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THESIS PROJECT

A LEARNING MAINTENANCE AND ASSET MANAGEMENT DEPARTMENT

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A Learning Maintenance and Asset Management Department

DSBV is since December 2003 responsible for all operations and maintenance activities. The first years of its existence DSBV focused mainly on the operations of the new waste water treatment plant (WWTP) Harnaschpolder (HNP) and its final building, testing and commissioning.
After this period it became clear that DSBV should establish adequate maintenance management and reorganized their asset and maintenance management department.
The last two years DSBV's maintenance and asset management (M&AM) focused, among other important changes, on the change from corrective maintenance to preventive and predictive maintenance. After executing several studies on improvement of the maintenance activities it is now the time for the next phase in this professionalizing.
This means that DSBV's M&AM department has to grow to a 'learning organization'. Therefore all current maintenance processes and activities have to be reviewed, adjusted and implemented.

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Management summery

This research has been executed as an in company thesis assignment for the Master of Engineering course Asset and Maintenance Management at the Hogeschool Utrecht.
This document describes the research for improving all Maintenance and Asset Management processes.

The assignment for investigation how DSBV's Maintenance and Asset Management (M&AM) department can become a learning organization was the result of draughting the research model. It became clear what area's were to be investigated and which important area's were to be excluded from this research. From there the main research question was formulated:

How can a learning M&AM organization be achieved and implemented within DSBV?

The motive for this research is the need for transparent control and steering mechanism for the M&AM department. Therefore kPI's have to be set, which resulted in the urgency to (re)design all M&AM processes. The agreed objective for this research is to create a learning M&AM department with continuous improvement.

This report describes all the phases of the research. An introduction will explain the background and objectives of this research. An interesting comparison between modifying the existence and innovation is made in chapter 2.

Chapter 3 is a literature research that will explain several Business Improvement Methodologies and their comparison, resulting in a responsible selection.
The researched methodologies were the *Instituut Nederlands Kwaliteits model*, the INK model; Six Sigma and Balanced Score Card; the BSC. The comparison has been made by applying the Deming circle, which resulted in decision to apply the Methodology of Methodic Innovation.
The applied techniques, used in the selected Methodic Innovation Methodology, will be explained in chapter 4.

Chapter 5 will describe the research and its outcomes as results of the applied methodologies techniques.
The current situation has been investigated by applying several research techniques. The actual performance was the base whereon improvement possibilities were determined.
By applying the same techniques a proposed situation was agreed upon, so all M&AM department processes, activities and information exchange have to be re-designed, deleted of newly designed.

The conclusion : **"The (re)design of all current M&AM department processes accomplish the research objective of reaching a learning M&AM department"** will be motivated in chapter 6

Recommendations based on the outcomes of the research are formulated in chapter 6.

Chapter 7 describes the personal objectives of this thesis research.

Acknowledgements

A lot of people have supported me during this course of Master in Engineering; Maintenance and Asset Management. I like to thank them all, but the most important persons to be thankful and grateful to are my girlfriend, my partner in life, and my daughter.
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A significant part of my social life has been secondary during this course as well. Hereby I like to thank my family and friends for their support and understanding.

For the quality of the content of this report, but also during the entire course, I owe the lecturers of the Hogeschool Utrecht many thanks, but special thanks for:

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- Mr. T.M.E. Zaal, Emeritus Associated Professor, for being the second accompanist.

Both lecturers attended and coached me to accomplish the standards this thesis research complies to.

Special thanks to my internal supervisor Mr. N. van Gool for assistance on this research and colleagues for participation in the research team.

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1 Introduction

1.1 Company background

At December 2003 the Water Board Delfland engaged in a Public Private Partnership (PPP) with the private companies Veolia Water, Evides, Heijmans, Strukton Finanance and the Rabobank.
The PPP concerns a Design, Build, Finance and Operate contract (DBFO-contract) with a length of 30 years. This contract provides for the construction of the Waste Water Treatment Plant (WWTP) Harnaschpolder, the refurbishment of the WWTP Houtrust and the operation and maintenance for both WWTP's and their transport system (120 km pressure mains and 18 pumping stations) up to 2033.

Delfluent Services BV is the operation and maintenance organisation. Its shareholders are Veolia Water and Evides.

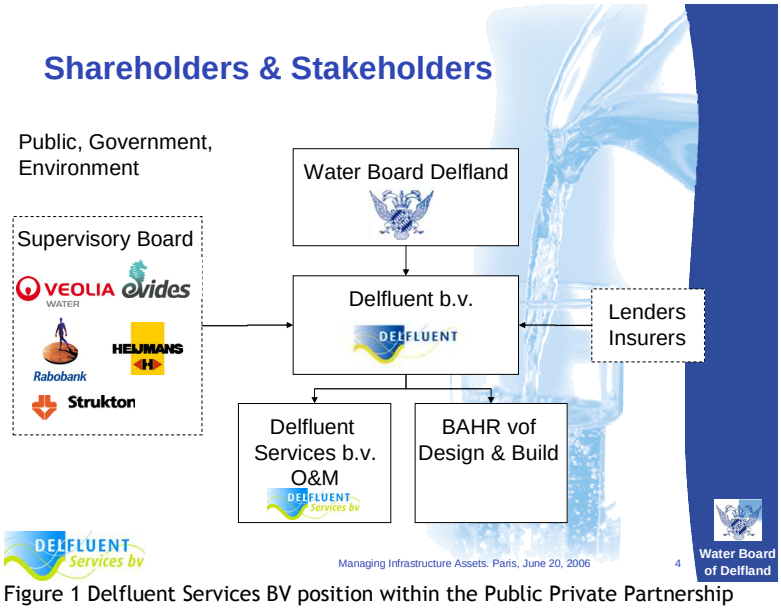


Figure 1 Delfluent Services BV position within the Public Private Partnership

Water Board Delfland remains publicly and judicial responsible for the waste water treatment performance. Within the PPP its role is described as asset owner. The role of Delfluent Services BV is described as both asset manager and asset operator. The responsibility of Delfluent Services is to operate the assets in such a manner that they are able to deliver a sustainable performance level at lowest cost. The contract states that after the 30 years of contract the assets shall be handed over at defined structural performance grades or the capability of complying with the contractual maintenance requirements with only routine or preventive maintenance for a period of at least five years as from hand-back.
Delfluent Services is set up according next organ gram, with the relevant Asset and Maintenance Department worked out.

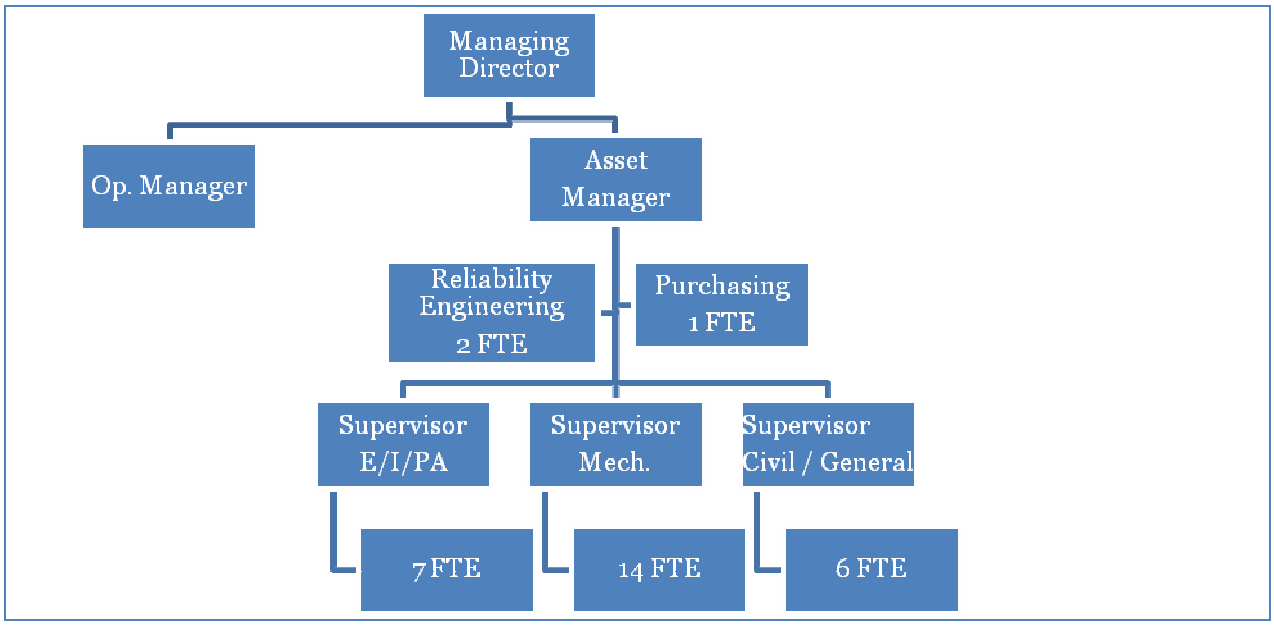


Figure 2 Organizational chart of DSBV

1.2 Research methodology and scope

Next model shows how the thesis main research question and its sub questions are investigated. The goal 'a learning organization' will be achieved by implementing key Performance Indicators (kPI's) for the Maintenance & Asset Management department of DSBV.
Therefore kPI's has to be identified for:

- Workflow management.
- Maintenance Budget.
- Operating & Maintenance Contract. (these are determined in the contract and non – negotiable)

Before implementing Workflow Management kPI's all workflow management procedures has to be improved. This will be the focus and scope of this research.
Workflow Management kPI's are derivated from the M&AM objectives as derivatives from the company objectives.
The knowledge area of this thesis is product data modeling, therefore this is an important condition, even as Change Management for the human factor. This however will not be part of this study.
The O&M contract with the Waterboard of Delfland is already established and therefore treated as obligated.
The Computerized Maintenance Management System (CMMS) is already in place, but it has to be professionalized. Although it is also an important condition, it will be no part of this study.

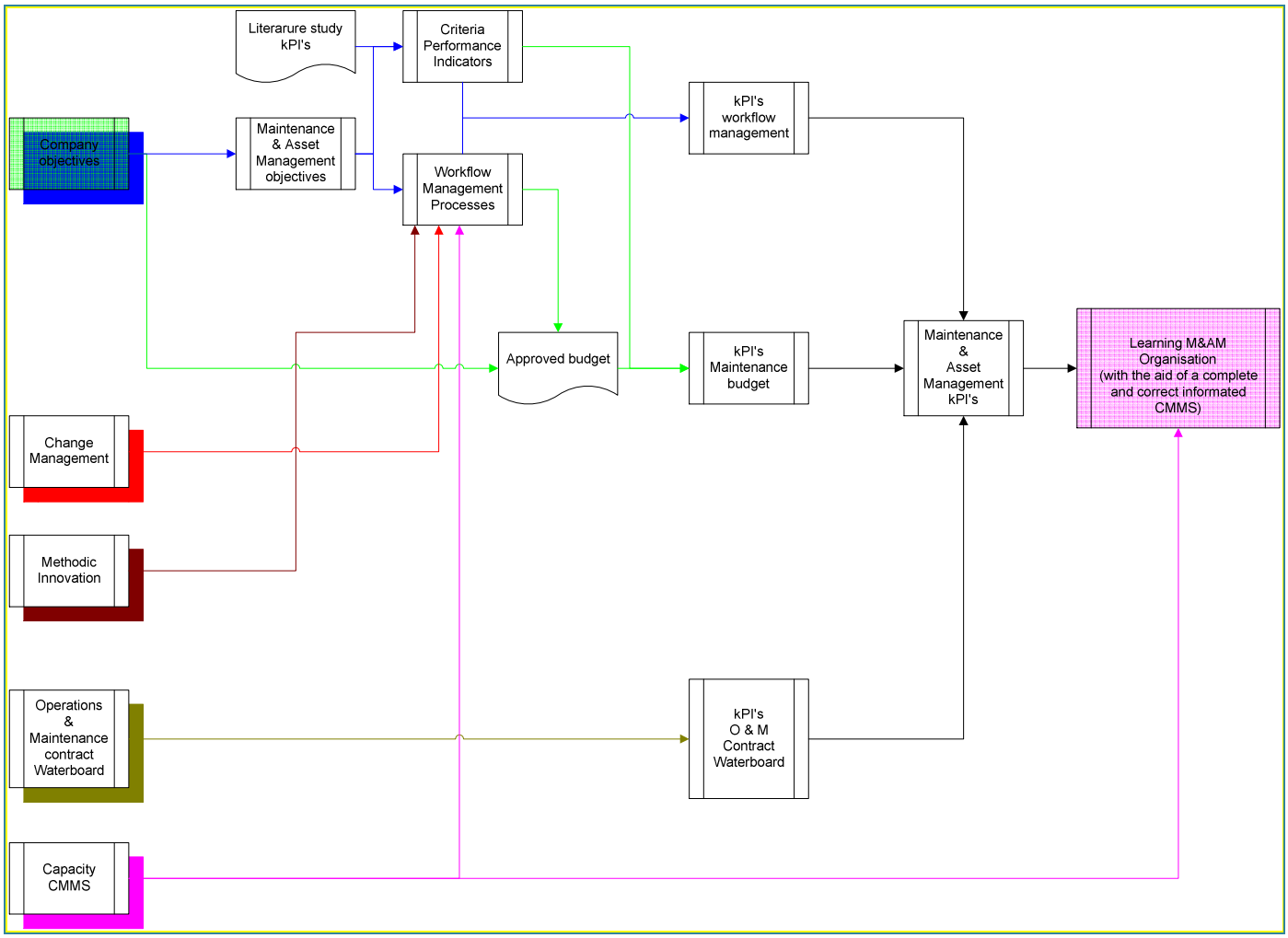


Figure 3 Research model

1.3 Objectives

1.3.1 Project objectives

The implementation of revised work flow processes and their new to be set key performance indicators will give added value with respect to control and steering mechanism for the Maintenance and Asset Management department. This will provide a clear insight of the departmental objectives and how to monitor and control those.
The main objective of this study is, after presenting the actual performance levels of the M&AM department, to be able to create a learning organization with continuous improvement.

1.3.2 Personal objectives

Through this study I want to extend my knowledge about process data modeling. How to investigate actual processes and be able to alter these processes in order not only to meet corporate objectives, but also to involve important stakeholders, i.e. people, to optimize their working environment.

2 Introduction: Innovation as a discovery – journey

Innovation is for a lot of companies very urgent. Producing more or less is not sufficient anymore; the competitor can do the same.
Furthermore the consumers are easily satisfied with existing products and services and will extend the technical possibilities for renewal of these products and services, especially with Information- and Communication Technology (ICT).
The influcance of these three actors on organizations will increase continuously.

2.1 Modification versus innovation

There is a difference between modifications and innovation. By applying two metaphors of a train journey and discovery journey this difference will be explained.

Modify (producing or doing more or less the same) and innovation (creating or doing something new) are types of changes who differ a lot. With modifications the objectives are determined, the process to reach the objectives is planned. This is different for innovations. The objective and process to reach the objectives is just upfront general formulated and will be clear along the process.
The difference between modification and innovation are to be investigated by applying metaphors. The train journey is the metaphor for modifications, the discovery journey for innovations. This method of research of change processes with the aid of these metaphors is based on the 'system dynamics'. The routine path of concepting, formalization, operating and analyzing will be strongly simplified by and for everyone familiar with conceptual modeling. Difficult formalizations, operations and analyzes will be prevented because the model is already in operational form available while the behavior of this model is known.
Important differences between the train – and discovery journey are therefore to be identified by checking where these journeys differ. This will be explained by next figure.

	Modification / train journey	Innovation / discovery journey
Objective and process	Previous determined and agreed	Only general formulated, during process will become clear
Planning	Detailed plans	Predefined detailed plans not useful
Controlling	Targeted controlled	Contentiously altering plans to experiences
Organisationstructure	Mechanical	Organic
Knowledge	Knowledge previously collected	Most knowledge collected during process
Failures	No failures allowed	Inescapable and source for new knowledge
Learning abilities	During process no need for learning, perhaps afterwards	Learning and exploring lessons during process is essential
Competences	Team members have to be skilled to performed there predefined tasks	Team members must be skilled, but also have the ability to adapt changing circumstances, must have drive and endurance
Leadership	Technocratic leadership is sufficient	Coaching and inspirational leadership is important
Internal communication	The plan is base for communication	Extended exchange of experiences, knowledge and ideas
External communication	Reporting progress to predefined objectives	Feedback of experiences, new developed insights and ideas about objectives and process
Relation with contractor and sponsors	Little necessary	The assigners and sponsors have be kept interested and pro-activity be engaged when new insights developed.
Relation with adherents	They know the objectives, goals and process. No need for involvement with team	They have to be confided about the objectives and process and have to be engaged
Drive	Energy 'obligated'	Change energy have to come from within the team

Table 1 Differences between modification and innovation

This table shows a number of differences between modifications and innovations. With these metaphors the differences can be transferred as total - overview and total – feeling to the next five aspects:

1. Innovation is not to be managed as modifications
2. Innovation objectives and processes will be clear in detail along the process
3. Innovation asks for learning during practice an knowledgemanagement
4. Innovation asks for drive from within, endurance and stimulating leadership
5. Innovation can be managed methodically.

2.2 Synthesis of designing and developing

Within the total of theories of organizational changes they are to be divided in two major theories:

1. Theories for 'design'. Simplified; these theories consist of determine problem, develop vision, describe current situation, determine proposed situation, designing change-plans and execute this change.
   This correspondence with the train journey metaphor. The advantage of 'design' approach is that the plans are based on a thorough problem analyze and they visualize a strategic vision.
   Disadvantage is executing these plans are usually difficult because of a changing reality.

