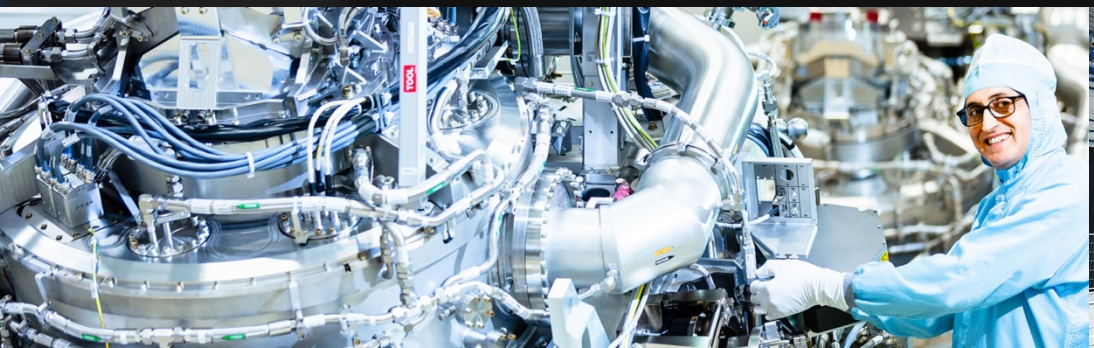
Designing, implementing, and evaluating a real-time performance dashboard

Arthur Kambartsumjan

October, 2021



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Master Thesis
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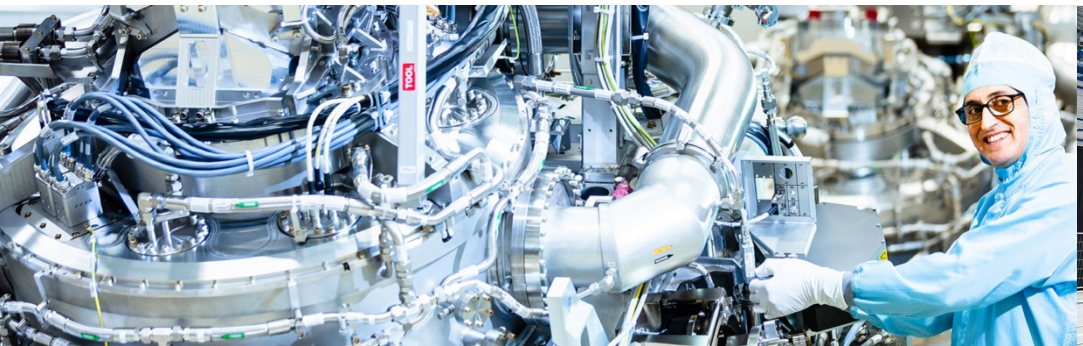

Management summary

VDL Enabling Technologies Group (ETG) Almelo offers services including engineering, prototyping, and serial manufacturing of products characterized by high complexity and relatively small production numbers. The company aims to exceed the expectations of the customers by guaranteeing high quality and service levels in the supply of mechatronic modules. To grow steadily and keep its market position in the future, VDL ETG Almelo aims to increase its efficiency by process automation as well as the implementation of a digital factory with a focus on the implementation of a new Enterprise Resource Planning (ERP) system. We assume that our research will be used within this new IT architecture. One of the business needs for the implementation of this digital factory, which is also the core problem of this research, is that real-time performance information per department is currently lacking. Therefore, the research objective is formulated as follows:

To design, implement and evaluate a real-time performance dashboard per department

We conduct a systematic literature review to find key performance indicators (KPIs) currently used by manufacturing companies. Based on this review, we provide a list of potential KPIs per department. After an analysis of the current situation, we use the KPIs identified by the literature as a basis to give each manager some ideas of how KPIs are used in other manufacturing environments. Subsequently, we translate the operational goal of each department into measurable KPIs. A large amount of data is available to measure these KPIs and therefore an efficient new IT architecture is required to ensure that the dashboards can cope with it. Before we construct this new IT architecture, we have participated in a training session of Microsoft on the 22nd of July to learn more about Microsoft Power BI. After this session, we constructed our model and defined relationships between the data tables within the Power BI tool from Microsoft. Next, we provide more insights into the visualization of data. Finally, in the last section, we compare the current situation with the new situation to assess the practical impact of our research.

The dashboards developed for the Sales, Human Resource Management (HRM), Production, Purchasing, Quality, and Finance departments can not be shown due to confidential reasons. We provide some layouts to give an indication of these dashboards in Section 7. Next to that, we construct a user guide for each department. All in all, these dashboards have fulfilled the norm set by VDL ETG Almelo and therefore the core problem has been solved:

Norm	New situation
• **Real-time:** the dashboards should be real-time connected to the data warehouse where possible.	✓
• **Performance information:** the operational goals of each department should be measured.	✓
• **Process of developing the dashboards:** one person should be able to make the dashboards.	✓

Firstly, the dashboards are real-time connected to the data warehouse which means that the management team always looks at updated KPIs. In the old situation, there was always a chance that something has been changed in the data warehouse which then can not be observed by the management. Secondly, we identified the operational goal of each department and concluded whether each goal is measured. As a consequence, new KPIs are defined and some already used KPIs are emphasized. Each department has now a complete overview of relevant KPIs which improves the quality of decision making. Finally, only one person is currently needed for developing the dashboards in the new situation compared to eight persons in the old situation. Therefore, we save a lot of time and human mistakes are avoided.

Besides that, we see that we significantly have improved the following by using Power BI:

- In the dashboards we can easily zoom in from high-level information to more specific details.
- Due to the ability of Power BI in which functions and roles can be defined we can secure the dashboards.
- In Power BI it is easy to define interactions between dashboards. Therefore, our dashboards can be connected to several other dashboards.
- Power BI is a cloud-based service. Saving a backup on your personal computer is not needed anymore.

Finally, we recommend VDL ETG Almelo to:

- Integrate all currently used dashboards within each department to our dashboards. This ensures that everybody uses the same data.
- Clean the data warehouse once since we have observed redundant views with different values of the same data.
- Investigate how we can optimize the generation of data especially for the Finance and HRM department.
- Organize the location on the server where each file source should be saved for especially the Finance and HR department. Also, the Financial Administrator of VDL ETG Almelo should invest some time to learn the language of this tool to update the dashboards.

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Preface

Dear reader,

This master thesis: *"Designing, implementing, and evaluating a real-time performance dashboard"* marks the end of my student time and my master Industrial Engineering & Management at the University of Twente.

I would like to thank VDL ETG Almelo for this opportunity and, especially, Paul Koch for his guidance during my research. Our discussions about digitalization helped me a lot to come up with this result. In my research, I completely had the freedom to design and implement a dashboard for the management team. It was great to see the enthusiasm of the managers when they were using our dashboard.

Furthermore, I would like to express my gratitude to Reinoud Joosten and Abhishta Abhishta as my supervisors from the University of Twente for providing valuable input during this research.

Finally, I would like to thank my family and friends for the support they gave me during my research.

I hope you enjoy reading this thesis.

Arthur Kambartsumjan
Almelo, October, 2021

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1. Introduction

We have conducted this research at VDL Enabling Technologies Group (ETG) Almelo B.V. to complete my master's program Industrial Engineering and Management at the University of Twente. This section provides an introduction to our research. Section 1.1. contains a brief description of VDL ETG to provide some context about the company. Section 1.2 contains more about the relevance and motivation of our research. We provide the problem context in Section 1.3. Section 1.4 includes the research objective and Section 1.5 contains more about the research questions and the problem-solving approach. Finally, Section 1.6 includes the definition of the norm set by the company.

1.1 VDL ETG

The company Philips Machinefabrieken was founded in 1900. From 1990 up to 2000, the company offered integrated solutions to Philips and other customers internationally. In 2006, VDL Group, which consists of many operating companies all over the world, took over the company. From 2006 up to now, VDL ETG continued its development with support from its financially powerful parents VDL Group. VDL ETG is a tier-one manufacturing partner with global operations. The service offered by VDL ETG include engineering, prototyping, and serial manufacturing of products characterized by high complexity and relatively small production numbers. VDL ETG aims to exceed the expectations of the customers by guaranteeing high quality and service levels in the supply of mechatronic modules. A simplified overview of the processes involved in this supply is shown in Figure 1. From this figure, we see that the first step is to receive an order from a customer. If the order is a build to print order, the materials can directly be purchased and the products can be manufactured. If the order is a build to specifications order, the products should first be engineered before they can be manufactured. After these steps, the products are assembled and delivered to the customers. This process is roughly the same for the different business units in Eindhoven (NL), Trübbach (CH), Singapore, and Suzhou (China).

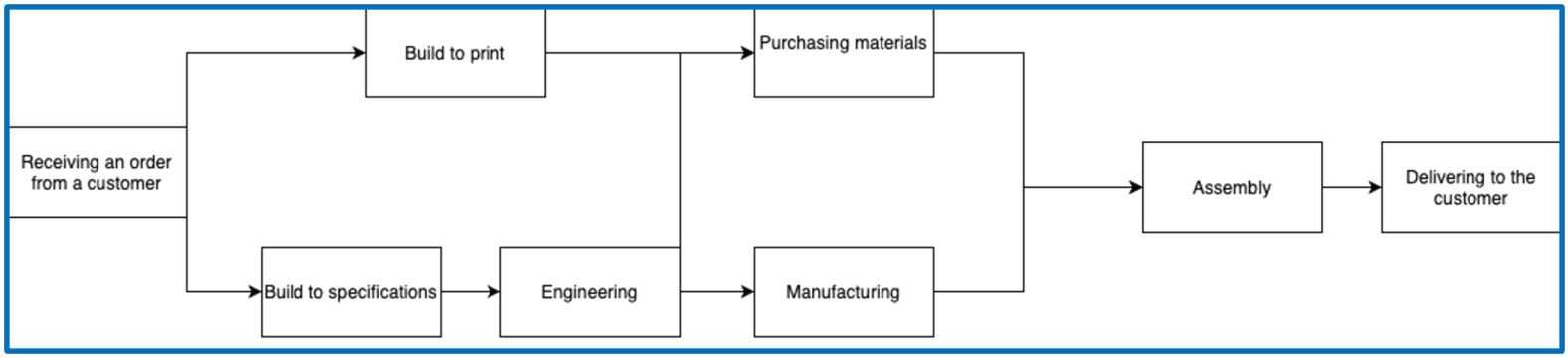

Figure 1: Simplified overview of the manufacturing process.

1.2 Relevance and motivation of this research

Over the last three years, the revenue level of VDL ETG Almelo has doubled and an additional total revenue increase of 30% is expected in the next two to three years. The additional revenue should be realized without increasing the number of employees significantly. Thus, to grow steadily and keep its market position in the future, VDL ETG Almelo aims to increase its efficiency by process automation. To realize these business needs, a sufficient, service-oriented IT architecture needs to be implemented. This implementation has already been started where the main focus is on the implementation of a new Enterprise Resource Planning (ERP) system. We assume that our research will be used within this new IT architecture. Furthermore, as already mentioned, we conduct our research at the business unit in Almelo and it will function as a pilot test for all other business units.

1.3 Problem statement

Currently, VDL ETG Almelo's IT architecture does not fulfill the business needs. The scope of our research is to fulfill one of these business needs which is that VDL ETG Almelo lacks real-time performance information per department. Currently, static Excel and Powerpoint files interconnected with macros, are used to show the KPIs and results to the management team per department. This leads to several problems, first, the manual creation of these files is a waste of time for each department. Additionally, human mistakes are made. Second, the management team is looking at numeric values which are not real-time and thus static. Therefore, there is always a chance that something has been changed in the data warehouse which then can not be observed by the management. Third, these values are used with a lack of visualization. Fourth, the static tools do not have any user interaction. For example, it is not possible to click further on a graph to see more about a specific day or order. This has as a consequence that there is no insight into more in-depth data. All these problems are visualized below in the Problem Cluster.

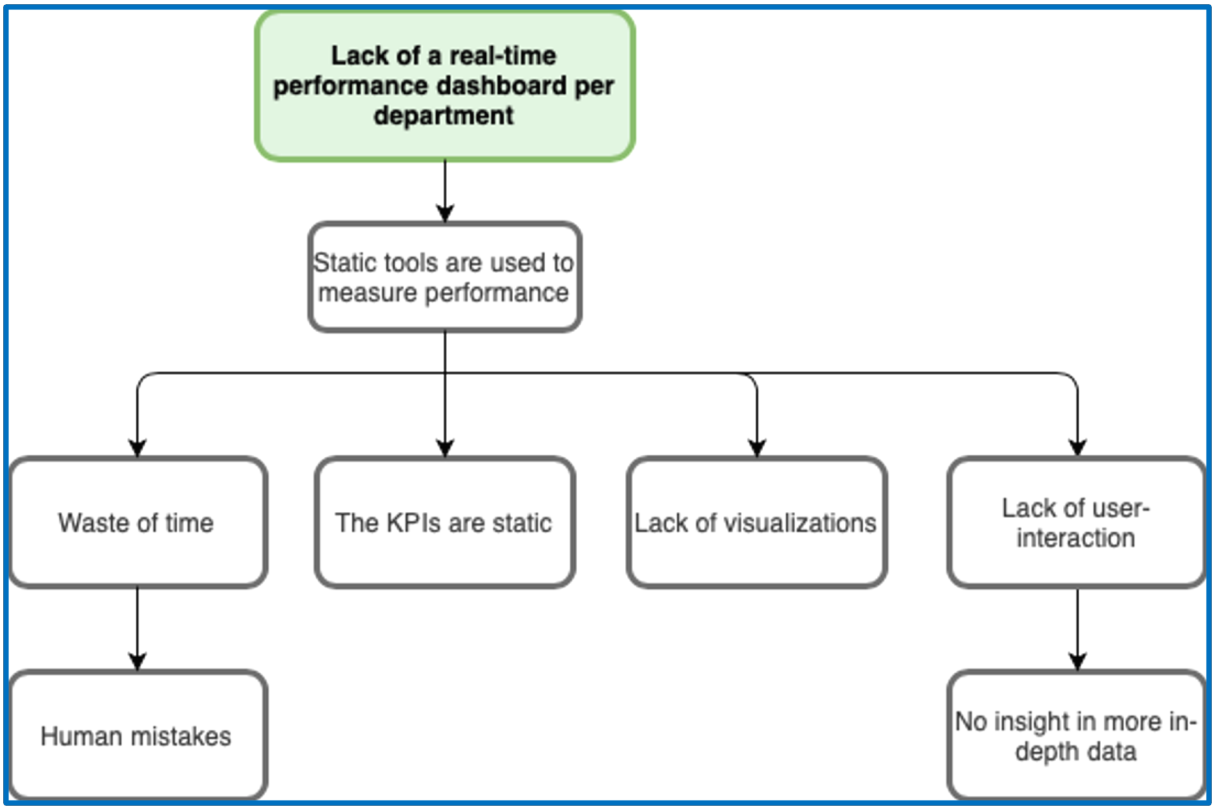

Figure 2: The Problem Cluster.

From the Problem Cluster above, the problem statement is formulated as follows:

There is currently no real-time performance information per department

The next section provides the research objective of this problem statement. Afterwards, the research questions are defined.

1.4 Research objective

The objective of our research is to design, implement and evaluate a real-time performance dashboard for the management of VDL ETG Almelo. The scope of our research is to develop this dashboard for each department and as already mentioned, it will function as a pilot study for all other business units of VDL ETG Almelo. With this in mind, we define the objective of our research as follows:

To design, implement and evaluate a real-time performance dashboard per department

In Section 1.5, we define several research questions to achieve the research objective. These research questions are structured by sub-questions. Here, each research question is answered by a separate chapter, and each sub-question is answered by a section within the corresponding chapter.

1.5 Research questions

1) Which KPIs are used by manufacturing companies in the literature?

First, we define KPIs and give the goal of using KPIs within a dashboard. Next, we conduct a systematic literature review to find performance KPIs currently used by manufacturing companies. It might be that some KPIs exist in the literature that would be beneficial to measure for management.

2) What is the current situation?
   - 2.1 How is the current static dashboard constructed, updated, and visualized?
   - 2.2 Which KPIs are currently used to measure the performance of VDL ETG Almelo?
   - 2.3 How are these KPIs calculated and which data are needed for these KPIs?

Second, we describe the current situation to understand how decisions are taken by management, and how the performance of each department is measured. This could give a direction to the type of data that should be measured in a later stadium when the real-time performance dashboards has been developed.

3) What are the needs of management?
   - 3.1 What is the operational goal of each department?
   - 3.2 Which currently used KPIs make the operational goals per department measurable?
   - 3.3 Which additional KPIs should be incorporated to make these operational goals measurable?

Third, as in our research a completely new dashboard will be developed, our research starts by interviewing the manager of each department to identify the goal of each department. This includes looking at the KPIs currently measured as there is a chance that these do not even make the goals measurable. Next, it might be that some value-adding KPIs are identified from the literature review or the meetings with the management, and as a consequence, new data should be measured and generated.

4) How to structure the data in a data model to develop a real-time Power BI dashboard?

Fourth, an efficient new IT architecture is required to ensure that the dashboard can handle such a large amount of data. Also, an overview should be made about the data relationships of the different data sources to see how this can be modeled efficiently in the new dashboard.

5) What is the most suitable way to visualize each KPI?

Fifth, an overview of all types of visualizations should be given. Next, it is important to know the goal and data characteristics of each visualization type. With this information, the research question can be answered and, as a consequence, interpretation mistakes of the management team are avoided.

6) How can the outcome of the real-time BI dashboard be used to measure the performance of each department?

Sixth, a user guide on how to use the BI dashboards should be made. This would help to make each department acquainted with the new dashboards.

7) What is exactly the improvement compared to the current situation?

Seventh, since this research is also focused on the evaluation of the new dashboards, the new situation should be compared to the current situation. Based on this information, we may assess the practical impact of our research.

1.6 Norm of the company

We defined the core problem as follows: "*There is currently no real-time performance information per department".* We should be able to specify the core problem to say if we have solved it at the end of the research. In consultation with the management team of VDL ETG Almelo, we have defined the norm as follows:

Current Situation

- **Real-time:** the dashboard is connected to multiple Excel files and databases which should be refreshed before the time that the dashboard will be used by the management. Also, the screenshots of the Powerpoint files should exactly be made at this specific time. Therefore, it is very likely that the management is not looking at real-time data.
- **Performance information:** the current used KPIs have not been changed over approximately 15 years and therefore do not measure the current operational goals of each department.
- **Process of developing the dashboard:** seven managers and one financial administrator are involved in the process of making the Powerpoint and Excel files.

Norm

- **Real-time:** the dashboards should be real-time connected to the data warehouse where possible.
- **Performance information:** the operational goals of each department should be measured.
- **Process of developing the dashboards:** one person should be able to make the dashboards.

2. Literature study

First, we define KPIs and identify the goal of using KPIs within a dashboard. After that, we answer the first research question "Which KPIs are used by manufacturing companies within the literature?" using a systematic literature review. We describe the process of this systematic literature review in Section 2.3. Finally, we use the results of this literature review in Section 4 to give the management team some insight into well-known and often used KPIs by manufacturing companies in the literature.

2.1 The definition and goals of using KPIs

"KPIs are defined as quantifiable and strategic metrics that measure an organization's critical success factors (CSFs)" according to Manan & Ridzwian (2019). This process is visualized below.

Figure 3: The process to business success (Manan & Ridzwian (2019)).

From this figure, we can conclude that critical success factors determine the business success of a company. This is in line with the definition of CSFs according to Manan & Ridzwian (2019), CSFs are "elements in an organization that determine the current and future success of an organization's operations". Hatzigeorgiou & Manoliadis (2017) define KPIs as "the measures of the performance of the process critical to its success" which is again in line with the definition given for CSFs and KPIs above. Therefore, with this information, we can conclude that the goal of KPIs is to measure CSFs which again measure the performance and success of a specific company.

Many CSFs determine the performance of VDL ETG Amelo. As a consequence, there are a lot of KPIs which could be used to measure this performance. Therefore, we should first classify these performance KPIs before conducting the systematic literature review. This classification will be explained in the next section by using the well-known Balanced Scorecard (BSC) introduced by Kaplan & Norton (1992).

2.2. Performance measurement

BSC is a concept of performance measurement which uses a balanced approach to measure a company's performance. The BSC shows that a focus on solely financial accounting measures gives useless signals to executives, therefore a focus on a mix of financial and non-financial measures should be considered. Non-financial measures can be drivers of financial outcomes which makes control for managers easier. The BSC disciplines executives to focus on several important measures that drive the company strategy according to Kaplan & Norton (1996). In this way, the extent can be measured to which a company achieves its vision and mission. This approach consists of four perspectives:

1. The Financial Perspective: the BSC uses this perspective to measure the financial performance of a company. This perspective is valuable since it summarizes the economic consequences of actions already taken.
2. The Customer Perspective: this perspective pays attention to identifying the customer and meeting the expectations of this customer.
3. The Internal-Business-Process Perspective: here, executives identify the critical internal-business-processes in which the company must excel. The focus should be on the internal processes that have the greatest impact on customer satisfaction.
4. Learning and Growth Perspective: finally, this perspective identifies the infrastructure that the company must build to create long-term growth and improvement, and therefore to its current and future success.

The vision and strategy of a company are dependent on the measurement of objectives from these four perspectives. This process is illustrated in Figure 4 below.

