, setup is fixed at 35 or 45 or 55 its needed from there on. If so speed from 80% tweak them here and there. Use some small adjustments that make the machine run at 90%. So start a little below lower and as a standard gives you no problem at all and start to bit by bit tweaking so that you gain 90%.

S: Is that the type of fine tuning the operators do?

P: That's what they should normally do. They are usually running in convenient mode. They are not lazy but say in their comfort zone. The prediction is that small or no downtime. If you are going to try to reach the 100% max to machine and backup a bit, then you need to be very skilled and if there is a problem, it needs to be solved and not everybody is trained for that problem.

S: So with COALA, they may not need that training and directly start in a most optimal way. Is that what you are thinking?

P: Yes. Correct. And give them this perspective from this COALA, a hunch two or three options - have you done this - have you done this? No? Then do this and see the result so that you can funnel your problem more or less. Continuity with max tech that you want.

S: How do you usually compare the data from different analyses?

P: Not yet. You can compare operators among each other. So, for instance, rinsing the whole process from mixing to filling each and every operator has a different kind of rinsing the machine . So there must be a best practice for all the operators.

S: Currently, are there any manual methods you use to get the best practices?

P: Oh yes. There is. But sometimes it's not followed by the whole group. That's more or less the issue.

S: How do you do the manual best practices? How do you identify?

P: Identify by how they do it by looking at it. Do a time measurement, collect them, write them down and compare with each other. And then put information added to it like… how did the tech time, how they run it, what will be the fastest and how many SKUs they do in this time. Eventually, that gives you a tech on for each product family I make an approximation that gives you the prep the mean and the average value and I will compare it with each operator that runs this line for say 80% of the time. I will get an overview for changeover along each operator and how long it takes for each operator. I collected manually at the line physically by myself.

S: Does it not take other colleagues to do it together?

P: Yeah but, time wise.. Actually I am the only one… They are too busy running the process. I would say they don't have much spare time to collect this kind of data. I will ask him about this and it's not standard.

S: how often do you do it?

P: Few months, I will do it by myself. I would say, once every 4 weeks.

S: During the meetings Barnabas used to mention about safety being an issue on the site. How often do safety issues occur on site?

P: I wouldn't say that much

S: Is that something that is interesting for COALA to explore if the frequency is very less?

P: What would be good to check … safety first at the plant or would say there is not too much of the occurrence that it happens at the line.

S: Do you have any numbers or frequency how often it happens?

P: I need to ask the safety officer. On top of my mind, I do not know.

S: How do these safety issues occur? Some examples.

P: safety issues would be like a spill… or contamination with acid and other stuff that can't be mixed. Sometimes if you need a product and one of the hazards could be … mixing two products that can't be together. So that forms like a hazardous contamination and risk of explosion.

S: At the site, can it cause an explosion?

P: Yes

S: are there any safety issues that arise from the side of operators?like something that can be seen with the camera? Like running or lying down on the floor can be considered a safety issue.

P: Sometimes it is… Sometimes at a fast pace or running you will see that sometimes. That would be fine to detect. Lying on the floor like more than 2 mins.. This could be some reason that someone is not well. But that's an incident that never appears here. Maybe wearing the safety mask can be recognisable. Dunno if it is feasible. Like if you have a problem with the filling machine, you open the machine and there is an acid spill. There everyone wears safety goggles. Maybe it can detect a full face mask. If it is required. Maybe it can detect wearing gloves when it is needed on some special products. Ya.. I would say there are not too many occurrences that I know of due to high risk of safety negligence.

S: If anything occurs, how is it usually identified and rectified?

P: You mean like an accident?

S: Ya

P: A while ago someone had his fingers between two boxes. That was kind of an accident but he got only a swollen finger. Got some cold water and got some band aid on his fingers. We reported this into a special system called ALIS. There are some docs to be filled, What was the cause of the accident? If he is at home? If he is hospitalised? This kind of information. Actually it is an excellent report.

S: Something to come back to in data analysis and representations. What is the type of data analysis or representations you are using to visualize? Do you use any data viz. to compare the data?

P: Actually in the whiteboard, you can see the time efficiency, the time SKUs has been done, per shift for the last 24 hours. What we can see is the demand in the market. You can see the target for the last 24 hrs and if the target has been reached. If not reached, the report on downtime and this downtime is analysed. Ths is made once a week and we have a review data meeting where we go back in time to the last days. So and explain how the downtime occurred. What was the reason for that and what was the action taken to resolve this for the future

S: Currently it is like a tabular form. Do you have any viz. like a graph or chart?

P: Actually it's not ready yet, we are actually looking into getting the data from the database. I have made a template where you can see the target and actual. You can see downtime. You can see the pareto. All kinds of information in one template and is like in an A3. That will be made in the near future. I would say this week or maybe next week we are able to retrieve all data from the database and ICT company is helping in retrieving the data and put the data into the right spot. That can make it every morning to recall the last 24 hours having this filled in template.

That was if it was a future idea and now it is getting realistic. In a matter of a few days it is completely done.

S: Do you viz. anything like an operator walking path, activity they do. Is there anything that has been done manually?

P: Like a spaghetti diagram?

S: Yeah

P: not being recorded at all.

S: Are you interested in having that also?

P: Yes. If you are installing the Zed 2 camera, it can get the positional data. It can find if it is a changeover or a problem or module on a certain machine. If that is recorded, any indication of where the operator has spent most of his time.

S: In the data you collect for the 9 o' clock do you use any ML techniques in patterns?

P: No. It's done manually. If something is recurring we need to pinpoint yourselves by looking into a list.

S: would you be interested in applying suc tech to find unforeseeable patterns?

P: Yes. Like looking forward into the future. If you can predict the future that would be nice.

S: I will see to that. Right now you said you are observing the activities. So instead of having a person observe the activities, we are planning to set up a position sensor which could detect the skeleton data, something like this. We take the skeleton you see here and export it into an excel sheet and do the analysis. What are your thoughts about such a method? What value does this give you?

P: Well… You need what would be important to me is like.. For instance time along, is he working at a station.. To define it as a downtime issue or changeover, this would be very interesting to know. The time what would be the average. Spreading deviation would be nice to have . What would be avg for changeover for an operator or what would be the downtime for a specific module that can be found the same problem as the week before and the one before. So.. how to deal with this problem. Actually what you could see is a skill matrix for the average operator how long does it take to solve a problem.

S: When you viz. The data would you prefer certain parameters, the way you wanna visualize it like per SKU, per shift , etc.?

P: What you can viz, is whether it is 5L or 10L can or if it is using a sticker or sleeve, that would be nice to recognise. It can assist to recognize the cap?

S: It would be difficult. As of now, the camera is made to sense only the operators. It can not sense whether it is 5L or 10L. Is it possible this data can be taken from the PLC? THs system where they input all the data. Is it possible to sync the data between PLC and camera?

P: I don't know. This question you need to ask the electronics guy in the maintenance dept.

S; Could you send me his details?

P: Yes. His name is Geert and Michael Winkelman. I will send you their details.

S; That would be nice. Since they do not know me, they would not be answering them.

P: What i can do is,,, if you need to interview them as well. At first, you can get in contact with Herman, he is the maintenance manager. He can help you get in touch with these two guys and explain what is possible. It can be like 10 mins or if you need anything more you need to schedule it. If you get approval of Herman, that's great.

S: You mentioned about downtime vs changeover. Since the camera is based on visuals. Is there anything that visually is recognisable for this?

P: Probably you need to track the changeover and I would say analyse what would be the average. If the average above 10-15-20%, then you can recognize it as a downtime.

S: My question, I was asking about when the machine is not running, how can I identify that there is a changeover happening or its a stoppage happening?

P: I would say, during changeover there is always some rinsing. With changeover, there is a rinse process, that would eb a trigger to say, that would be time of changeover….

S: For the camera to recognize it is difficult to classify?

P: What you could track is a station where rinsing is being done. There is a module called HMI. THis HMI is specific for rinsing. So, if he spends a lot of time over there, it is a changeover and he is rinsing. So this is a trigger. The module if you are standing in front of the filling station. There Is a box which is the HMI to start rinsing.

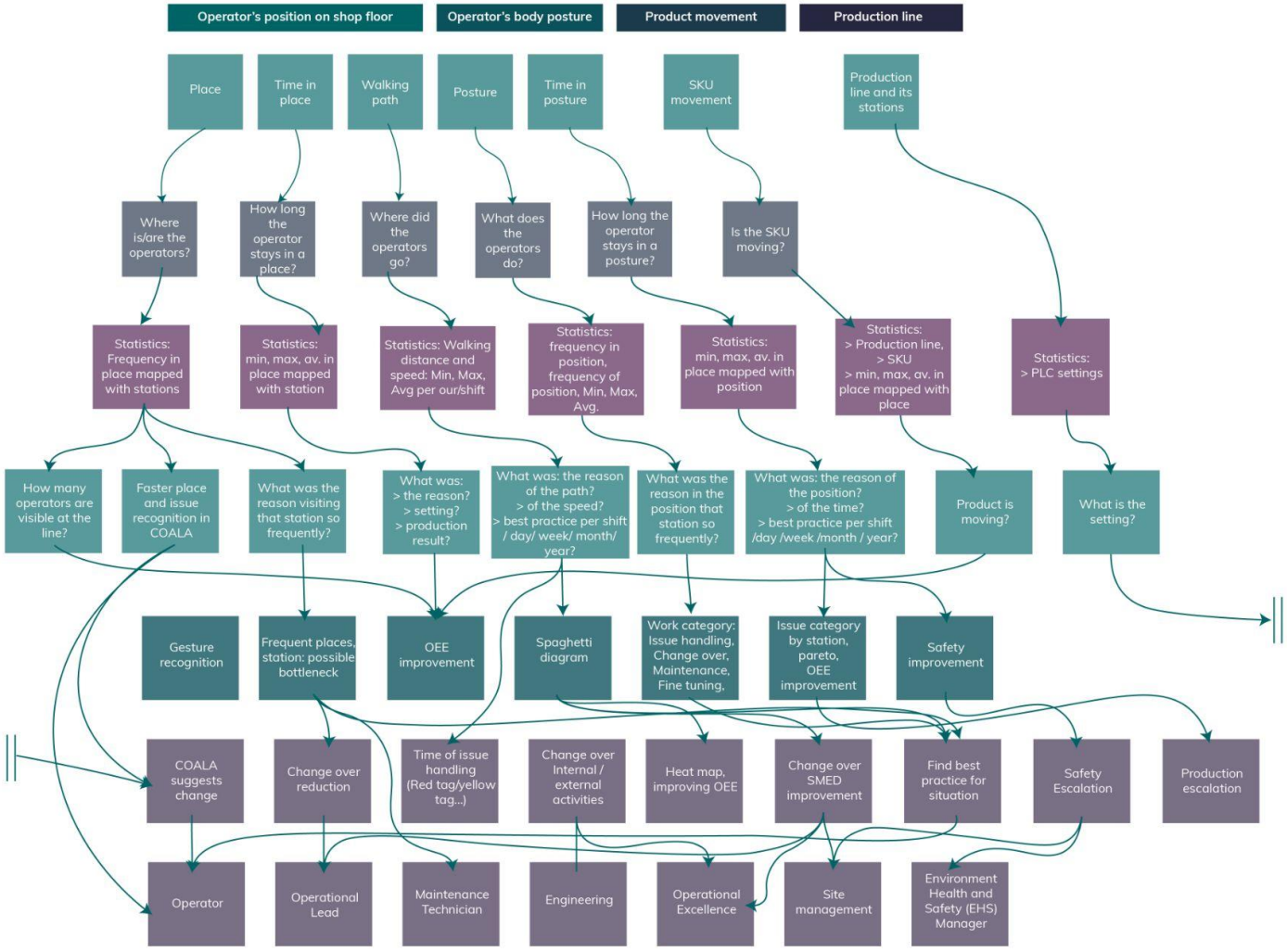
If you see a busy occurrence over there, then it is a changeover.