2. Theories for 'developing'. Simplified; these theories consist of planning improvements from the current situation and execute them in a reputedly, gradually process.
   This correspondence with the discovery – journey metaphor.
   The advantage of this approach is that the plans joining the reality and the opportunity to change en the support. They also lead to direct improvements.
   Disadvantage is that is has not a significant role while formulating strategic or tactical visions.

When an important change has to be implemented a dilemma occurs. When there is to be chosen for one of the approaches, there has to be chosen between advantages and disadvantages of both approaches.
It seems to be prudent to alter between the approaches regularly so the advantages of both will be achieved and disadvantages will be avoided, but in reality it is proved to be difficult. Both approaches appeal on the difference images of organizations and with the role people of that organisation fulfill.
Due to potential conflict between these images it is hard for effective alternation between the two approaches during a change process.
Instead of alternating between the two approaches a real syntheses of the two approaches is required.

With these syntheses the growth – abilities have to come from the bottom up and the lessons learned methodic, gradually and controlled being used when realizing a continuously developing tactical en strategic vision.

By using the approach of a methodic executed discovery – journey as a model, the syntheses approach for innovative organizational changes can be described in the next two phases:

- Preparation
  - Lessons learned from previous change projects
  - Generally describe the objectives, possible processes, identify the most important steps and milestones
  - Create a 'discovery team' of people with knowledge of the subject, knowledge and experiences in discovery journeys, enthusiast and with drive.
  - Facilitate in sufficient equipment for the team
  - Facilitate support from assigners and sponsors

- Execution
    - Make sure that making plans, execution, evaluations and learning are fast moving cycles, whereby the process objectives can be changed.
    - Makes sure that the progress can deliver results within a short period of time, getting closer to the objectives and that there are lessons to be learned.
    - Facilitate in collecting, recording and using of experiences.
    - Facilitate in communication with the adherents, assigners and sponsors. Especially about new discoveries and their consequences regarding the objectives and the process.

The important feature of this synthesis – approach is the fast moving planning- and learning cycles. Next table shows the differences between the design-, develop- and synthesis approach of changes. The alternating approach is not specified, these are results of the both first approaches.

Methods of controlling innovative changes			
	Design approach	**Develop approach**	**Synthesis approach**
Metaphor	Train journey	Discovery journey	Methodic discovery journey
Description related to metaphor	Predefined objective will be reached by predefined process by executing predefined plans	Based on experiences an interesting objective will determined and aimed for in the near future	In a short-cycle of plan making, executing, evaluating and learning along the process will be discovered how the general described objective will be specific, where it is and how to get there
Strategic objective and its process	- In place - Learning by experience Is not applicable	Not in place down	- General in place - Learning by experience is applicable
Operational plans	Top – down as derivates for strategic objectives	Will be established along the process from bottom-up	Will be established along the process from bottom-up and top-down by using bottom-up developments to come closer to the strategic objectives and executing top-down actions from strategic objectives, while considering learning experiences
Plan- and learning cycles	Long, afterwards of the journey On strategic level	Short On operational level	Short On operational, tactical and strategic level
Type of organizational changes	Modification	Movement	Planned innovation

Managing innovation effectively seems to be impossible by using a design approach, while using a develop approach leads to movements and perhaps a nice journey, but not to predefined objectives.
A synthesis approach seems to be suitable, but will demand a lot from involved innovation managers. Within the synthesis approach plans are often general formulated and will be followed up quickly by the next version of the objectives, wherein new experiences are digested. A lot of managers are unfamiliar with this because they are used to 'train journeys' wherein a clear plan and a linear execution leads to success. Besides this unfamiliarity temptation and resistance preclude the transition to cycled controlling process.
Plans and discussing these plans are more comfortable than executing this plans, it is therefore tempting to produce paper. Also starting a journey without predefined objectives will rise resistance with managers because there are no predefined risks and control measurements for these risks. They also have difficulties with general formulated objectives and processes.
The execution problems are arguments for not applying the synthesis approach. Even when results are accomplished, recording and learning of these results and adjusting plans is a difficult process. There is a temptation not to close the controlling cycle, but go on linearly, especially in companies where failures will be punished.

Besides the planning- and learning aspects of this synthesis approach mental, psychological, communicational and cultural aspects are important. Managers must be able to support, coach en

mentally support their team. It is therefore important that they have learning abilities, endurance, initiative, drive and controlled courage.

Although the synthesis approach seems to be the most effective way for innovation, a lot of innovation projects are not successful. The cause of this is already described and this may lead to the conclusion that, when successfully executing an innovation process is not possible, there should be aimed for a self managing, innovating and learning organization.

3 Literature research

3.1 Instituut Nederlandse Kwaliteit model

The *Instituut Nederlandse Kwaliteit* model is a management model for organizations to evaluate themselves. By this model the maturity of an organisation will be determined and improvements identified. This model helps the organisation to focus on the areas to be improved.
A company has a variety of stakeholders, they are not only interested in their shareholders, but also in employees, partners, clients and environment.
The INK model is applicable for companies because this model:

- It is a 'stakeholders value' model wherein chains of interested parties are central and not only the shareholders
- It comprises the philosophy of increasing of properties / abilities: financial, commercial, social and intellectual. Balance increasing of these properties will provide a healthy organisation with right to exist for a long period of time.

In 2003 the INK adjusted a number of elements to join the changing reality.

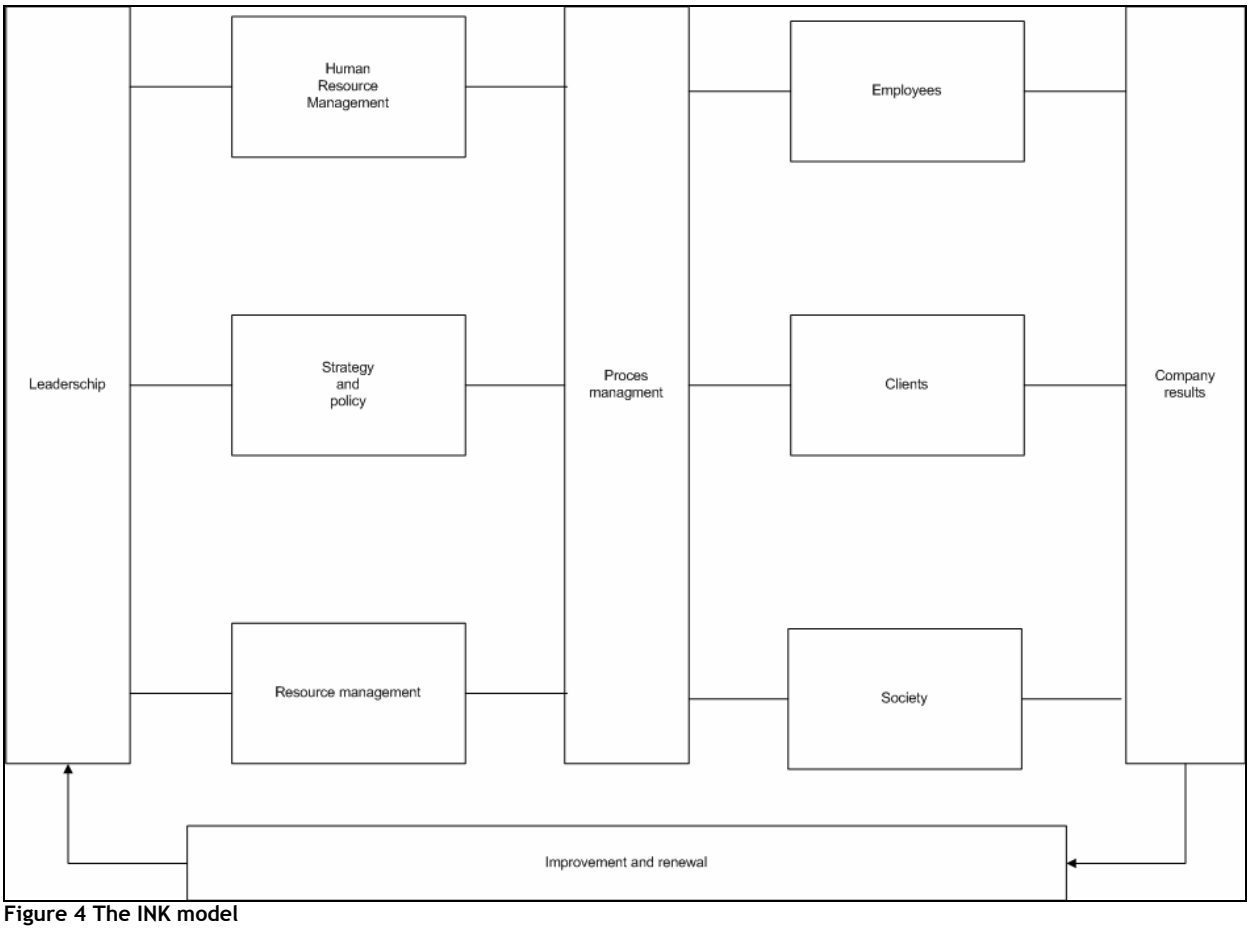


Figure 4 The INK model

For applying this model there has to be sufficient knowledge about procesmanagement and developing a Quality Management System. Fundamental knowledge of quality management is crucial.

To improve, this model have to:
- Implemented in phases
- Be no objective itself
- No theoretical exercise

The organization:
- Have to be stringent to itself throughout the entire company

- Is not seeking for tricks and / or appreciation
- Must have an open en positive culture to let the procesmanagement succeed.

This model divide an organization in three main areas, which are divided is several sub area's:

Organization	
Leadership	Attitude and behavior of all personnel with super visional responsibilities. (director, managers and team leaders) They have to be inspiring and coaching.
Strategy and policy	What is de mission, vision and objectives of the organization? How can, by continuous improvement, this become an excellent organization?
HRM	Use of all potential, knowledge and skills for optimal working manors to improve continuously
Resource management	The way the company handles resources as finance, materials, information, buildings etc.
Process management	How are current internal and external processes being improved continuously?
Results	
Clients	Is the client satisfied with the results and how this result is achieved?
Employees	How content are employees? What will be done to keep them content?
Society	How is the company involved with their social obligations?
Company results	Financial and operational results. Are the objectives (of all stakeholders) to be realized?
Remaining	
Improvement and renewal	This is the feedback loop of the model

The results of this evaluation will be put in the development phases of the organization. These phases are a Dutch addition to the model and will give an overview of the phases an organization has to proceed to come to maturity whereby everything is arranged optimal. The model comprises five phases:

Development phase	**Explanation**
Activity oriented	Quality of own working environment, everybody aims for perfection
Process oriented	People know all separate steps of the process. Tasks and responsibilities are determined.
System oriented	On all levels people work on continuous improvement, prevent problems instead of solving them
Chain oriented	Together with partners aimed for maximal added value
Transformation oriented	Strategy is to be on the top!

The objective of this model is to evolutes the organization so the company results improve towards an excellent organization. The organization is now capable of anticipating on changes in markets; prices, products, services, clients, competitions etc. When this model in common knowledge within the organization they are able to anticipate adequately.
This model is not only applicable for larger organizations on top of the market, it is useful for all organizations where it is about quality-thinking and continuous improvement.

3.2 Balanced Score Card (BSC)

The business balanced score card (bbsc), of in short balanced score card (bsc) is developed by Norton and Kaplan because they realized that an organization cannot just been established and managed for the interests of the shareholders.
It is concluded that the organization cannot just manage in the direction of improving working capital, a financial driver. Improvements on working capital can be reached by, for example, decreasing stocks. But how is production guaranteed and customers are served in time after decreasing the stocks?
Decreasing purchasing leads to decreased working capital, but who will guarantee the cheaper raw materials will not lead to problems with production?

Decreasing working capital asks for changes in the production, a change that cannot negatively influence customers or integrated cost prices.
Certain issues should be balanced and therefore working capital management, normally financial driven, becomes a different, more complex dimension. A dimension of quality management.

In the BSC are areas connected to each other. A connection that matches the result areas of the INK model. It is therefore possible to use the models together.

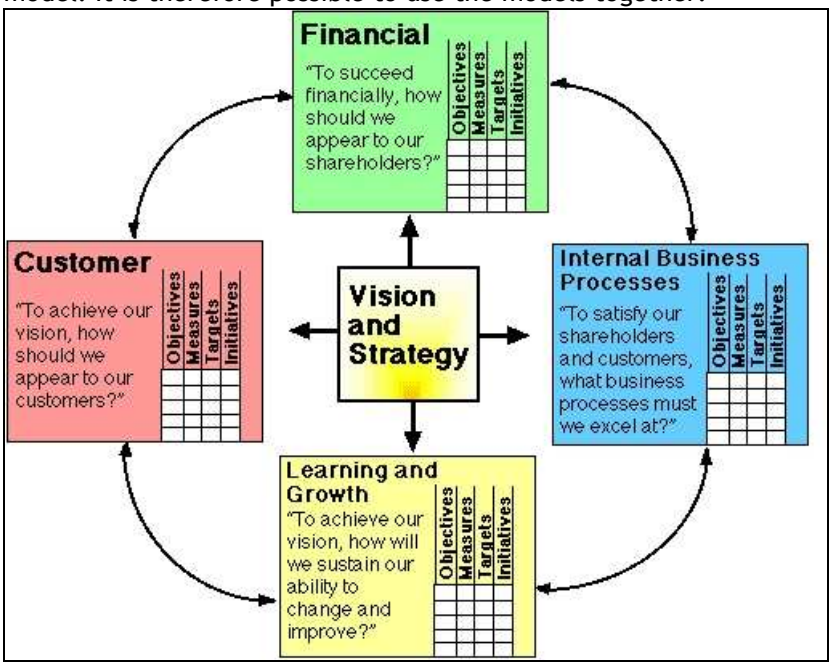


Figure 5 The BSC model

It is important that organizations specify their objectives per perspective and based on these objectives the organization manage through process management. Pitfall during specifying the objectives is that there are objectives formulated just to formulate objectives. Objectives have to be realistic!
Objectives are derivates from the vision and mission of an organization. These are strong, concrete and demarcated statements, wherein the management declares what the objectives for the coming years will be, what the real core business is and what their competition- / market position is.
These has to be measurable and short statements that can be used in the balanced score card.
For example: The organization will have a effectiveness increased with 6% in three years time by decreasing the production costs with 5%.
From here the four perspective – objectives can be formulated on tactical and operational level.

These procedure has the advantage that everyone, manager and employee, exactly knows what to do and what their role is and where the complete organization will put their effort in.
This saves a lot of meeting time and decisions making will be faster.

The other advantage of this model is that the formulated objectives can be directly transferred in department-, process-, and individual objectives.

This model is slightly deviating from the standard quality management systems. This model is actually not a management system but a report system. It is possible to use it a report model as supplement to, for example, financial reports. In a financial report often absent the not – financial results. Furthermore, in a financial report absent the mutual relations with the objectives set by the organization.

The purpose of this model is to gain information about facts. It is possible for a standalone model, but also in combination with the INK model, ISO 9001 etc.

The disadvantage of this system is that is mainly an instrument for the management of an organization and less suitable for the entire organization. Implementation however is easier, there is no need for documentation and employees doesn't have to be trained.
It is a instrument for management so they can, based on the gain information, determine actions.

3.3 Six Sigma

Six Sigma originated as a set of practices designed to improve manufacturing processes and eliminate defects, but its application was subsequently extended to other types of business processes as well. In Six Sigma, a defect is defined as any process output that does not meet customer specifications, or that could lead to creating an output that does not meet customer specifications.

Like its predecessors, Six Sigma doctrine asserts that:

- Continuous efforts to achieve stable and predictable process results (i.e., reduce process variation) are of vital importance to business success.
- Manufacturing and business processes have characteristics that can be measured, analyzed, improved and controlled.
- Achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management.

Features that set Six Sigma apart from previous quality improvement initiatives include:

- A clear focus on achieving measurable and quantifiable financial returns from any Six Sigma project. An increased emphasis on strong and passionate management leadership and support.
- A special infrastructure of "Champions," "Master Black Belts," "Black Belts," "Yellow Belts", etc. to lead and implement the Six Sigma approach.
- A clear commitment to making decisions on the basis of verifiable data, rather than assumptions and guesswork.

The term "Six Sigma" comes from a field of statistics known as process capability studies. Originally, it referred to the ability of manufacturing processes to produce a very high proportion of output within specification. Processes that operate with "six sigma quality" over the short term are assumed to produce long-term defect levels below 3.4 defects per million opportunities (DPMO).

Six Sigma's implicit goal is to improve all processes to that level of quality or better.

In recent years, some practitioners have combined Six Sigma ideas with lean manufacturing to yield a methodology named Lean Six Sigma.
Six Sigma projects follow two project methodologies inspired by Deming's Plan-Do-Check-Act Cycle. These methodologies, composed of five phases each, bear the acronyms DMAIC and DMADV.

DMAIC is used for projects aimed at improving an existing business process and has five phase:

1. ***D**efine* the problem, the voice of the customer, and the project goals, specifically.
2. ***M**easure* key aspects of the current process and collect relevant data.
3. ***A**nalyze* the data to investigate and verify cause-and-effect relationships. Determine what the relationships are, and attempt to ensure that all factors have been considered. Seek out root cause of the defect under investigation.
4. ***I**mprove* or optimize the current process based upon data analysis using techniques such as design of experiments, poka yoke or mistake proofing, and standard work to create a new, future state process. Set up pilot runs to establish process capability.
5. ***C**ontrol* the future state process to ensure that any deviations from target are corrected before they result in defects. Control systems are implemented such as statistical process control, production boards, and visual workplaces and the process is continuously monitored.