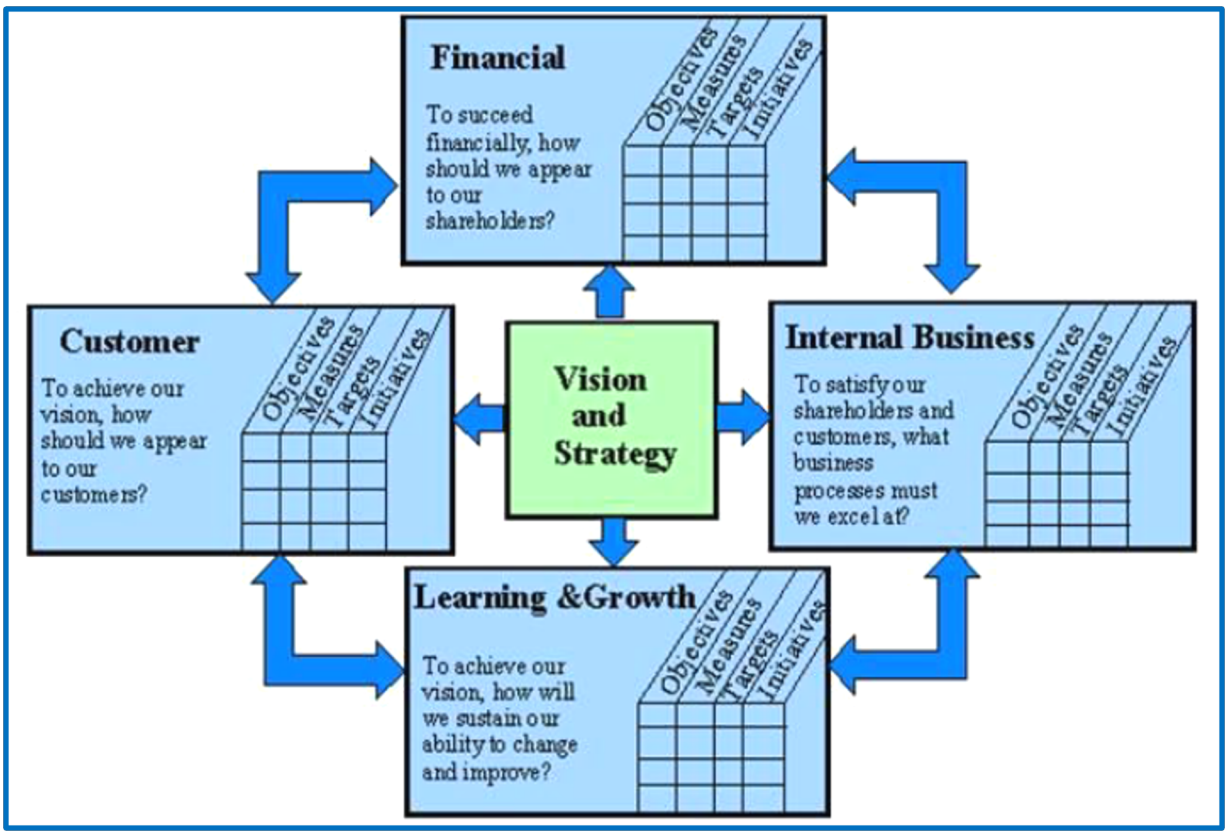

Figure 4: The BSC (Kaplan & Norton (1996)) .

Lastly, to be able to measure the performance of a company appropriately, we should include all these perspectives. We ensure this by measuring the performance of VDL ETG Almelo per department since each perspective of the BSC is related to at least one department. This relationship is expressed in Table 1.

VDL ETG's department	Related BSC perspective	Reason
Sales	The Customer Perspective	The Sales department ensures that the customer expectations are always met.
System Integration (production)	The Internal-Business-Process-Perspective	The customers of VDL ETG Almelo are satisfied when their ordered products are appropriately manufactured and of high quality.
Purchasing	The Internal-Business-Process-Perspective	The Purchasing department ensures that high quality materials are purchased which will lead to customer satisfaction.
Finance	The Financial Perspective	The Finance department summarizes all the financial consequences of the actions which are already taken by the other departments.
HRM	The Learning and Growth perspective	The HRM department ensures that the company hires qualitative employees to grow each year.
Quality	The Customer Perspective	Besides the Sales department, the Quality department also ensures that the customer expectations are always met.
Parts (production)	The Internal-Business-Process-Perspective	The customers of VDL ETG Almelo are satisfied when their ordered products are appropriately manufactured and of high quality.

Table 1: The relationship between the BSC and the departments of VDL ETG.

Therefore, all perspectives of the BSC are included when we measure the performance of VDL ETG Almelo per department. However, according to Lucianetti (2010), the BSC implementation is conditional on the adoption of strategy maps. Additionally, according to Kaplan & Norton (1996) strategy maps enhance learning processes in the organization and this will help employees to understand how objectives can be achieved and therefore evaluates an individual's performance on strategically linked measures.

According to Singh & Woo (2008) "Organizational goals are categorized into three distinct levels, the strategic, tactical, and operational level. At each level, the goals are defined with different degrees of abstraction, inherit varying complexities, and serve different purposes." Goals at the strategic level are abstractly defined and support the long-term mission and vision statement of the company. There are no clear directions of how to realize this goal at this level. The tactical level supports the strategic level goals with a focus on a monthly trend analysis. The operational level supports the tactical level and includes a week-to-week analysis of the performance.

We show the relationship between the Strategy Map and the BSC, also involving the action plan in Figure 5 according to Kaplan & Norton (2004). However, our research only focuses on the measurement of KPIs using a real-time performance dashboard and not on which actions the management team has to make. Due to this, the action plan is out of the scope of our research.

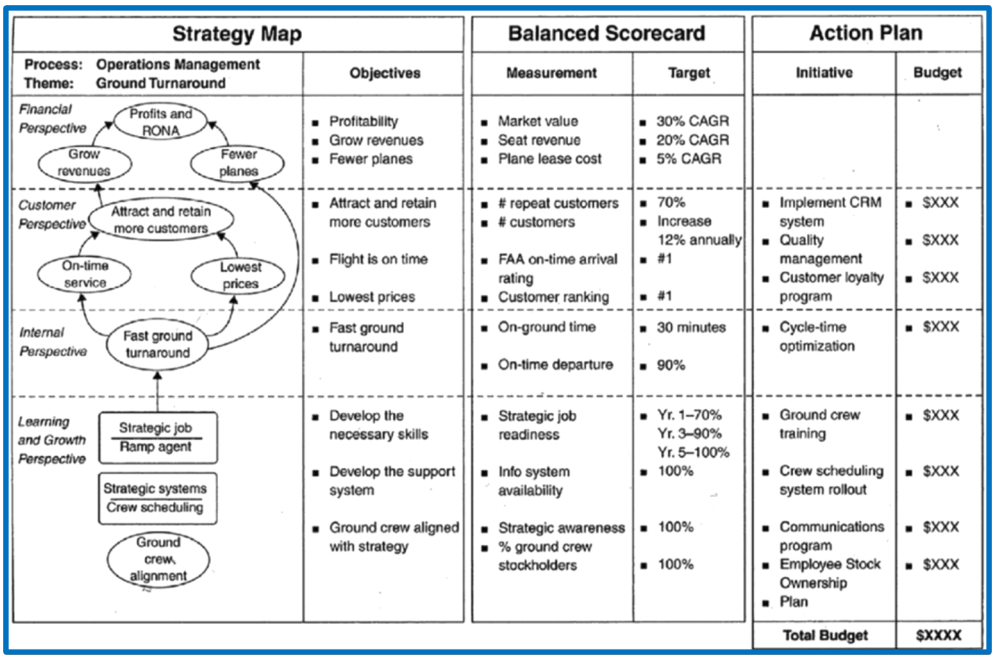

Figure 5: The relationship between the strategy map and the BSC (Kaplan & Norton (2004)).

As is mentioned by Singh & Woo (2008) the operational level includes analysis of the performance on a week-to-week basis. As the focus of this research is to provide real-time information per department on a week-to-week basis, we use Figure 5 at the operational level to visualize the goals of the management team per department and per BSC perspective. The same approach can be used for the strategic and tactical levels. Furthermore, we conduct a systematic literature review per department to find performance KPIs currently used in the literature. We elaborate on the steps and the outcome of this systematic literature review in the next section.

2.3 Performance KPIs in literature

Xiao & Watson (2019) described a step-by-step approach for conducting a systematic literature review. These steps are explained in Appendix 1. Table 15 in Appendix 2 shows the nine identified articles that should be reviewed from this systematic literature review. The KPIs mentioned per article for each department are shown in Table 16 in Appendix 3. By looking at this table, we may conclude that some KPIs are mentioned several times among the articles. Therefore, these KPIs have been removed from this table and, as a result, Table 2 is constructed. We use Table 2 in Section 4 to discuss which KPIs are beneficial to measure for making adequate management decisions per department. This discussion will take place with the management team and the outcome of this discussion will be described in Section 4.

Table 2: KPIs from the literature.

KPIs					
Sales	**Purchasing**	**Finance**	**HRM**	**Quality**	**Production**
Revenue	Inventory reduction	Resource utilization	Employee attendance rate	Customer complaint rate	Delivery punctuality
Sales growth	Inventory turnover	Revenue growth	Employee turnover	Non-conformity costs	Delivery reliability
Sales percentage fluctuation	On-time delivery rate	Capital turn over	Employee skill level	Amount of products of good quality	Orders delivered on time
Sales potential forecast	Out-of-stock rate	Current ratio	Qualification growth	DPU	System/line/workstation efficiency
%Complaints	Raw material costs	Customer value	Salary conformity	Mean time between failure	Capacity utilization rate
Customer acquisition rate	%Delayed purchases	Market share growth	Accident frequency rate	Quality of items produced	Comfort level of work
New customers added	Defect rate of purchased material	New revenue sources (market share)	Output/employee	Suppliers quality	Production backlog
Ratio of number of served complaints	Improve lead time	Product unit costs	Percentage of skilled employee	FPY (first pass yield)	Production capacity
%Number of local customers	Lead time	Profit margin	Satisfied employees	Machine capability	Quantity produced
Gross profit	Order fulfillment costs	Rework cost reduction	Skills improvement	Production quality/quality ratio	Resource utilization rate
Net profit	Supplier backlog	ROA	Work accident rate	Reclamations	Average productivity level
Re-buyer rate	Supply chain cycle time	ROI		Unit/Line reliability	Actual production time
Retained customers	%Slow moving stock	Satisfied customers		%Equipment quality rate	Factory productivity
Return on sales	%Warehouse space utilization	%Business asset			NEE (Net Equipement Effectiveness)
Satisfied customers	%Cost avoidance savings in procurement	%Business profit			Order to delivery lead time
	Cash to cash cycle time				Overall equipment effectiveness index
	Costs due to unsatisfied demand				Product cycle times
	Safety stock				Production lead time
	Weeks of forecast planning				Tact time
	Improve supplier relations				Number of patents generated
					Number of product types generated
					Process efficiency
					Product flexibility
					Use of technology

3. The current situation

We begin this section by giving a global overview of how the current static dashboard is constructed, updated, and visualized. After that, we describe the current measured KPIs per department. Finally, we explain how these KPIs are calculated and which data are needed for this calculation.

3.1 The current way of working

As already is mentioned, currently, static tools are used to measure the performance of VDL ETG Almelo. As can be concluded from Figure 2, this problem leads to a waste of time due to the manual creation of these files which again leads to human mistakes. The process of constructing the currently used dashboard is visualized below.

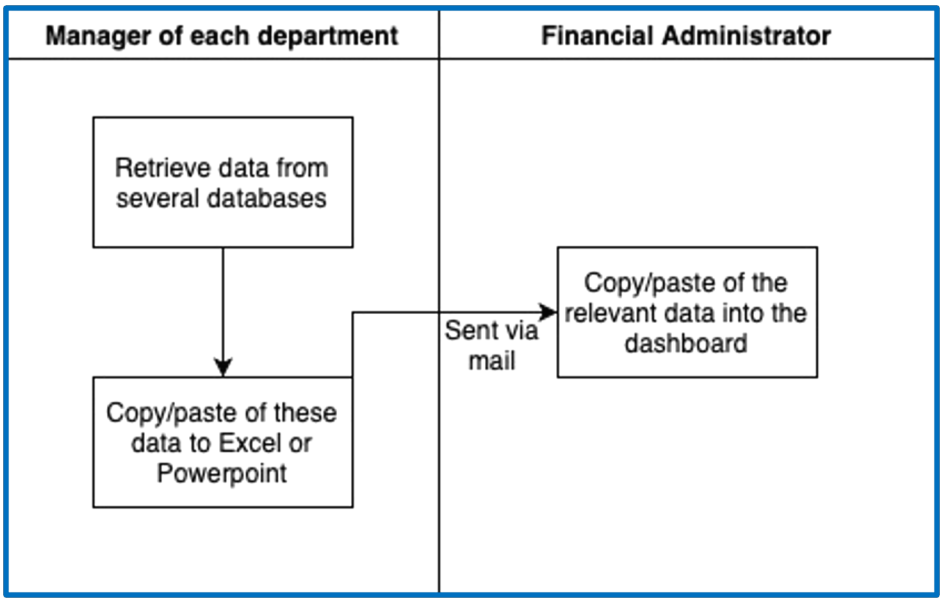

Figure 6: The process of constructing the dashboard.

This process repeats every week. It starts with the retrievement of data from several databases which is done by each manager of the seven departments mentioned in Table 1. For example, the HR manager gathers data from the MyVDL system whereas the Quality manager retrieves data from the Q system. Next, all these data are exported to Excel or Powerpoint and sent to the Financial Administrator of VDL ETG Almelo. This person again manually copy/paste these data to another Excel file which represents the dashboard of Figure 7.

MT Almelo

Weekly KPI Report format

KPI no	KPI	Unit	Cum.	Owner
1	Order intake	kEuro		PJ
2	Revenue	kEuro		PJ
3	CLIP	%		EH / AvdV
4	Fabr. Efficiency Utilisation	%		EH
5	Fabr. Efficiency Order Effect	%		EH
6	Physical Inventories	% Sales		JF
7	Coverage C.O.O.	kEuro		PK
8	Hiring In			AH
9	Hiring Out			AH
10	ConQ 3mnd	%		HK
11	QMM 3mnd			HK
12	CLIP Suppliers	%		JF
13	CLIP WF-Parts	%		AvdV
14	Dir./Indirect ratio			PK

Can not be shown due to confidential reasons.

Figure 7: The currently used dashboard.

The retrievement of data is done every week, therefore, the dashboard of Figure 7 is updated every week. From this figure, we see that the dashboard currently consists of only numerical values and no visualizations.

3.2 The currently used dashboard

Within Figure 7 the column “KPI no” represents the number of the KPI. Currently, 14 KPIs are measured in total, an overview of which KPIs are measured per department is provided in Table 3 below. Next to that, we will define all the KPIs per department.

Sales	System Integration	Purchasing	Finance	HRM	Quality Management	Parts
Order Intake	Confirmed Line Item Performance (CLIP)	Physical Inventories	Coverage C.O.O.	Hiring in	ConQ 3mnd	CLIP
Revenue	Fabr. Efficiency Utilisation	CLIP Suppliers	Direct/Indirect ratio	Hiring out	QMM 3mnd	
	Fabr. Efficiency Order Effect					

Table 3: The measured KPIs per department.

- Order Intake: the number of orders brought in by Sales multiplied by the selling price.
- Revenue: the number of orders realized times the selling price per order.
- CLIP: percentage of orders that are delivered on-time.
- Fabr. Efficiency Utilisation: the employee production hours divided by the hours in which the employees are present at the factory.
- Fabr. Efficiency Order Effect: the expected employee production hours divided by the actual production hours.
- Physical Inventories: the work in process (WIP) divided by the expected revenue of next year.
- CLIP Suppliers: percentage of orders that are delivered on-time from the suppliers.
- Coverage C.O.O.: the coverage of the production costs multiplied by the hourly rate, the material surcharges, and the general administrative surcharges.
- Direct/Indirect ratio: this number shows the ratio between the number of direct and indirect employees.
- Hiring in: the number of employees that could be hired in from employment agencies.
- Hiring out: the number of employees that could be hired out to other VDL ETG companies.
- Costs of non-quality (ConQ) 3mnd: the costs of having a quality issue divided by the revenue of the past three months.
- Quality management meeting (QMM) 3mnd: the number of customer complaints divided by the revenue of the past three months.

3.3 Data KPIs

The column "KPI" in Figure 7 represents which KPI is measured. By clicking on the name of the KPI, a Powerpoint or Excel file will be opened in which more detailed information about the calculation of this specific KPI is given. An overview of what kind of data is shown per document per KPI is provided in Table 4.

KPI	Unit	Connected document	Data mentioned in the document
Order Intake	kEuro	Powerpoint	Figure 28
Revenue	kEuro	Excel	Figure 29
CLIP	%	Powerpoint	Figure 30
Fabr. Efficiency Utilisation	(%)	Excel	Figure 31
Fabr. Efficiency Order Effect	(%)	Powerpoint	Figure 32
Physical Inventories	(% Sales)	Powerpoint	Figure 33
Coverage C.O.O.	(kEuro)	Excel	Figure 34
Hiring in		Excel	Figure 35
Hiring out		Excel	Figure 36
ConQ 3mnd		Powerpoint	Figure 37
QMM 3mnd		Powerpoint	Figure 37
CLIP Suppliers	%	Powerpoint	Figure 30
CLIP WF-Parts	%	Powerpoint	Figure 30
Direct/Indirect ratio		Excel	Figure 38

Table 4: Data per document per KPI.

To visualize such a large quantity of data we have used the following symbols within the Figures that are mentioned in Table 4:

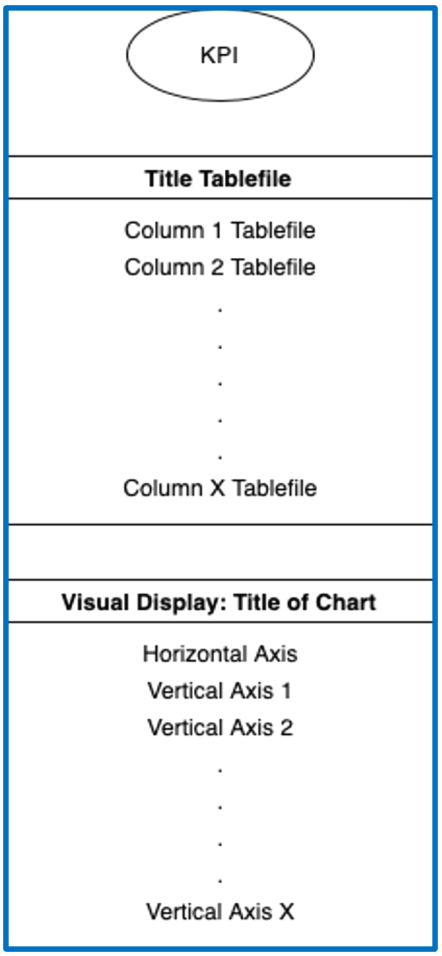

Figure 8: Symbols to visualize the data.

We discussed Figures 28 – 38 of Appendix 4 with the management team to establish whether all these data should be incorporated in the dashboards to make adequate management decisions. We will describe the outcome of this discussion in the next section.

4. Goals of the management

We describe the outcome of the several meetings that we had with each manager. In each meeting, we used the identified KPIs by the literature as a basis to give each manager some ideas of how KPIs are used within other manufacturing companies. Figures 28 – 38 of Appendix 4 are used to give the managers some impression of the large volumes of data shown in the documents and to establish whether all these data should be incorporated in the dashboards. We construct a strategy map to show the goal of each department and we explain this in Section 4.1. In Section 4.2, we identify whether each already measured KPI does add value per department by looking at the strategy map. Finally, we identify whether some additional KPIs should be incorporated to make adequate management decisions per department.

4.1 Goal per department

The strategy map is shown in Figure 39 in Appendix 5. From this figure, we have summarized the operational goal per department below.

Department	Operational goal
Finance	Being in financial health
Sales	Ensuring customer satisfaction by managing the orders of the customers and developing new businesses
Quality	Ensuring customer satisfaction
Production	Producing efficiently and on-time
Purchasing	Purchasing of qualitative material on-time
HRM	Recruiting quantitative, qualitative, on-time, and within the budget workforce

Table 5: Operational goal per department.

Now, the question remains how we could make these operational goals measurable. This will be discussed in the next section.

4.2 Making the goals measurable

In Table 6 each currently used KPI is shown and it is questioned whether each KPI does make the operational goal measurable.

Department	Current KPI	Does this KPI make the operational goal measurable?
Finance	Coverage C.O.O.	Financially health
Finance	Direct / Indirect ratio	Financially health/qualitative workforce
Sales	Order Intake	Business development
Sales	Revenue	Business development
Quality	ConQ 3mnd	Customer satisfaction
Quality	QMM 3mnd	Customer satisfaction
Production	CLIP	On-time
Production	Fabr. Efficiency Utilisation	Efficiency of employees
Production	Fabr. Efficiency Order Effect	Efficiency of employees and machines
Purchasing	Physical inventories	Financially health
Purchasing	CLIP Suppliers	On-time
HRM	Hiring In	No
HRM	Hiring Out	No

Table 6: Relationship between current KPIs and the goals.

The KPI “Coverage C.O.O.” measures how much costs per department are covered. The actual costs are booked every month and therefore the coverage is directly an indicator of the profitability of a project. In the monthly financial report, we assume that we currently have 3.5 times more direct employees than indirect employees. Therefore, this is a crucial KPI for being financially healthy and at the same time, it gives more insight into the qualities of the workforce which is one of the goals of the HRM department. The KPI “Physical inventories” indicates the turnaround time of the inventory. Here, it is important to minimize the amount of inventory to have more liquidity.

The focus of the Sales department is to manage the orders of the customers, to find new customers and, at the same time, to find new businesses within our current customers. The currently used KPIs “Order Intake” and “Revenue” make the goals of finding new customers and new businesses measurable. Next to that, the goal of the Sales department is to ensure customer satisfaction. This goal is ensured by evaluating the service of VDL ETG Almelo at their largest customers.

Customer satisfaction is also the focus of the Quality department. This is ensured by minimizing the customer complaints and the costs of having a quality issue.

The goal of the Production department is to produce efficiently (employees and machines) and on-time. Producing efficiently is currently measured by the KPIs “Fabr. Efficiency Utilisation” and “Fabr. Efficiency Order Effect”. Producing on-time is measured by the CLIP.

Purchasing qualitative material on-time is the goal of the Purchasing department. On-time is currently measured by the CLIP. Therefore, we conclude that we currently do not measure whether our purchased material is of the required quality in the current dashboard.

From Table 6 we see that we currently do not measure anything for the HRM department which makes the goal measurable. This is the case because the current used KPIs are not updated every week. Therefore, we should incorporate some new KPIs in the dashboard which make the operational goal measurable. We define the newly introduced KPIs in the next section.

4.3 New KPIs

In this section, we introduce some new KPIs which are not defined in the current dashboard yet. Besides that, we introduce to emphasize some important KPIs which are already defined in one of the files of Table 4 but are overlooked due to the large volume of data visualized. These KPIs are shown in Table 7.