S: Ya, that's all the questions I had of now. That was great. Was nice talking to you. I got a lot of ideas.

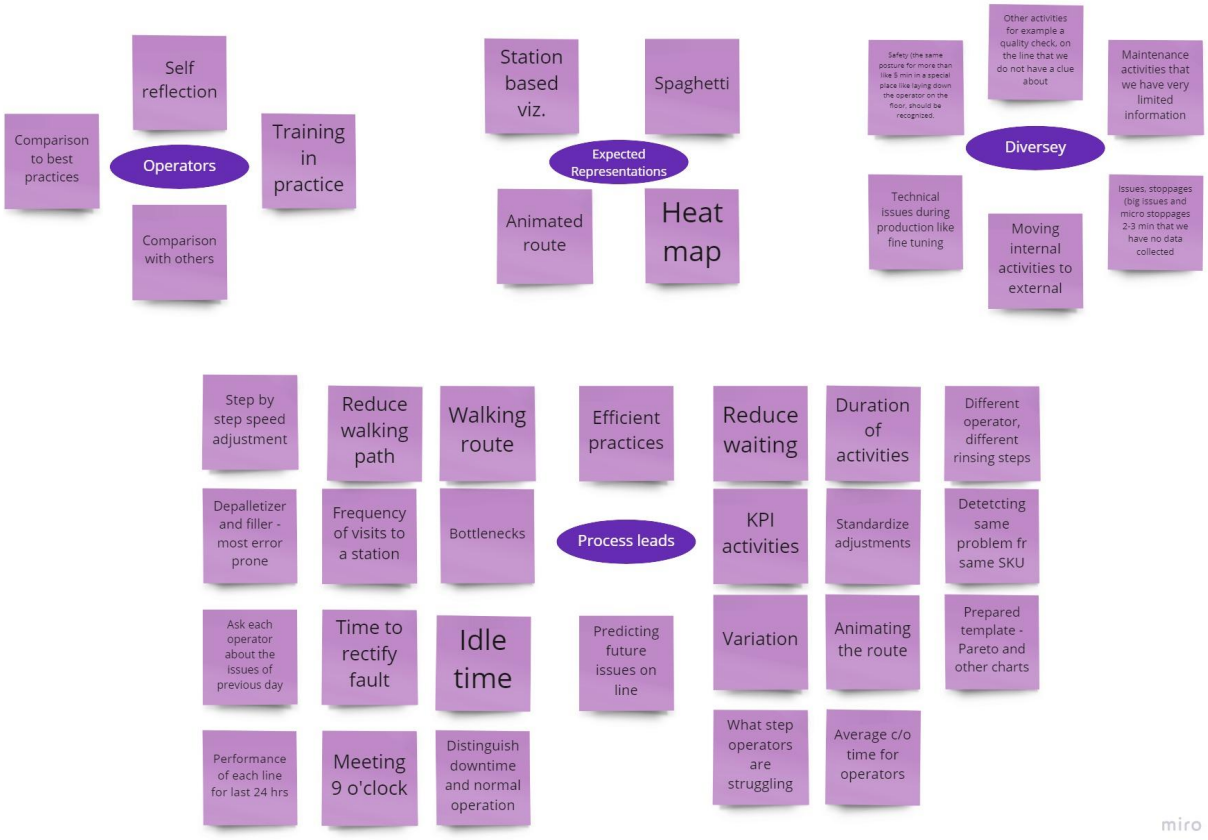
P: Thank you

S: Thank you. Bye

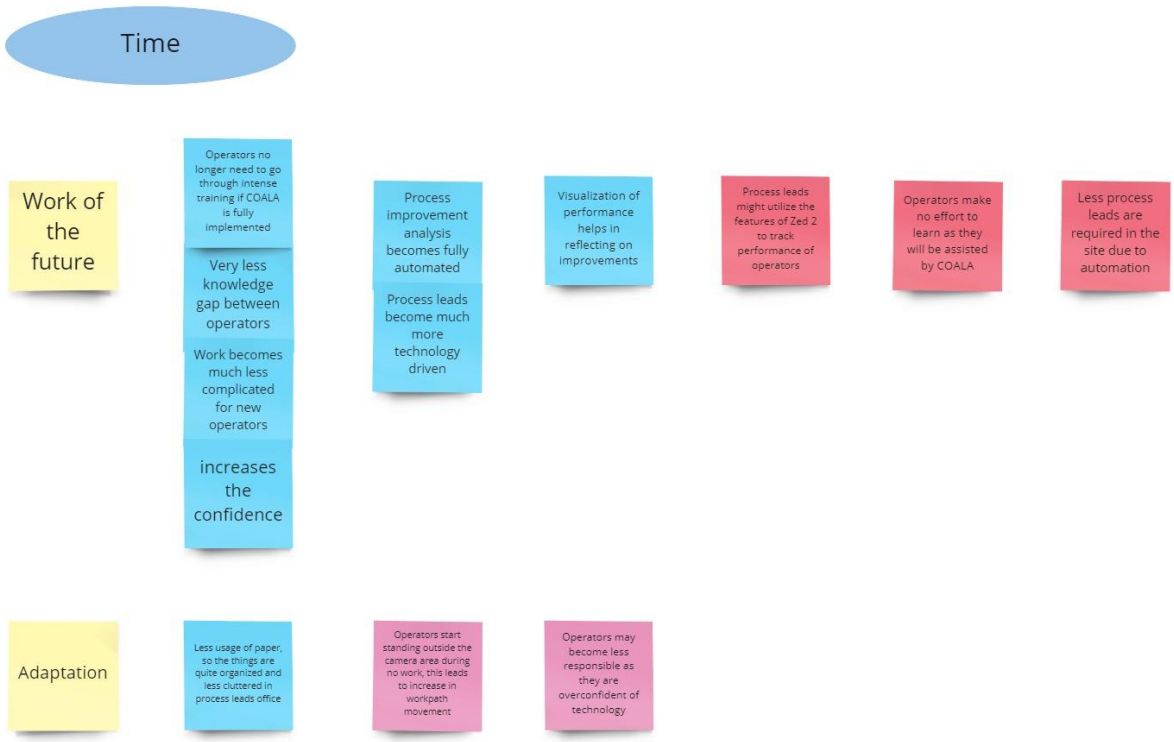
D - Brainstorm session with Diversey

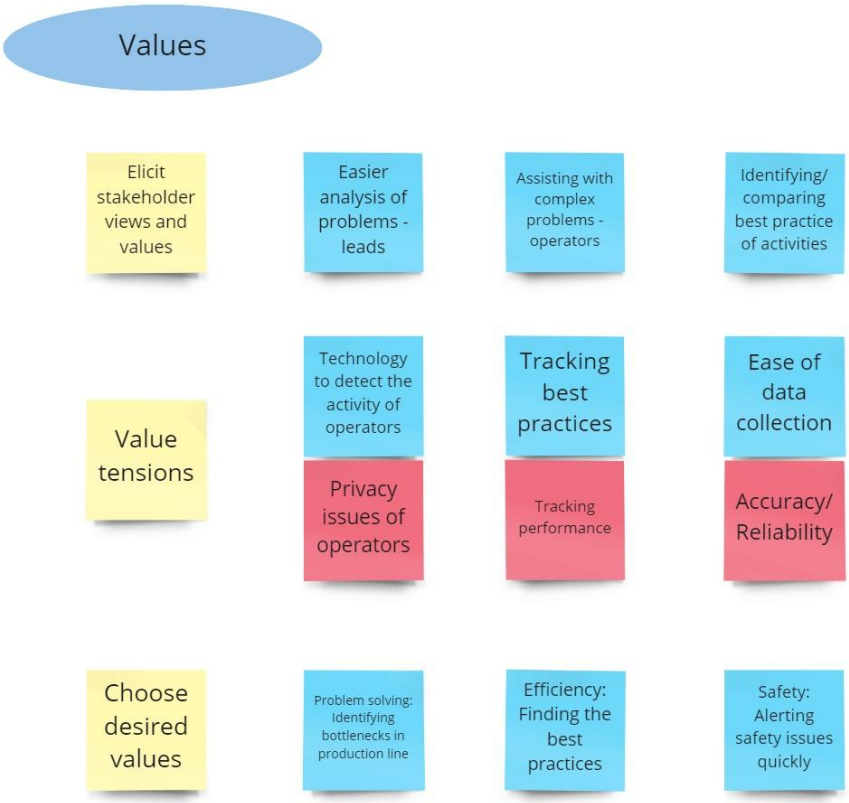


E- Stakeholder analysis



F - Value Sensitive Design


Time
Work of the future
Operators no longer need to go through intense training if COALA is fully implemented
Very less knowledge gap between operators
Work becomes much less complicated for new operators
increases the confidence
Process improvement analysis becomes fully automated
Process leads become much more technology driven
Visualization of performance helps in reflecting on improvements
Process leads might utilize the features of Zed 2 to track performance of operators
Operators make no effort to learn as they will be assisted by COALA
Less process leads are required in the site due to automation
Adaptation
Less usage of paper, so the things are quite organized and less cluttered in process leads office
Operators start standing outside the camera area during no work, this leads to increase in workpath movement
Operators may become less responsible as they are overconfident of technology