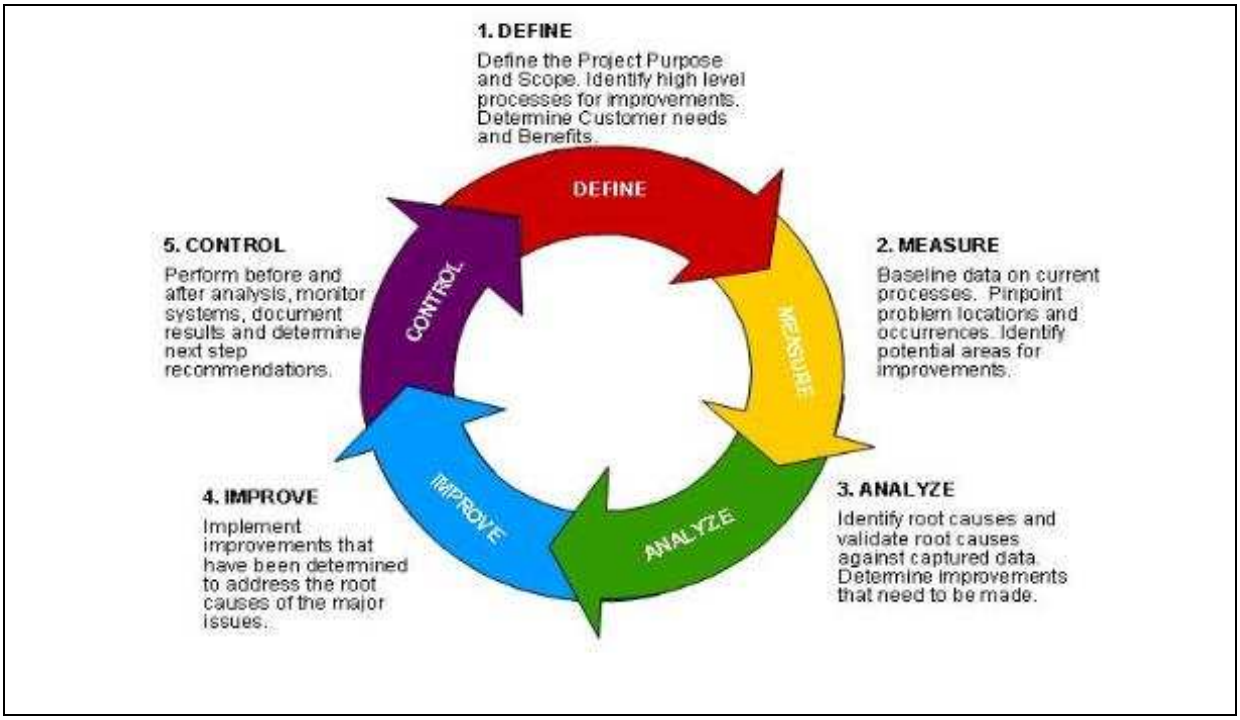


Figure 6 The six sigma DMAIC circle

DMADV is used for projects aimed at creating new product or process designs.

The DMADV project methodology, also known as DFSS ("**D**esign **F**or **S**ix **S**igma"), features five phases:

1. ***D**efine* design goals that are consistent with customer demands and the enterprise strategy.
2. ***M**easure* and identify CTQs (characteristics that are **C**ritical **T**o **Q**uality), product capabilities, production process capability, and risks.
3. ***A**nalyze* to develop and design alternatives, create a high-level design and evaluate design capability to select the best design.
4. ***D**esign* details, optimize the design, and plan for design verification. This phase may require simulations.
5. ***V**erify* the design, set up pilot runs, implement the production process and hand it over to the process owner(s).

3.4 Methodic Innovation

The purpose of Methodic Innovation (MI) is to enlarge the knowledge productivity and innovation abilities in order to energize the organisation to reach World Class Performance.
MI is an systematic approach to absorb knowledge about several aspects if Integrated Design (ID) and subsequently apply these knowledge to improve work processes, products and services. During MI *working different* will be crucial in the 'own' organisation, working areas an working roles.

The approach of MI is execute on-the-job innovative ID assignments to develop knowledge competences to innovate the works/techniques/processes and come to a learning organization towards knowledge economy.

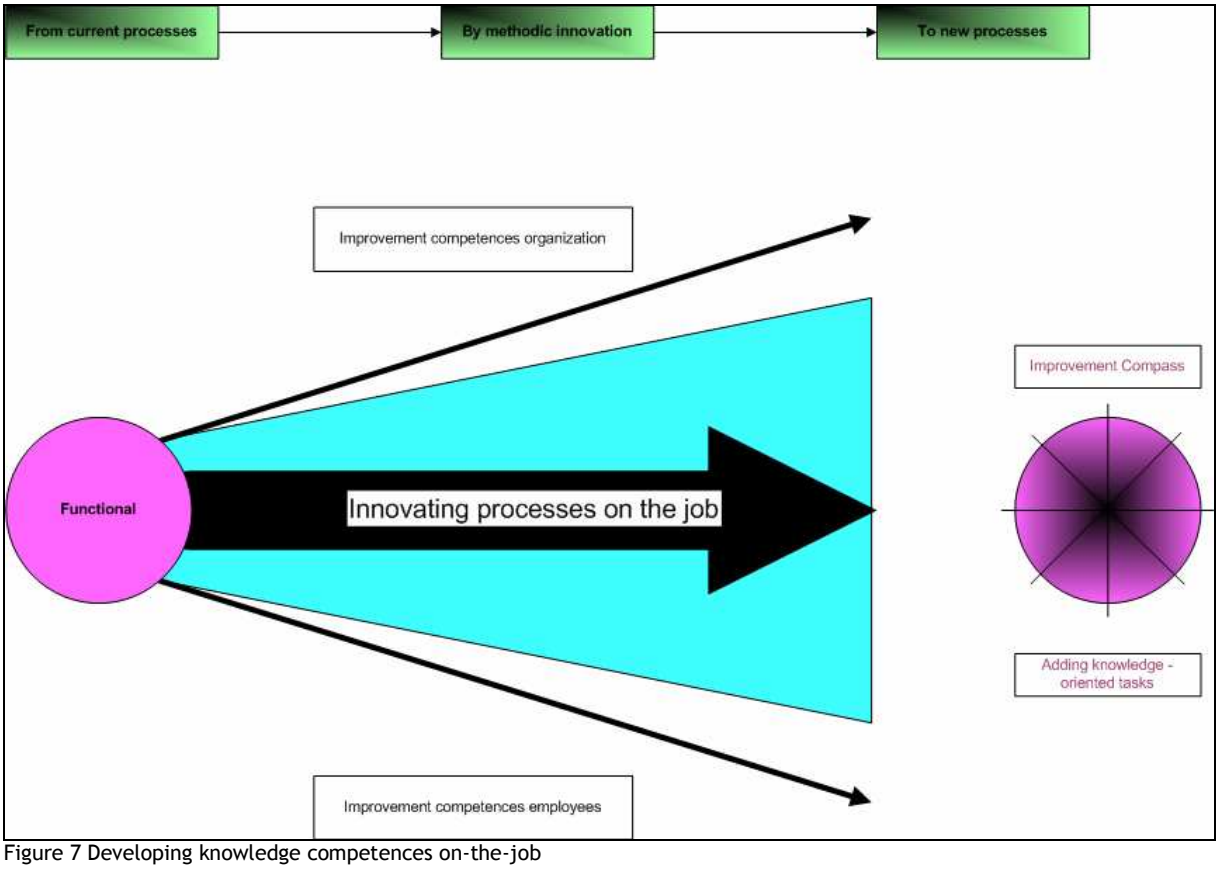


Figure 7 Developing knowledge competences on-the-job

The feature of this method is that the competences of the people and organization will develop simultaneously. This is only achievable with teams which consist of employees and management and will be executed within their own working environment. This is a process off *discovery learning*.

The four phases of Methodic Innovation

During executing a MI route four logical sequential phases will be expedited. See figure 8. After each phase several improvement aspects for product, process and facility will be evaluated. During the entire route management and direct stakeholders will be actively involved in this improvement process by organizing several knowledge-creation workshops.

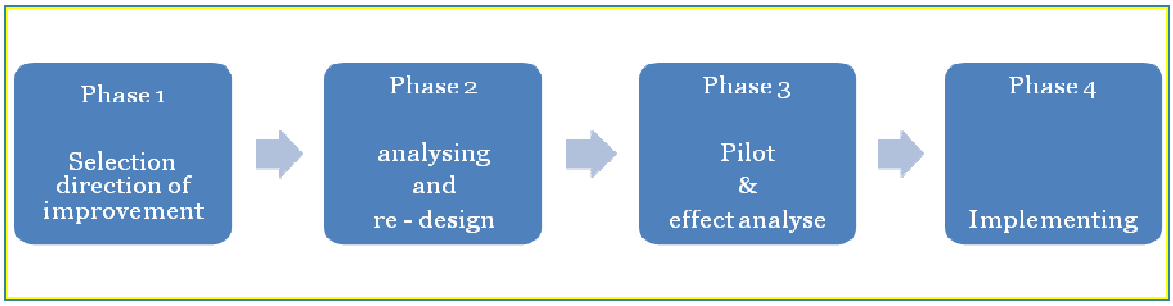


Figure 8 Phases of methodic innovation

Phase 1 Selection direction of improvement.

During this phase stakeholders discover improvement opportunities within the organization regarding efficiency and knowledge productivity. With the aid of an Integrated Design Scan (see figure 9) important areas will determined where improvements should be made. Analysing these area's will indicate where and how these improvements can be made.

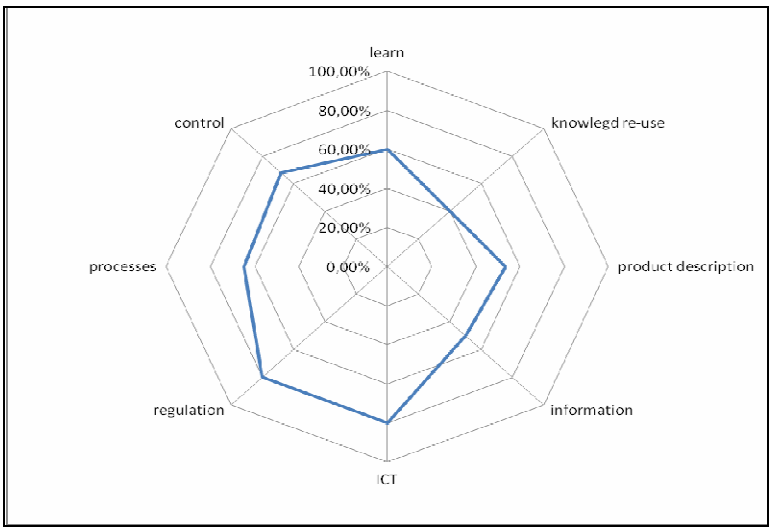


Figure 9 Example of outcome of an ID scan

Phase 2 Analysing and re-design

The innovation process can only be started when the current situation is investigated based on the present knowledge regarding the organizations processes. When there is clear insight of the current situation improvements can be identified. This will be done according the concepts of Integrated Design.
The knowledge of current situation and the redesign of it will be registered by several research models.

Phase 3 Pilot and effect analyze

Executing a pilot and effect analyze is done by establish a prototype system to visualize the new working processes. This should be done, within the provided ICT structures, based on the redesigned processes from phase 2.

Phase 4 Feasibility and Implementing

The knowledge and experiences of previous phases and results will be used to set up an innovation proposal for implementing an securing the new processes within the organization. This plan includes an estimation of costs and benefits of implementing this innovation.

3.5 Comparison various methods

To determine which method have to be used to perform the thesis research the four methods will be compared.
This comparison will be done by investigation the pro's and contra's of each method by applying the Demming circle. This is because within DSBV the Quality Management System is established according this principle.

The quality circle Deming is a creative aid for quality management and problem solving developed by Edwards Deming.
This circle describes four activities applicable for all organizations. These four activities will ensure improvement of quality. Its cyclic character guarantees that there is constant focus on quality improvements.

The four activities are:

- Plan: investigate current processes and make a plan for improvements and their objectives.
- Do: Execute planned improvements in a controlled pilot.
- Study: Measure the results of the improvements and compare those with the original situation and ensure they comply to the objectives.
- Act: Actualize the planning, adjust (parts of) the planning according the results

Figure 10 The Deming circle

By applying this model to compare various methods (see figure 11) it is concluded that applying the method of Methodic Innovation will be the most suitable for DSBV. The reasons are:

- This approach provides that the innovation team have to consist of both managers and executers.
- Bottom-up and top-down approach will give consistent improvements
- Is consistent with DSBV's objectives regarding continuous improvement and involving employees.
- The mathematical conclusion (pro's minus contra's: INK:0, BSC:-2, SS:+5, MI:+7)

		INK model	BSC model	Six Sigma	MI
PLAN	+	Organizations determination positions	Gaps of implementation strategy to be determined	Bottlenecks to be quantified by CTQ's	Quantitative judgment on 8 generic aspects
		Quantitative judgment by 9 criteria	Project selection based on qualitative info from vision and strategy (KSF and KPI)	Project selection to-down and bottom-up	Project selection based on this judgment
		Strategic plans based on results of self-evaluation		Tactical and operational plans based on this info	Tactical and operational plans based on this info
		Normative			
	-	Just direction of solutions	Less defined to focus-area's, risk for underexposure	Strategy not explicit clear	General formulated aspects
		Focus on diagnose	Periodic revision necessary	Pitfall is strong focus on troubleshooting	
		Controlling is derivative from position determination	Improvements initiatives mainly top-down	Bottom-up approach can lead to inefficient use of resources	
DO	+			DMAIC structure concrete established to realize defined improvements by CTQ's	Methodical recording of improvements
					Method established to realize defined improvements by kPI's
	-	Only identifying	Only identifying	Organizations wide executing of DMAIC demands extreme investments of recourses	
		Gives input for only strategic level	Gives input for only strategic and tactical level		
		No clear direction for realization of improvements	No clear direction for realization of improvements		
CHECK	+	Periodic qualitative evaluation of 9 criteria op general strategic level	Periodic qualitative evaluation of 9 criteria op general strategic and tactical level	Processes are predicable by knowledge of variations	Clear definitions of performance
				Clear definitions of performance	Comparison between performance of processes
				Comparison between performance of processes	
	-	Qualitative evaluation can lead to subjectivity	Quantitative information based on average ratios		
ACT	+	Review of strategic objectives	Review of strategic and tactical objectives	Review of tactical and operational objectives	Review of tactical and operational objectives

Figure 11 Comparison various methods by Deming circle

4 Used research techniques within Methodic Innovation

As already described in the literature study, the method of Methodic Innovation comprises four phases.
This research will be limited to the first two phases of this method, selection direction of improvement and analyzing and redesign.
Phase 3; 'pilot and effect analyze' and phase 4; 'feasibility and implementing' will be no part of the scope of this research.

4.1 Phase 1 Selection direction of improvements

The selection of the direction of improvements will be determined by scanning the organization of a department of the organization. This scan, the Integrated Design scan is an qualitative instrument to determine the strategy of an organization regarding the developments leading to World Class Performance. The scan focuses on selecting the direction of improvement, in cooperation with the management, of the working areas of employees.
In the next phases (phase 2) the improvement direction will be a platform for designing a desired / proposed situation. In phase 3 a pilot will be executed and analyzed and in phase 4 the feasibility will be investigated and the project will be increased.

Phase 1 comprises four steps as shown In next figure.

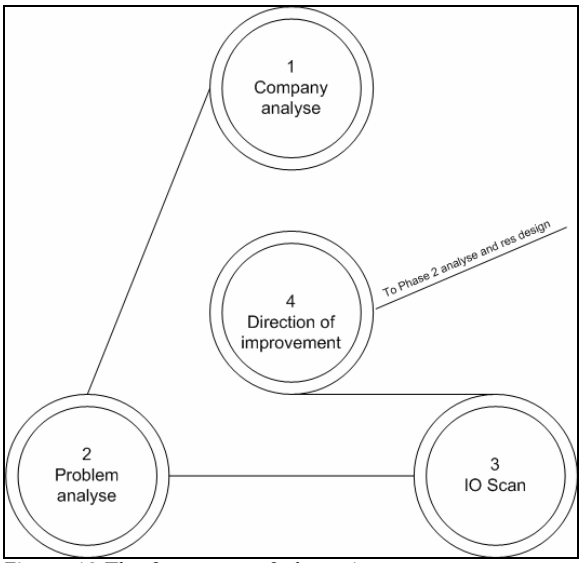


Figure 12 The four steps of phase 1

First of all the company will be analyzed where after the identified problems can be investigated by executing an ID scan. The results of this scan are an indication for possible improvements.
This scan is applicable for all levels in the organization, but a high aggregation level is abstract and will have limited details and a low aggregation level will be more specific and contains more details.

The, to be investigated, part of the organization will be considered as a system to perform the ID scan. This system is a collection of elements forming a complete system with mutual relations. It is a simple visualization of reality.