Department	New KPI	Emphasized KPI	Definition	Does this KPI make the goal measurable?
Finance		Indirect hours	The indirect hours of an employee	Financial health
Finance		Absenteeism due to illness hours	The hours of absence of an employee	Financial health
Finance		Holidays hours	The holidays hours of an employee	Financial health
Sales	Accounts receivable		The balance of money that should be paid by customers but is within the payment term	Financial health
Sales		Amount overdue	The balance of money that should be paid by customers but is outside the payment term	Financial health
Sales		Plan to win (PTW)	The revenue that is expected by the Sales department	Business development
Quality		Number of issues per million turnover	The number of issues divided by the turnover	Customer satisfaction
Production	Production hours (unmanned and manned)		Number of unmanned and manned hours per machine	Efficiency of machines
Purchasing		Supply Chain Commitments	The number of outstanding commitments within the supply chain separated into four different categories	On-time
Purchasing		Inventory level	The inventory level separated into three different categories	On-time
Purchasing	Out-of-stock rate per article		The out-of-stock rate per article	On-time
Purchasing	Reliability supplier		The delivery reliability per supplier	On-time
HRM	Number of employees		The number of contractual, temporary, in sourced, and apprenticeship agreement employees	Quantitative workforce
HRM	Average of absenteeism due to illness		The average illness rate of all the employees	Qualitative workforce
HRM	In-out flow		The inflow and outflow of employees	On-time workforce

Table 7: New KPIs.

We emphasize three KPIs for the Finance department, the indirect hours, the absenteeism due to illness hours, and the holidays hours. Assumptions of the averages of these KPIs are made in the monthly financial report. The target for the indirect hours as a percentage of the total hours is equal to 4%, and for the illness hours this ratio is equal to 5%. When the averages of these KPIs are higher than the target, it means that we should book more costs than expected. The assumption for the holiday hours as a percentage of the total hours within the monthly financial report is equal to 13%. However, here a lower or higher percentage does not necessarily mean higher costs since this depends on the current workload. When we have a high workload, we prefer to minimize this percentage and vice versa.

For the Sales department, we introduce one new KPI in the current dashboard which is the accounts receivable. The accounts receivable shows the balance of money that still should be received but is within the due date. When this amount is received, it increases the liquidity level which is a goal of the Finance department. We choose to emphasize the amount overdue which shows the amount that still should be received but where the due date has expired. Again, when this amount is received, it increases the liquidity level. We have decided to give the Sales department the responsibility of both KPIs, since they are responsible for the customer contact and in this way can monitor these KPIs. The target of the amount overdue is equal to zero whereas the accounts receivable is more intuitively without a target. The third KPI, the PTW, shows the expected revenue according to the expectations of the Sales department. In this way, we can look a few months ahead to conclude whether new businesses are developed.

The number of issues per million turnover is emphasized in the dashboard of the Quality department. This KPI counts the quality issues of the whole supply chain instead of only the end customer. A supplier could also be a customer and therefore this KPI should be included in the dashboard. Customer satisfaction is not only about the end customer but about the whole supply chain.

We add the unmanned machine hours and the manned machine hours in the dashboard of the Production department. By measuring these KPIs, we could measure the efficiency of the machines directly. Here, we define the efficiency of machines as the hours that the machines are producing unmanned. An assumption that is made within the monthly financial report is that this amount should be equal to 380 hours per week. When this KPI is higher this would mean that we have fewer employee costs and thus we save costs.

We introduce four KPIs in the dashboard of the Purchasing department. All KPIs measure whether our suppliers are delivering on-time. The first KPI, the number of outstanding commitments, gives an indication about the growth of the company but it has not a specific target. The materials should always be purchased when an order is registered in the ERP system. The yearly target for the revenue is equal to 250 million which means that more materials should be purchased to realize this target. The products that are manufactured by VDL ETG Almelo have a long lead time and therefore the inventory level is relatively high. This level is growing due to the growth of the company and has again not a specific target. The third new KPI which is the out-of-stock rate per article is part of the Vendor Managed Inventory (VMI) system of VDL ETG Almelo. This is an agreement where the suppliers have control of the inventory levels. By measuring this KPI we see which supplier has the highest reliability of delivering the raw materials on-time which is the fourth KPI.

For the HRM department, we add three new KPIs that all measure a part of the goal. We see that we currently do not have added a KPI that measures the HRM budget, this is the case because the budget is already known and monitored within the department and therefore it is not relevant to show it weekly to the other managers. The first KPI, the number of employees, gives an overview of the different types of employees. This is an important KPI since VDL ETG Almelo is growing in its business activities and therefore more employees should be hired. The average illness rate of the company is measured to indicate the productivity of the workforce. This number should be less than 4%. Finally, the in-out flow of employees measures whether the HRM department already has found someone for an employee that is leaving. It is important to replace an employee on-time since the business activities are growing.

With the value-adding KPIs of Table 6 and the introduced KPIs of Table 7, we have identified all the KPIs which will be included in the dashboards. These KPIs are all shown in the strategy map of Figure 39 in Appendix 5. By looking at this figure we already see that some KPIs which also have been found in the literature are included in the dashboards. Therefore, we have made an overview of these KPIs in Figure 40 in Appendix 6. Reasons for excluding some particular KPIs are also mentioned within this figure.

5. The data model

We develop the dashboards using the Power BI tool from Microsoft. This decision has been made in consultation with the management of VDL ETG. Microsoft is again for the twelfth time positioned in 2021 as the leader of its market according to Richardson et al. (2021). The results of this study are shown below in Figure 9.

Figure 9: Magic quadrant for analytics and BI platforms (Richardson et al. (2021)).

According to the training session of Microsoft, in which I have participated on the 22nd of July, the steps for developing a data model are as follows:

1. Access: having access to the source database is necessary to retrieve the data for the dashboard.
2. Clean and transform: once you have access to the data source, cleaning and transforming the data is crucial for the next step.
3. Mush-up: connect the datasets by creating relationships between the different tables.
4. Explore and visualize: when the data model is developed and the relationships are identified, the data can be visualized.
5. Share: share the developed dashboard with the managers of the company.

The first three steps will be explained in this section. These steps are visualized in Figure 10.

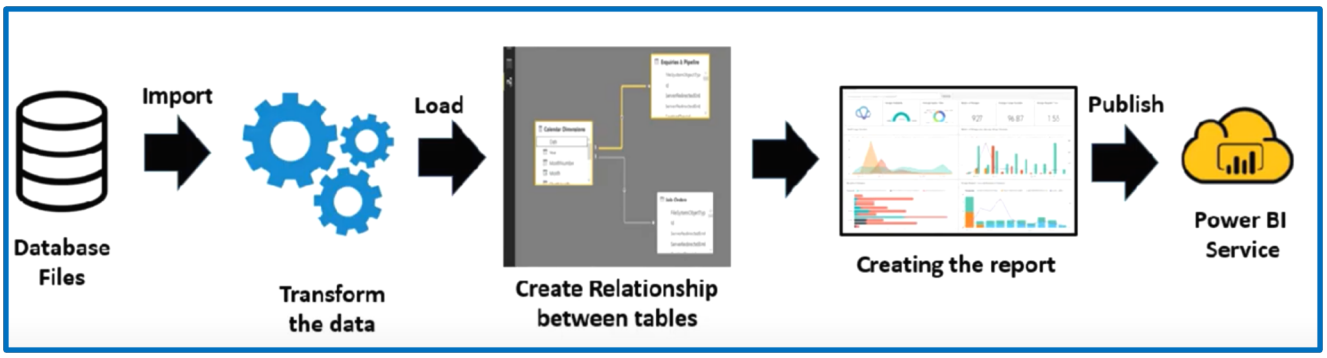

Figure 10: Steps to take for developing the dashboard.

5.1 Step 1/2: Access and cleaning of the database

We always focus to make access to the database files within the data warehouse of VDL ETG. However, some specific data are only registered by the ERP system of VDL ETG Almelo which is already more than 30 years old. Due to this, a connection to Microsoft Power BI is not possible and therefore Excel files should be used as input files. This decision has been made in consultation with the management of VDL ETG and these files are especially used for the Finance and HRM department. A new ERP system will be implemented in which this connection is possible for all departments. For step 2, the cleaning and transformation step, we use the query editor tool within Microsoft Power BI. An example of the cleaning and transformation code for the table “HRM_Ziekteverzuim per functie 2021” is shown in Figure 41 in Appendix 7.

5.2 Step 3: Relationships between tables

By creating relationships between the unique keys of the tables we ensure connectivity. An overview of all the tables that are used in the dashboards is shown in Figure 11. We have used two types of relationships, a one-to-many relationship, and a many-to-many relationship. In a one-to-many relationship, one record in a table can be associated with one or more records in another table. In a many-to-many relationship which is shown in Figure 12, more records in a table can be associated with more records in another table.

The first 3 steps of the step-by-step approach are now explained. In the next section, we will elaborate more on step 4: the visualization of data.

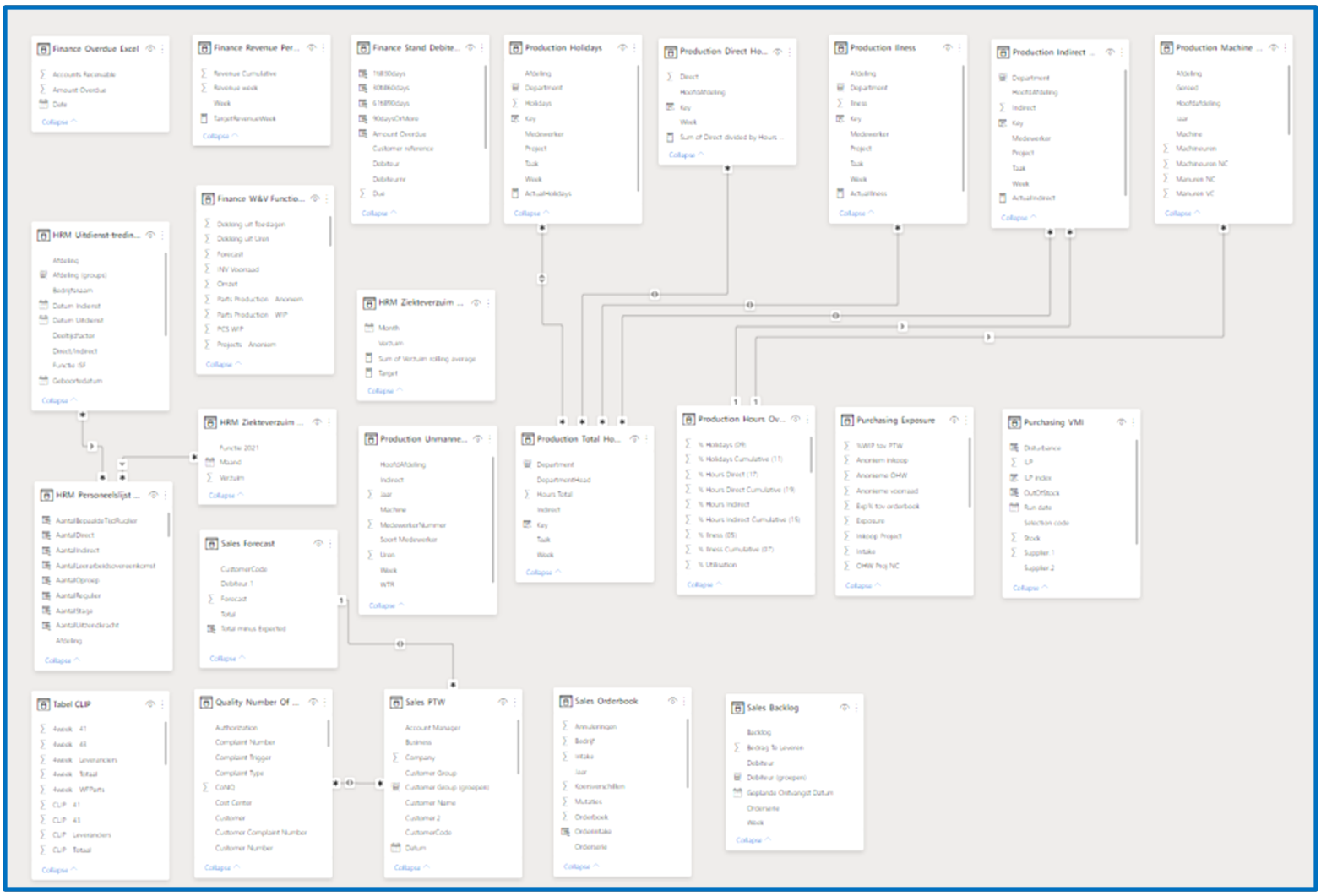

Figure 11: Relationships between the tables.

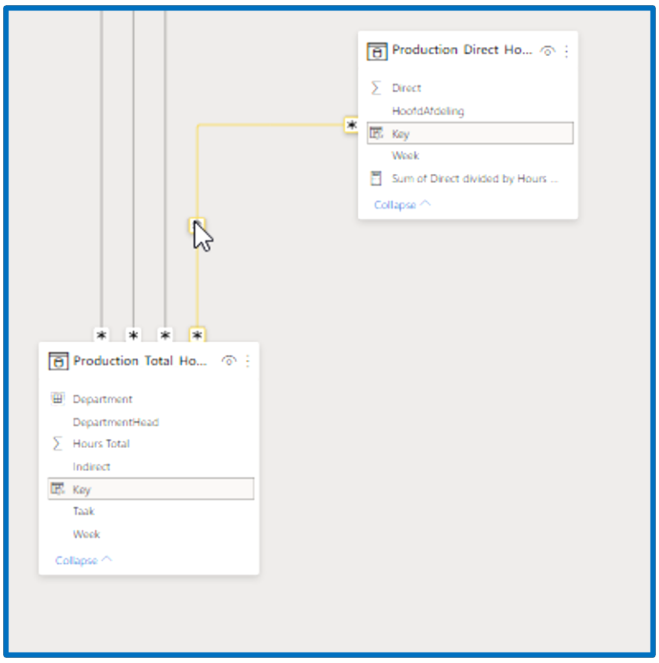

Figure 12: Many-to-many relationship.

6. Data visualization

By visualizing data, we aim to prevent problems regarding interpretation mistakes of the management team. In this section, we answer the research question "What is the most suitable way to visualize each KPI" and hence step 4 of the step-by-step approach mentioned in the previous section will be explained.

According to the training session of Microsoft, the steps to data visualization are as follows:

1. Consider who your audience is:
    a. What should be the purpose of the dashboard?
    b. How will the dashboard be used?
    c. What information does the reader need to be successful?
2. Use-best practice dashboard as follows:
    a. Good dashboards tell a story with data that does not become overwhelming.
    b. Look through the eyes of the user. Start by telling the story in the upper corner of the screen to the lower corner of the screen.
    c. The developed dashboard should be simple with only 3-5 charts or tables. This will avoid that data become overwhelming.
    d. Provide adequate context and keep items next to each other.
    e. Avoid showing KPIs with only single values without any context.
    f. Avoid variety in data visualization.
    g. Place tables at the bottom of your dashboard to ensure that the dashboard is relatively simple.
3. Avoid common data visualization issues:
    a. Choose appropriate data visualization chart.
    b. Be consistent! This means that chart scales, chart dimension ordering, and the colors used for dimension values should be the same within charts.
    c. Do not exceed three or four numerals when displaying values.
    d. Do not mix levels of precision and time within one chart.
    e. Do not mix large and small measures on the same scale within one chart.

Regarding the first step of this step-by-step approach, Janes & Succi (2013) mentioned that a useful dashboard should be related to the business goals of the organization. The development of this dashboard requires the involvement of the management and is a continuous process since the organization is always learning. Here it is important to constantly ask whether the current business goals, assumptions, strategy, and measurement goals should be updated. Janes & Succi (2013) also emphasized the importance of the visualization of data. The visualization is crucial since it has a huge impact on the acceptance of the dashboard.

We already have answered the three questions of the first step in Section 4 where the needs of the management are described.

Kelleher & Wagener (2011) have listed ten guidelines for an effective dashboard which is the second step. These ten guidelines support the primary objective of effectively conveying the relevant information from the dashboard. The first guideline is to “create the simplest graph that conveys the information you want to convey”. This means that for example, three-dimensional plots are often not desired as it is difficult to compare datasets and to distinguish values. “Focus on visualizing patterns or on visualizing details, depending on the purpose of the plot” is the third guideline. Here the choice is between displaying patterns or details. The purpose of each chart is important to be aware of. The possible chart types in Power BI are already shown in Table 8. The fourth guideline is “select meaningful axis ranges”. The axis range is dependent on the graph’s purpose and type. When for example only absolute values are important to the user, the vertical axis should begin by zero. The ninth guideline is to “keep axis ranges as similar as possible to compare variables”. By ensuring the same ranges between the plots, the plots can be more easily compared and we will save more time. The last guideline is stated as to “select an appropriate color scheme based on the type of data”. This guideline is also mentioned by Janes & Succi (2013). They stated that “the colors of the dashboard indicators show how urgent the matter is. Red indicators typically mean that the problem is serious and that some action is needed immediately. Yellow indicators show that some action is required soon. Green indicators inform the driver that some system is turned on”.

The second step will be considered by the design of the dashboards in the next section. The third step corresponds to choosing data visualization charts. Janes & Succi (2013) mentioned the following considerations regarding the visualization of data:

- The dashboard should be visible to the user without any effort. The information should be pushed to the users without their active participation.
- The user of the dashboard should not need to interact between different visualizations to understand the data. Here, every visualization must have its purpose.
- The visualized data in the dashboard should be arranged to minimize the time needed to consult the dashboard. This means that the same information should always be placed in the same plot which will allow the user to develop habits.
- The dashboard should guide the user to important information, but it should not be overused. For example, the user will ignore it when everything on the dashboard is blinking.

We made an overview of which chart types are available within Microsoft Power BI including the purpose of each chart and an explanation. This overview is provided in Table 8.

Table 8: Visualization types in Power BI (Microsoft Power BI (2021)).

Chart Name	When to use	Explanation
Basic Area chart	• To see and compare the volume trend across time series • For individual series representing a countable set	Area charts show the magnitude of changes over time.
Bar chart	• For comparison of specific values across different categories	Bar charts show bars for each category. The length represents the measured value of the category.
Cards	• Showing a single number which is the most important	This type of visualization just shows a single number.
Combo chart	• Same X-axis for both charts • To compare multiple measures with different value ranges • To illustrate correlation	A combo chart combines a column chart and line chart. By combining these two charts it might be that comparison of data will be made easier.
Doughnut charts and pie charts	• To show the relationship of parts to a whole	These charts visualize the value of some parts to the total value.
Funnel charts	• When data are sequential and move through at least four stages • To identify bottlenecks	Each funnel stage represents a small percentage of the total value. Therefore, this chart is shaped like a funnel in which the first stage is the largest and each subsequent stage smaller than its predecessor.
Gauge chart	• To show progress towards a goal • Single measure	The line of the gauge chart represents the target value whereas the shading represents the progress towards the goal.
Key Influencer Visualization	• To show the factors which affect the metric being analyzed the most	This chart analyzes your data, ranks the factors that are important automatically, and displays these factors as key influencers.
KPIs	• To show progress towards a goal • Single measure	This type of visualization just shows a single number.
Line charts	• To display trends and values usually over time	Line charts show usually a value over time which is useful when visualizing trends.
Maps	• To display points on a map	This chart is useful when the user has geographical data to visualize on a map.
Matrix and table	• Data that is meaningful across multiple dimensions	A matrix value is similar to a table where data is displayed in two dimensions. Besides that, the data are flat which means that duplicate values are displayed and not aggregated.
Ribbon charts	• Effective at showing rank change	Ribbon charts are effective at showing the rank change in which the highest value is always displayed on the top.
Scatter and bubble charts	• To show relationships between two numerical values	Data points or bubbles are shown to identify a relationship between two numerical values.
Tree-map	• When a bar chart can not effectively handle a large number of values • To display large amounts of hierarchical data	Treemaps display hierarchical data as a set of nested rectangles. Each level of the hierarchy is represented by a colored rectangle containing smaller rectangles.

7. Implementation of the dashboards

When designing the dashboards, we have used the best-practice dashboard design of Section 6. Next to that, it is important to mention that the management team only wants to see more specific details about a KPI if that particular KPI is not meeting its target. Otherwise, the KPI is meeting its target, and therefore the management team can go on to look at the next KPI. This philosophy is incorporated when designing the dashboards. As is mentioned, we only provide the workflow per department below as the dashboards can not be shown due to confidential reasons. We explain more about the visualization types of the developed dashboards at the end of this section.

7.1. Dashboards per department

7.1.1 Finance

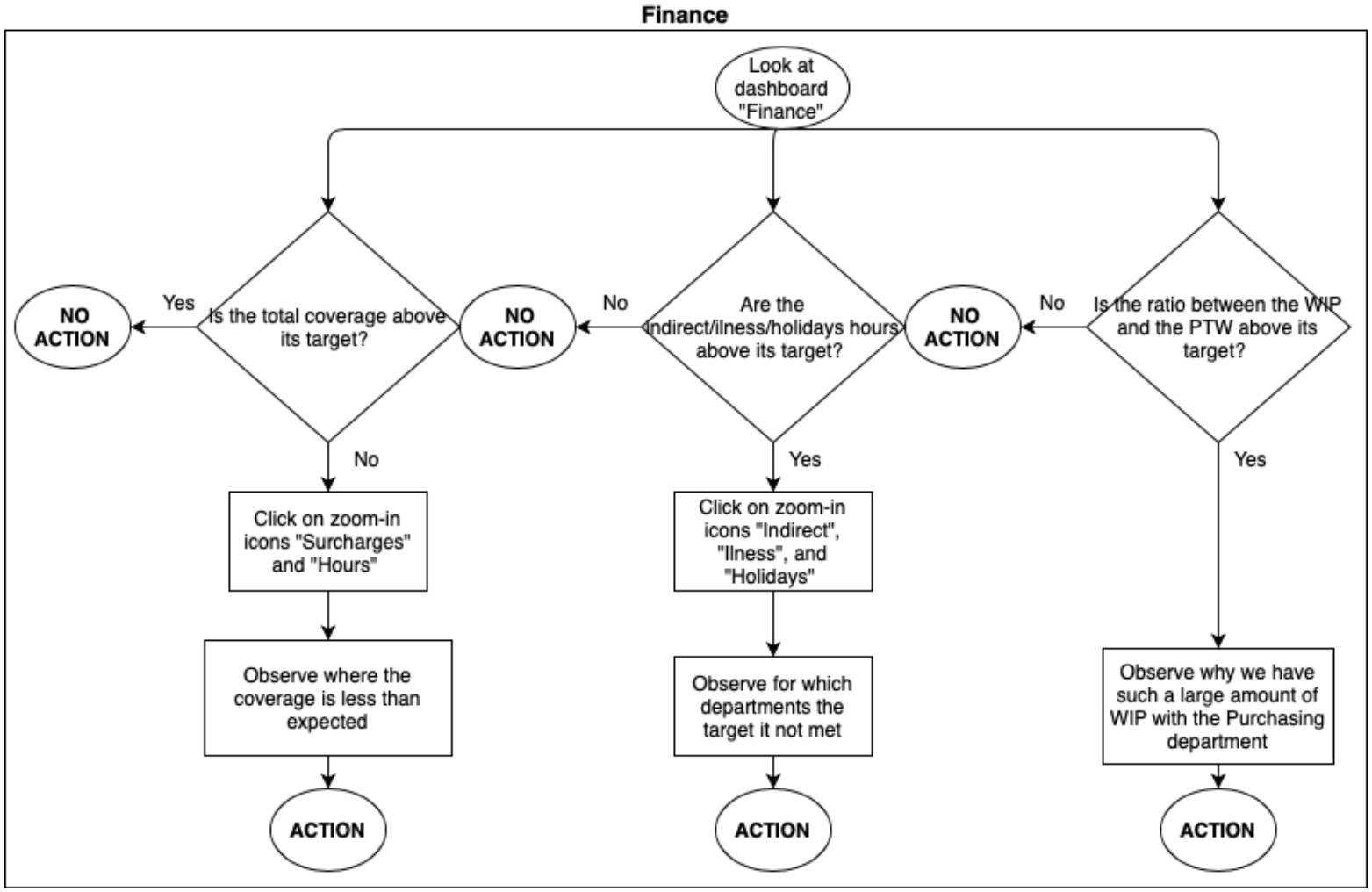

Figure 13: Finance dashboard.