Values
Elicit stakeholder views and values
Easier analysis of problems - leads
Assisting with complex problems - operators
Identifying/ comparing best practice of activities
Value tensions
Technology to detect the activity of operators
Tracking best practices
Ease of data collection
Privacy issues of operators
Tracking performance
Accuracy/ Reliability
Choose desired values
Problem solving: Identifying bottlenecks in production line
Efficiency: Finding the best practices
Safety: Alerting safety issues quickly

G - Site observation results

Observation plan

1. What are the operators doing? How many are working at the same time?

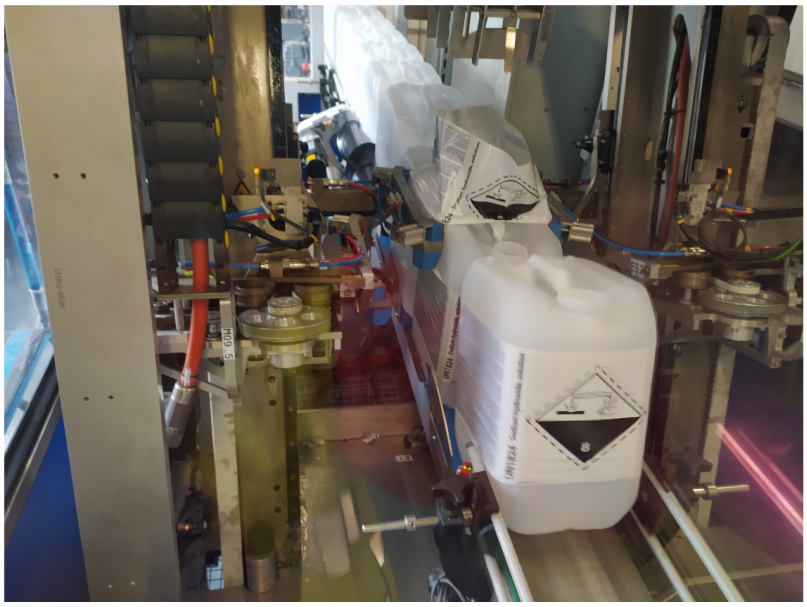
- The operators are always on the run for one thing or the other. Start of the production run, one operator handles the cleaning process and the other with the input of the next run into the system. Most of the time errors were occuring and operators were constantly looking after some issue. There were small gaps in between the stoppages. The person who worked on the stoppage will take care of inputting the error report into the system.
- In case the line changes from 5L to 10L, few of the activities to do are:
  - Capper change

➢ Sleever roll change

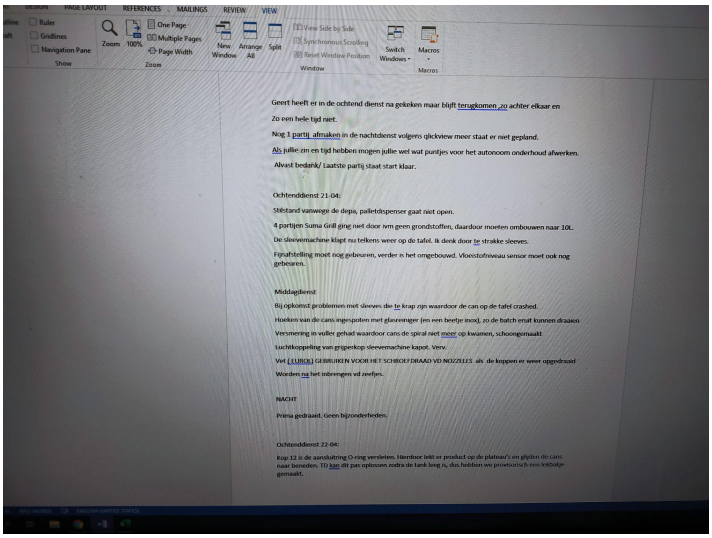
❖ Canister loading (10L canisters are manually loaded while 5L are machine automated loading.

- Flushing the nozzles of filler stations. Once flushed take a sample to check pH.

- Faulty canisters were removed manually by operator



- The stoppages beyond 3mins were documented on PC



Geert heeft er in de ochtend dienst na gekeken maar blijft terugkomen ,zo achter elkaar en
Zo een hele tijd niet.
Nog 1 partij afmaken in de nachtdienst volgens qlickview meer staat er niet gepland.
Als jullie zin en tijd hebben mogen jullie wel wat puntjes voor het autonoom onderhoud afwerken.
Alvast bedankt/ Laatste partij staat start klaar.

Ochtenddienst 21-04:
Stilstand vanwege de depa, palletdispenser gaat niet open.
4 partijen Suma Grill ging niet door ivm geen grondstoffen, daardoor moeten ombouwen naar 10L.
De sleevemachine klapt nu telkens weer op de tafel, ik denk door te strakke sleeves.
Fijnafstelling moet nog gebeuren, verder is het omgebouwd. Vloeistofniveau sensor moet ook nog gebeuren.

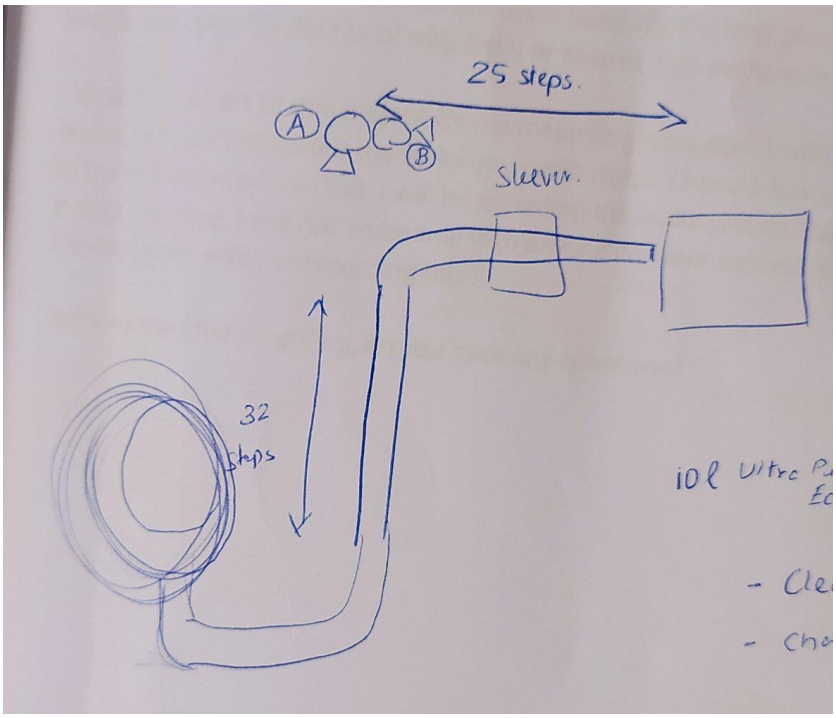
Middagdienst
Bij opkomst problemen met sleeves die te krap zijn waardoor de can op de tafel crashed.
Hoeken van de cans ingespoten met glasreiniger (en een beetje inox), zo de batch eruit kunnen draaien
Versmering in vuller gehad waardoor cans de spiral niet meer op kwamen, schoongemaakt
Luchtkoppeling van grijperkop sleevemachine kapot. Verv.
Viel [EUROL] GEBRUIKEN VOOR HET SCHROEF DRAAD VD NOZZLES als de koppen er weer opgedraaid
Worden na het inbrengen vd zeefjes.

NACHT
Prima gedraaid. Geen bijzonderheden.

Ochtenddienst 22-04:
Kop 12 is de aansluiting O-ring versleten. Hierdoor lekt er product op de plateau's en glijden de cans naar beneden. TO kan dit pas oplossen zodra de tank leeg is, dus hebben we provisorisch een lekbakje gemaakt.

- Two were found working at the same time on the line.

2. How big is the area?



Each step is around 30cm
So approximately 7.5m from point B to canister loading (rightmost station in diagram) and 10 m from point A to labeller (bottom most point in the diagram).

3. Is the area illuminated well for detection?

Yes. except the canister loading area is separated by a film partition.

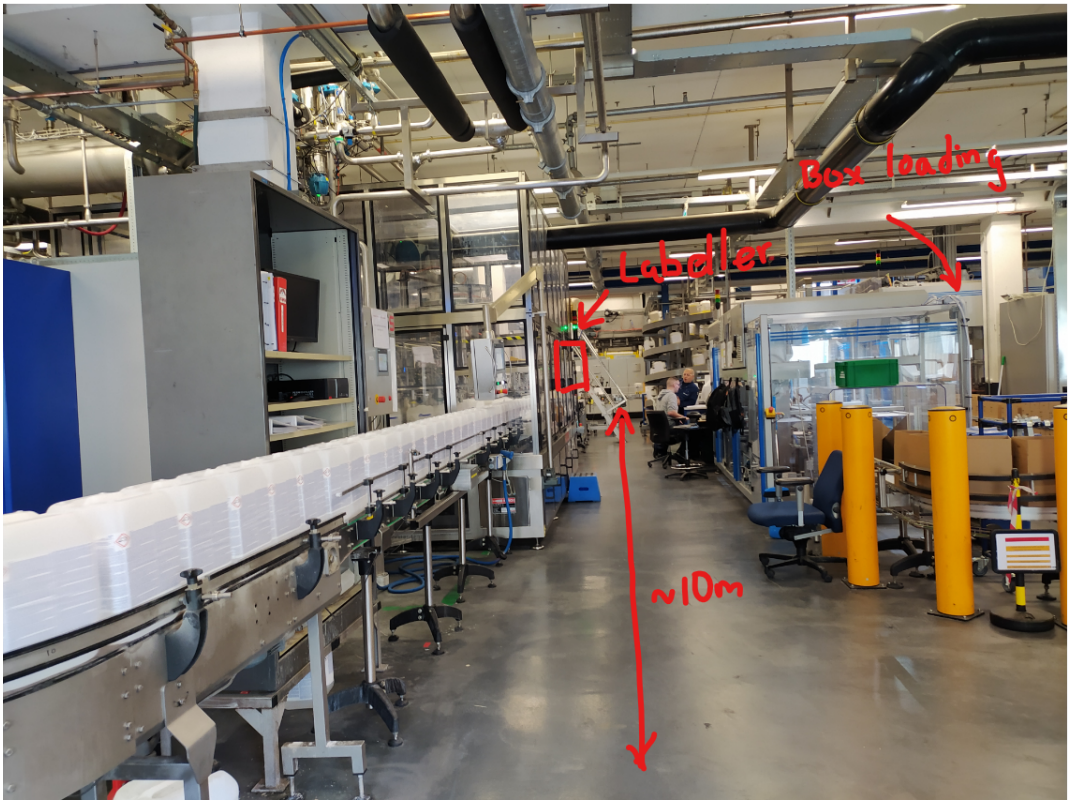
4. How do they react to the events?