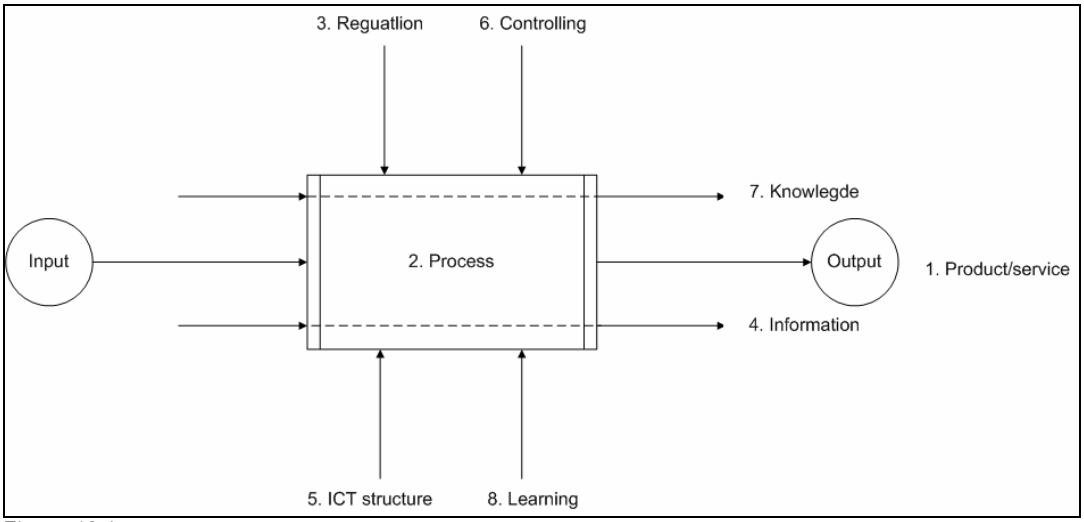


Figure 13 A system as a process

4.1.1 Used technique

The Integrated Design scan

The used technique to select the direction is an investigation of the current situation by executing an Integrated Design scan[1].
The ID scan is based on the principle of figure 13, the eight generic aspects are the eight arrows of this scan.

1 Product / Service

This aspect describes whether the product is complete, consistent and integrate to eliminate failures. Product description is an indication for productivity and efficiency. Because a complete product description leads to better products and less failures.
In this aspects it is about the integrated description of the product or service. The three dimensions are all aspects of a lifecycle (specs, design, develop, use, recycle) and all disciplines. They can be expressed in Low, Average and High;

- Integration of aspects
- Integration of product life cycle
- Integration of disciplines.

[1] See appendix D Integrated Design Scan (in Dutch)

2 Process

The aspect process describe the level and potency of customer orientation and added value to the client.
The underlying model of this aspect is the Life Cycle Engineering process model wherein several processes are collected in a specific connection.

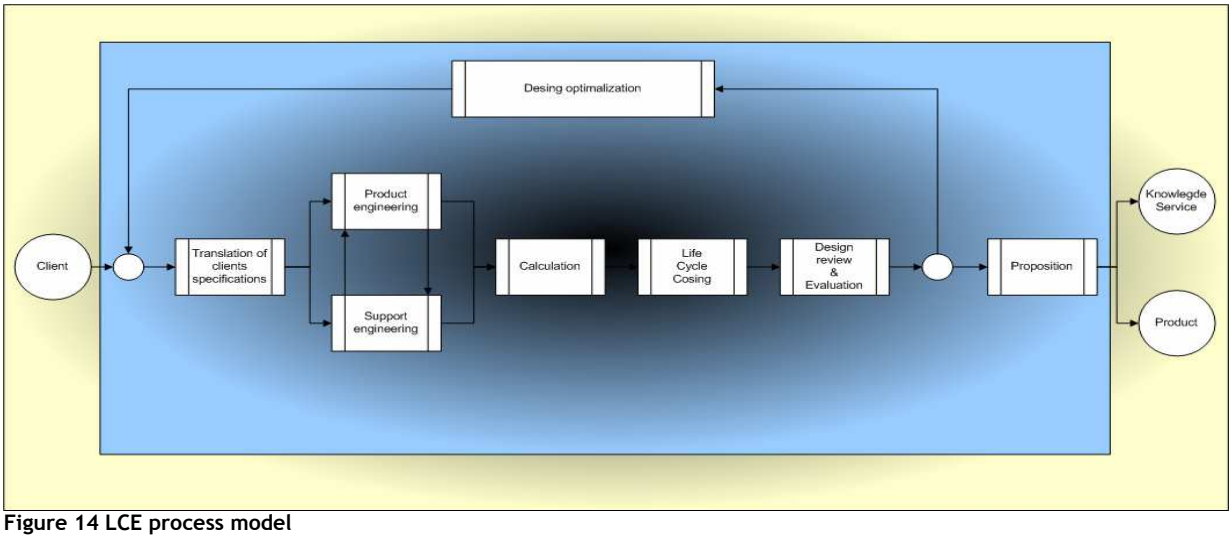


Figure 14 LCE process model

The customer orientation of the process is expressed how the eight sub processes are being executed. These processes are:

- Translation of the clients specifications.
  This is the digestion of the customer requirements to an internal level. Language and presentations used by the client will be translated in an internal standard format.
  This will be valued as Low, Average or High.
- Product engineering
  Designing the products based on the translated customer requirements. Standard design aspects will be filled in.
  This will be valued as Low, Average or High.
- Support engineering
  Designing added valued issues for supporting the product based on the customer requirements. (i.e. maintenance plans)
  This will be valued as Low, Average or High.
- Calculation
  Calculate the cost-price of the design, only the initial costs will be represented.
  This is not being represented in the ID scan.
- Life Cycle Costing
  Calculating the costs of using the product. Only the operational costs will be represented, considering Nett Present Value of the investment, spare parts and works.
  This will be valued as Low, Average or High.
- Design review & Evaluation
  Controlling and judge the design against customer requirements.
  This will be valued as Low, Average or High.
- Design optimalization
  Investigation of improvements on the design, structure, components of requirements
  This is not being represented in the ID scan.
- Proposition
  Draughting a proposition wherein all initial and operational costs are represented.
  This is not being represented in the ID scan.

3 Regulation

This aspect describes the coordination mechanism off the organization. This is the ability to tune and adjust processes. The focus will be on the operational level of the organisation. This aspect indicates the flexibility, effectiveness and efficiency.
Underlying model is the Steady State Model of In 't Veld (2002).

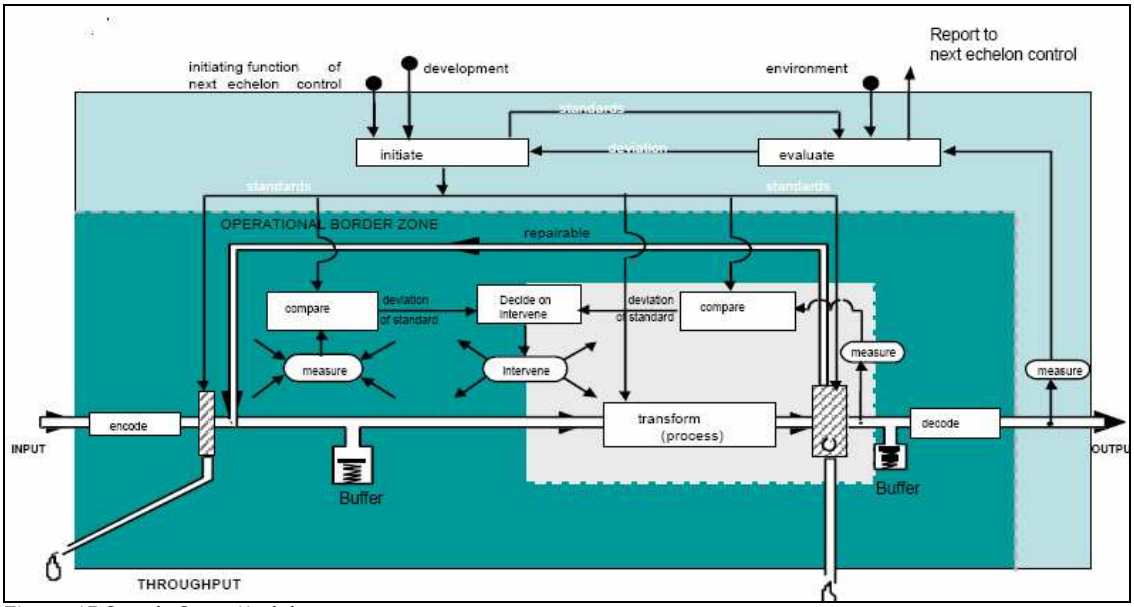


Figure 15 Steady State Model

- Task level
  This is the line of transforming (process). Necessary materials and data will be checked by filtering the encode, when not useful it will be dispatched. After checking of the input the transformation will take place. After this process it will be checked again on quality and quantity. After approval the product can continue its process.
  On this level employees are authorized to regulate only their own works. On higher levels this will be done by their team leaders or management.
- Process level
  This is indicated with the dotty frame. The transformation process needs to be corrected. There are two regulation principles:
  - Forward notification
    The failure will be notified, an correction compensates the failure effect. The input is measured including the failure, this measurement will be compared to the standards and de regulation will take action for correction
  - Afterwards notification
    The failure will be measured in the output and compared to the standards. Again a regulation will adjust with the necessary actions on the input of the process.

  The employees are authorized to regulate their works on process level. When interruptions influences their work they are entitled to adjust the process. On system level this will be done by their team leaders or managers.
- System level
  This is illustrated in the biggest frame. To regulate there are standards where to can be compared. These standards will be derivated by an initiating organ on a more abstract level. From this level the system will be established. These standards will be evaluated regularly.
  Employees are authorized to regulate their works on this level. This is a combination of activities and their mutual relations, quality and results.
  Besides employees can adjust interruptions in their own works, they can, based on standards of a more abstract level, formulate, evaluate and adjust standards for their own works.

The ID scan investigates the next features:

- Responsibility level
    - Task
    - Process
    - System
- Process regulation, maintaining objectives: Low, Average and High
- Standards regulation, adjusting objectives: Low, Average and High
- Project communication (participation): Low, Average and High
- Chain regulation(cooperation with externalities): Low, Average and Hihg

4 Information

This describes the aspects of information that an organization document and communicate. It is an indication of the organization of information facilities by investigation of its descriptions. Information is an aid to improve the effectiveness and efficiency in communication. Information is being expressed in a quantitative scale from two subjects;

1. **Shape**
   The shape is expresses in three categories: Document, Data and Model

   Document
   There is written communication. Transferring will be done by writing because effective. Complex information can be recorded effectively and communicated. Disadvantage is that it can be lost.

   Data
   There is communication based on digital documents. Transferring of information on digital documents is done because it is effective to create. The advantage is that is available for a lot of people and reusable.
   Disadvantage is that document control have to adequate. This type of information is implicitly. One has to read and interpret the information himself.

   Model
   There is communication based on shared integrated information. Transferring is base on this because the information is accessible and of correct version. (Project) information will be stored in model-shape. Features, standards are clearly stored, interpretable and accessible.

2. **Completeness**
   This is about the completeness of the information, is all relevant information available for adequately executing of works. Completeness is expressed in a simple Yes or No

   Yes
   There is sufficient information, formulating and expressions are complete.

   No
   There is not sufficient information, issues are being estimated due to lack off relevant data.

5 ICT

This aspect describes how the organization organizes the complete information exchange by how information is being distributed. Information architecture is an architectonical aid to realize effectiveness and efficiency in communication.
The integration principles are being expressed by three categories: Island, Coupling and Integrated.

Island
There is no common information and communication. There is no (ICT) exchange. Data is to be imported repeatedly and / or to be copied / pasted. The risk of failures is high.

Coupling
There is no common information and communication. Exchanges are realized by specific couplings and procedures. Loss of data during conversion is a risk. Common, routine acts saves time and some failures.
There are however several moments of import and export, so specific couplings and procedures has to be established.

Integrated
There is neutral common information and communication. Exchanges are being realized by couplings between the neutral and specific part. There is less loss of information. Information is now integrated, clear and stored at a central place and therefore available for everyone. Consistence of the information is now secured.

6 Controlling

This aspect describes the level of dynamics and learning of an organization. It indicates the potential to be a flexible organization. Dynamic organizations develop new competences and knowledge within a relative short period of time.

Underlying model is the business model of Prof. P. Malotaux.

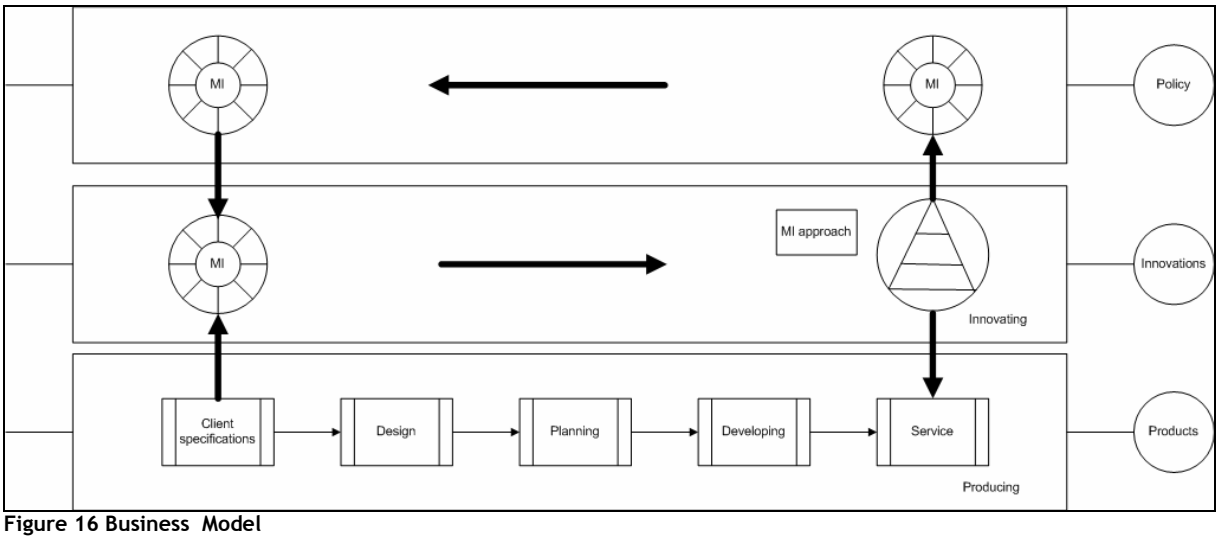


Figure 16 Business Model

Controlling will be expressed on a quantitative scale of five aspects. These five aspects are derived from the manor of controlling of the innovation process:

1. Spent time on controlling (steering capacity).
   Are employees responsible for improving their working environment and how much time do they spent on this?
2. Team learning (knowledge growth)
   Amount of time spent by employees in improvement process work and learned together in teams, knowledge creation by socializing and externalizing of knowledge to combine these knowledge to ne knowledge.
3. Steering style
   How the management controls the direction of improvements in relation to the input of employees:
   - Top down
   - Bottom up
   - Middle out
4. Integrated design
   How all aspects of a working area (product, service, processes, support) will be part of integrated design.
5. Applying / Practice
   How the improvements will be applied in a (pilot) project to develop new competences.

7 Knowledge

This aspect describes how the organization will reused knowledge in their works. It is an indication of then potency to deal with knowledge. Reuse of knowledge has a lot to do with productivity and efficiency.
The underlying model to investigate the level of reuse of knowledge is a combination of the:

- World Class Performance Model
- Steady State Model
- V-model

This model illustrate the reuse of knowledge.

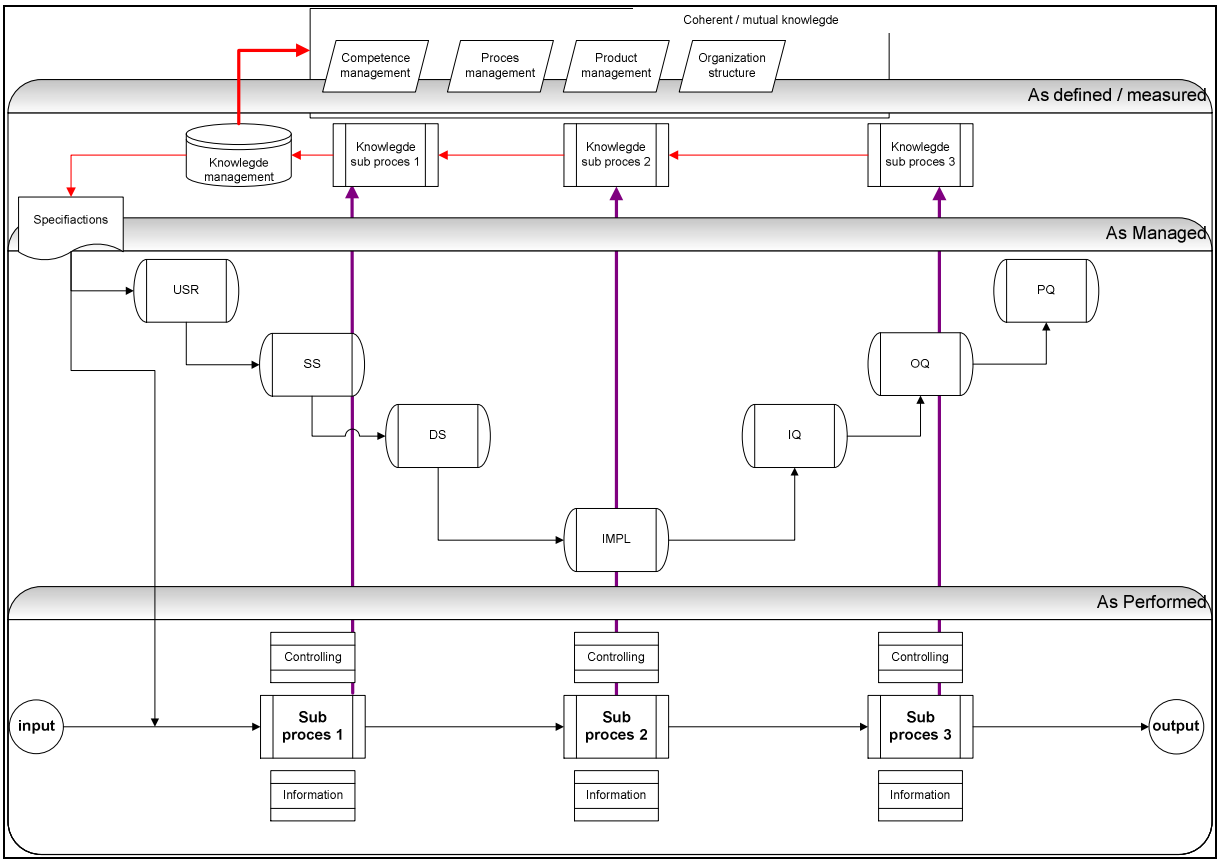


Figure 17 Reuses of knowledge in projects

Explanation abbreviations:

USR	User Requirements Specifications
SS	System Specifications
DS	Design Specifications
IMPL	Implementation
IQ	Installation Qualification
OQ	Operating Qualification
PQ	Performance qualification

In the ‘as performed’ part of this model the business processes are described, based on the lifecycle of the product.
The ‘as defined / measured’ part of this model the standards of the product is described. This are all standards, agreements, procedures, legislations etc. These standards are controlling during executing the business processes.
The ‘as managed’ part describes all the regulations for the business processes based on the V-model for projects.