7.1.2 Sales

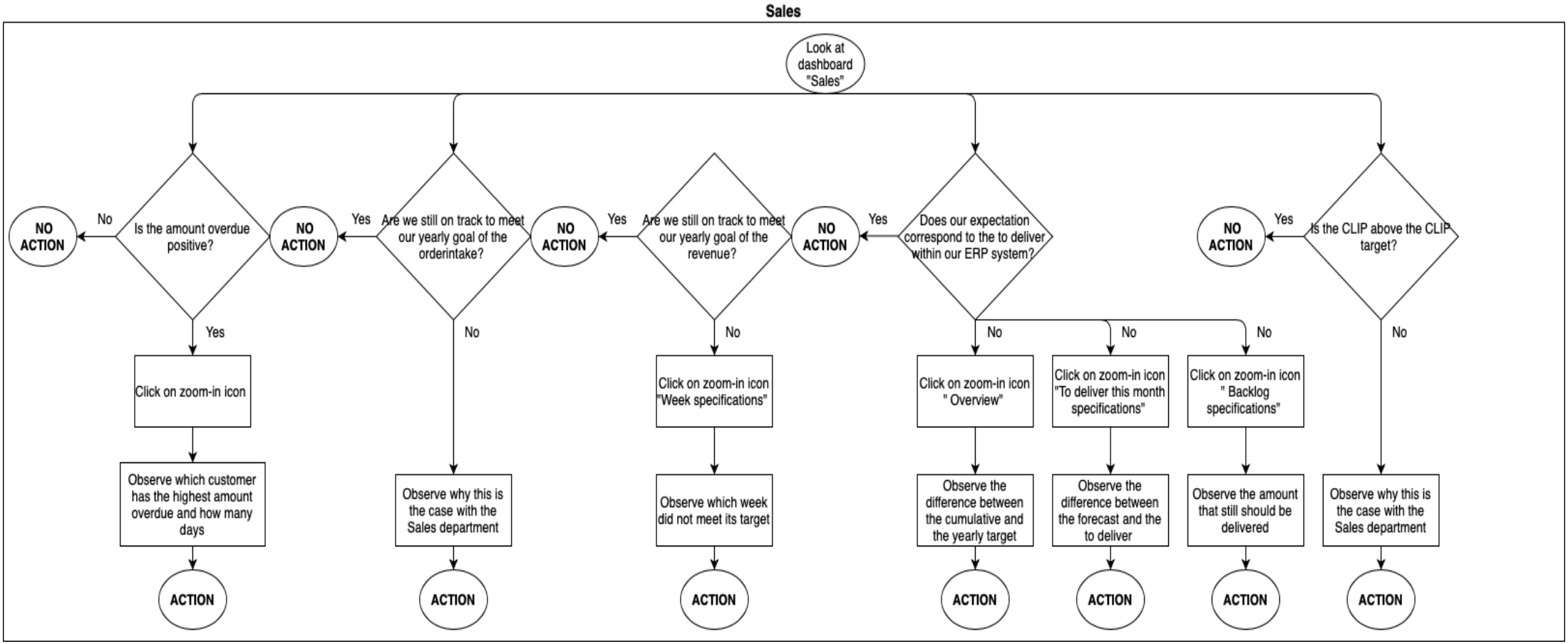

Figure 14: Sales dashboard.

7.1.3 Quality

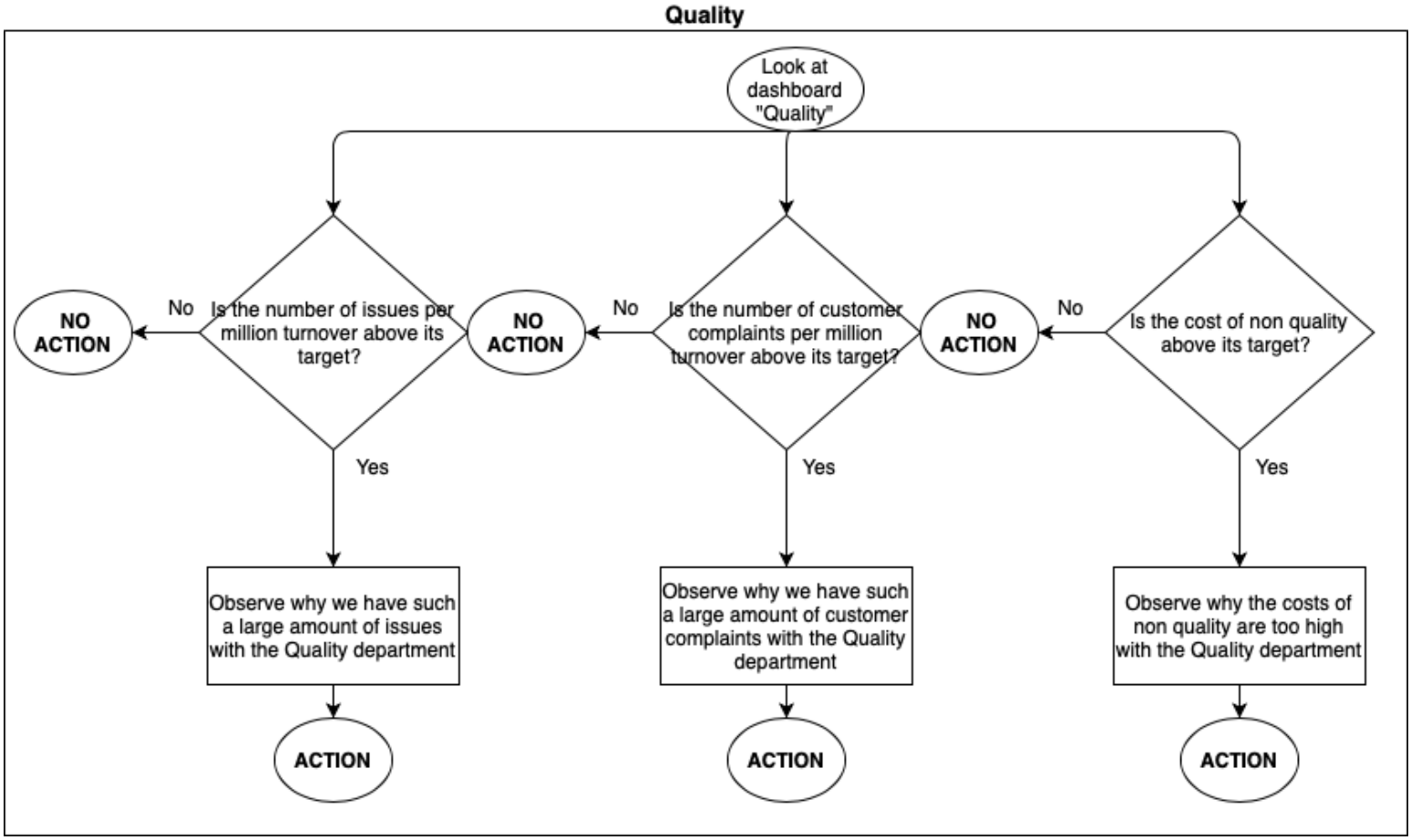

Figure 15: Quality dashboard.

7.1.4 Production

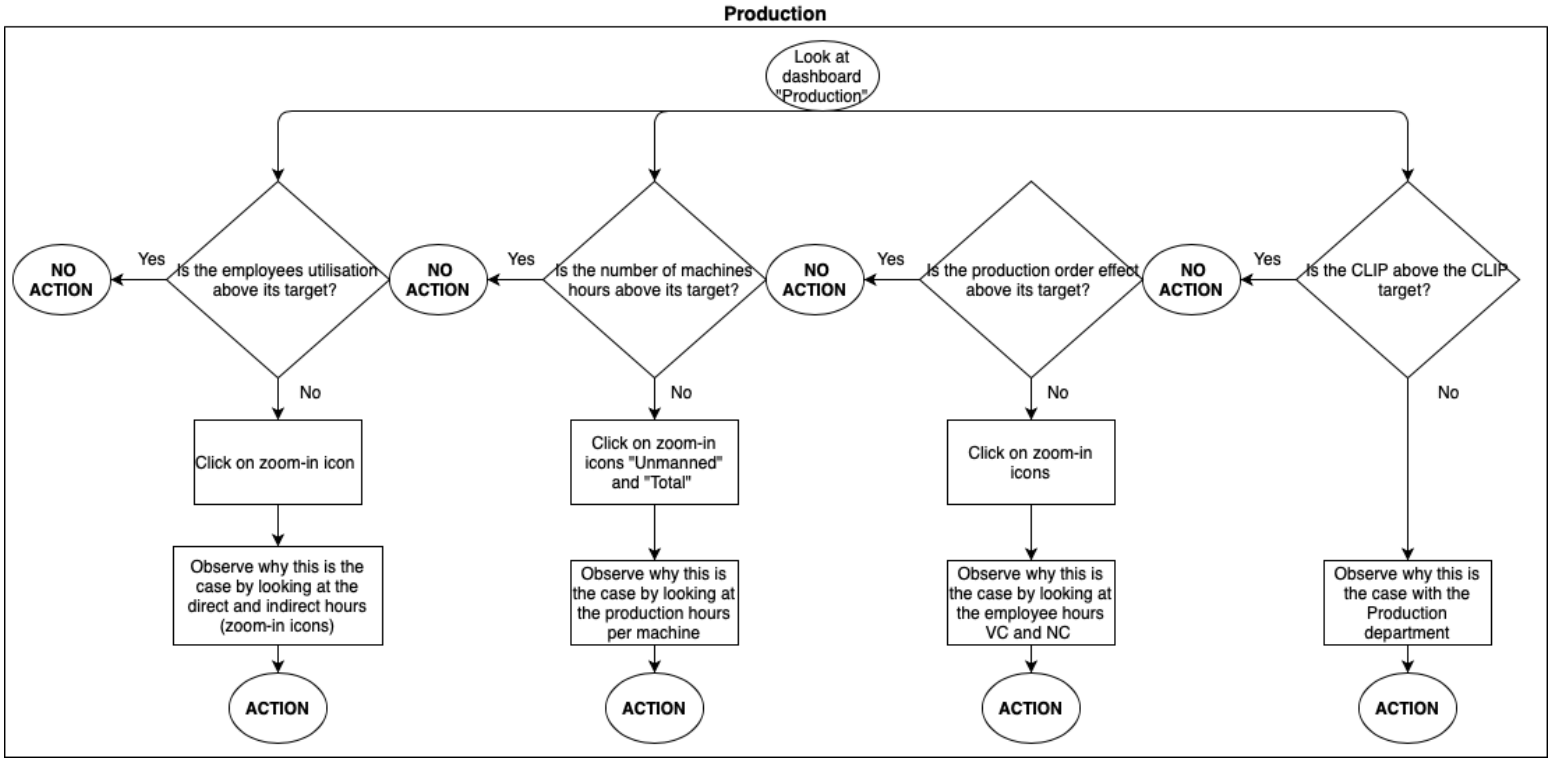

Figure 16: Production dashboard.

7.1.5 Purchasing

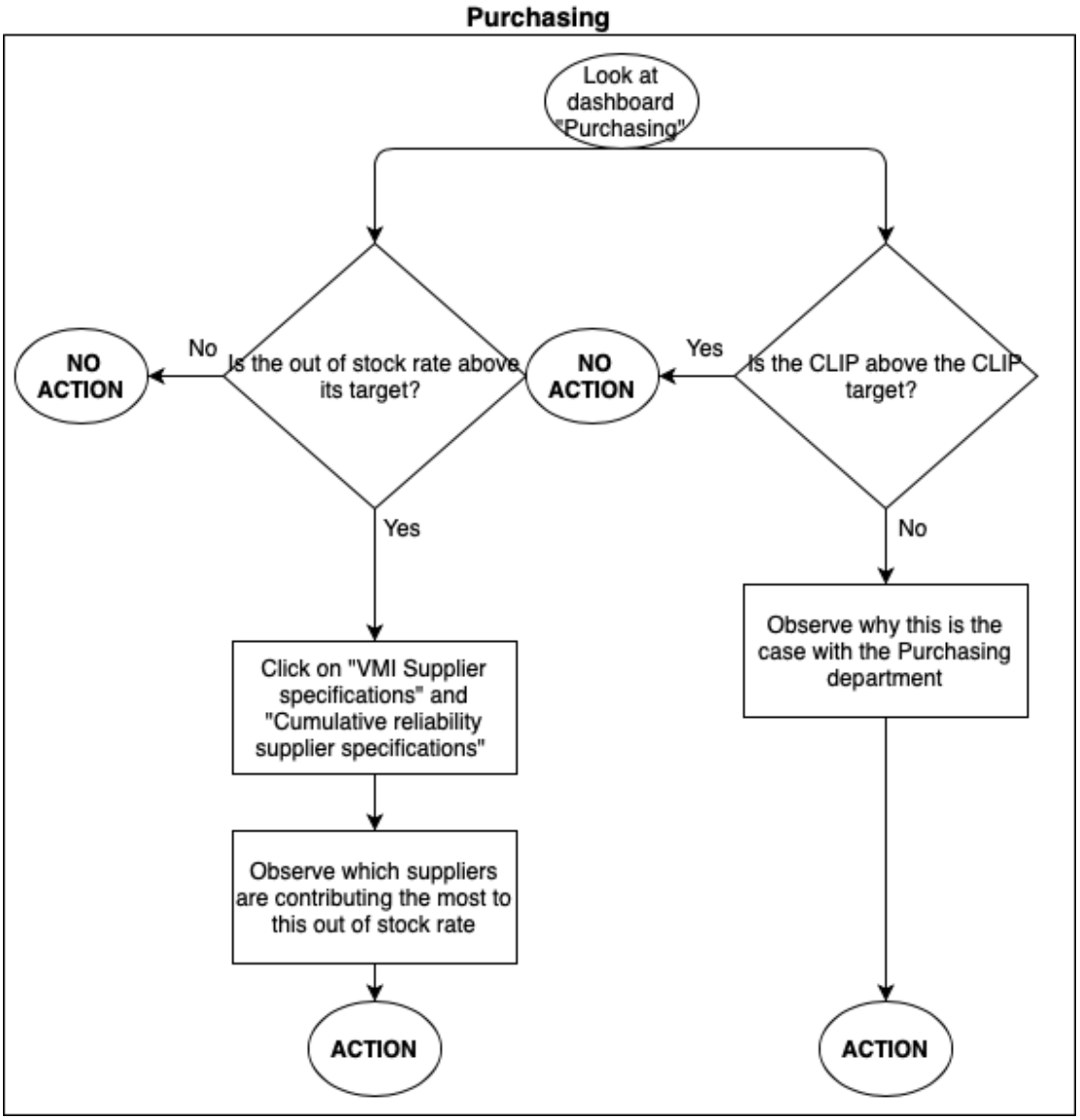

Figure 17: Purchasing dashboard.

7.1.6 HRM

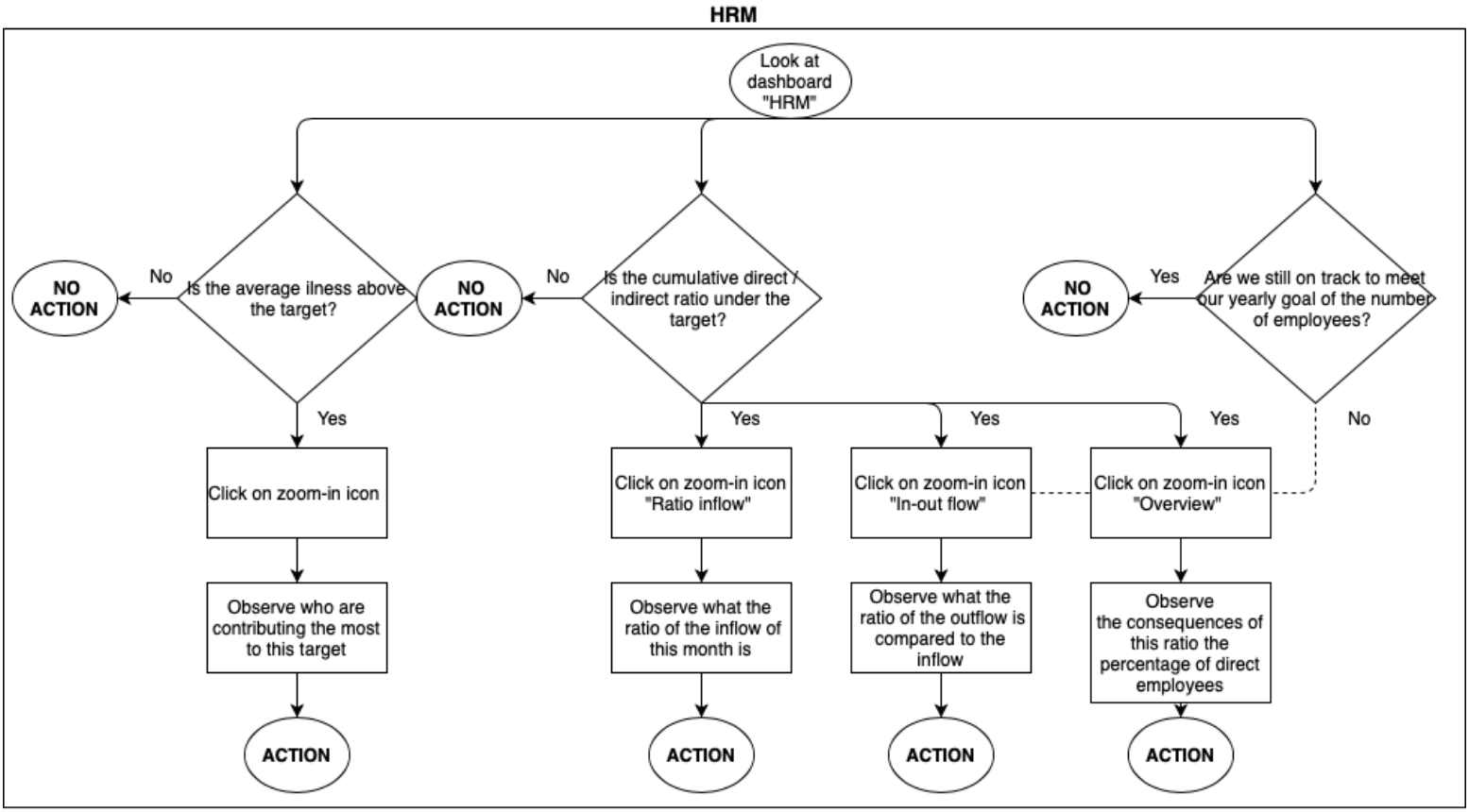

Figure 18: HRM dashboard.

7.2 Explanation of the dashboards

Examples of the most important measurements programmed in Power BI are shown in Appendix 8. For example, measurements for calculating a rolling average every week or a cumulative over 11 months were necessary to make the visualizations that were desired by the management. In this section, we elaborate more on five dashboards.

The first example is part of the Financial dashboard which is shown in Figure 19. The left graph shows the total coverage separated in the coverage from surcharges and hours. The most important point is whether the total coverage is above its target. Besides that, it is important to know the ratio between surcharges and hours for the Financial manager. Therefore, we have chosen to use a bar chart with a target line. A bar chart should be used when specific values should be compared across different categories. This is exactly the purpose of visualizing the total coverage since the ratio between surcharges and hours is important. When the user is curious about the trend of the surcharges or hours, the user can click on the zoom-in icon to see the specifications over the weeks. The right graph of Figure 19 shows the cumulative average of the indirect, absenteeism due to illness, and holidays hours. The purpose of this graph is to see directly if our average is significantly different compared to the previous week. If this is the case, the user can again click on the zoom-in icon to see the specifications of this week compared to the specifications of the cumulative average.

The second dashboard is part of the Quality dashboard and is shown in Figure 20. The left graph shows the number of customer complaints per million turnover. Here, the target for the 12-month rolling horizon is visualized. The dotted line shows the 3-month rolling horizon which gives more information about the short-term trend of this KPI. We have decided to use a line chart for this visualization as we would like to observe a trend. The outcome is marked green because the current value of the KPI is below the target which means fewer customer complaints. The right graph has the same axes as the left graph to easily compare whether a high number of customer complaints lead to high costs of non-quality as is mentioned by the ninth guideline of Kelleher & Wagener (2011). In this graph, the outcome is marked red when the current value of the KPI is above the target which means high costs of non-quality.

The third and the fourth dashboards are part of the Sales dashboard and are shown in Figure 21 and Figure 22. The third dashboard shows the revenue versus the amount that still should be delivered versus the expected revenue (PTW). We have decided to use a bar chart because the ratio between the revenue and the amount that still should be delivered is important. “Red indicators typically mean that the problem is serious and that some action is needed immediately” according to Janes & Succi (2013). Therefore, the amount that still should be delivered is colored red. The user can click on the overview button to see the exact values and the cumulative expected revenue over the year. The second button shows the customers that still should be delivered this month with the forecasts of the Sales department. Some action is needed if there is a large difference between these two values. The third button shows the amount that still should have been delivered in the past months which is also known as the backlog. This amount is shown per customer to know which person should take some action.