They are quick to go check the errors. Did not see them struggle to find where the issue is. Eg: (1) The sleever machine had a problem on the day. When the line stops and alarm beeps, they directly go towards the machine and start to rectify it.

(2) The cleaning water discharge was collected in a big box as shown here in the picture below. Once during the cleaning, the box was full and started foaming outside. There are two boxes and have to manually open the valves to direct the liquid to the boxes. Once full, they move it using a pallet jack (seen in the picture).

5. What are the suitable positions for the camera?

Option 1: The suitable positions are from the camera points marked A and B in question 2.



Option 2: Atop the spiral conveyor (facing towards as shown in picture). Mixing station and the box loading area can be tracked from the at position. Labeler will be missed in this view.

6. What are the tools used?

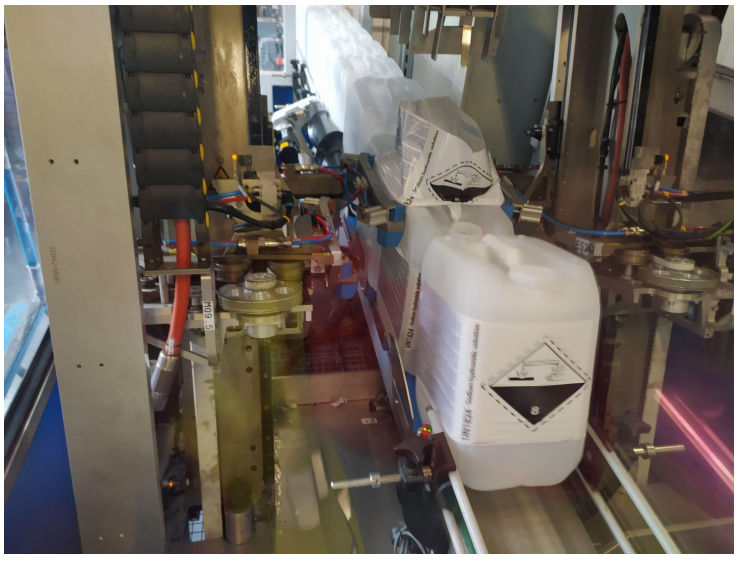
N/A. Saw them use only bare hands for all activities.

7. How frequent are the activities?

Issues found today:

1. There was leak/dripping during filling that the canisters started slipping back downwards on spiral conveyor (after labeller)

2. Sleever was always causing errors. Operators were quick to decide that it's because the sleever label was too tight



Usually some fine tuning done after such events; reduced speed of running, etc.

Refer to the next page for the frequency table of activities.

8. Interview for further information. New questions?

- Why were the canisters weighed randomly during the run?
    - At every 30mins, one random sample will be weighed on a separate weighing scale. The value has to be noted down in the worksheet.
- How did you rectify the sleever issue?
    - The issue seemed to them as the sleeve was too tight for the canister and that caused it to crush it.
    - The sleever roll was fine adjusted - like tapping on the roll from the top. Tearing off and removing three or 4 sleeves from the roll
    - Reducing the PPM of the line.
- What were the main technical issues encountered in the line?
    - Filler encounters problems sometimes
    - Ink printer that prints batch code. Sometimes the printing is not proper, the ink nozzle may need to be checked and corrected before continuing the run.

New table

Machines	Cansiter loading	Canister set rolling	Sleever	Filler	Capper	Weight check
Activities	Manual loading for 10L		1. Change roll when empty 2. Change roll during changeover 3. Adjust sleeve / remove some sleeves when issue occurs	1. Sample taken before changeover 2. Spilling occurs then cleaning of area to be done.	1. Change capper for changeover	1. After a stoppage all canisters crowd together at the weight check point. To be rolled on to line manually
Events						
Frequency of events	-	-	5	1	2	-
Camera location	Option 1	Option 1	Option 1	Option 1/2	Option 1/2	Option 1/2

miro

New table

Machines	Box loading	Box opener	Box bottom sealer	Box packing	Box top sealer	Labeller	Box arrangement
Activities							
Events							
Frequency of events							
Camera location	Option 2	Option 2	Option 2	Option 2	Option 2	option 1	

New table

Machines	Waste water discharge						
Activities	1. Has to be moved out of the place when full using pallet jack						
Events	The box was full and started foaming						
Frequency of events	1						
Camera location	Option 2						

H - Pilot test results

Goal:

- To identify best height position of camera setting
- To check the XYZ axes direction of a camera pointed downwards at an angle.
- To identify the limits of the camera (range, obstruction)
- To identify the consistency in captured operator skeleton data during performing the same task in a large area similar to the production floor.
- Identify the hand movements and interactions at different angles to camera (facing forward, back facing, sideways)
- Detect the position of person with respect to a station
- Identify the difference in walking pace to detect the emergency of the event.

Equipment:

⬜ Zed 2 stereo camera (own)
⬜ Nvidia Jetson Xavier (own)
⬜ USB connector
⬜ Keyboard (own)
⬜ Mouse (own)
⬜ Masking tape (PMB)
⬜ Extension cord (own)
⬜ Markers (own)
⬜ Facemask(own)
⬜ Overalls (PMB)
⬜ PC screen (Servicepoint)
⬜ Measuring tape (Applied Labs)
⬜ Standards to inform about experiment (Servicepoint)
⬜ Sanitizing spray and paper tissue (Servicepoint)
⬜ Camera stands (Applied Labs and Servicepoint)

Test setup:

Zed 2 camera powered by Nvidia Jetson, containing the code for data collection, which would be connected to the power socket available in the setup areas. Peripherals such as mouse and keyboard for operation and running the code. A PC screen from the faculty will be used for visualizing and real-time validating the captured data. Masking tape and markers will be used

for designating the points on the floor. Stands will be used to set up the Zed camera at a height.

Figure 1: Coordinate system of Zed 2 camera

Figure 2: Test setup

Test plan:

The participant would be wearing the workshop coat from PMB and a face mask. The test will capture the XYZ position data and XYZ skeleton data of the participant. The location of capture would be downstairs the main hall and the camera would be set up at different heights. The Zed camera would be set at an elevated height using camera stands. The whole experiment would be recorded only for the purpose of double-checking the collected data.

Before start:

- ⬜ Sanitize the working desk
- ⬜ Code ready to run
- ⬜ Camera test run
- ⬜ Overalls from PMB
- ⬜ Information stands
- ⬜ Face mask

First test: Identify the best positions for camera height

“This experiment is to find the best height to set the camera. The object detection ability of the camera from different heights will be measured. First I will set the camera and the necessary setup. What you have to do here is to walk in the vision of the camera in the direction I specify at a normal pace. When I lose the object detection, I would ask you to stand still at that point, maybe walk backwards a step or two to confirm the range. First stand 5 metres away from the camera and walk towards it to measure the nearest point. We will do this thrice. Next you would walk away straight from the camera to measure the farthest point. This also will be done thrice”

1. Mark point of camera with masking tape. Note down the height of the camera set up from the floor.
2. The participant will be asked to move towards the camera starting from a 5 metre distance in the vision of the camera..
3. Note down the nearest point where the object detection starts to flicker.

4. Check for object detection and skeleton detection if proper or not on the screen. Note down the distance from the camera if it goes missing.
5. Repeat above steps thrice at different heights of the tripod.
6. Determine the best camera height for better range of detection.
7. Note down any other points that affect the tracking.

Position 1	Position 2
Height from floor: 2.35m ✔️Object detection ✔️No obstruction in view ✔️Skeleton detection Nearest point from camera 1. 2.15m 2. 2.14m 3. 2.14m Max distance from camera: 1. 11.5m 2. 11.3m (Figure 3) 3. 12.3m	Height from floor: 2.0m ✔️Object detection ✔️No obstruction in view ✔️Skeleton detection Nearest point from camera 1. 1.42m 2. 1.44m 3. 1.44m Max distance from camera: 1. 13.4m 2. 13.39m 3. 13.6m

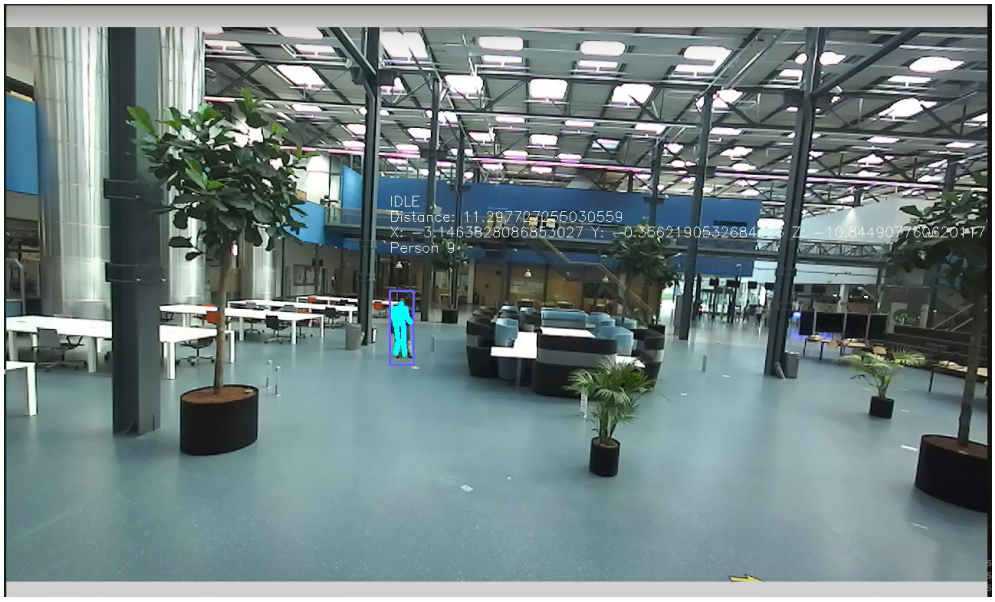


Figure 3: Maximum distance of object detection with camera height 2.35m from floor

Conclusion

Position 2 had a better range of view. This was chosen as the best camera position for the rest of the tests. The nearest point of detection is 1.44m and the farthest was at 13.4m

Problems detected:

- Occasional flickering on video - no data issues found in the recorded data (See figure 4)