The score of reuse of knowledge will be determined for the next levels:

1. Knowledge is personal.
   It is in peoples head, own files or books
2. Copying from previous projects
   Information from previous projects will be copied in current projects. Data will be changed, erased of copied.
3. Common dictionary
   Knowledge of specific features is registered.
4. Product models
   Knowledge of products and how they are connected will be determined in general forms.
5. Integrated knowledge library
   Knowledge of all aspects from products is determined in registered forms. Knowledge is applicable for all relevant disciplines.

8 Learning

The aspect learning describes the level wherein is explained how developments are organized. It is an indication of what the organization will do to improve their competences. Organization who stimulate learning and coordinate this learning are able to adapt themselves to new circumstances. Underlying model for learning on the group/organizational level is the Nonaka model (see figure 18). This model symbolizes the constructive path of knowledge creation in the knowledge-spiral. This path passes through the next four quadrants:

1. Socialization
   This is a process whereby personal tacit knowledge (implicit and unaware) is stated. Now knowledge that is hard to exchange or hidden knowledge will now be available for others.
2. Externalization
   This is a process whereby implicit knowledge from the socialization process will become explicit. The use of metaphors and analogies is an instrument to explain personal complex knowledge or difficult matters.
3. Combination
   This is a process whereby existing and new available knowledge will be combined and crystallized to new ideas.
4. Internalization
   This is a process whereby new knowledge will be adapted. Learning by experiences. Again will be worked with tacit knowledge in the new situation to improve again.

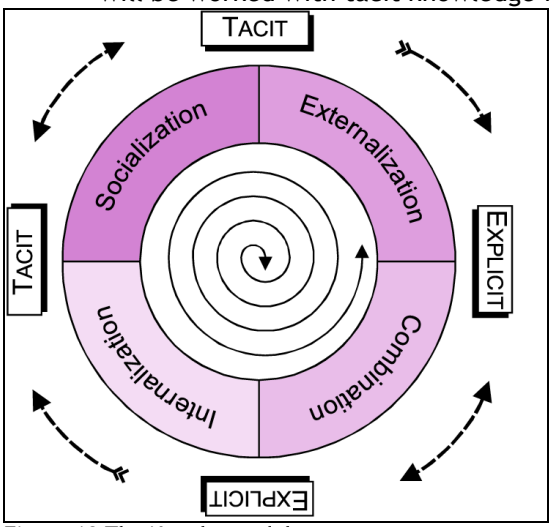


Figure 18 The Nonaka model

There are three categories wherein of learning:

1. 1st learning level
   Learning is by experiences, repair failures during executing works. Without changing boundaries regarding these works, employees has to deal with certain problems. There will no actions to prevent this problems and there is no mutual exchange of knowledge. Learning is based on repeating failures.
2. 2nd learning level
   Learning is done together. Based on experiences existing procedures, standards and policy will be adjusted. This means that boundaries have to change, employees has to learn to deal with the new boundaries. There are also actions to prevent problems structural. The focus is long term.
3. 3rd learning level
   Learning and its style is important. There is recognition of the urgency and controlling of the 1st and 2nd learning level. This means that the focus of an organization is on learning. The organization is aware of the learning effects and organize processes and styles on different levels to stimulate effective and efficient learning.

Aspects of the ID scan

The explained eight generic aspects will be investigated in an organization. The results of this scan will be represented in a spider diagram.
Next figure shows in how the scan is build up, which aspect represent the investigation questions How is the organization doing, whereby do the facilitate and what knowledge is necessary.
The aspects Controlling, Learning and Knowledge reuse are project – independence, the aspects Regulation, ICT and Information are project – depended.

The aspects are divided in a scale from 0 – 100%, the scores of each independent aspect can be related to the desired level, for example the World Class Performance Level. This level is different for each branch the organization is part of.

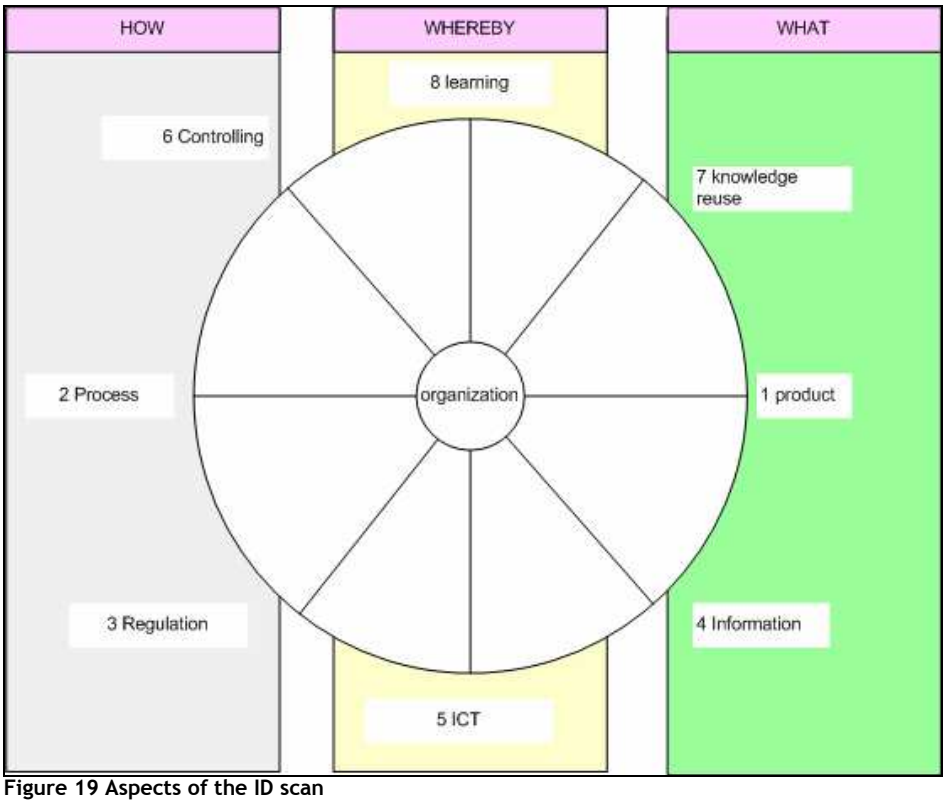


Figure 19 Aspects of the ID scan

4.2 Phase 2 Analyzing and re-design.

4.2.1 Analyzing

I don't know where I'm going,
But I sure know where I've been
….[2]

The Integrated Analyze

Now when ID scan is executed and the results are presented in the ID scan, the comparison with an desired situation can be made. Therefore this desired situation has to be obvious before performing the ID scan or has to be determined afterwards depending on the outcome.
When the current situation is determined, an organization can set objectives for improvement. Several aspects can be identified wherefore improvements should be made. It is almost impossible to improve all eight aspects at once. Therefore several aspect has to be identified and focused on. While improving these aspects, other aspect will improve as well, without having focus and / or objectives for these aspects. When the identified aspects are improved, the other aspects will be improved as well. Now new aspects can be identified for improvements, whether a new ID scan is to be executed or not.

The identification for improvements will be done by the Integrated Analyze. This method will collect the results of the ID scan and an overview for improvements, with the purpose for an improvmentplan, will be represented.
This overview consist of the eight generic aspects of the ID scan, their scores, features and possible improvements.

IO-aspect		Current situation		Proposed situation		Improvements (quality)		Developments (actions)	KPI's
Nr.	features of improvements according ID scan	%	Features current situation	%	Features proposed situation	%	Qualitative improvements	Necessary actions	Key Performance Indicators
1	**Control (developing):** Time spended on controling (steeringcapacity)								
2	**Learn (knowledgecreation):** - Learning level 1 - Learning level 2 - Learning level 3								
3	**Product (integrated):** - Integration of aspects - Integration of productie life cycle - Integration of disciplines								
4	**Knowledge (re-use):** - Knowledge re-use								
5	**Information:** - Form / shape - completeness								
6	**Information architecture (unlocking / opening)** - Integration principles								
7	**Process (customer focus):** Translation of customer specifications Supportengineering Life Cycle Costing Design review & evaluation								
8	**Regulation (targeted):** Level of responsibility (complexity) Process control (maintaining objectives) Standardization (adjusting objectives) Projectcommunication (participation) Managing supply chain (cooperations with external parties)								

Figure 20 Integrated Analyze

- IO aspects
  In these columns important features of the generic aspects described. Based on these features the integrated analyze will be performed.
- Current situation
  This is the inventarisation of the current situation. The outcomes of the ID scan will be represented: the actual score of the aspect and their important features will be represented.

[2] Whitesnake; Here I Go Again (*Snake & Sinners*, 1982)

- Proposed situation
  The proposed situation is an estimation of the scores from the ID scan for a desirable situation. This can be a predefined score, based on experiences, of this score is to be defined when the actual score determined. The features must be representing the improvements of knowledge.
- Improvements (quality)
  In this column important features of qualitative improvements are described. The percentage is the difference between the current and proposed situation.
- Developments (actions)
  Based on the analyzed quantitative improvements developments can be formulated and these will be the base for developing an action – plan.
- Key Performance Indicators.
  The kPI's have to represent the (subjective) benefits of when the improvements are realized. These are assumptions depending on the organization and its culture.

4.2.2 Re - design

Used techniques

The Process Model / IDEF-0 model

Through applying the IDEF-0 technique to a specific process it's possible to visualize and simplify complex processes. The strength of this method lies within the various point of views from which the process is analyzed. The first point of view is at the highest abstraction level of the process in the organization (A0), depending of the complexity of the process, the analysis can go several levels deeper (A1, A12, A123 etc.)

The IDEF-0 method is based on the following principle and is comparable with the process model wherein all eight generic aspects of the ID scan are represented, as explained in paragraph 4.1 The only differences with that model are that the aspects 4 (information) and 7 (knowledge) are not specified in the IDEF-0 model.
It is to be presumed that these aspects are incorporated in the ICT structures, the ICT structure are to be established to meet the objectives of those two aspects because ICT, information and learning are inextricably connected to each other!

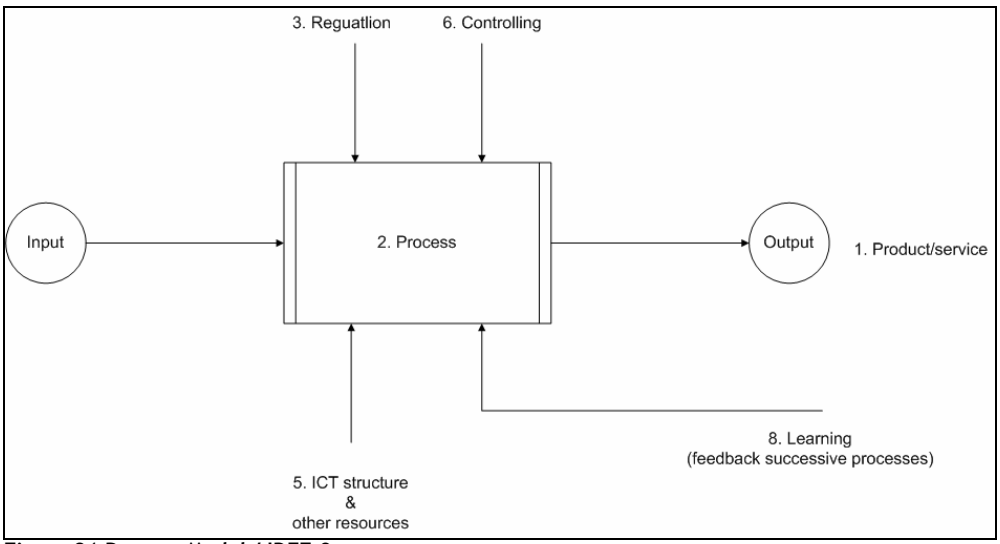


Figure 21 Process Model / IDEF-0

Processes can be connected to each other by the inputting the outcomes, regulation or controlling from another processes.
There is no time-line connection, but an independency – connection. Then input for a (sub) process depends on the outcomes from a previous (sub) process. This is illustrated in next figure.
The main process (A0) consist of several sub processes (A1 – A3).

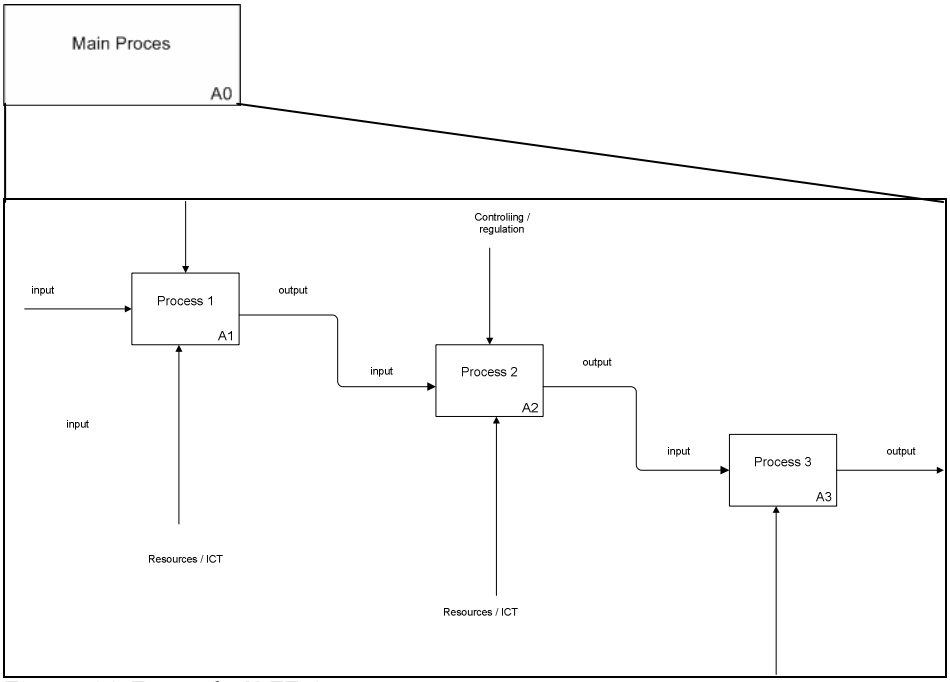


Figure 22 Example IDEF-0 structure

This technique is not only be used to investigate the current processes. When current processes are determined, it is possible to use this technique for re-designing these processes or design new processes in order to meet the objectives as set in the Integrated Analyze.

Activity Diagram

An activity diagram is a model wherein work processes concerning their activities, information flows and information content (documents and data-files) are interconnected visualized.
This model can be descriptive and predictive.
When it is descriptive it is about facts and collecting an overview of the current situation, when it predictive it is to predict the future situation and to predict the consequences of several alternatives.
To, from a current situation, come to improvements of knowledge productivity is it important to describe and visualize for both situation the processes and information flows, and –content in an activity diagram.

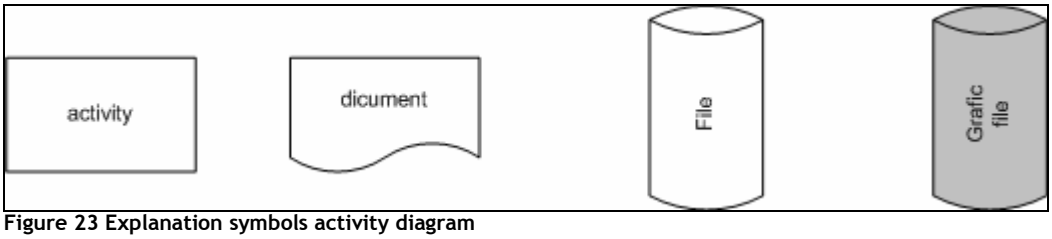


Figure 23 Explanation symbols activity diagram

Visualization of processes in an activity diagram is based on the gathered information. To support the analyze- and redesign process several activities and their will be explained in next table.