The fourth dashboard shows the cumulative revenue over the year. We have decided to use a bar chart because the user can click on a specific customer and a ratio of the cumulative bar chart will be visualized. This part belongs to the revenue of the specific customer and in this way we can see the trend per customer and the ratio to the total revenue. When the cumulative revenue is not in line with the expectations of the user, the user can click on the week specifications where the revenue per week will be visualized together with a target per week.

Finally, the inflow and outflow of employees per month are shown in Figure 23. This dashboard is part of the HRM dashboard. The pie chart is interactive, because when the user clicks on a part of the pie chart, another chart will be visualized which shows the inflow and outflow of employees per department. Again, when the user clicks on a specific department, another chart will be visualized which shows the inflow and outflow of employees per function. We have chosen to visualize the inflow of employees the same as the outflow to easily compare both values. A bar chart is used because we should compare different categories to the total number of employees, namely the direct/indirect ratio, the department of an employee, and the function.

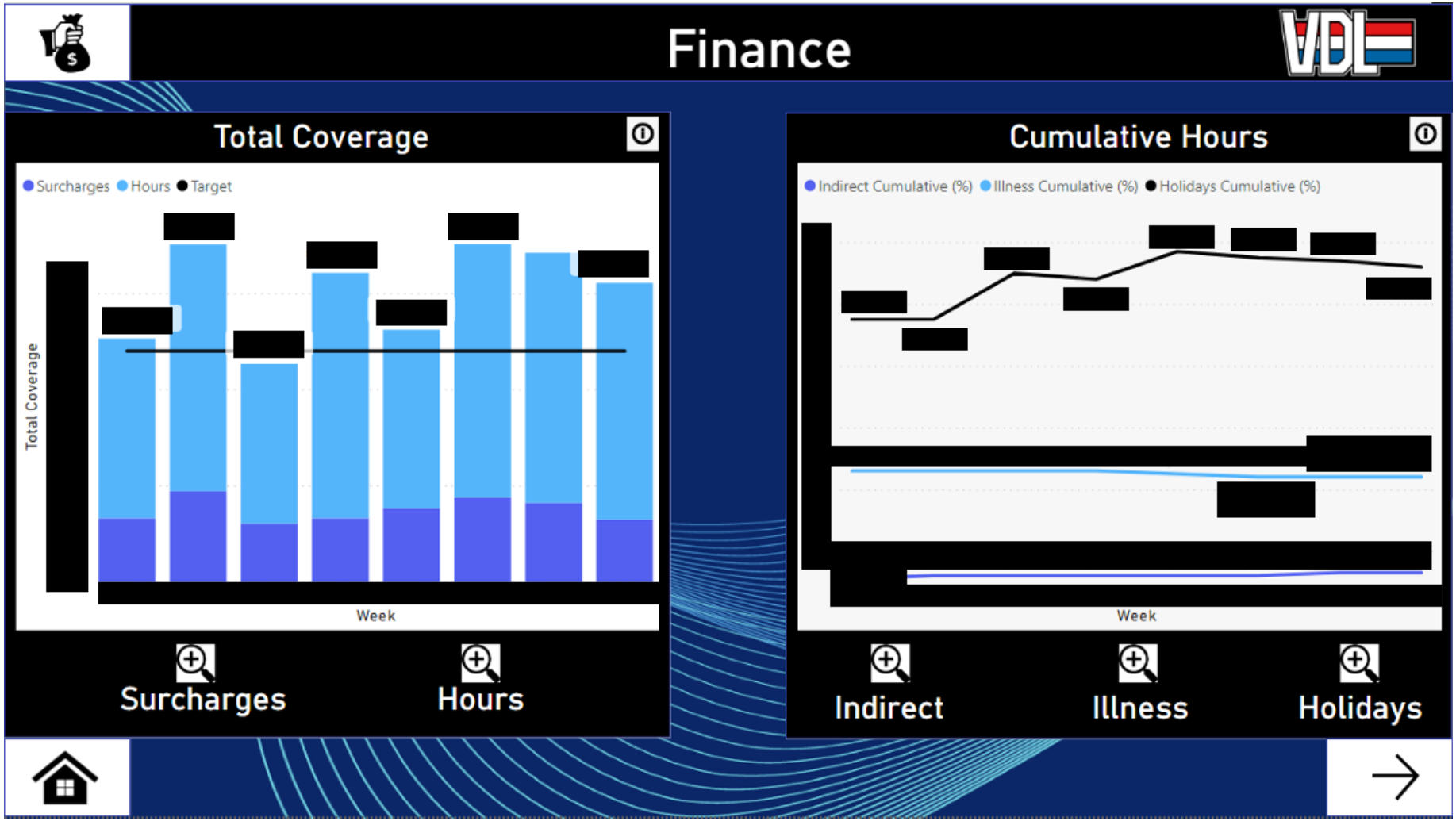

Figure 19: Finance dashboard: total coverage and cumulative hours.

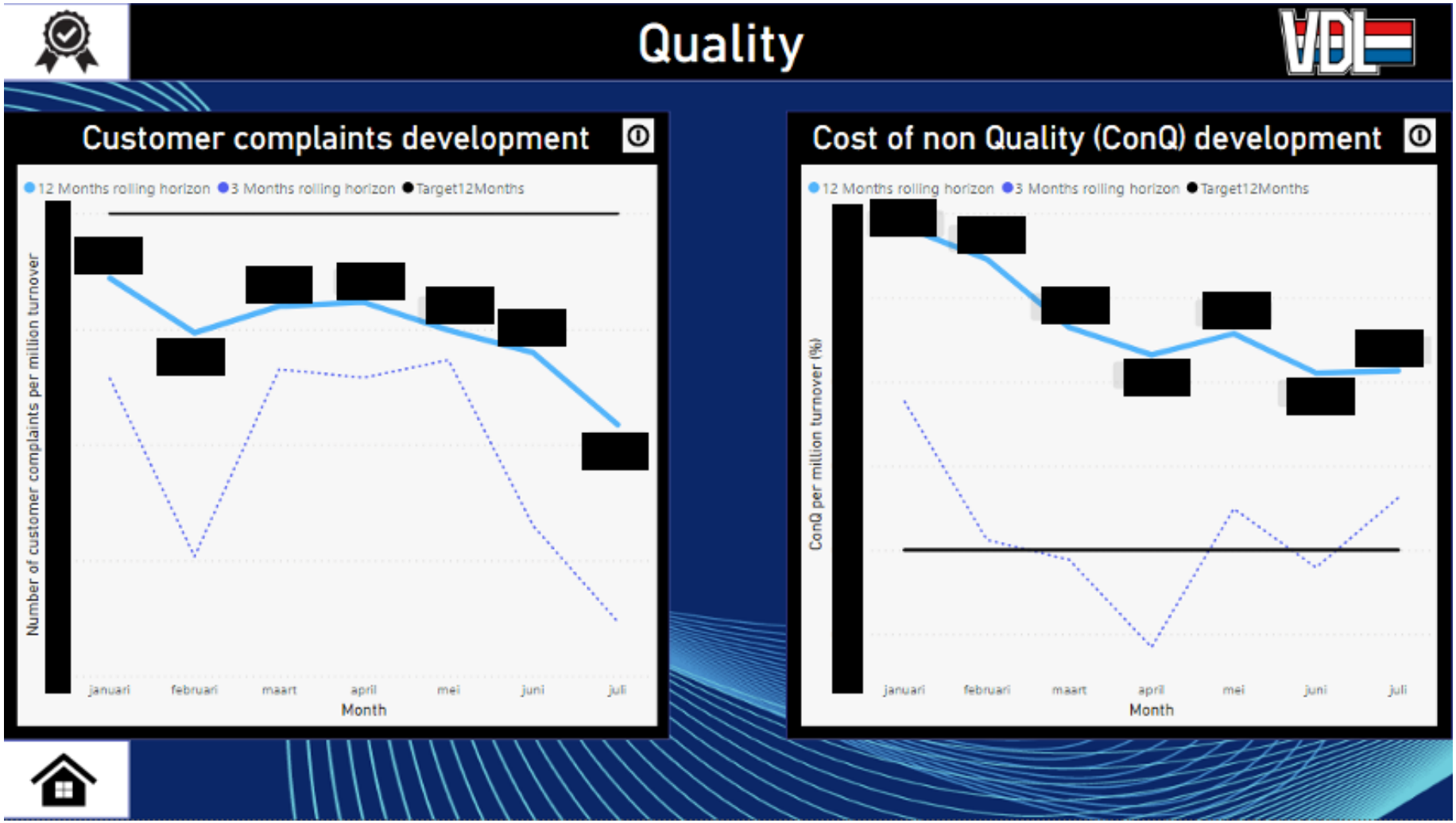

Figure 20: Quality dashboard: customer complaints development and ConQ.

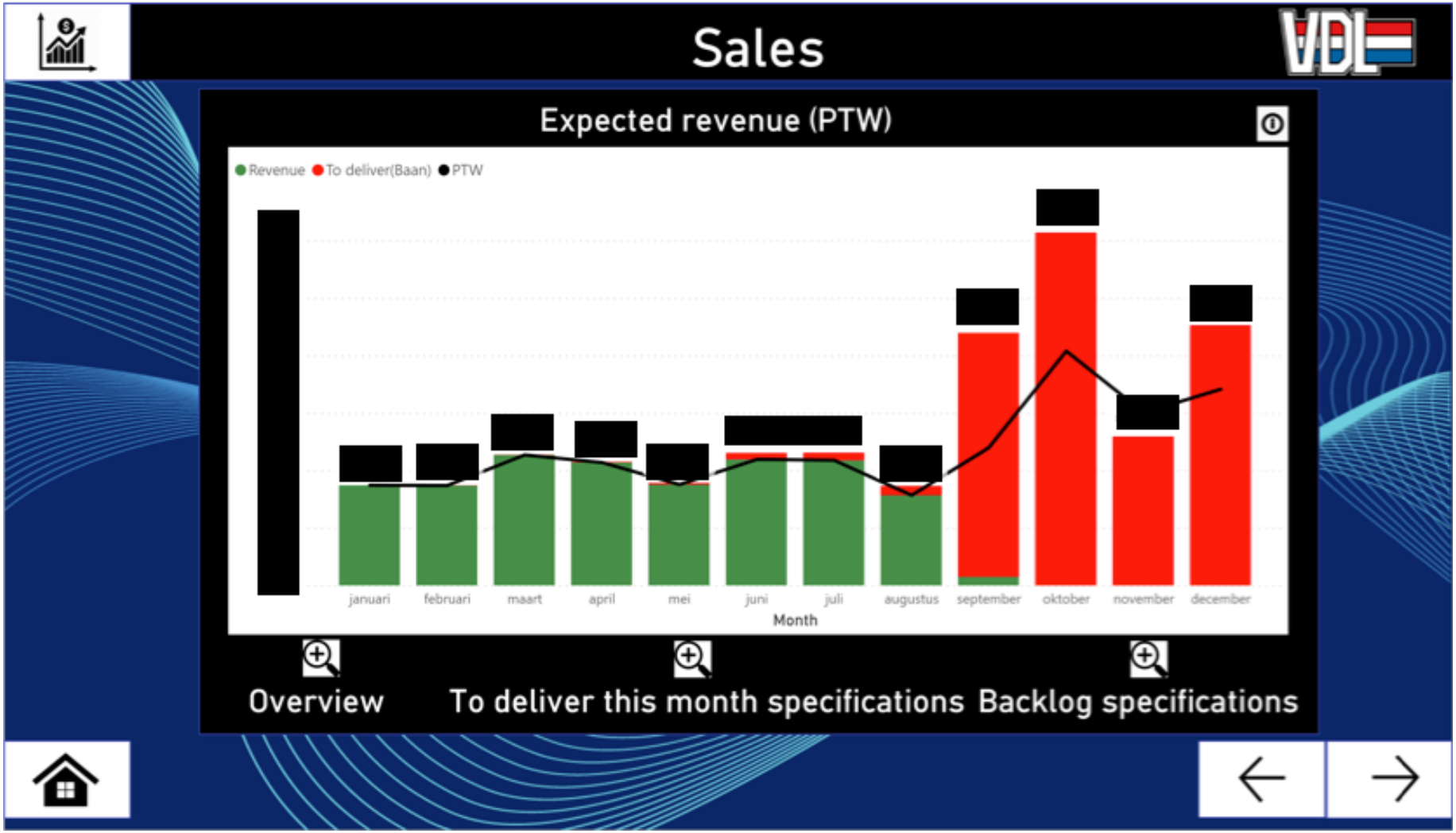

Figure 21: Sales: expected revenue (PTW).

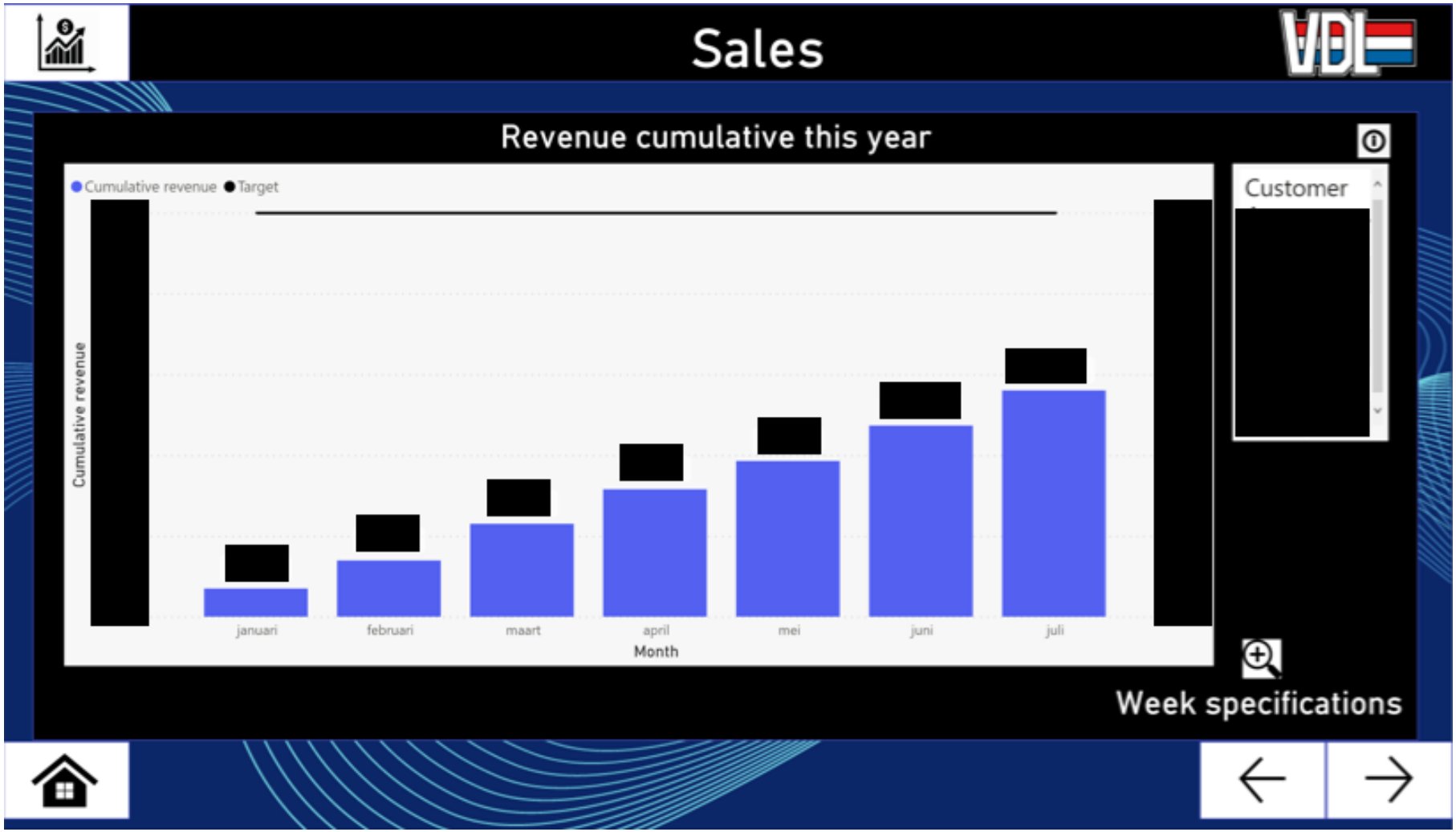

Figure 22: Sales: revenue cumulative this year.

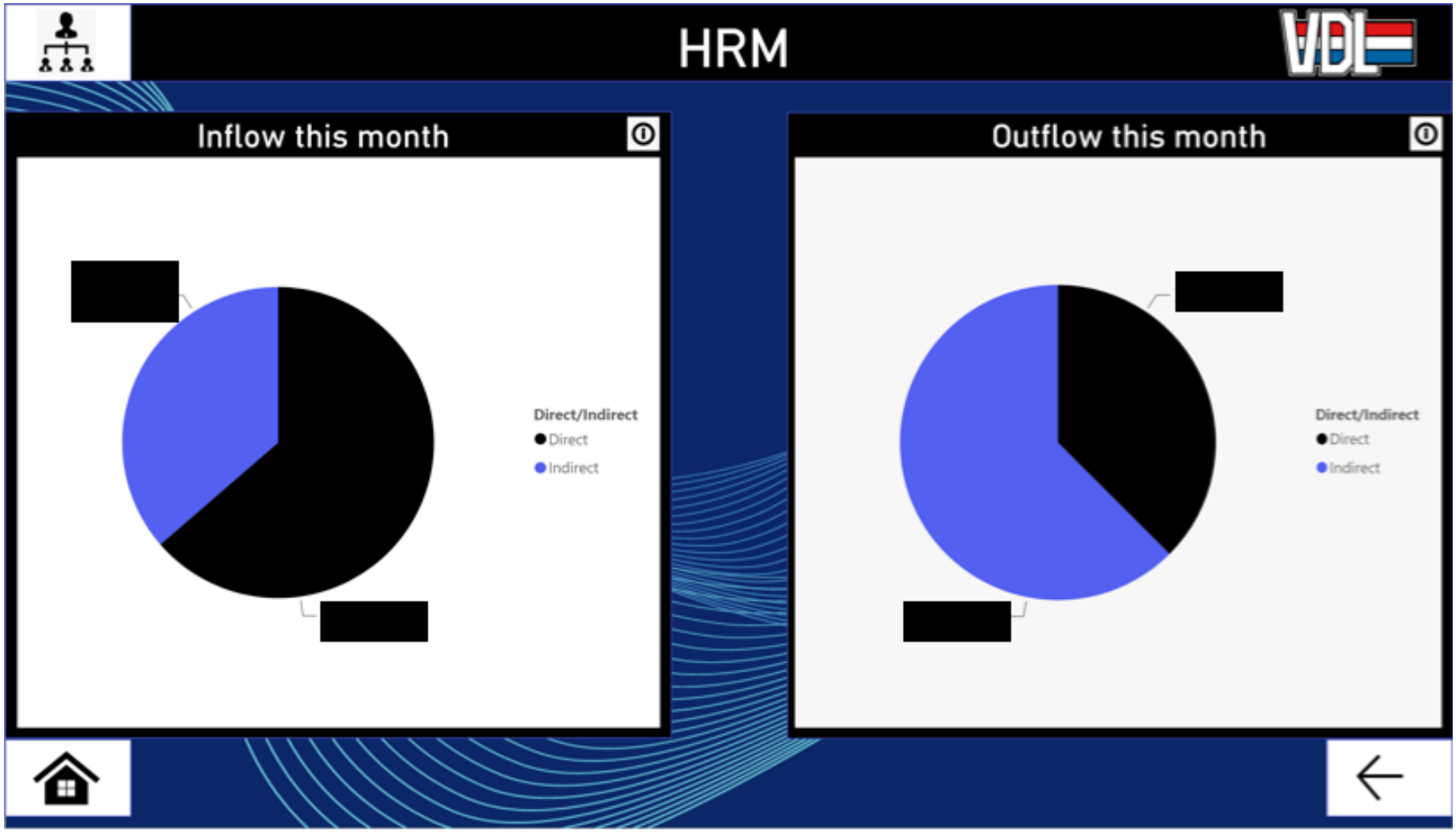

Figure 23: HRM: inflow and outflow this month.

8. Evaluation

According to the training session of Microsoft, four user groups will use the dashboards:

- Information Consumers: the most important user group are the decision-makers who drive change management strategies based on the data shown in the developed dashboards. Within VDL ETG Almelo, this group is the management team.
- Developers: this group maintains the information sources which are used in the dashboards. The information sources are maintained by the IT department of VDL ETG Almelo.
- Administrators: this group regulates the software, hardware, and IT infrastructure. The IT department of VDL ETG Almelo is also responsible for this part.
- Power Users: the group that is responsible for the development and publishment of the dashboards. In this research, I am the power user who is responsible for the development of the dashboards.

From each perspective, there are several criteria on which the dashboards can be evaluated. These criteria are shown below.