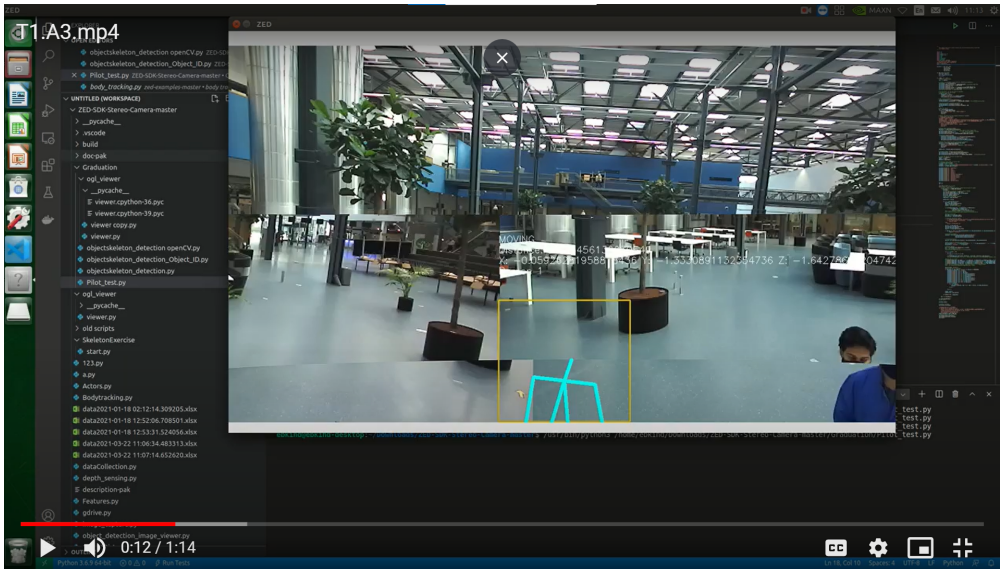


Figure 4: Flickering in the video

- Sometimes an imaginary object with ID 4294967295 found on screen. Can be rectified in code. (See Figure 5)

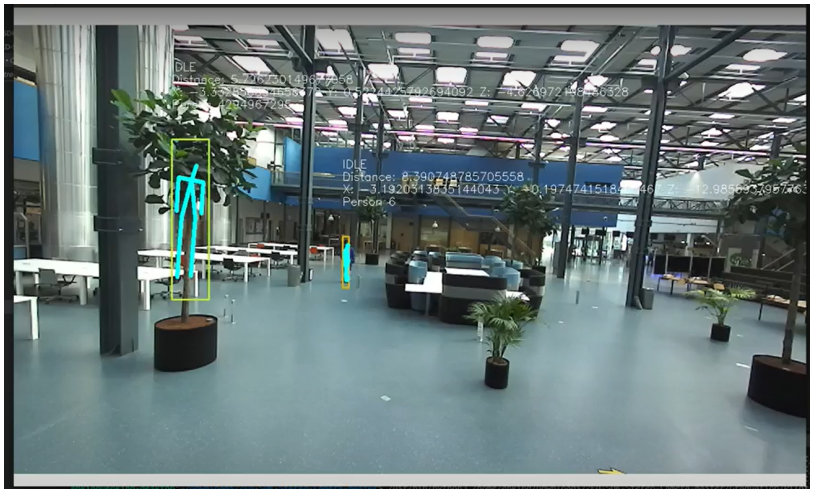


Figure 5: Wrong objects detected

- When such an object is detected, the distance from the camera of the main object gets reduced by a value same as that shown on the imaginary object. Need to identify the issue. (See Figure 5)

Second test: Checking the XYZ direction of the camera kept facing at an angle.

(Determining quaternion transformation requirement)

"This test is done to understand if the camera coordinate system is good enough for tracking or requires coordinate transformation. First we mark two points on the floor X and Y in the vision of the camera. You will stand at point X first, I will note down the values and then you will stand at point Y. We repeat this thrice."

1. Keep the camera tilted 45degrees to the horizontal in the best height chosen.
2. Mark two points anywhere in the vision of the camera with a distance of 2 metres measured perpendicular to camera.
3. Ask the participant to stand at the point X and then at point Y.
4. Note down the XYZ coordinates when the participant stands at both points.
5. Repeat 3 and 4 thrice.
6. Find the difference in the coordinates here.
7. Note down any other points that affect the tracking.

Point X	Point Y
1. X=0.67 Y=1.03 Z=-3.17 2. X=0.55 Y=0.96 Z=-3.12 3. X=0.64 Y=0.99 Z=-3.07 Average X=0.62 Y=0.99 Z=-3.12	1. X=0.82 Y=2.41 Z=-5.21 2. X=0.76 Y=2.26 Z=-4.98 3. X=0.80 Y=2.29 Z=-5.03 Average X=0.79 Y=2.32 Z=-5.03

The intended value from point A to B should have been only in the Z axis. Since considerable difference is found in the Y axis also, a coordinate transformation may need to be applied for getting the correct position.

Conclusion:

Y and Z coordinate was seen to change significantly which shows that necessary transformation of coordinate system is required.

Third test: Consistency in skeleton tracking

“ This test is to determine the consistency of skeleton tracking when you do certain actions. First we remove the earlier points and mark new points A and B, one each on the left and the right side of the left camera lens. Walk towards point A from another random point outside of camera view and stand still at point A. Do three times starting from different starting points. Repeat this for point B also. After this test, we will test out the skeleton data of an interaction at different angles. So, I will keep a bag at point A. You would stand next to the point at angle 0,45,90…. And do the same lifting the bag action. It will be done in one go but I will instruct you when you should switch to the next angle. Till I say keep lifting bag and keeping it down repeatedly at a normal speed of motion”

1. Keep the camera in the normal angle facing the widest area at the best position chosen in the first test.
2. Mark two points in the vision of camera A and B which are at the opposite sides of the camera view.
3. The participant will be asked to walk towards from a random point outside the camera view and stand still at Point A.
4. Three recordings will be noted as well as saved in excel sheets.
5. XYZ values of the point will be noted. The consistency of the XYZ values will be tested by comparing the values from excel sheets. (Name the sheets like T3.A1, A2, A3, B1, B2, B3 → Point A, recording 1)
6. Repeat for point B.
7. The participant will be asked to perform a “lifting bag” interaction at every 45 deg angle on point A. The accuracy of skeleton data and the object XYZ data will be evaluated in real-time on the screen.
8. Note down any other points that affect the tracking.

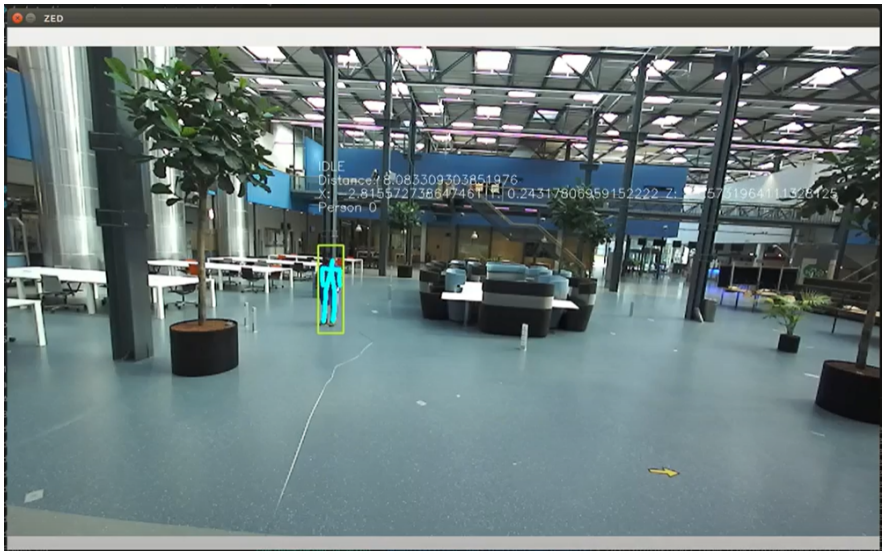


Figure 6: Object detection at point A

Point A (random point on left side of camera)	Point B (random point on right side of camera)
1. X = -3.05 Y = 0.26 Z = -8.57 2. X = -3.21 Y = 0.29 Z = -8.69 3. X = -3.07 Y = 0.26 Z = -8.26 Max. deviation in above observation: X = 0.16 Y = 0.03 Z = 0.43 From the collected excel sheet, Consistency of: X ✔️ Y ✔️ Z ✔️ Skeleton data ✔️ Lifting bag ✔️0 ✔️45 ❌90 ✔️135 ❌180 ❌-135 ❌-90 ✔️-45	1. X = 4.95 Y = -0.36 Z = -7.95 2. X = 5.01 Y = -0.33 Z = -7.96 3. X = 4.85 Y = -0.31 Z = -7.72 Max. deviation in above observation: X = 0.16 Y = 0.05 Z = 0.23 From the collected excel sheet, Consistency of: X ❌ Y ✔️ Z ❌ Skeleton data ❌

Check the "calculations.xlsx" sheet in the Test 3 folder for the consistency calculation. The consistency requirement was standard deviation less than 0.3.

Point A was found consistent while point B was inconsistent for both object and skeleton detection. The first and third recording at point B was found to vary a lot while the second recording showed considerably stable values. This must have been due to some slight error in the recording.

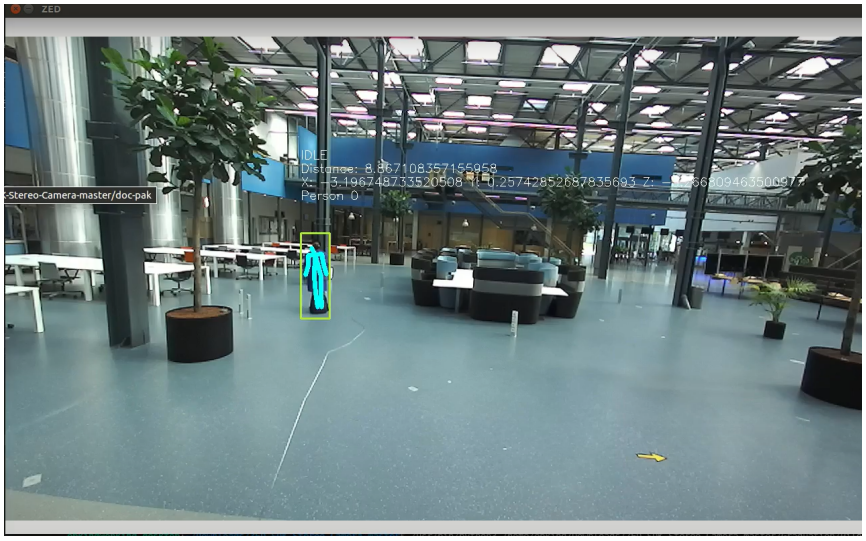


Figure 7: Skeleton detection at point A

Conclusion:

The object detection at a certain point can be concluded as consistent if the point B recording errors are ignored. The skeleton detection was not successful as the actions could not be interpreted correctly at most angles which are not facing the camera. The angles between -45 and 45 was best for skeleton detection.