Nr.	Activity	Result
1	Departments and processes are black-boxes. Investigate only input and output	Insight in information, -flows and 'behaviour' of an organization
2	Derivation of input and direction of output?	Insight in relations between departments, processes together. Schematically.
3	Which activities take place in an organization	Insight in progress of processes
4	Which input and output is related to an activity?	Insight in information content, -flows and activities.
5	Description of activities (how, why, whereby, who)	Insight in working method per activity.
6	Inventarisation of data and media per activity	Insight in data.
7	Inventarisation of relations between data.	Insight In mutual relations and files.
8	Who, when, how often is data consulted	Insight in controlling and securing data.
9	Checking whether activities and data-storing is double.	Limitation of unnecessary variety.
10	Draughting a procedure for: • Activity processing • Necessary input per activity • Output per activity • Relations between departments • Relations between activities • Relations between information, materials, activities and data-files	Insight in functionality of an organization. Integration of performed activities in stead of a procedure per separate department.
11	Inventarisation of problems and bottlenecks per department	Insight in problems and bottlenecks.

World Class Performance model

World Class Performance is originated from the CMMI-standards[3]. Literature study learned that CMMI was developed by a group of experts from industry, government and the Software Engineering Institute (SEI) at Carnegie Mellon University. CMMI models provide guidance for developing or improving processes that meet the business objectives of an organization. A CMMI model may also be used as a framework for appraising the process maturity of the organization.
The CMMI model consist to five levels.

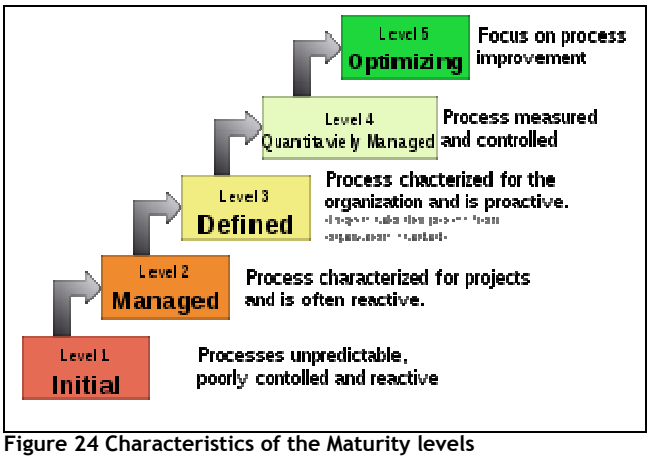


Figure 24 Characteristics of the Maturity levels

Since there is no generic World Class Performance model, (several companies uses several models to obtain WCP) the CMMI model and the Steady State Model (see paragraph 4.1 Aspect 3 Regulation of the ID scan) are combined to visualize the Capability Levels of Performance.

[3] Capability Maturity Model Integration

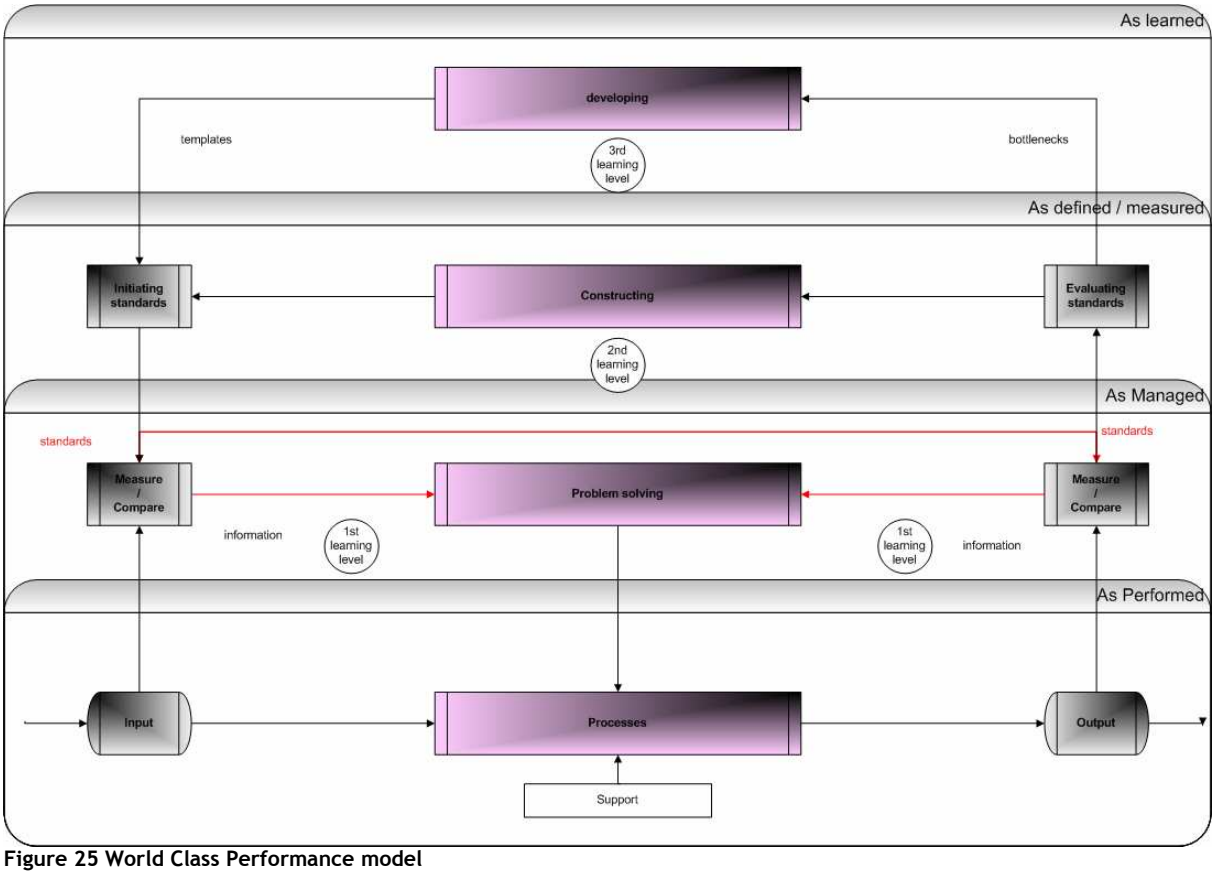


Figure 25 World Class Performance model

Level 1: As performed

A level 1 process is characterized as a "performed process." A performed process is a process that satisfies the specific goals of the process area. It supports and enables the work needed to produce work products.
Although capability level 1 results in important improvements, those improvements can be lost over time if they are not institutionalized.
Processes are usually ad hoc and chaotic. The organization usually does not provide a stable environment to support the processes. Success in these organizations depends on the competence and heroics of the people in the organization and not on the use of proven processes. In spite of this chaos, at this level organizations often produce products and services that work; however, they frequently exceed their budgets and do not meet their schedules.
These organizations are characterized by a tendency to over commit, abandonment of processes in a time of crisis and an inability to repeat their successes.

Level 2: As managed

A level 2 process is characterized as a "managed process." A managed process is a performed (level 1) process that has the basic infrastructure in place to support the process. It is planned and executed in accordance with policy; employs skilled people who have adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to its process description. The process discipline reflected by this level helps to ensure that existing practices are retained during times of stress.
When these practices are in place, projects are performed and managed according to their documented plans.
At this, the status of the work products and the delivery of services are visible to management at defined points (e.g., at major milestones and at the completion of major tasks). Commitments are established among relevant stakeholders and are revised as needed. Work products are appropriately controlled. The work products and services satisfy their specified process descriptions, standards, and procedures.

Level 3: As defined / measured

A level 3 process is characterized as a "defined process." A defined process is a managed (level 2) process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines, and contributes work products, measures, and other process improvement information to the organizational process assets.
A critical distinction between levels 2 and 3 is the scope of standards, process descriptions, and procedures. At level 2, the standards, process descriptions, and procedures may be quite different in each specific instance of the process (e.g., on a particular project). At level 3, the standards, process descriptions, and procedures for a project are tailored from the organization's set of standard processes to suit a particular project or organizational unit and therefore are more consistent, except for the differences allowed by the tailoring guidelines.
Another critical distinction is that at level 3, processes are typically described more rigorously than at level 2. A defined process clearly states the purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria. At level 3, processes are managed more proactively using an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.

A level 3 process is also characterized as a "as measured." A measured process is a defined process that is controlled using statistical and other quantitative techniques. Quantitative objectives for quality and process performance are established and used as criteria in managing the process. Quality and process performance is understood in statistical terms and is managed throughout the life of the process.

Processes are well characterized and understood, and are described in standards, procedures, tools, and methods. The organization's set of standard processes, which is the basis for level 3, is established and improved over time. These standard processes are used to establish consistency across the organization. Projects establish their defined processes by tailoring the organization's set of standard processes according to tailoring guidelines. A critical distinction between levels 2 and 3 is the scope of standards, process descriptions, and procedures. At level 2, the standards, process descriptions, and procedures may be quite different in each specific instance of the process (e.g., on a particular project). At level 3, the standards, process descriptions, and procedures for a project are tailored from the organization's set of standard processes to suit a particular project or organizational unit and therefore are more consistent, except for the differences allowed by the tailoring guidelines.

The organization and projects establish quantitative objectives for quality and process performance and use them as criteria in managing processes. Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers. Quality and process performance is understood in statistical terms and is managed throughout the life of the processes.

For selected sub processes, detailed measures of process performance are collected and statistically analyzed. Quality and process-performance measures are incorporated into the organization's measurement repository to support fact-based decision making. Special causes of process variation are identified and, where appropriate, the sources of special causes are corrected to prevent future occurrences.

Level 4: As Learned

A level 4 process is characterized as an "as learned process." An optimizing process is a quantitatively managed (level 3) process that is improved based on an understanding of the common causes of variation inherent in the process. The focus of an optimizing process is on continually improving the range of process performance through both incremental and innovative improvements.
This level focuses on continually improving process performance through incremental and innovative process and technological improvements. Quantitative process improvement objectives for the organization are established, continually revised to reflect changing business objectives, and used as criteria in managing process improvement. The effects of deployed process improvements are measured and evaluated against the quantitative process improvement objectives. Both the

defined processes and the organization’s set of standard processes are targets of measurable improvement activities.
A critical distinction between levels 3 and 4 is the type of process variation addressed. At level 3, the organization is concerned with addressing special causes of process variation and providing statistical predictability of the results. Although processes may produce predictable results, the results may be insufficient to achieve the established objectives. At this level, the organization is concerned with addressing common causes of process variation and changing the process (to shift the mean of the process performance or reduce the inherent process variation experienced) to improve process performance and to achieve the established quantitative process improvement objectives.

5 The research

5.1 Stakeholder analyze

Results of this research will initiate several changes in the M&AM environment, this change will cause emotions. The management of these emotions is the most important aspect for the success of the research project, so an early recognition and responding on expectations and the emotions of the stakeholders of the project is crucial.
These emotions are e.g. uncertainty, interests, status, views and values. In this research the management of stakeholders will get separate attention. This to mobilize support.

During start up of the project all stakeholders are to be analyzed. A stakeholders is a person or group with an interest or influence on the achievement, process or success of the organization. Bases on this analyze is to be determined how the interests of users, suppliers and other relevant parties are being managed.
This analyze is the 'stakeholder analyze'. This analyze determine the stakeholders management strategy, which will be translated to the manor of control of all stakeholders.

The stakeholder management consist of several phases:

- Inventarisation of all stakeholders groups and – persons
- Analyze the importance of these stakeholders on the project results
- Analyze the possible contradictions between the project-objectives and the objectives/interests/views of the stakeholders
- Determine stakeholder profile
- Determine applicable stakeholders strategy
- Transform this strategy to activities and resources
- Monitor and evaluate the effectiveness of determined strategy
- Monitor and evaluate effects of new developments
- Update the stakeholders management strategy.

The analyze of stakeholders is to identify their exact interest on this research an how important they are for the successes and whether their interests are complying to the aimed results and objectives.
The interest of stakeholders are e.g. usage of the results, working processes etc. etc. Depending on their interest stakeholder are negative, critical, waiting of positive to the research project. This attitude will be determined on rational and emotional arguments.
The analyze results are being presented in a matrix. In this matrix are several profiles;

- Very important, low interest
- Very important, high interest
- Not important, high interest
- Not important, low interest.

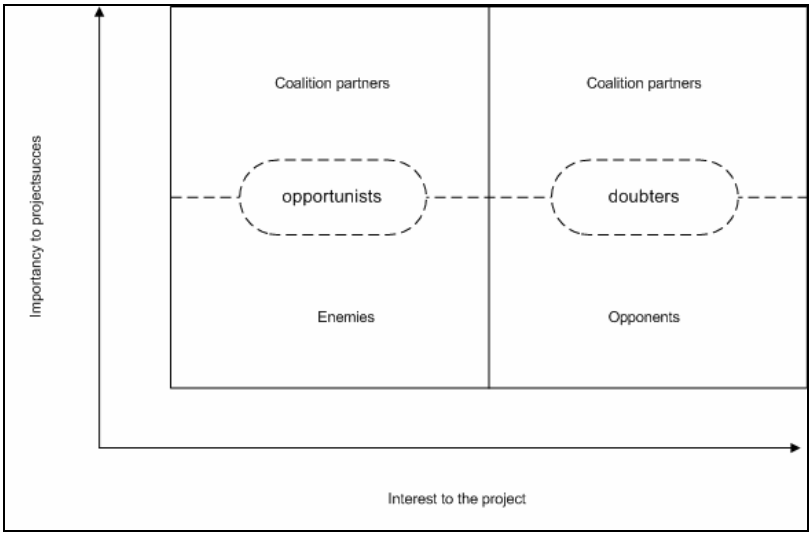


Figure 26 Stakeholders analyzing model

This stakeholder analyze is the result of sub question 1[4]: Who are the stakeholders in this project? This part of the research is important to determine the interest of all relevant persons within the organization who will be representative for their sub-department or group off employees.
From all relevant sub-departments of the M&AM department as well as the MA&M client Production and management several representatives are invited to the project team.

In the table stakeholder inventory[5] of DSBV, functions are specified in order to investigate their interests. Each function has its own objectives to improve the knowledge productivity. Therefore each stakeholder has interest in this project.
The next overview shows the stakeholders and their relation to this project and the control measurements identified for each stakeholder.

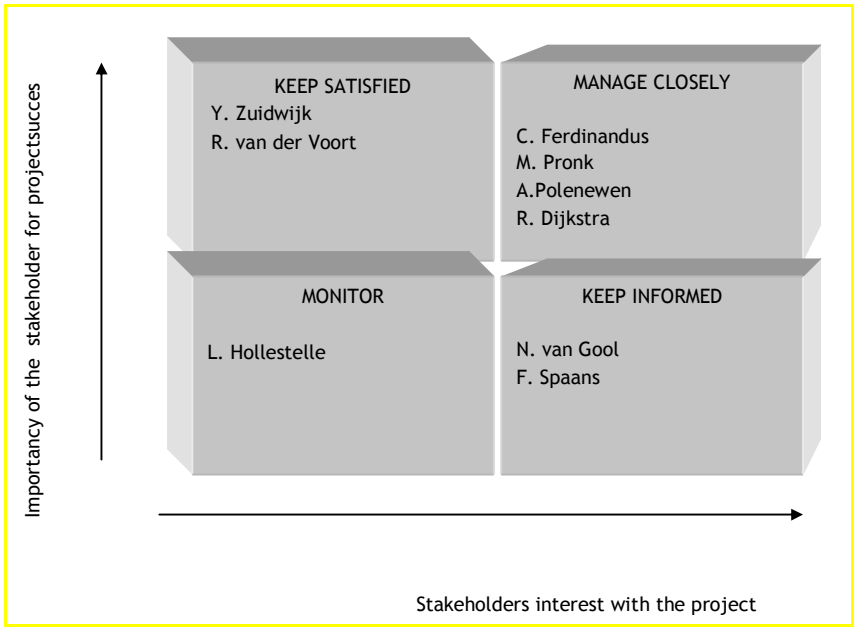


Figure 27 Overview stakeholders analyze

[4] See appendix A Main research and sub questions
[5] See appendix B Stakeholder analyze

The persons who are to be ‘managed closely’ are the persons with the most interest of this research project. These employees will most affected by the outcomes of these research. They are all members of the M&AM department.
It is therefore important to involve these stakeholders in the whole process of determine the current situation and re-designing in order to meet the project objectives. By involving these persons in an early stage of the process support of the results and proposed changes is already mobilized.

The persons who have to be informed are DSBV’s supervisor of this research project and a member of the operational department. It is important to inform this department as they are the M&AM internal client. They have to adapt some procedural changes in order to contribute to the research objectives.

The department of reliability engineering have to kept satisfied. They have to implement the research outcomes within the Computerized Maintenance Management System and other relevant systems.

The purchase department is to be monitored as they don’t have a significant part in this research project, but there are some minor changes to be expected for their working procedures.

5.2 Investigation current situation

5.2.1 Phase 1 Selection direction of improvements

After explanation of the IO scan, its methods, questions and benefits, all nine mentioned stakeholders have executed this scan[6] separately. These scans are the result of sub question 6: What is the current level of the 'learning organisation'?
After performing this IO scan the scans are evaluated combined and individual.