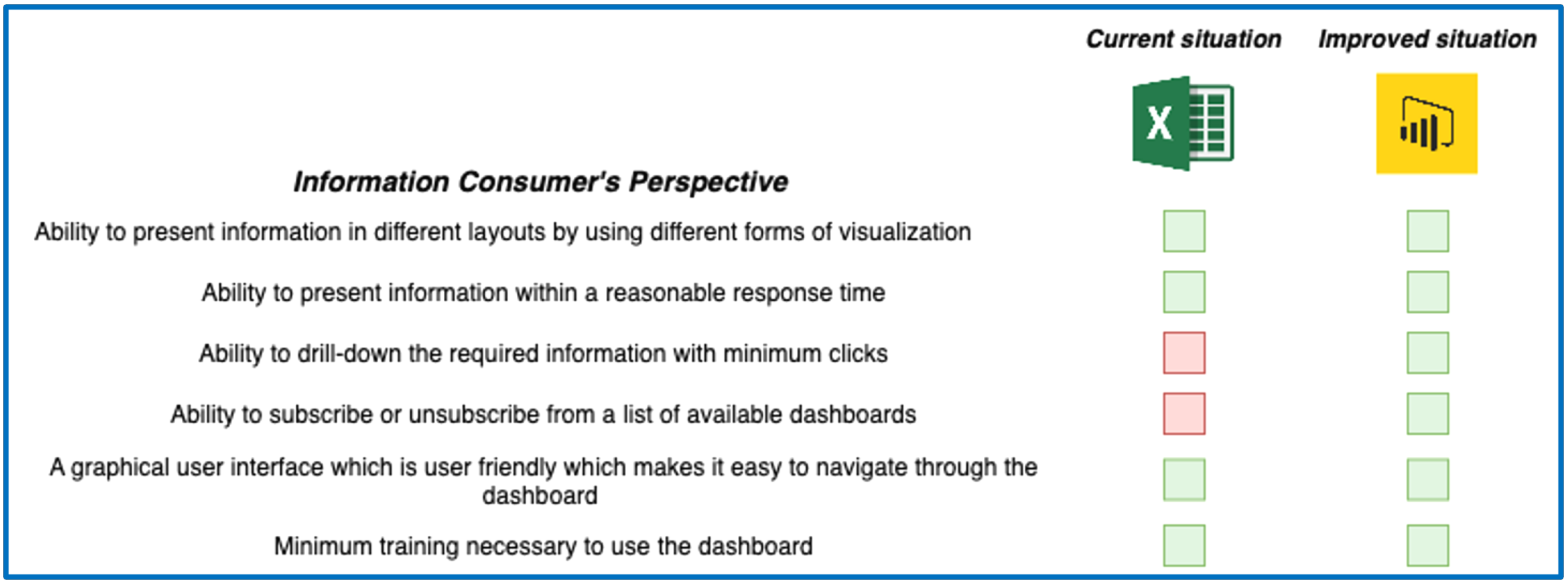

Figure 24: Information Consumer's Perspective.

In Figure 24, we see that the improved situation has two additional abilities. Namely, the ability to drill down the required information with minimum clicks. This feature of Power BI is used in the dashboards to drill down from high-level information to more specific details. This feature helps the management to focus on only one visualization and they have the option to drill down when they need to see the details. The second additional ability of Power BI is to subscribe or unsubscribe from a list of available dashboards. This means when more dashboards are developed in Power BI we can easily give access to some specific people for each dashboard.

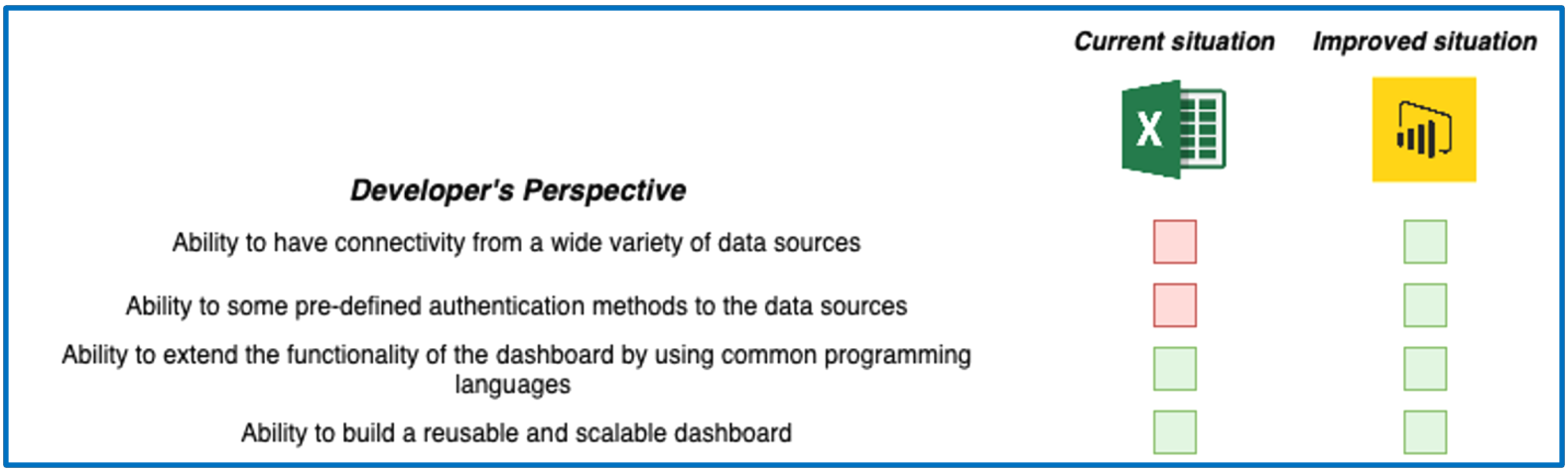

Figure 25: Developer's perspective.

From the developer's perspective, we again see that Power BI has two additional features. The ability to have connectivity from a wide variety of data sources is one of the main features of Power BI. Due to this feature, we can visualize real-time data. The second ability, the ability to some pre-defined authentication methods to the data sources ensures the protection of the data sources.

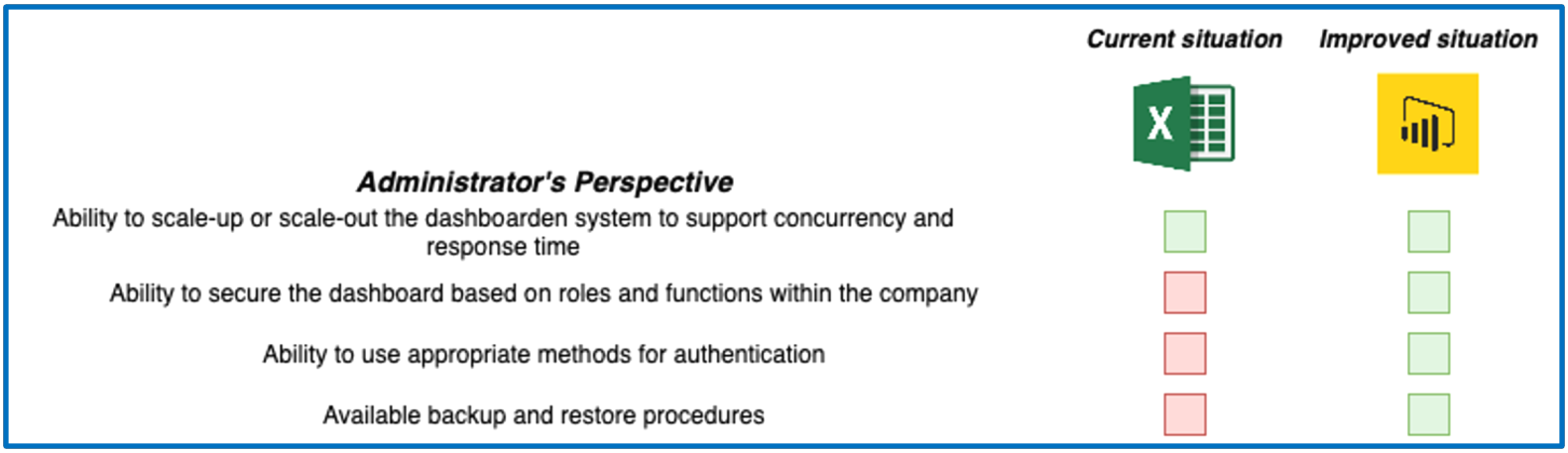

Figure 26: Administrator's perspective.

The current situation lacks three abilities from the administrator's perspective. The ability to secure the dashboards based on roles and functions is crucial within the company for our dashboards. We should only give the management the role to have access to all visualizations of these dashboards. Besides that, for example, the Sales Engineers should only have access to the Sales dashboard whereas the Production Leaders should only have access to the Production dashboard. The definition of these roles can be easily set in Power BI. The second feature, the ability to use appropriate methods for authentication, again ensures the protection of the data sources. Power BI is a cloud-based service and therefore, the last feature, available backup and restore procedures are available. This means that it does not store any data on the hard disk of your personal computer. With Power BI you can access data from a remote server, therefore saving a backup on your personal computer is not needed anymore.

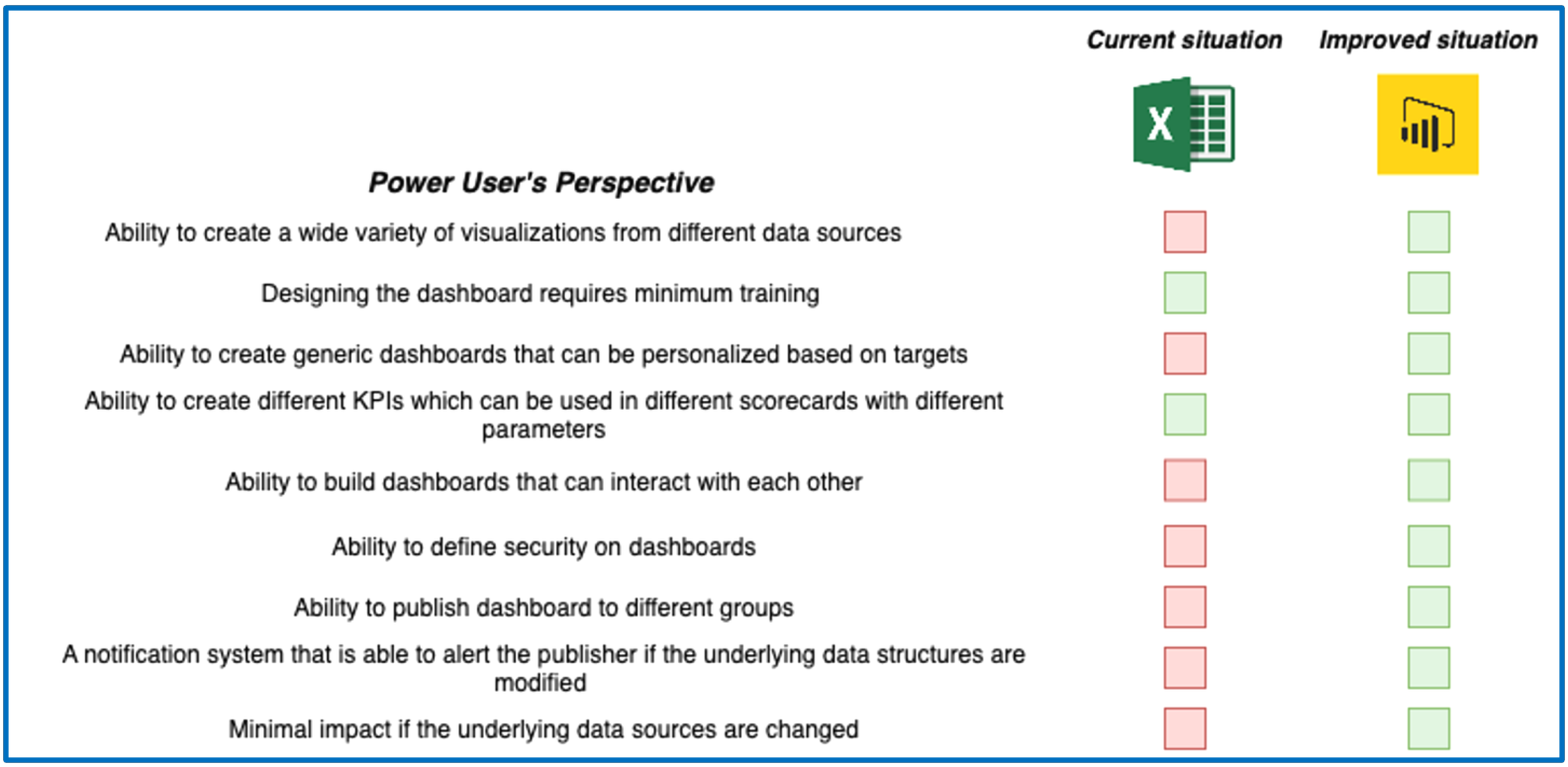

Figure 27: Power User's perspective.

As we already have discussed, Excel does not have the ability to create a wide variety of visualizations from different data sources. The second feature which is the ability to create generic dashboards that can be personalized based on targets is because of the definition of roles in Power BI. The ability to build dashboards that can interact with each other is another main feature of Power BI. The developed dashboards in this research can be connected to several other dashboards of each department. Due to this interaction between these different dashboards, we ensure that everybody is looking at the same connected data instead of different Excel and Powerpoint files which are not connected. We already have discussed the fourth and the fifth feature in the other perspectives which are all about the security and the definition of roles and functions in Power BI. Lastly, Power BI has an embedded notification system that can alert the publisher if the underlying data structures are modified. Therefore, we observe minimal impact if the underlying data sources are changed. For example, when you are working with an Excel file and someone from the IT department changes the underlying data structure, you will not even note it which can have a high impact on your data visualizations.

9. Conclusion

The core problem of this research is defined as follows: "*There is currently no real-time performance information per department".* This problem is connected to all other problems of the problem cluster shown in Figure 2. As a consequence, if we solve the core problem, all other problems are solved as well. In Section 1.6, we have defined the norm of the company. To be able to say whether we have fulfilled the norm, we should compare the norm with the new situation:

Norm	New situation
• **Real-time:** the dashboards should be real-time connected to the data warehouse where possible. • **Performance information:** the operational goals of each department should be measured. • **Process of developing the dashboards:** one person should be able to make the dashboards.	✓ ✓ ✓

We conclude that we have fulfilled the norm within the new situation. Firstly, the dashboards are real-time connected to the data warehouse which means that the management team always looks at updated KPIs. In the old situation, there was always a chance that something has been changed in the data warehouse which then can not be observed by the management. Secondly, we identified the operational goal of each department and concluded whether each goal is measured. As a consequence, new KPIs are defined and some already used KPIs are emphasized. Each department has now a complete overview of relevant KPIs which improves the quality of decision making. Finally, only one person is currently needed for developing the dashboards in the new situation compared to eight persons in the old situation. Therefore, we save a lot of time and human mistakes are avoided.

In Section 8, we have compared the current situation to the new situation. From this comparison, we see that the new situation significantly improves the following:

- In the dashboards we can easily zoom in from high-level information to more specific details.
- Due to the ability of Power BI in which functions and roles can be defined we can secure the dashboards.
- In Power BI it is easy to define interactions between dashboards. Therefore, our dashboards can be connected to several other dashboards.
- Power BI is a cloud-based service. Saving a backup on your personal computer is not needed anymore.

With this information, we may conclude that the management can make real-time decisions based on the KPIs visualized per department. Next to that, we may conclude that the overall contribution of this thesis to other industries is threefold. Firstly, the structured approach of emphasizing the currently used KPIs and using the BSC in combination with a strategy map and a systematic literature review can be used in other industries as well. Secondly, we have explained the general approach for developing the data model, the construction of the user guides per department, and the general approach of constructing effective data visualizations. Finally, we described the significant improvement of using Power BI compared to Excel which is also the same for all industries.

10. Limitations

First, the department per employee, function per employee, and the number of FTE's are not correctly registered in the HRM system. As a consequence, the data visualized of the HRM dashboard are not correctly visualizing the real-world. We have visualized this problem to make the employee who is responsible for this system aware of it. Besides this problem, the data registered by the HRM system do not match with the system that is used by Finance for the payment of wages. This problem has no consequences for the outcome of our research but is important to mention.

Second, absenteeism due to illness is measured per function in the HRM system. Therefore, it is useless for the managers to make some conclusions. However, we should again make the employees of the HRM department aware of this problem by visualizing it.

Third, the in-sourced employees are currently not included in the calculation of absenteeism due to illness. Therefore, these dashboards currently do not show the total absenteeism.

Fourth, the system used by Finance for the payment of the wages only registers the hours of direct personnel. The dashboards are therefore not showing the total hours of all personnel. For example, currently, we are not able to show the absenteeism in hours for the indirect personnel which is also important.

Fifth, the KPI "CLIP" visualized in the Production, Purchasing, and Sales dashboard is not correctly registered in the data warehouse. When someone sets for example the due date of a specific order to next week, this order will not be included in the CLIP measurement of next week which therefore gives an incorrect CLIP. This problem is solved in an Excel file and therefore this is used as a data source in the dashboards. Besides this problem of not retrieving the data in real-time, the CLIP measurement takes all types of orders into account. When a less important internal order is registered in the ERP system which includes for examples screws or bolts, this will be included in the CLIP measurement.

Sixth, the data source of the indirect hours, absenteeism due to illness hours, and holidays hours is not correctly showing the cumulative percentage. When summing up these hours for each department manually, we see a different value compared to the value that is shown in the data source.

Finally, the goal of the Purchasing department is the purchasing of high-quality material on-time. We introduced some KPIs to ensure on-time delivery of the purchased material. However, whether the material is of high-quality is not measured in the dashboard yet.

11. Recommendations and future research

First, the problem of the registration of incorrect data in the HRM system should be investigated. We would recommend to update this list correctly. After this, it should be compared to the data registered by the system that are used by Finance. By programming different cross-checks between both lists, it would be easy to visualize the differences.

Second, we recommend measuring the absenteeism in the HRM system per employee or per cost number instead of per function. After this, the managers can take action based on the data.

Third, it should be investigated how the in-sourced employees can be included in the calculation of the absenteeism. We recommend to measure it separately from the total.

Fourth, besides the registration of the hours of direct personnel, it should be investigated whether it is possible to register all hours for indirect personnel to have a complete overview.

Fifth, the CLIP measurement should be registered correctly in the data warehouse. Also, we would recommend measuring the CLIP in two categories, for example, contractual orders and non-contractual orders. It should be more important to score a higher CLIP on the contractual orders compared to the non-contractual orders.

Sixth, more research is necessary to conclude why the data source of the indirect hours, absenteeism due to illness hours, holidays hours, and direct hours is not correctly showing the cumulative percentage. This data source is provided by VDL ETG Eindhoven, therefore, we would recommend to first contact them how they update this source.

Seventh, to measure the quality of the purchased material, we would recommend introducing a new KPI called the reject rate per supplier. These data are available and measure the percentage rate of purchased material rejected by VDL ETG Almelo due to quality issues. VDL ETG Almelo is currently implementing this KPI within the Power BI dashboard of the Purchasing department. Therefore, we would recommend to connect our dashboard to this dashboard.

Eight, we recommend to organize the location on the server where each file should be saved weekly for especially the Finance and HRM department. This should be known by the person who will update the dashboards and, at the same time, this person should understand the software of Power BI very well. We already have given an introduction of the software to the Financial administrator of VDL ETG Almelo. However, an introduction is not enough, this person should also invest some time in the software to learn it.

Ninth, we recommend to all managers of VDL ETG Almelo to integrate all the dashboards used within their department into these dashboards. This ensures that everybody is looking at the same data. During this research, we have observed some human mistakes in the currently used dashboards and this should be avoided.

Tenth, as is mentioned by Janes & Succi (2013) it is important to constantly ask whether the current business goals, assumptions, strategy, and measurement goals should be updated. The current dashboard have not been updated in 15 years, so we would recommend doing this every year.

Finally, the structure of the data warehouse should be investigated whether the correct values are generated in each view. During this research, we have observed redundant views of the same data with different values. Therefore, we would recommend cleaning the data warehouse once to have one place of truth.

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Appendices

Appendix 1: Systematic literature review

Xiao & Watson (2019) defined a step-by-step approach to conduct a systematic literature review:

1. Choose the channel for the literature search.

- Within our research, a literature review is conducted by using the databases Scopus and Web of Science (WoS).

2. Define the search string with the keywords used for the search and the criteria for inclusion/exclusion.

- Search String: we should consider a few things when selecting the correct keywords for the search string. Within this early stage of the literature review, being exhaustive is more important than being precise. This would avoid that the systematic literature review misses some potential articles. Also, we should pay attention to cultural differences in terminology, therefore, correct vocabulary should be used. Finally, it is very important to document the date of search, the search string, and the procedure. This would allow for other researchers to repeat the search on the same database as is used in this systematic literature review.
  From Table 1, we can conclude that each department is related to one of the four perspectives of the BSC which are mentioned in the literature study of Section 2. Therefore, we use the name of each department in the search strings in combination with the keywords "KPI" OR "Key Performance Indicator" OR "Dashboard". By using these search strings separately for each department, we ensure a list of potential KPIs per department. However, the System Integration department and the Parts department of VDL ETG Almelo are company-specific departments and therefore are included as production departments within the search strings of the systematic literature review. An overview of the different search strings is provided below.

#Search	Search String
1	"Sales" AND ("KPI" OR "Key Performance Indicator" OR "Dashboard")
2	"Purchasing" AND ("KPI" OR "Key Performance Indicator" OR "Dashboard")
3	"Finance" AND ("KPI" OR "Key Performance Indicator" OR "Dashboard")
4	"Human Resource Management" AND ("KPI" OR "Key Performance Indicator" OR "Dashboard")
5	"Quality Management" AND ("KPI" OR "Key Performance Indicator" OR "Dashboard")
6	"Production" AND ("KPI" OR "Key Performance Indicator" OR "Dashboard")

Table 9: Search strings.

- The exclusion criteria are shown in Table 10 below. We use these criteria to filter only the relevant articles which can be used for our research. As a consequence, all criteria which are not mentioned within this table are included within the systematic literature review.

#Exclusion	Exclusion Criteria	Reason
1	Non-English and non-Dutch articles	Very hard to read these articles
2	All articles that are published <1995	At the time before 1995, no BI dashboards exist
3	All documents that are not accessible	Not able to read these articles
4	All other subject areas than Engineering	The article should be written within a production and engineering environment

Table 10: Exclusion criteria.

- The search results of this systematic literature review are given below in Table 11 - 14.

#Search	Search within	Date	#Articles
1	Article title, Abstract, Keywords	28-06-2021	406
2	Article title, Abstract, Keywords	28-06-2021	74
3	Article title, Abstract, Keywords	28-06-2021	161
4	Article title, Abstract, Keywords	28-06-2021	245
5	Article title, Abstract, Keywords	28-06-2021	458
6	Article title, Abstract, Keywords	28-06-2021	2261
Total			**3605**

Table 11: Search results Scopus.

Total articles Scopus	**3605**
Exclusion criteria #Search 1	-393
Exclusion criteria #Search 2	-70
Exclusion criteria #Search 3	-148
Exclusion criteria #Search 4	-232
Exclusion criteria #Search 5	-445
Exclusion criteria #Search 6	-2255
Duplicates	-13
After reading	-44
Total articles Scopus selected to review	**5**

Table 12: Total articles Scopus.

#Search	Search within	Date	#Articles
1	Topic	28-06-2021	69
2	Topic	28-06-2021	18
3	Topic	28-06-2021	35
4	Topic	28-06-2021	15
5	Topic	28-06-2021	47
6	Topic	28-06-2021	710
Total			**893**

Table 13: Search results WoS.