Fourth test: Finding the limits at best camera position

“Here we test out the area of coverage of the camera. It is similar to the first test we did but here we will mark out the area and measure it. First you stand at the nearest point detected in the first test and walk to both sides of the camera. When the object is not detected, I would ask you to stop and mark the point with masking tape. Do this for both sides. Repeat the step thrice. Now walk towards the earlier marked longest point. Walk towards the side as earlier and mark the corners with masking tape. Do for both sides. Repeat thrice. Innermost points of the corners would be taken for final area calculation.

After this test, we will test out the skeleton data of an interaction at different angles with an obstruction. Similar to the third test, I will keep a bag at point A. You would stand next to the point at angle 0, 45, 90…. Degree angles and do the same lifting the bag action. It will be done in one go but I will instruct you when you should switch to the next angle. Till I say keep lifting bag and keeping it down repeatedly at a normal speed of motion”

1. Stand at the nearest point marked in the first test.
2. Walk to the left of the camera.
3. Find the spot where the object detection is lost. Mark with masking tape.
4. Do the same for the right side of the camera.
5. Repeat steps 1 to 4 thrice.
6. Choose the innermost points for final area marking.
7. Stand at the farthest point marked in the first test.
8. Walk to the left of the camera.
9. Find the spot where the object detection is lost. Mark with masking tape.
10. Do the same for the right side of the camera.
11. Repeat steps 7 to 10 thrice.
12. Choose the innermost points for final area marking.
13. Measure the boundary lengths with measuring tape.
14. Place an obstructing object in front of point A and ask the participant to stand directly behind it. Note down if the detection is proper.
15. Perform the lifting bag operation behind the object at every 45deg angle to see if the detection is proper.
16. The accuracy of skeleton data and the object XYZ data will be evaluated in real-time on the screen. Note down in the checklist.

Measure of area =

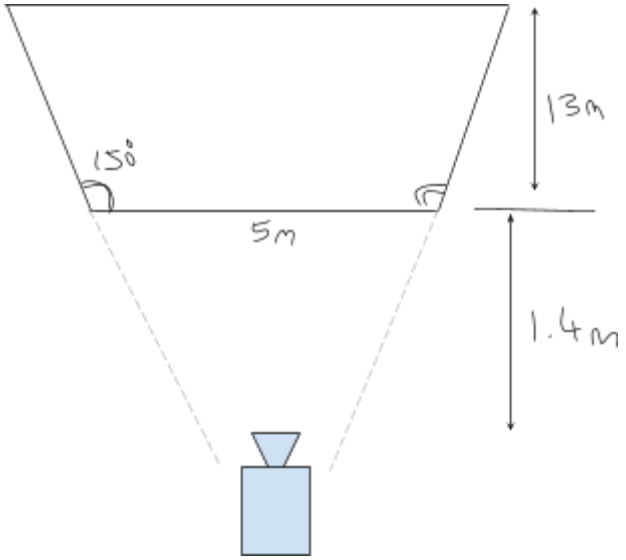


Figure 8: Measure of area of detection

Point A			
Unobstructed skeleton detection (Figure 9)			
✔0	✔45	✘90	✔135
✘180	✘-135	✘-90	✔-45

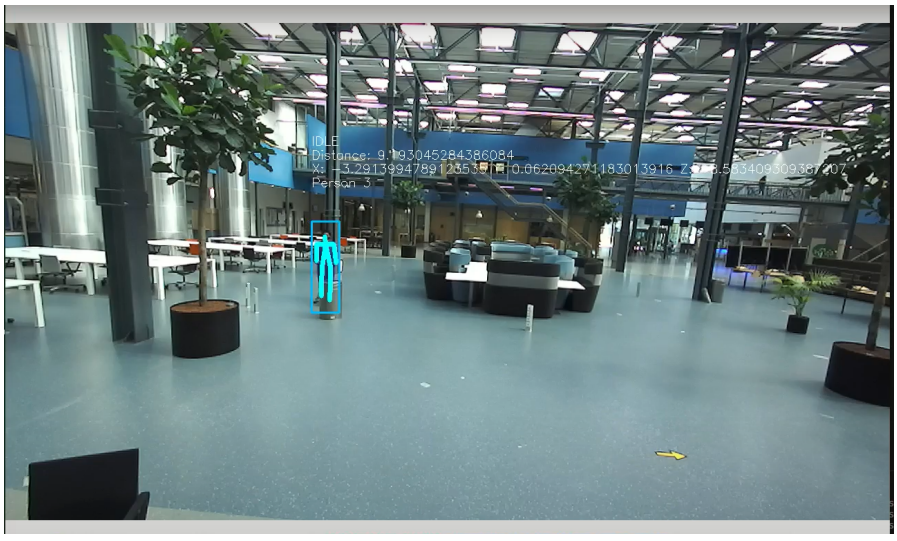


Figure 9: Skeleton detection with an obstruction

Conclusion:

The skeleton detection with obstruction showed the similar results as in the previous test without obstruction.

Fifth test: Detection of proximity to station

“Here we try to evaluate if the camera detects accurately if the person is working on a specific machine based on the proximity of coordinates. We take the same points A and B and make a rectangle over there on the floor. I will draw a rectangle of an arbitrary size suitable for a machine area on the floor. Stand on each of the corners of the rectangle facing forward while I note down the coordinate values. After this, you have to walk from outside the camera frame and stop next to the station to pick up the bag and place it down.

1. Mark with tape on floor, two station areas in the scene at point A and B.
2. Calibrate the coordinates with the participant and put it in the code.
3. Place a bag in the station area A
4. Rerun the code to switch off and on the camera.
5. Ask the participant to walk towards the station A from another random point away from the station and stop next to it.
6. Ask the participant to lift the bag and place it down.
7. See if the participant activity is detected as “Station A” (or B). Mark in the checklist.
8. Check if the skeleton data is detected correctly.
9. Repeat steps 4 to 8 thrice starting from different starting points. Repeat for station B.

Station A

Station XZ value calibration using person

1	X= -4.0 Z= -9.6	X= -3.95 Z= -9.3	X= -3.79 Z= -8.9
2	X= -2.12 Z= -9.01	X= -2.2 Z= -9.48	X= -2.16 Z= -8.8
3	X= -2.01 Z= -7.4	X= -2.07 Z= -7.5	X= -2.05 Z= -7.79
4	X= -3.6 Z= -7.87	X= -3.74 Z= -7.86	X= -3.63 Z= -7.67

The station coordinates are
X = -4.0 to -2.0

Z = -7.67 to -9.5.

1. ✔️ Station detected
   ✔️ Skeleton detected

2. ✔️ Station detected
   ✔️ Skeleton detected

3. ✔️ Station detected
   ✔️ Skeleton detected

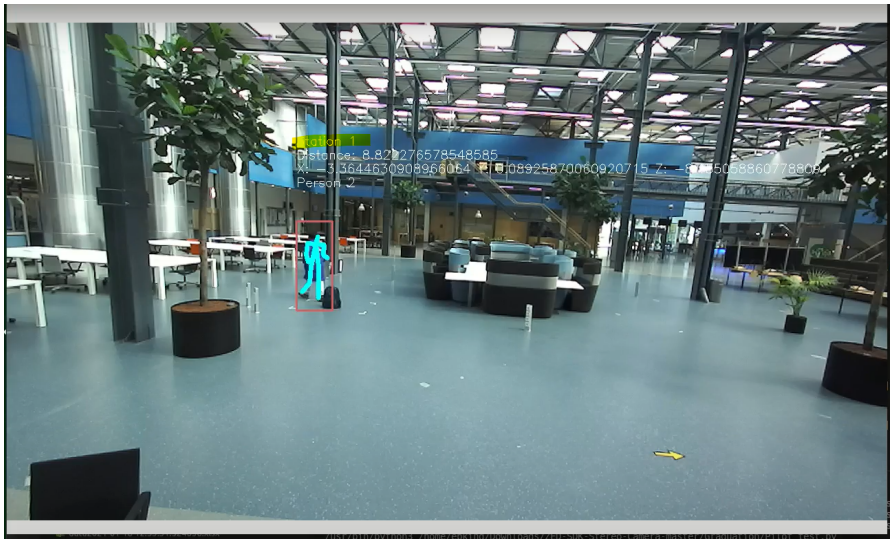


Figure 10: Station detected at proximity

Conclusion:
The station detection was as planned and worked correctly. A designated area was always detected as a particular station and the person in the proximity was identified as working on the station.

Sixth test: Brisk walking

"Here the point A is your idle point and point B is where you have a work assigned. In the production floor running is not permitted. Here I am trying to determine the range of walking speeds depending on the urgency of the event. I willmark a new point C in this test. From A, you will start walking normally towards point B but midway I ask you to go towards a very urgent event at point C and you have to walk at a faster pace. Stop next to point C, lift the bag up and walk back to point A at a slower pace"

1. Mark another point C which will form a shape as shown in figure 11.
2. Point A will be designated idle point, B as a machine point and point C as emergency issue point.
3. Ask the participant to walk from point A to B. Before the person reaches the point B, ask the person to go for an emergency event at point C.
4. Ask the participant to walk back leisurely to point A(idle point) after lifting bag operation at point C.
5. Store the excel sheets as 6T.1, 6T.2, 6T.3.
6. Note down the velocity of each pace of walking.
7. Repeat for three observations.
8. Calculate the range for each of the pace of walking.