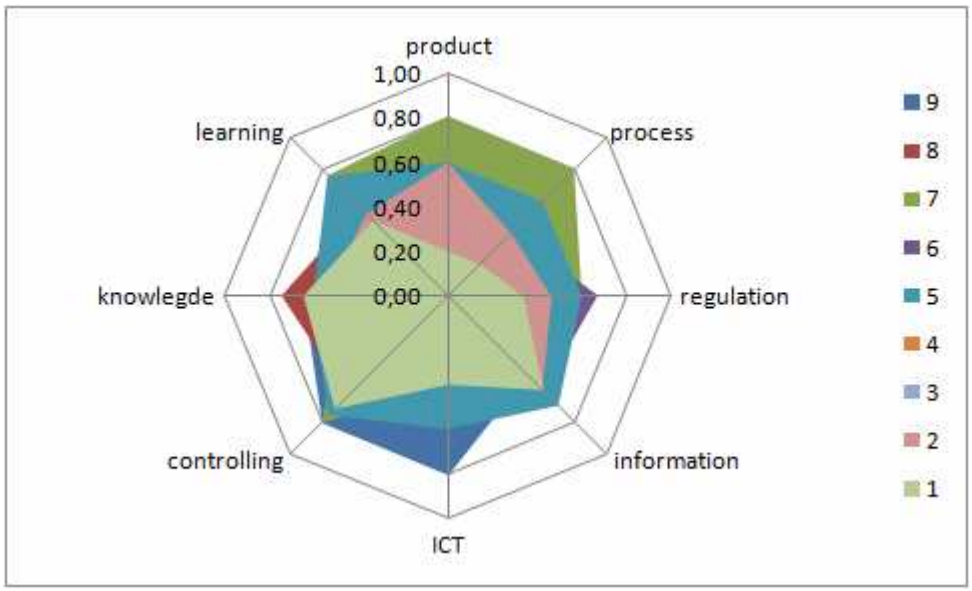


Figure 28 Combined results ID scan

The conclusion of the combined diagram seems to be that the M&AM organization scores average or above average. This however is not representative, when analyzing all ID scans individual next overview shows the variety of scores on the eight generic aspects of the ID scan. When analyzing the ID scans it has been determined that from each ID scan three lowest scoring aspects are to be assigned to be approved. This results in next figure.

nr.	knowledge	learn	product	process	regulation	information	ict	control
1	X	X	X					
2	X		X				X	
3	X	X	X	X		X	X	X
4	X	X					X	
5								
6	X							
7				X			X	
8	X	X				X		
9	X							
TOAAL	7	4	3	2	0	2	4	1

Figure 29 Individual scores ID scan

This overview concludes that three generic aspects of the ID scan are being identified wherefore improvements should be made:

[6] See appendix C and D: Integraal Ontwerp Scan

1. **Learn**

Four out of the nine stakeholders indicate this aspect as level 1-2, the first learning level.
This means that routine – learning is based on solving recurring failures during executing work according predefined standards. There is an invoke on problem-solving capabilities of employees. Without changing the standards, employees has to learn to deal with several problems. These problems are not structurally being prevented. This is due to retaining to certain core values or that there is not enough time or interest to change sustainable. There is no mutual change of knowledge and learning is based on solving repeating problems.

2. **Re – use of knowledge**

From the nine stakeholders, seven indicate this aspect as level 1 – 2 of the scale.
This means that:

- Knowledge is in peoples head
  Knowledge is based on experience and common practices without explicit reflection hereof. The organization is highly dependent on these employees. Knowledge is only accessible by interviewing these important employees. Their knowledge can be applied limited. Knowledge has no meaning for their colleagues.

- People copy from previous projects.
  Information from previous project are being copied in the new projects. Data can be altered, deleted or completely copied and will gain new value.
  This approach is often not applicable and produce a lot of mistakes, failures and ambiguities. Repeatedly there are no standards wherein latest changes are incorporated. This means solving problems that already has been solved previous!

3. **ICT**

Four out of the nine stakeholders indicate this aspect as level 1-2.
This means that the information is categorized according the integration principles as;

- **Island**
  There is no common information and communication. There is no (ICT) exchange. Data is to be imported repeatedly and / or to be copied / pasted. The risk of failures is high as data also can being erased or lost due to personalizing relevant data.

This outcome of the first investigation of the current situation will be the focus for the remaining research of this project and an important foundation for the redesigning the current M&AM processes.

5.3.Phase 2; Analysing and re-design

5.3.1 Analyse of current processes

As obligated by the Waterboard Delfland, DSBV has to comply to the standards set by the ISO 9001. But in order to meet the corporate objectives of continuous improvement, DSBV decided to comply to the standards of ISO14001 and PAS 55 as well.

Therefore a Quality Management System has been set up wherein all business processes (BP) are described.
This Quality Management System comprises:

- a summary management part including the mission and the strategic objectives
- the business processes including the tactical and operational details

The business processes are subdivided into:

- the controlling and policy processes including the tactical details of the mission and the strategic objectives
- the primary processes including the operational conversion of the policy into the core activities of the company and the process of producing and delivering the product / service plus maintaining the operational resources required to do this
- the supporting processes including the operational conversion of the policy into the supporting activities needed to ensure that the primary processes run smoothly

As well as the business processes, the quality system also covers any associated work instructions.

The diagram below gives a schematic representation of the structure of the quality system.

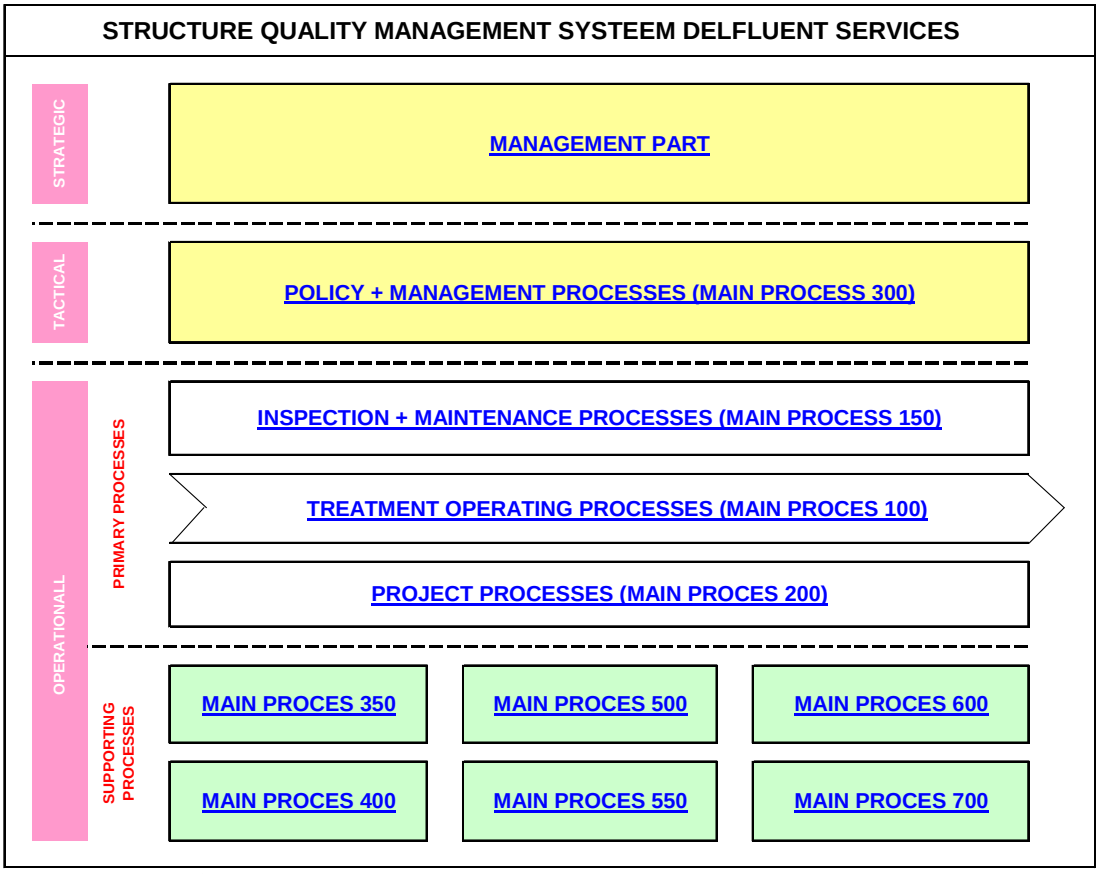


figure 7 DSBV's Quality Management System

The processes to be investigated are part of the next main processes:

- BP 100 Production
- BP 150 maintenance
- BP 550 purchase and logistics

Investigation of these processes shows the next overview of these sub processes to be investigated This overview is the result of sub question 2: Which processes are part of this project?

- BP 100.15 monitoring and handling alarms for pumping stations (PS) and pressure mains (PM)
- BP 150.05 Resolving urgent problems
- BP 150.10 Planning, agreeing inspections and maintenance
- BP 150.15 Preparing inspection- and maintenance shutdowns
- BP 150.20 Performing inspections and maintenance
- BP 150.30 Monitoring and evaluating maintenance

BP 550 is not to be investigated, these processes are considered as supporting processes and are not solitary for the M&AM but for other departments as well. Therefore these processes will not be part of the scope of this research.

The research technique to investigate all relevant business processes has been the IDEF-0 technique. With this modeling technique is possible to investigate these processes and their mutual relations. Hereby the sub question 3: How are the current processes designed? will be answered.
The IDEF-0 technique is explained in paragraph 4.2.2, but will briefly be explained.

Through applying the IDEF-0 technique to a specific process it's possible to visualize and simplify complex processes. The strength of this method lies within the various point of views from which the process is analyzed. The first point of view is at the highest abstraction level of the process in the organization (A0), depending of the complexity of the process, the analysis can go several levels deeper (A1, A12, A123 etc.)
The IDEF-0 method is based on the following principle:

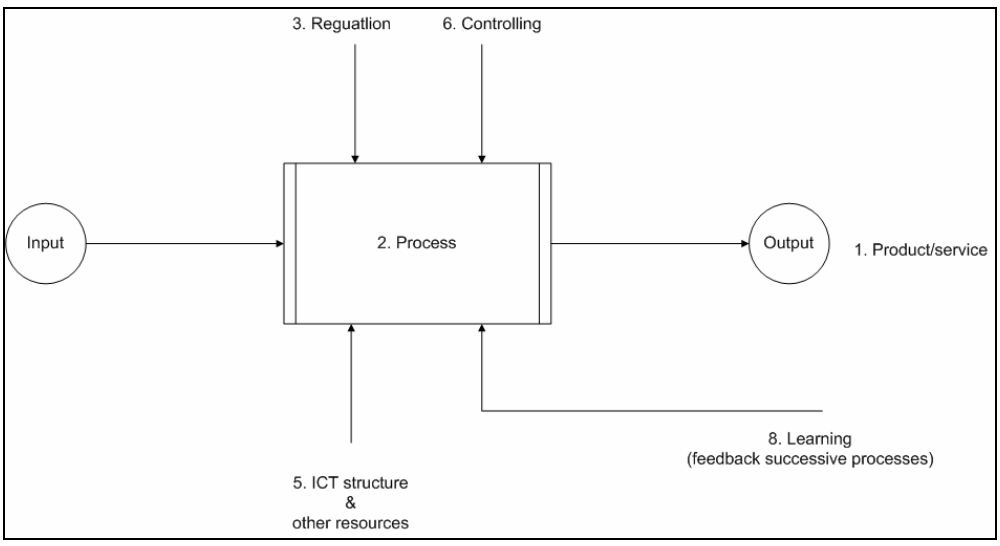


figure 8 Principle sketch of IDEF-0 technique

All relevant processes were set up according this technique[7] by not only the literature study of DSBV's QMS, but also by interviewing the relevant stakeholders whether they comply to these processes or not.

The research of how current processes are incorporated within DSBV's structure has been done by setting up all relevant processes according to the IDEF-0 technique. Source for this was the schematic flow charts and explanation of each process. When all processes were draught they were compared to the actual performance according these process by interviewing relevant stakeholders as they were mentioned in the RASCI[8] model of each process.
After finalizing the draught IDEF-0 models of each process, these processes were assigned to the different stages of the Deming circle. (see next figure as explained on page 22)

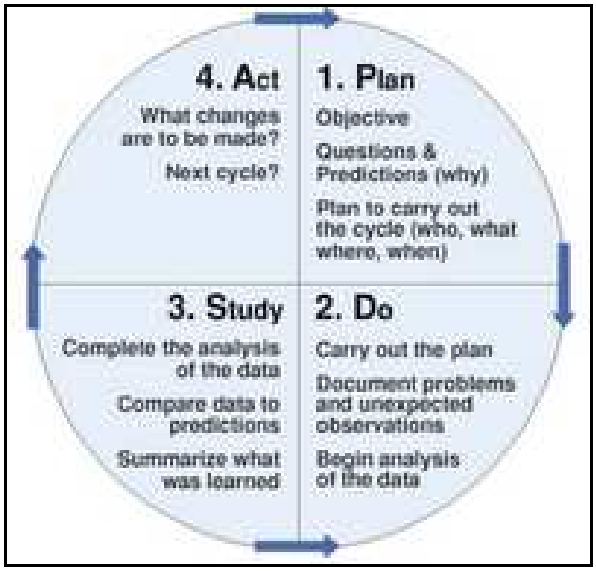


Figure 30 The Deming circle

After this investigation, evaluating and draughting all these processes it is to be concluded that:

- due to the design of the processes, it is not possible to 'improve continuously'. The Demming / PDCA circle is not properly implemented. Several processes to fill all aspects of this circle are missing.
- Some process titles are not complying with the content of the process
- Some processes are not finalized
- The processes are focused on corrective maintenance
- There are no processes formulated to implement DSBV's strategic objective of implementing Reliability Centered Maintenance.
- Important sub processes are not described, or described insufficient

[7] See appendix E IDEF-0 current situation
[8] Responsible, Accountable, Supporting, Consulting and Information

5.3.2 Analyse of activities in current processes

During investigation of the current processes, and especially during the interviews it was difficult to identify all performed activities persons executed within the existing processes although they were mentioned in the RASCI of these processes.
It was not clear who has to do what and why they have to do it.

Therefore a succeeding research has to be done in order to visualize all activities in relation to responsibilities, information, information content and their mutual relations and independencies. This has been done by draughting an activity diagram[9]. (see page 38 for explanation)
By setting up this diagram sub question 4 What data is used during these processes? will be answered.

This diagram shows the roles within the current processes all relevant stakeholders fulfill.

- Process operators (and others)
  The responsibilities of the process operators is to operate the WWTP's. This means that they are the MA&M internal client, they are the most affected as they set the standard for Reliability and Availability (R/A) of the process equipment.
  When the R/A is decreasing and will influence the required process standards they have to communicate this to the M&AM department.
  The production is also directly affected by the execution of maintenance, whether it is corrective, preventive of predictive maintenance.
  The others in this column are mainly the rest of the organization as everybody is entitled to request maintenance to be done as corrective maintenance or modification.
- Reliability engineers
  These are the staff of the M&AM department. They are responsible for identifying all preventive and predictive maintenance and implement this maintenance requirements in the CMMS[10].
  They are responsible for analyzing kPI's and initiate improvements as result of this evaluation.
- Supervisors
  This role is implemented in the M&AM department in 2008/2009. Therefore this role did not exists. The daily controlling of the department has been done by the team leader maintenance, the reliability engineers fulfilled the roles of work-preparationers and purchasers. This has been changed by employing three supervisors:
  - Supervisor Mechanical
    Responsible for all maintenance on mechanical and rotating equipment.
  - Supervisor Electrical, Instrumentation and Process Automation
    Responsible for all maintenance on all electrical and PA systems.
  - Supervisor General & Civil
    Responsible for all other maintenance activities on non-process related equipment, cleaning of production locations and supporting roles as greasers etc.
- Engineers
  All maintenance executing employees and rayon-engineers who control and maintain all pumping stations under the responsibility of the supervisors.
- Maintenance Manager
  Responsible for the M&AM department.

In this activity diagram all relevant processes are schematically divided over the separate roles with the information every role has to produce or deliver. It is now clear what information is transferred and being available within the entire MA&M department.

[9] See appendix F Activity diagram
[10] Computerized Maintenance Management System

After this investigation, evaluating and draughting all these processes and information into this diagram it is to be concluded that:

- Exchange of information is very poor:
    - Important information (e.g. planning) is only accessible for people off the M&AM department, but will be distributed separately.
    - There is no feedback from executing maintenance to maintenance preparation or existing preventive / predictive maintenance plans.
    - There is no feedback to the work order requestor.
    - The Plan of Approach for shutdowns is only accessible for those on the mailing list.
- ICT systems are not having the significance and importance as it should be. The existing CMMS is only used for editing work orders
- Relating documents as work permits and (incomplete)planning are made up in a separate system, work instructions are not available
- The only way to analyze and improve that is being provided is the overview of key Performance Indicators that will be send monthly to the maintenance manager. Investigation of these kPI's concluded that they are not specified, to be monitored, accepted by the organization, realistic and proper validated.
- Engineers are not involved in work preparation of preventive / predictive maintenance plans.

These conclusions are consistent with the conclusions of the ID scan. The three generic aspects of this scan which are identified as where improvement are to be made for are:

1. Learn
2. Re-use of knowledge
3. ICT

5.3.3 Comparing to the World Class Performance Model

World Class Performance is the highest level of achievement an organization can accomplish within its environment.
The objective of this model is to investigate what level the organization is performing on, but also to identify what learning level is actual.

Draughting this WCP model[11] sub question 5 What is the level of World Class Performance of current processes? will be answered.