Total articles WoS	**893**
Exclusion criteria #Search 1	-63
Exclusion criteria #Search 2	-11
Exclusion criteria #Search 3	-29
Exclusion criteria #Search 4	-10
Exclusion criteria #Search 5	-38
Exclusion criteria #Search 6	-699
Duplicates	-12
After reading	-27
Total articles WoS selected to review	**4**

Table 14: Total articles Wos.

Appendix 2: selected articles from the literature review

From Table 12 and Table 14, we have selected in total nine articles to be reviewed. Out of these nine articles, each article defines some KPIs which could be valuable for minimal one department of VDL ETG Almelo. An overview of which department is mentioned per article is shown below in Table 15.

	Department					
	Sales	**Purchasing**	**Finance**	**HRM**	**Quality**	**Production**
Mert, G. et al. (2014)					X	
Tokola, H. et al. (2016)					X	X
Manan & Ridzwian (2019)	X					
Kasie & Belay (2013)	X	X	X	X		X
Putri, C.F. et al. (2019)	X		X	X		X
Verhaelen, B. et al. (2021)	X	X	X		X	X
Kaganski, S. et al. (2017)		X	X	X	X	X
Saraswati, J. et al. (2018)	X	X	X		X	X
Dumitrascu, O. et al. (2020)	X	X			X	X

Table 15: Department per article.

Appendix 3: KPIs from the literature review

The table below gives an overview of all KPIs which are mentioned per article.

Table 16: KPIs mentioned per department per article.

	KPIs mentioned per department per article					
	Sales	**Purchasing**	**Finance**	**HRM**	**Quality**	**Production**
Mert, G. et al. (2014)					Machine Capability	
					Mean time between failure	
Tokola, H. et al. (2016)					Reclamations	Delivery reliability
					Quality of items produced	Delivery punctuality
					Amount of products that are of good quality	Production lead time
					Suppliers quality	Order to delivery lead time
						Resource utilization rate
						Overall Equipment effectiveness index
						Capacity utilization rate
						Factory productivity
						Quantity producted
						System/line/workstation efficiency
Manan & Ridzwian (2019)	Revenue					
	Gross Profit					
	Net Profit					
	Return on Sales					
	Sales Percentage Fluctuation					
Kasie & Belay (2013)	Sales Growth	Defect rate of purchased material	Profit Margin	Satisfied employees		Orders delivered on-time
	Satisfied customers	Lead time	ROA	Accident frequency rate		Failure cost (internal and external)
	Retained customers	Raw Material Costs	Market share growth	Employee turnover		Process efficiency
	New customers added			Output/employee		Product cycle times
				Employee skill level		
				Qualification growth		

Putri, C.F. et al. (2019)	Sales Growth		%Business Asset	Employee turnover rate		Average Productivity Level
	%Number of Local Customers		%Business Profit	Skills improvement		Number of Patents Generated
	Customer Satisfaction		ROI	Percentage of skilled employee		Number of Product Types Generated
	%Complaints		Quick Ratio	Work Accident rate		Use of Technology
	Ratio of Number of Served Complaints		Current Ratio	Salary Conformity		
			Capital Turn Over	Comfort Level of Work		
				Employee attendance rate		
Verhaelen, B. et al. (2021)	Customer acquisition rate	On-time delivery rate	Revenue growth		Non-conformity costs	Product Flexibility
	Re-buyer rate	Out-of-stock rate	Profitability		Customer complaint rate	Capacity Utilization rate
	Customer satisfaction index		New revenue sources (market share)		Quality rate	
			Product Unit Cost			
			Resource Utilization			
			Customer Value			
Kaganski, S. et al. (2017)		On Time Delivery		Employee efficiency	Production quality/quality ratio	Actual Production Time
		Inventory Turnover			DPU (Defects Per Unit)	Tact Time
					FPY (First Pass Yield)	OEE (Overall Equipment Effectiveness)
					Unit/Line reliability	NEE (Net Equipement Effectiveness)
Saraswati, J. et al. (2018)	Sales Growth	Inventory Reduction	Increase of revenue and profit		Quality Improvement	Increased flexibility
		Improve lead time	Rework cost reduction			Reduce Waste
		Improve supplier relations	Overall cost reduction			Cycle time reduction
		Improve delivery performance	Increased market share			Productivity improvement
						Total productive maintenance

Dumitrascu, O. et al. (2020)	%Customer complaints due to poor service or product quality	Weeks of forecast planning			%Equipment quality rate	Production capacity
	Sales potential forecast	Supply Chain Cycle Time				Tact time
	%Sales growth	Order fulfilment costs				Production backlog
	%Gross margin return on investment	Costs due to unsatisfied demand				Production lead time
	Revenue	Cash to cash cycle time				
		%Supplier on-time delivery				
		%Production delivery performance				
		%Cost avoidance savings in procurement				
		%Delayed purchases				
		Material acquisition cost				
		%Delivery performance				
		Supplier backlog				
		Supplier lead time				
		%Warehouse space utilization				
		Safety stock				
		% Slow moving stock				

Appendix 4: Data per document

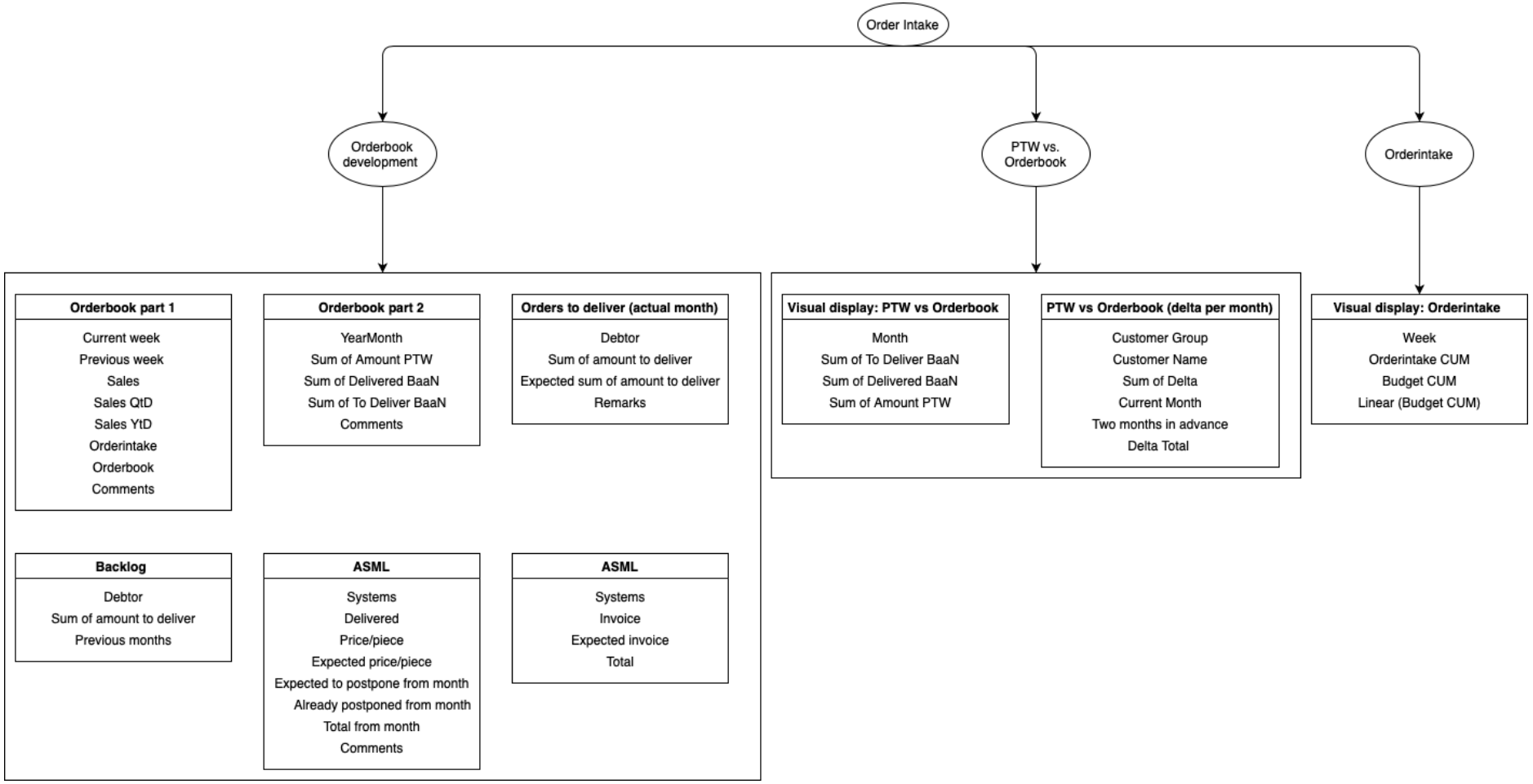

Figure 28: Powerpoint KPI orderintake.

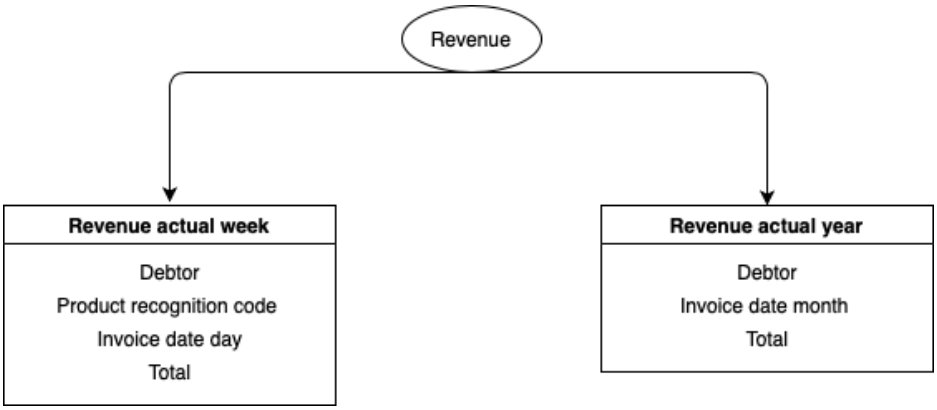

Figure 29: Excel KPI revenue.

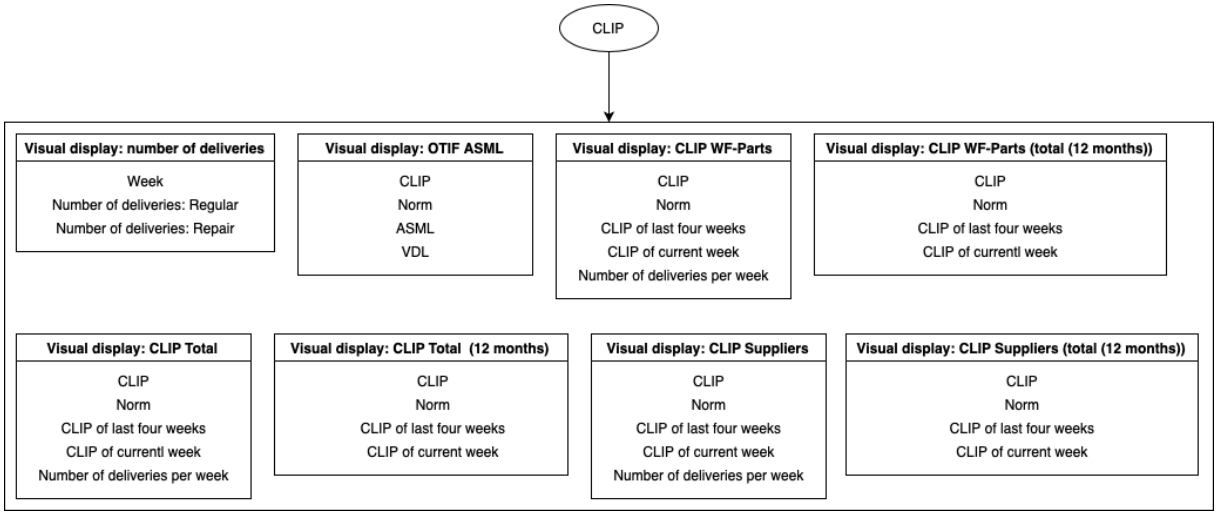

Figure 30: Powerpoint KPI CLIP.

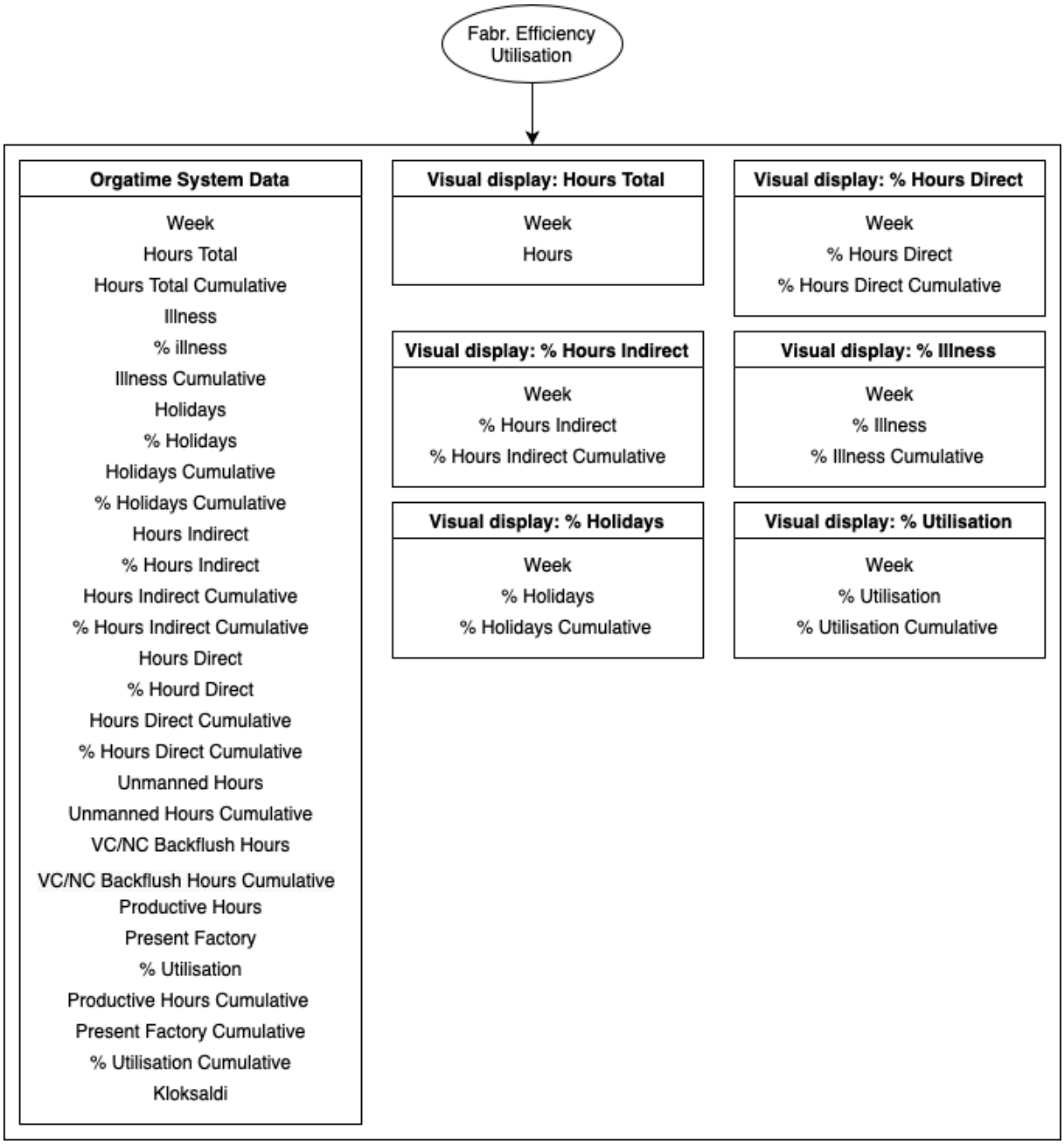

Figure 31: Excel KPI fabr. efficiency utilisation.

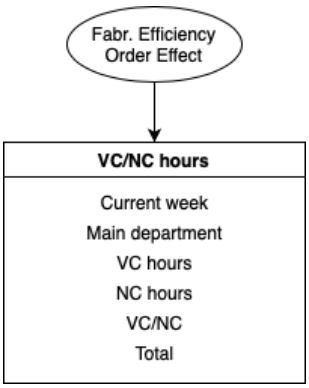

Figure 32: Excel KPI fabr. efficiency order effect.

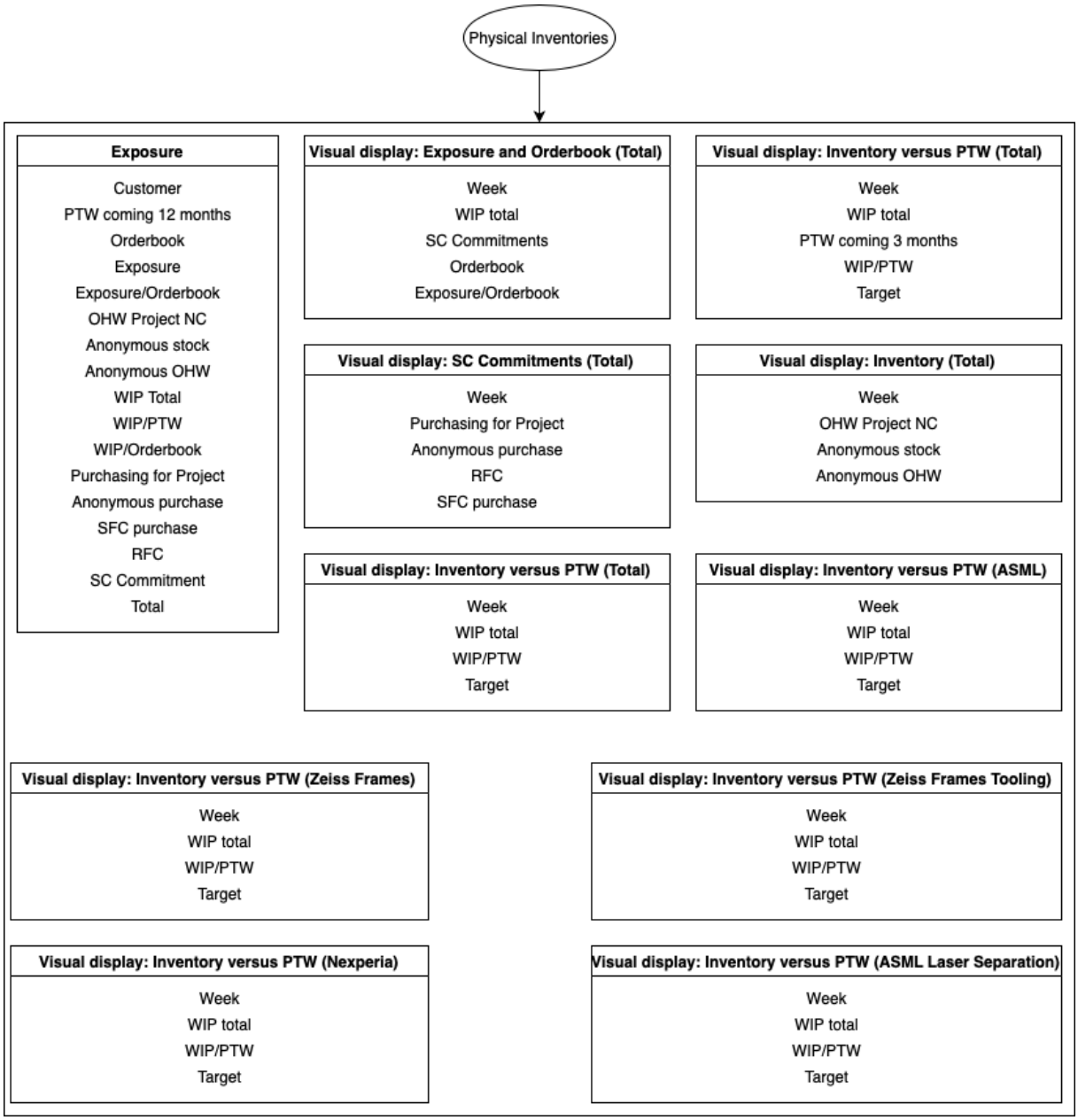

Figure 33: Powerpoint KPI physical inventories.

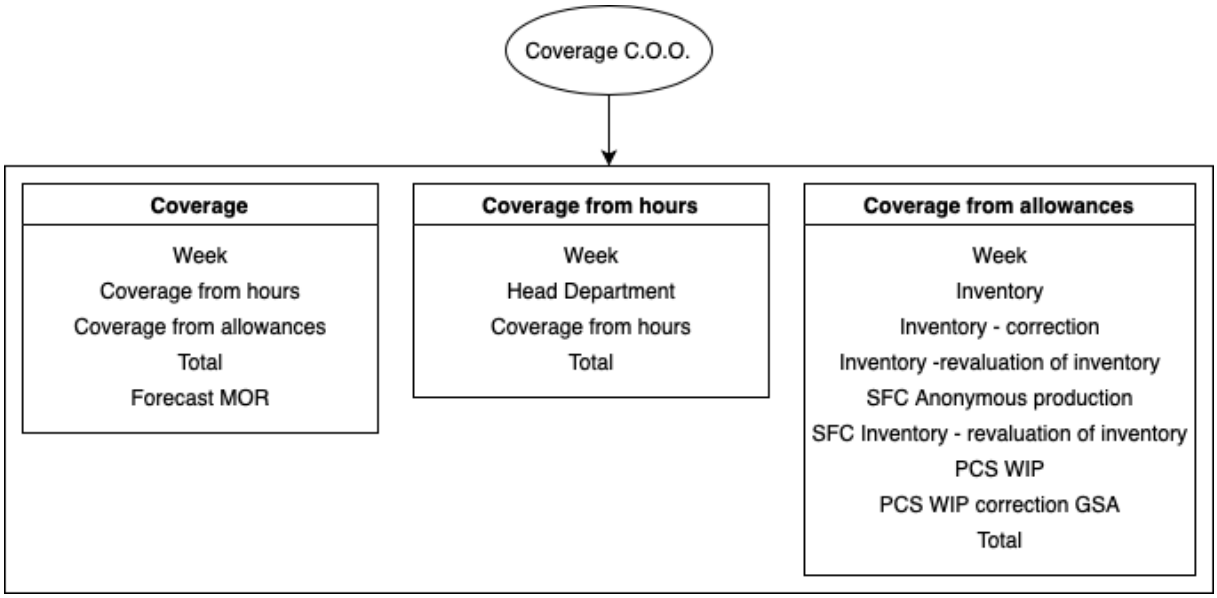

Figure 34: Excel KPI coverage c.o.o.