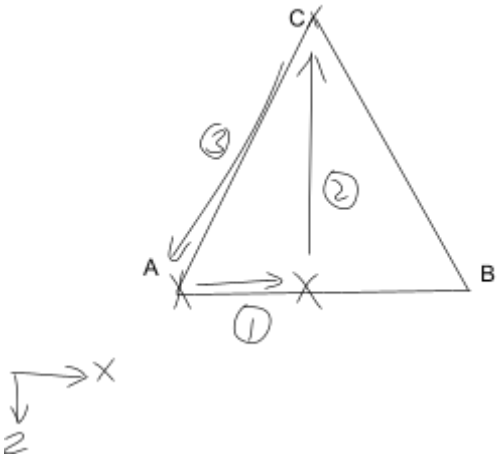


Figure 11 : Points marked in the view of camera

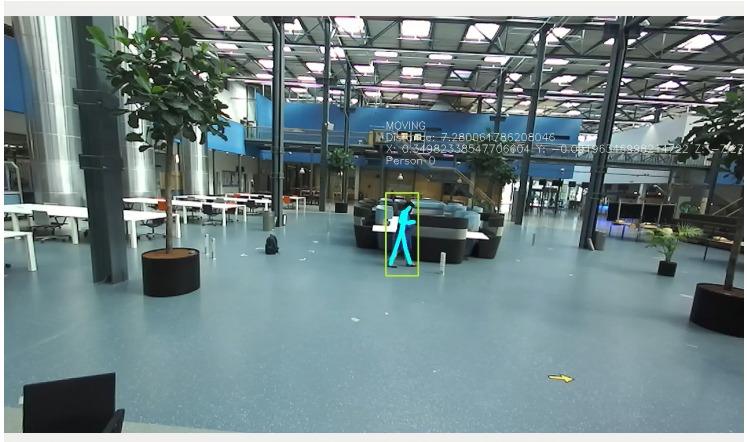


Figure 12 : Velocity determination experiment

Refer Excel sheet “Calculations” under Test 6 folder.

Slow	Normal	Fast
Range = 0.38 to 0.79 m/s	Range = 0.58 to 0.88m/s	Range = 0.49 to 1.52 m/s

Adjusting the values,
Slow is considered between 0 and 0.5 m/s
Normal is between 0.5 and 0.85 m/s
Fast is above 0.85 m/s

J - Evaluation test results

Aim
This experiment aims to test the following:

- Desirability of the visualizations
- Feasibility of using this interface for process improvement
- Interactivity

Test setup:
The dashboard for data visualization with data buffered from 16th June 15.00 to 18.00 on the same day. The dashboard is loaded with capability to view Spaghetti chart, Spaghetti chart animated, heat map of operators' location and Pareto chart of time spent at each station. The dashboard is interactive with provision for choosing the date of data, time range sliders, selection of what activity to see. Also, a side by side graph was provided by data comparison of two different times.

Participants
Barnabas Kiss
Peter Slot

Points to note:

- How do they use this?
- What are the questions they have?
- Are the interactions intuitive?
- Are the graphs desirable for process improvement?
- How do they interact to different scenarios
- Does the graphs help in visualizing the required information?

Instructions

1. Provide the participants with a research consent form and get it signed before the start of the experiment.
2. Explain the experiment and what their roles are.
3. Participants will be connected through Microsoft Teams.
4. Provide remote access control.
5. Provide the scenarios
    a. Scenario 1: Stoppage at 15:30 - 15:35

    b. Scenario 2: Changeover at 15:50 - 16:00
    c. Scenario 3: Normal operation from 15:00 - 16:00
    d. Scenario 4: Compare changeover at 15:20-15.30 and 15:50-16.00
    e. Participant defined scenario
6. After all scenarios provide 10 minutes for rating and providing feedback in Google forms.
7. After all the scenarios, ask the following questions
    a. What other questions do you have about the scenario?
    b. How was the overall experience of the dashboard?
    c. Do you foresee the feasibility of using the dashboard for process improvement?
    d. Name three positives
    e. Name three negatives
    f. Do you have any suggestions for improvement?

Results:

Scenario 1: Stoppage at 15:30 -15.35

- What information would they want to see at this time?

- How do they interact with the dashboard?

Scenario 2: Changeover at 15:50- 16.00

- What information would they want to see at this time?

- How do they interact with the dashboard?

Scenario 3: Normal operation from 15:00-16:00

- What information would they want to see at this time?

- How do they interact with the dashboard?

Scenario 4: Compare changeover at 15:18 and 15:40

- What information would they want to see at this time?

- How do they interact with the dashboard?

Scenario 5: Custom scenario

- What information would they want to see at this time?

- How do they interact with the dashboard?

Other opinions or questions:

1. How was the overall experience of the dashboard?
    - Nice, looking good
    - Increase font size

    -
2. Do you foresee the feasibility of using the dashboard for process improvement?
    - Yes, beneficial
    - Timewise, no need to go to operator
    - Instant access, intuitive picture of what is happening

    - Yes, beneficial for changeover and for lean activity like SMED and i could help us save improve the operating hours and throughput
    - Probably about business as usual, issue tracking, issue handling and changeover
    - Also could be when we try to find out what happened why something happened, eg: quality or technical issues
    - This gives an indication of what happened
    - It could give an information of more than 2 people at site
3. Name three positives
    - Instant access
    - Instant problem
    - Solving tool
    - Good quick view of analysing

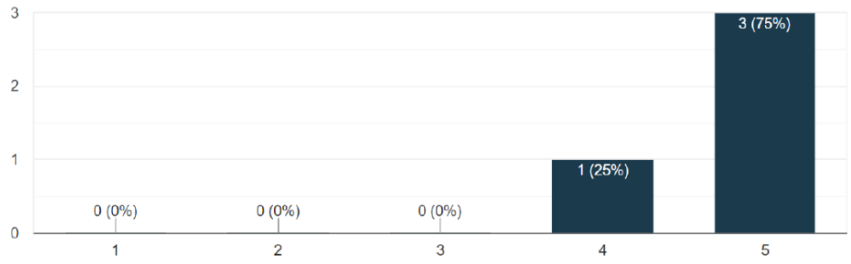
    - Automatic data collection with timeframe
    - Comparing with each other
    - Number of frequency and duration
    - Previously when we need SMED event, we needed 5 or 6 people, so spaghetti needed to be drawn, another person is time, another movie and another about process and another is expert
    - Now it can be done without any person
4. Name three negatives
    - Too many stations, heat map will confuse, too much probably
    - If you ask operator to use, he won't use it - it's more for technical dept and management

    - We couldn't see the animated spaghetti
    - Problem on selection of stations
    -
5. Do you have any suggestions for improvement?