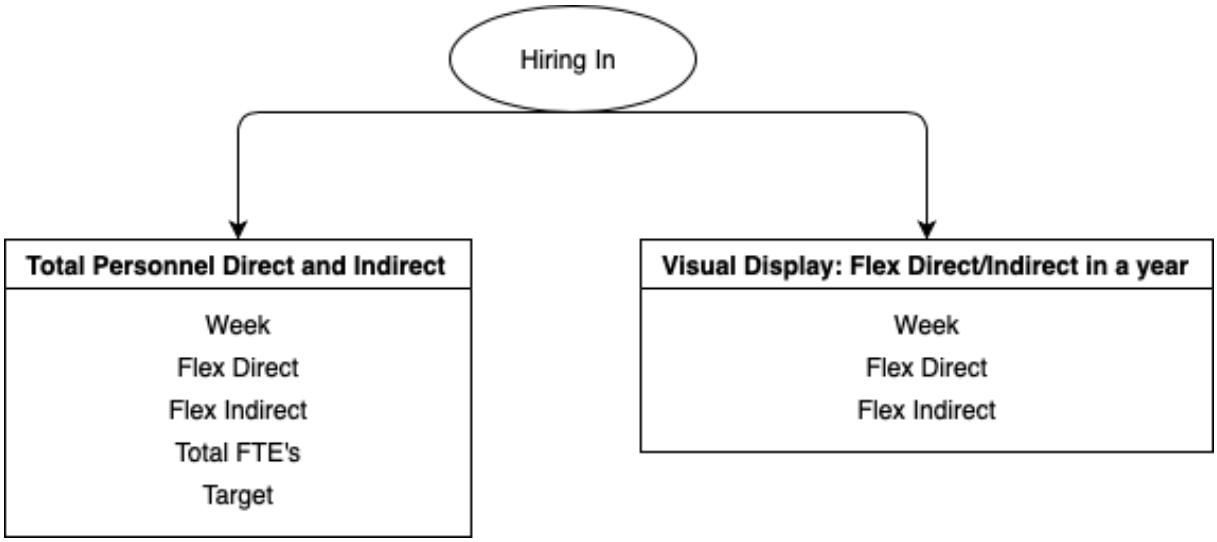

Figure 35: Excel KPI hiring in.

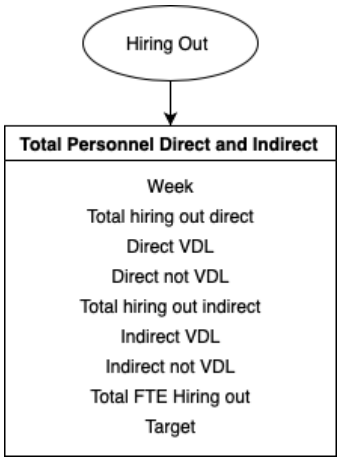

Figure 36: Excel KPI hiring out.

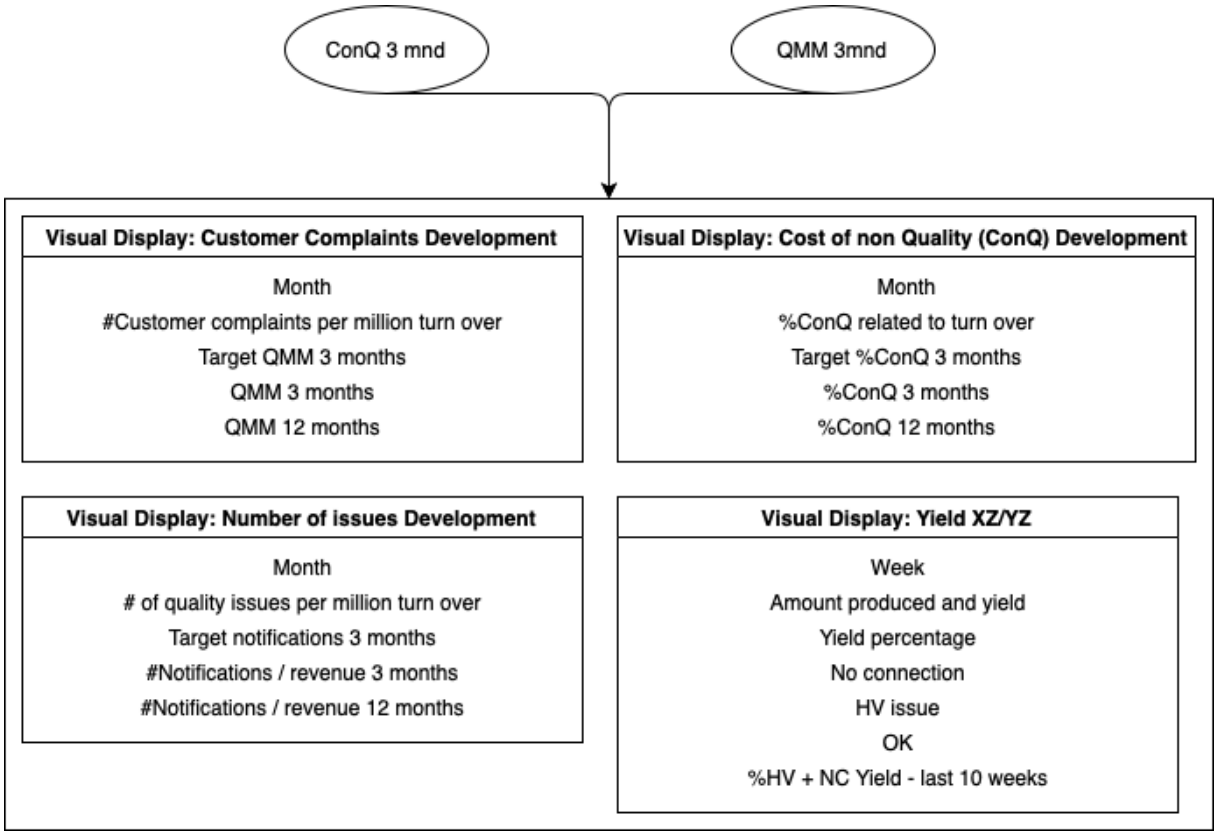

Figure 37: Powerpoint KPI ConQ and QMM.

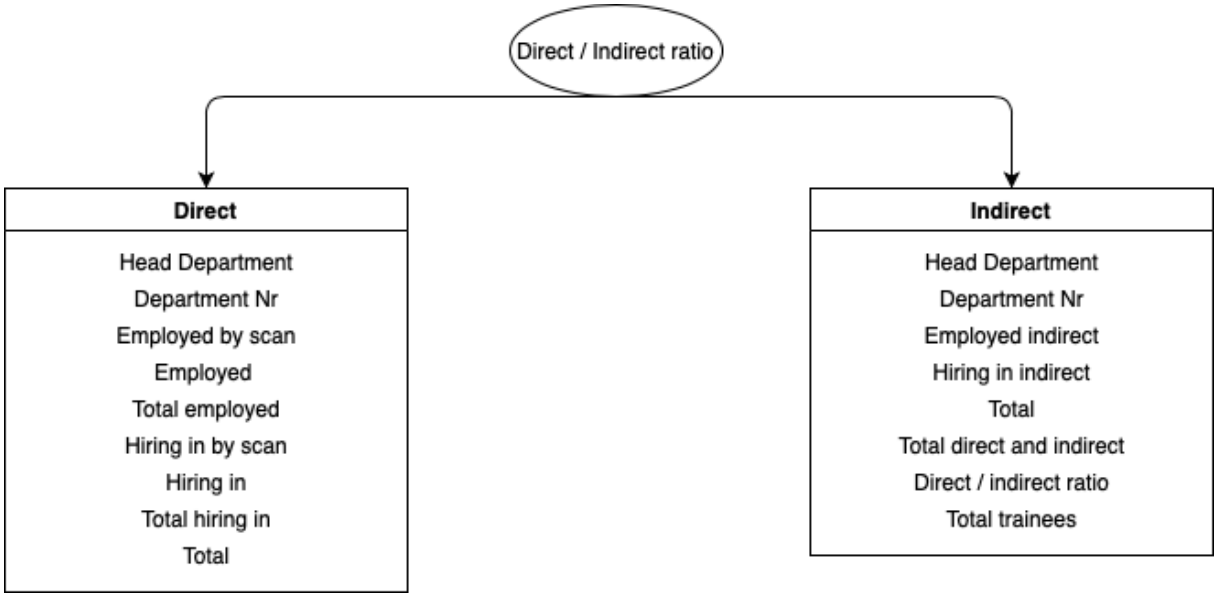

Figure 38: Excel KPI direct / indirect ratio.

Appendix 5: The strategy map

Strategy Map	Objectives	Measurement	Target
Financial Perspective (Finance) — Financially healthy	• **Financially healthy**	• Coverage C.O.O • Indirect, ilness and holidays hours • WIP/PTW	[redacted]
Customer Perspective (Sales and Quality) — Customer stisfaction (Sales and Quality); Business development (Sales)	• **Customer satisfaction** • **Business development**	• Accounts receivable and amount overdue (Sales) • Orderintake (Sales) • Revenue (Sales) • CLIP (Sales) • Plan to Win (Sales) • Number of issues per million turnover (Quality) • QMM (Quality) • ConQ (Quality)	
Internal Perspective (Production and purchasing) — Efficiently (Production); On-time (Production); Purchasing of qualitative material on-time (Purchasing)	• **Producing efficiently** • **Producing on-time** • **Stable and competitive value chain**	• Fabr. Efficiency Utilisation (Production) • Machine hours (unmanned and manned) (Production) • Fabr. Efficiency Order Effect (Production) • CLIP (Production) • Supply chain commitments (Purchasing) • Inventory level (Purchasing) • Out of stock rate per article (Purchasing) • Reliability per supplier (Purchasing) • CLIP (Purchasing)	Can not be shown due to confidential reasons
Learning and Growth Perspective (HR) — Quantitative and qualitative; On-time; Within budget	• **Quantitative and qualitative workforce** • **On-time** • **Within budget**	• Number of employees • Ilness average • Direct-indirect ratio • In-out flow	[redacted]

Figure 39: The strategy map.

Appendix 6: KPIs from the literature categorized

Figure 40: KPIs from the literature categorized.

KPIs					
Sales	**Purchasing**	**Finance**	**HRM**	**Quality**	**Production**
Revenue	Inventory reduction	Resource utilization	Employee attendance rate	Customer complaint rate	Delivery punctuality
Sales growth	Inventory turnover	Revenue growth	Employee turnover	Non-conformity costs	Delivery reliability
Sales percentage fluctuation	On-time delivery rate	Capital turn over	Employee skill level	Amount of products of good quality	Orders delivered on time
Sales potential forecast	Out-of-stock rate	Current ratio	Qualification growth	DPU	System/line/workstation efficiency
%Complaints	Raw material costs	Customer value	Salary conformity	Mean time between failure	Capacity utilization rate
Customer acquisition rate	%Delayed purchases	Market share growth	Accident frequency rate	Quality of items produced	Comfort level of work
New customers added	Defect rate of purchased material	New revenue sources (market share)	Output/employee	Suppliers quality	Production backlog
Ratio of number of served complaints	Improve lead time	Product unit costs	Percentage of skilled employee	FPY (first pass yield)	Production capacity
%Number of local customers	Lead time	Profit margin	Satisfied employees	Machine capability	Quantity produced
Gross profit	Order fulfillment costs	Rework cost reduction	Skills improvement	Production quality/quality ratio	Resource utilization rate
Net profit	Supplier backlog	ROA	Work accident rate	Reclamations	Average productivity level
Re-buyer rate	Supply chain cycle time	ROI		Unit/Line reliability	Actual production time
Retained customers	%Slow moving stock	Satisfied customers		%Equipment quality rate	Factory productivity
Return on sales	%Warehouse space utilization	%Business asset			NEE (Net Equipement Effectiveness)
Satisfied customers	%Cost avoidance savings in procurement	%Business profit			Order to delivery lead time
	Cash to cash cycle time				Overall equipment effectiveness index
	Costs due to unsatisfied demand				Product cycle times
	Safety stock				Production lead time
	Weeks of forecast planning				Tact time
	Improve supplier relations				Number of patents generated
					Number of product types generated
					Process efficiency
					Product flexibility
					Use of technology

Not feasible.
Not relevant.
Is already measured on operational level.
Will be used within the dashboard.

Appendix 7: Query editor code example

Advanced Editor

HRM_Ziekteverzuim per functie 2021

Display Options

```
let
    Bron = Excel.Workbook(File.Contents("H:\Data\Documents\06_Afstuderen\11_Dashboard\HRM\Ziekteverzuim per functie 2021.xlsx"), null, true),
    Sheet2_Sheet = Bron{[Item="Sheet2",Kind="Sheet"]}[Data],
    #"Type gewijzigd" = Table.TransformColumnTypes(Sheet2_Sheet,{{"Column1", type text}, {"Column2", type text}, {"Column3", type text}, {"Column4", type text}, {"Column5", type text}, {"Column6", type text}, {"Column7", type text}, {"Column8", type text}, {"Column9", type text}
    #"Kolom splitsen op scheidingsteken" = Table.SplitColumn(#"Type gewijzigd", "Column1", Splitter.SplitTextByDelimiter("-", QuoteStyle.Csv), {"Column1.1", "Column1.2", "Column1.3"}),
    #"Type gewijzigd1" = Table.TransformColumnTypes(#"Kolom splitsen op scheidingsteken",{{"Column1.1", type text}, {"Column1.2", type text}, {"Column1.3", type text}}),
    #"Lege rijen verwijderd" = Table.SelectRows(#"Type gewijzigd1", each not List.IsEmpty(List.RemoveMatchingItems(Record.FieldValues(_), {"", null}))),
    #"Kolommen verwijderd" = Table.RemoveColumns(#"Lege rijen verwijderd",{"Column1.3", "Column13", "Column14", "Column16", "Column17"}),
    #"Bovenste rijen verwijderd" = Table.Skip(#"Kolommen verwijderd",6),
    #"Omlaag doorgevoerd" = Table.FillDown(#"Bovenste rijen verwijderd",{"Column1.2"}),
    #"Tabel getransponeerd" = Table.Transpose(#"Omlaag doorgevoerd"),
    #"Headers met verhoogd niveau" = Table.PromoteHeaders(#"Tabel getransponeerd", [PromoteAllScalars=true]),
    #"Type gewijzigd2" = Table.TransformColumnTypes(#"Headers met verhoogd niveau",{{"Geen afdeling ", type text}, {"Per maand", type text}, {"VP totaal", type text}, {"Verzuimfrequentie", type text}, {"Gemiddelde verzuimduur", type text}, {"Geen afdeling _1", type text}, {"Per
    #"Kolommen verwijderd1" = Table.RemoveColumns(#"Type gewijzigd2",{"Geen afdeling ", "Per maand", "Verzuimfrequentie", "Gemiddelde verzuimduur", "Geen afdeling _1", "Per maand_2", "Verzuimfrequentie_4", "Gemiddelde verzuimduur_5", "Geen afdeling _6", "Per maand_7", "Verzuimfr
    #"Tabel getransponeerd1" = Table.Transpose(#"Kolommen verwijderd1"),
    #"Afgekapte tekst" = Table.TransformColumns(#"Tabel getransponeerd1",{{"Column1", Text.Trim, type text}}),
    #"Tekst opgeschoond" = Table.TransformColumns(#"Afgekapte tekst",{{"Column1", Text.Clean, type text}}),
    #"Namen van kolommen gewijzigd" = Table.RenameColumns(#"Tekst opgeschoond",{{"Column1", "Functie 2021"}, {"Column2", "Januari 2021"}, {"Column3", "Februari 2021"}, {"Column4", "Maart 2021"}, {"Column5", "April 2021"}, {"Column6", "Mei 2021"}, {"Column7", "Juni 2021"}, {"Colu
    #"Kolom opgesplitst op positie" = Table.SplitColumn(#"Namen van kolommen gewijzigd", "Functie 2021", Splitter.SplitTextByPositions({0, 8}, false), {"Functie 2021.1", "Functie 2021.2"}),
    #"Type gewijzigd3" = Table.TransformColumnTypes(#"Kolom opgesplitst op positie",{{"Functie 2021.1", type text}, {"Functie 2021.2", type text}}),
    #"Kolommen verwijderd2" = Table.RemoveColumns(#"Type gewijzigd3",{"Functie 2021.1"}),
    #"Namen van kolommen gewijzigd1" = Table.RenameColumns(#"Kolommen verwijderd2",{{"Functie 2021.2", "Functie 2021"}}),
    #"Type gewijzigd4" = Table.TransformColumnTypes(#"Namen van kolommen gewijzigd1",{{"Augustus 2021", Percentage.Type}, {"Januari 2021", Percentage.Type}, {"Februari 2021", Percentage.Type}, {"Maart 2021", Percentage.Type}, {"April 2021", Percentage.Type}, {"Mei 2021", Percent
    #"Draaitabel voor kolommen opgeheven" = Table.UnpivotOtherColumns(#"Type gewijzigd4", {"Functie 2021"}, "Kenmerk", "Waarde"),
    #"Namen van kolommen gewijzigd2" = Table.RenameColumns(#"Draaitabel voor kolommen opgeheven",{{"Kenmerk", "Maand"}, {"Waarde", "Verzuim"}}),
    #"Type gewijzigd5" = Table.TransformColumnTypes(#"Namen van kolommen gewijzigd2",{{"Maand", type date}})
in
    #"Type gewijzigd5"
```

No syntax errors have been detected.

Figure 41: Query editor code example.

Appendix 8: Measurements in Power BI

```
Direct / Indirect Ratio rolling average =
IF(
    ISFILTERED('HRM_Personeelslijst 2021'[Datum Indienst]),
    ERROR("Error."),
    VAR __LAST_DATE = ENDOFMONTH('HRM_Personeelslijst 2021'[Datum Indienst].[Date])
    VAR __DATE_PERIOD =
        DATESBETWEEN(
            'HRM_Personeelslijst 2021'[Datum Indienst].[Date],
            STARTOFMONTH(DATEADD(__LAST_DATE, -1, MONTH)),
            __LAST_DATE
        )
    RETURN
        AVERAGEX(
            CALCULATETABLE(
                SUMMARIZE(
                    VALUES('HRM_Personeelslijst 2021'),
                    'HRM_Personeelslijst 2021'[Datum Indienst].[Jaar],
                    'HRM_Personeelslijst 2021'[Datum Indienst].[QuarterNo],
                    'HRM_Personeelslijst 2021'[Datum Indienst].[Kwartaal],
                    'HRM_Personeelslijst 2021'[Datum Indienst].[MonthNo],
                    'HRM_Personeelslijst 2021'[Datum Indienst].[Maand]
                ),
                __DATE_PERIOD
            ),
            CALCULATE(
                [Direct / Indirect Ratio],
                ALL('HRM_Personeelslijst 2021'[Datum Indienst].[Dag])
            )
        )
)
```

Figure 42: Measurement: direct/indirect ratio rolling average.

```
#Meldingen12Months =
IF(
    ISFILTERED(Quality_Number_Of_Complaints[Date Created]),
    ERROR("Error"),
    VAR __LAST_DATE = ENDOFMONTH(Quality_Number_Of_Complaints[Date Created].[Date])
    VAR __DATE_PERIOD =
        DATESBETWEEN(
            Quality_Number_Of_Complaints[Date Created].[Date],
            STARTOFMONTH(DATEADD(__LAST_DATE, -11, MONTH)),
            __LAST_DATE
        )

    VAR __Count = COUNT(Quality_Number_Of_Complaints[Complaint Number])
    RETURN
            CALCULATE(
                [CountComplaintNumber],
                __DATE_PERIOD)
            )
```

Figure 43: Measurement: number of issues 12 months.

```
Complaints12Months =
IF(
    ISFILTERED(Quality_Number_Of_Complaints[Date Created]),
    ERROR("Error"),
    VAR __LAST_DATE = ENDOFMONTH(Quality_Number_Of_Complaints[Date Created].[Date])
    VAR __DATE_PERIOD =
        DATESBETWEEN(
            Quality_Number_Of_Complaints[Date Created].[Date],
            STARTOFMONTH(DATEADD(__LAST_DATE, -11, MONTH)),
            __LAST_DATE
        )

    VAR __Count = COUNT(Quality_Number_Of_Complaints[Complaint Number])
    RETURN
            CALCULATE(
                [CountComplaintNumber],
                __DATE_PERIOD)
            )
```

Figure 44: Measurement: customer complaints 12 months.

```
ConQ12Months =
IF(
    ISFILTERED(Quality_Number_Of_Complaints[Date Created]),
    ERROR("Error"),
    VAR __LAST_DATE = ENDOFMONTH(Quality_Number_Of_Complaints[Date Created].[Date])
    VAR __DATE_PERIOD =
        DATESBETWEEN(
            Quality_Number_Of_Complaints[Date Created].[Date],
            STARTOFMONTH(DATEADD(__LAST_DATE, -11, MONTH)),
            __LAST_DATE
        )
    RETURN

            CALCULATE(SUM(Quality_Number_Of_Complaints[CoNQ]), __DATE_PERIOD))
```

Figure 45: Measurement: ConQ 12 months.

```
OrderintakeCum =
CALCULATE(
    SUM('Sales_Orderbook'[Orderintake]),
    FILTER(
        ALLSELECTED('Sales_Orderbook'[Week]),
        ISONORAFTER('Sales_Orderbook'[Week], MAX('Sales_Orderbook'[Week]), DESC)
    )
)
```

Figure 46: Measurement: cumulative orderintake.

```
Geleverd running total in Maand =
CALCULATE(
    SUM('Sales_PTW'[Geleverd]),
    FILTER(
        CALCULATETABLE(
            SUMMARIZE(
                'Sales_PTW',
                'Sales_PTW'[Datum].[MonthNo],
                'Sales_PTW'[Datum].[Maand]
            ),
            ALLSELECTED('Sales_PTW')
        ),
        ISONORAFTER(
            'Sales_PTW'[Datum].[MonthNo], MAX('Sales_PTW'[Datum].[MonthNo]), DESC,
            'Sales_PTW'[Datum].[Maand], MAX('Sales_PTW'[Datum].[Maand]), DESC
        )
    )
)
```

Figure 47: Measurement: delivered running total.