Spaghetti chart

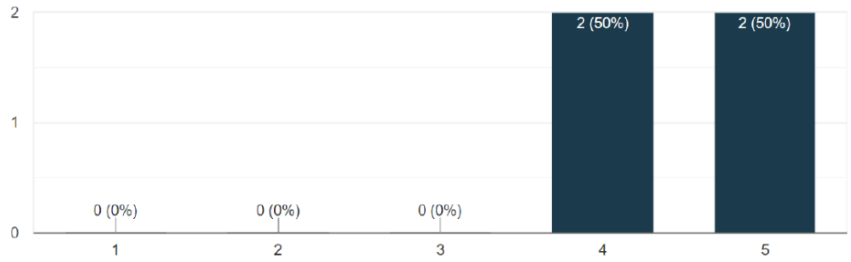
Appearance

4 responses



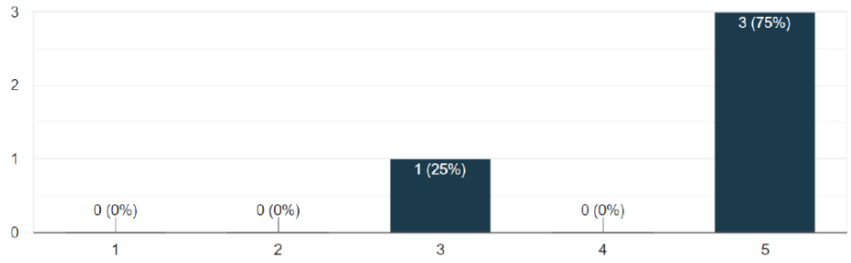
Usefulness of the chart/graph

4 responses



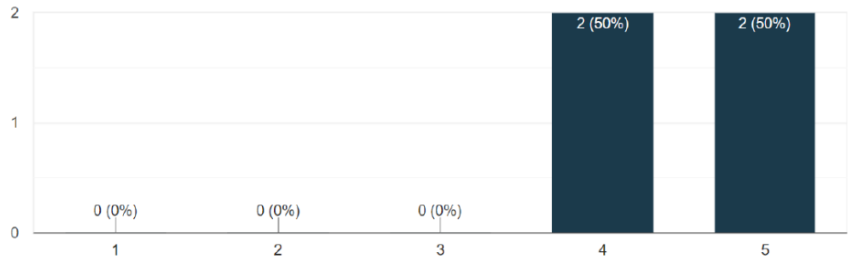
Intuitiveness

4 responses



Usefulness of hover data

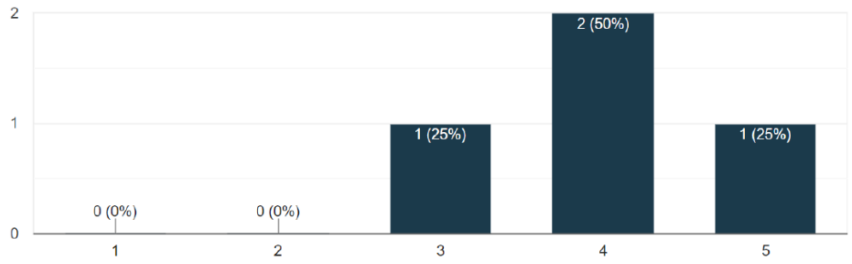
4 responses



Animated Spaghetti chart

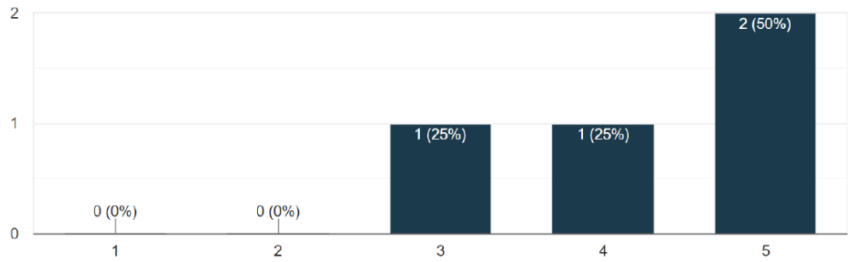
Appearance

4 responses



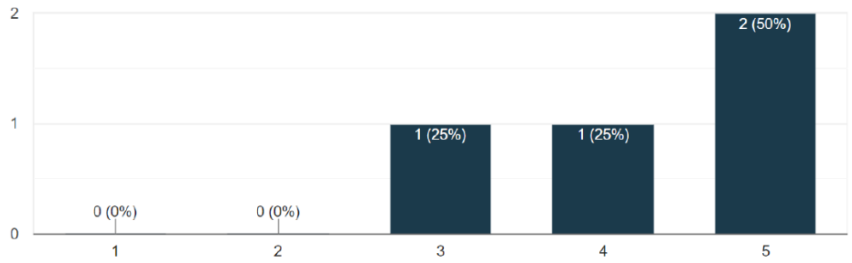
Usefulness of the chart/graph

4 responses



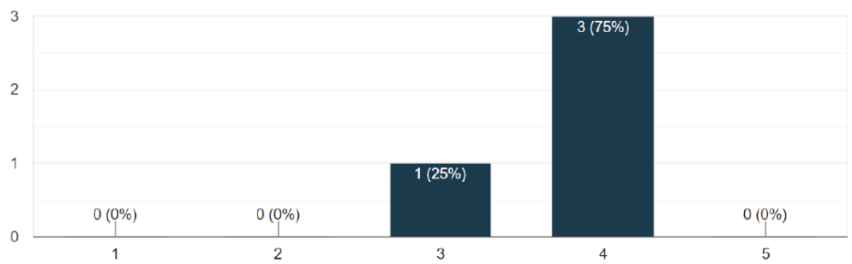
Intuitiveness

4 responses



Usefulness of hover data

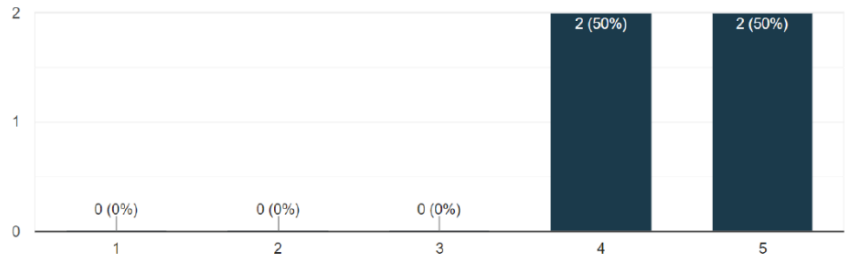
4 responses



Heat map

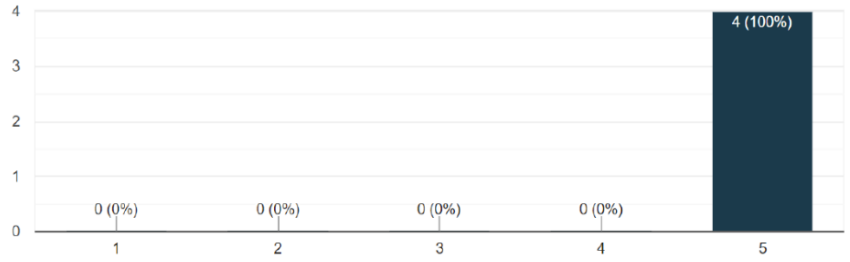
Appearance

4 responses



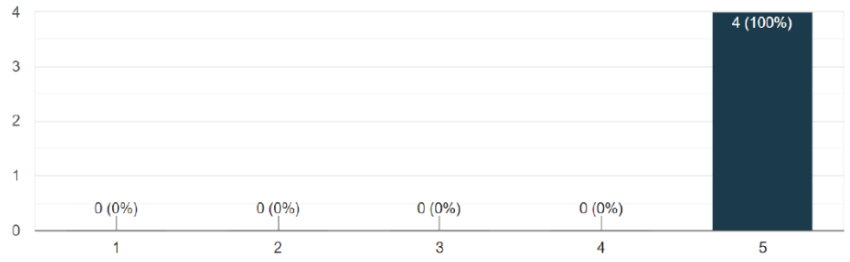
Usefulness of the chart/graph

4 responses



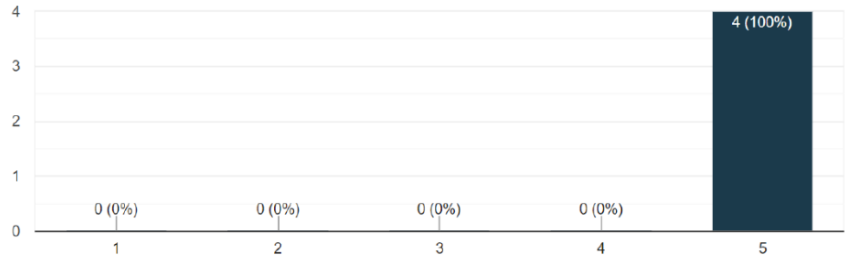
Intuitiveness

4 responses



Usefulness of hover data

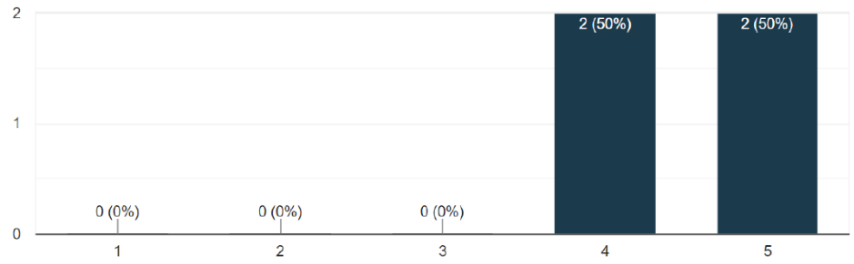
4 responses



Pareto chart

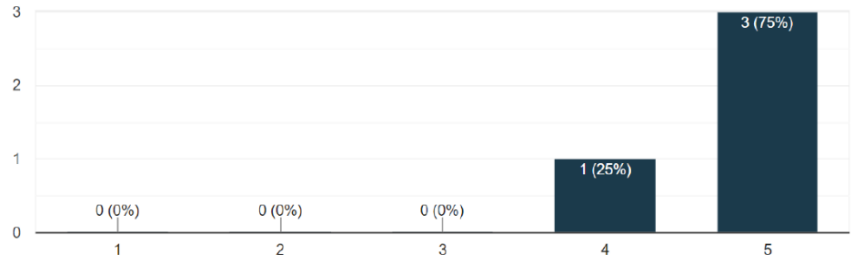
Appearance

4 responses



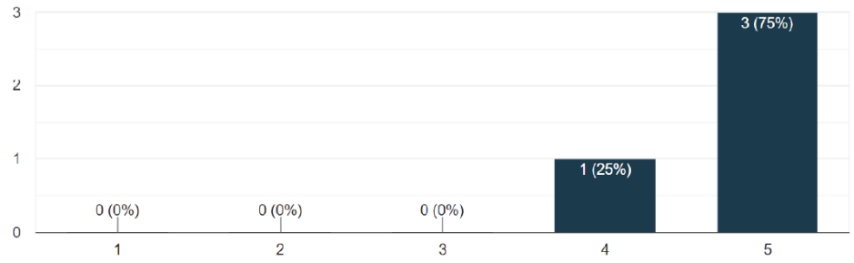
Usefulness of the chart/graph

4 responses



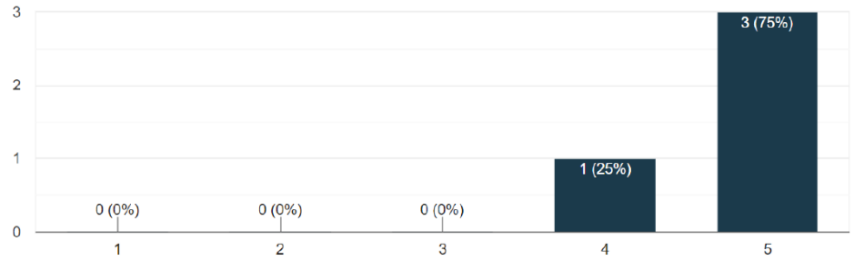
Intuitiveness

4 responses



Usefulness of hover data

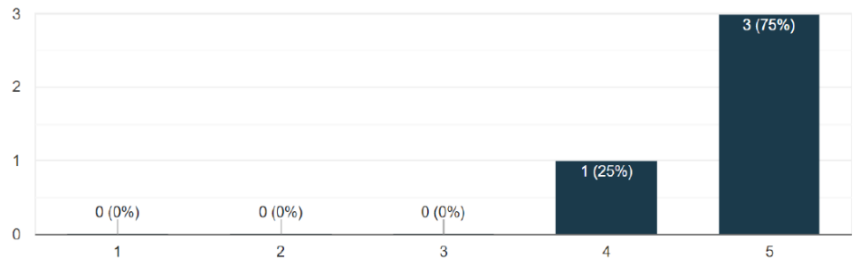
4 responses



Dashboard

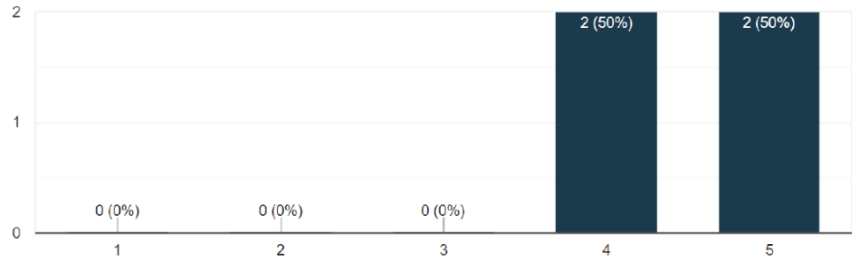
Appearance

4 responses



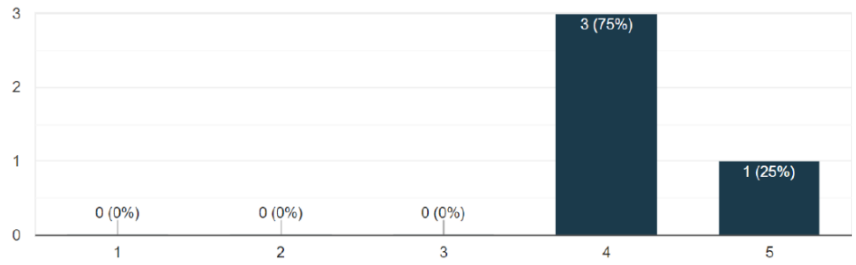
Feasibility for process improvement

4 responses



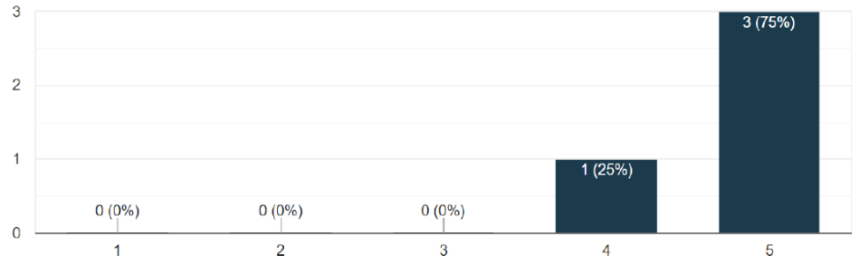
Features such as activity selection, datepicker

4 responses



Interactivity

4 responses



K- COALA Objectives