The conclusions of the outcome of this model are consistent with the outcomes of the IO-scan. Particularly the re-use of knowledge and the learning abilities of the M&AM department are to be considered as low.
It seems that the level 'as defined / measured' 2nd learning level is reached:

- As defined / measured. This means that the M&AM processes should comply to the next criteria:
    1. Standards, process descriptions, and procedures are derived from a set of standard processes to suit the M&AM department and consistent.
    2. Processes are typically described rigorously.
    3. Processes are managed proactively using an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.
    4. Processes are controlled using statistical and other quantitative techniques. Quantitative objectives for quality and process performance are established and used as criteria in managing the process. Quality and process performance is understood in statistical terms and is managed throughout the life of the process.
    5. Processes are well characterized and understood, and are described in standards, procedures, tools, and methods.
    6. Processes are used to establish consistency across the organization
    7. Detailed measures of process performance are collected and statistically analyzed.

- 2nd learning level

  Learning is done together. Based on experiences existing procedures, standards and policy will be adjusted. This means that boundaries have to change, employees has to learn to deal with the new boundaries. There are also actions to prevent problems structural. The focus is long term.

The conclusion however after investigation of the current processes by previous research techniques is that the M&AM department does not reach above mentioned level.
The reasons is that the current processes do not comply to the criteria of this level

[11] See appendix G World Class Performance Model current situation

5.3.4 Direction of improvement

As already described in paragraph 5.2.1 'Phase 1 Selection direction of improvements' it has been concluded that the focus of the improvement will be on the three lowest scoring generic aspects of the ID scan.
For these three aspects a proposed situation has been agreed within the improvement team and management. This proposed situation is being determined as improving these three generic aspects to the level of the other five generic aspects, so an equal score for all eight generic aspects will be achieved.
The improvements of these five generic aspects as result of the improvements of the three identified generic aspects will be treated as complementary and will not be part of the improvement plan.

The improvement objectives, obtained scores of the ID scan, qualitative improvements, necessary actions and key performance indicators are identified within the improvement team and management and are represented by setting up an Integrated Productivity Scan[12]
By setting up this scan sub question 10 "What is the proposed level of the 'learning organisation'?" will be answered.

The three generic aspect where this research is focusing on for improvements are:

1. **Learn (knowledge creation)**
   Learning and its style is important. There is recognition of the urgency and controlling of the 1st and 2nd learning level. This means that the focus of the M&AM department is on learning. The M&AM department is aware of the learning effects and organize processes and styles on different levels to stimulate effective and efficient learning.

   In order to reach the 3rd learning level it is important that employees have the authority to implement and adjust standards due to changed tendencies. It is therefore important that M&AM procedures are to be adjusted, controlling mechanisms to be implemented and boundaries to be defined.
   Standards, procedures and work instructions has to be set up with the aid of employees to create a transparent communication.

2. **Re-use of knowledge**
   The objected level of this generic aspect is level 3. This means that there has to be set up an common dictionary, wherein knowledge of specific features is registered so there will be data registered of product / services with specified information. Knowledge will be elementary registered. Although services classifications and –features are described integral, the processes will not be managed and controlled perfectly.

   To rationalize the existing knowledge of all employees, sufficient time shall be spent for setting up standards and work instructions.
   It is important to involve these employees while setting up these standards and instructions.
   When executing maintenance studies, improvement projects and optimizations it is necessary to involve these employees as well. This will benefit the knowledge creation of the M&AM department.

[12] See appendix H integrated productivity analyze

3. Information architecture (ICT)

The objected level of this generic aspect is level 3. This means that there is no common information and communication. Exchanges are realized by specific couplings and procedures. Loss of data during conversion is a risk. Common, routine acts saves time and some failures. There are however several moments of import and export, so specific couplings and procedures has to be established.

The data exchange has to be according a standard format the current ICT structures provide. When using the existing ICT structure properly work files will be exchangeable and accessible not only for all relevant employees of the M&AM department but also for Production and others, whether it is adjustable or only readable. The ICT structure can easily provide an authorization procedure.

5.3.5 Re-design of maintenance processes

Before redesigning all relevant M&AM processes it has been agreed with DSBV's Direction Operations that the all processes has to be (re) designed according the Deming – circle. (see page 22, comparison various Business Improvement Methodologies)
This means that every process has to be assigned to a phase of the Plan-Do-Check-Act circle.
The result of this starting point is that:

- Existing processes has to be re – designed
- New processes has to be designed.
- Several existing processes are to be relocated within the existing Quality Management System as the appeared to be supporting processes for other departments as well, e.g. purchasing etc.

The (re)design of these processes has been done by the IDEF-0 technique, as explained in paragraph 4.2.2 redesign.

By redesigning all M&AM procedures[13] sub question 7 What are the proposed processes? will be answered.

As a result of the objectives of this research to achieve a learning organization, this means that the learning level 3 has to be achieved. This indicates that the WCP level to be reached will be 'as learned'. This level is characterized as a learning process and focuses on continuous improving, both incremental and radical.

As the operational objectives for the M&AM department are derivates from the tactical and strategic objectives from DSBV, these are the input for re)designing all processes.

This means that during the Plan phase the inventarisation of all necessary maintenance, whether it is preventive, predictive, corrective maintenance or modifications, have to be in line with the tactical objective of performing the Operate and Maintain contract with DSBV's assigner Delfluent and their customer Waterboard of Delfland.
This means that:

- all maintenance shall be according the Reliability Centered Maintenance methodology.
- All processes meets the standards of IS0 90001, 14001 and PAS 55.

When all maintenance activities are investigated budgets can be estimated. The M&AM budget is derived according the M&AM organizational structure. This means that the M&AM budget is the total of several sub budgets:

- Mechanical maintenance
- E/I/PA maintenance
- Civil and general maintenance
- Overhead (e.g. communication, cars, security etc.)

The Do phase of the circle consist of several sub processes.

- Work order preparation
  Preparing and planning of all maintenance activities, resources, spare parts and material in consultation with operations.
  This also includes the maintenance requirements as results of Work Order Request process as failures of the production equipment as other maintenance requirements.
- Work order execution
  Describes standards of delegated prepared work orders, safety rules and feedback standards etc.

[13] See appendix I IDEF-0 proposed situation

After completion of all maintenance activities, in order to realize continuous learning and improving the Check phase of the circle is important. In this phase all imported data from previous the phases are collected.
The predefined key performance indicators will be adjusted by the new data, reports will be draught.
These report will be analyzed during the last phase; the Adjust phase of the circle.
By applying several analyzing tools as Pareto analyzes the kPI's will be analyzed, root cause analyzes will investigate the cause of deviations regarding the predefined kPI's and their several boundaries. This analyze will initiate several adjustments to the described processes and propose modifications to the assets.

The investigation and redesigning have resulted in next figure.

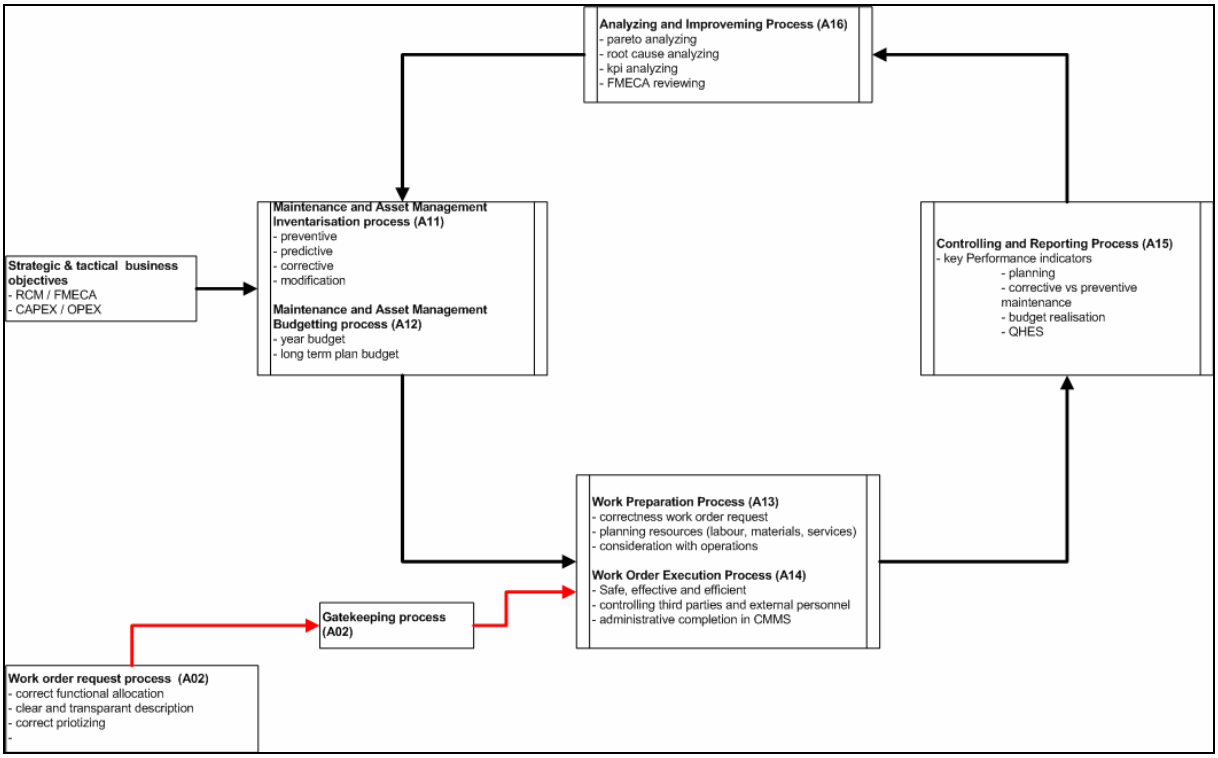


Figure 9 Maintenance and Asset Management processes in the Demming circle

5.3.6 Re-design of activities in maintenance processes

After (re)designing all M&AM processes all necessary data- and information transfers has to be re-designed as well since there a lot of new data and information available and to be externalized.
It is important to structure this data- and information exchange. Several roles in the M&AM department will now be responsible and accountable for the data to be imported in the existing ICT structures, so the RASCI of the (re)designed processes are to be redefined as well.
Therefore the current M&AM activities has to be (re)designed so a new activity diagram[14] will be draught to answer sub question 8 What data will be used in the proposed processes? will be answered.

This diagram shows the roles within the (re)designed processes all relevant stakeholders fulfill.

- Process operators (and others)
  The responsibilities of the process operators is to operate the WWTP's. This means that they are the MA&M internal client, they are the most affected as they set the standard for Reliability and Availability (R/A) of the process equipment.
  When the R/A is decreasing and will influence the required process standards they have to communicate this to the M&AM department.
  The production is also directly affected by the execution of maintenance, whether it is corrective, preventive of predictive maintenance or modifications as result of analyzing the M&AM processes or optimalizations as results of strategic / tactical / operational objectives.
  The others in this column are mainly the rest of the organization as everybody is entitled to request maintenance to be done as corrective maintenance or modification as the result of the process of Work Order Request.

- Reliability engineers
  These are the staff of the M&AM department. They are responsible for identifying all preventive, predictive maintenance and propose modifications as results of analyzing the M&AM processes.
  They are responsible for the Plan, Check and Adjust phase of the circle.

- Supervisors
  They are responsible for preparing and executing the maintenance. Therefore it is a very important role within this cycle. It is extremely important that all data and information gained during this process is imported in the ICT structures correctly. Therefore the ICT structures has to be adjusted so that it is obligated to import the needed data and information in these ICT systems.
  The supervisors are also responsible for communication regarding maintenance with operations and others.

- Engineers
  All maintenance executing employees and rayon-engineers who control and maintain all pumping stations under the responsibility of the supervisors.
  They are not only responsible for executing maintenance, but now they are responsible for importing relevant data in the CMMS. There are kPI's to be developed to monitor the quality of important data and information.

- Maintenance Manager
  Responsible for the M&AM department.

The most important difference between this activity diagram and this diagram from the current situation is the important role of ICT; the CMMS and financial system.

[14] See appendix J Activity diagram proposed situation

5.3.7 New level of world class performance

While agreeing on direction of improvement the standards were set. This means that the level for the three generic aspect has been determined. During the (re)designing the M&AM processes and their activities, is became clear that the (re)design resulted in a higher level than initially was agreed upon for the aspect 8 Learning.
Although it was agreed to reach the level 3: '2nd learning level' the 3rd level of learning can be achieved.
This means that M&AM department recognize the importance of learning and how learning has to be made possible. This is mainly caused by the average age of the employees of the department which has been considered as a risk by the improvement team.

After redesigning all M&AM processes and activities the new WCP[15] model give answer to the sub question 9: What is the proposed level of World Class Performance?
By draughting this model it became clear that the higher set standards for generic aspect 8 Learning causes the possibility to reach the level of 'as learned' in this WCP model.

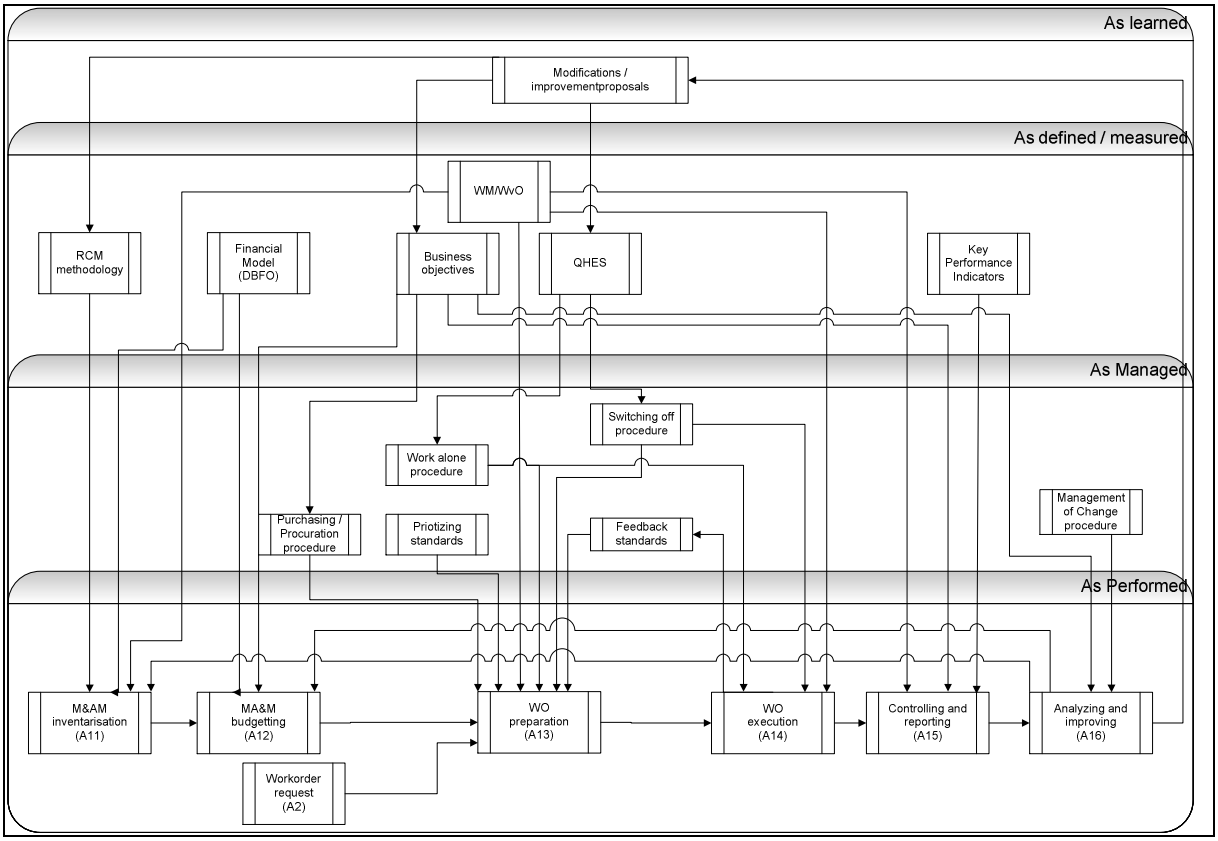


Figure 31 The proposed WCP model

The difference between the current and proposed situation is that all processes has been redesigned and located in the correct level of this model. Now it obvious that the main process, Maintenance and Asset management is performed by sub-processes. Several standards will manage all sub processes, while the sub processes and standards are controlled by predefined conditions and measurements.
The 3rd learning level will be reached by the ability of the organization to create incremental improvements by adjusting the predefined conditions and measurements.

[15] See appendix K World Class Performance Model proposed situation

6 Conclusions

6.1 Research objectives

The motive for this research is the need for transparent control and steering mechanism for the M&AM department. Therefore kPI's have to be set, which resulted in the urgency to (re)design all M&AM processes. The agreed objective for this research is to create a learning M&AM department with continuous improvement.

This research consisted of a study on several Business Improvement Methodologies, selecting the Methodic Innovation Methodology and applying several of its research techniques.
By investigation the current situation the actual performance has been determined. These were the base for improvement possibilities.
When the standards for the proposed situation were agreed upon, current processes and activities were re-designed, new processes designed and several current processed deleted from the M&AM processes.

The objective of reaching a learning M&AM organization can be accomplished when these procedures and several changes are implemented so the M&AM department is able to create incremental and radical improvement.

6.2 Innovation objectives

The objective set by Hogeschool Utrecht regarding the innovation worth of this research are accomplished.
The main reason is that, at the start of this research, the objective was described general and subjective. During the process, after several sub-researches, the final objectives and levels of performance were determined. As described in the introduction of this report these are the features of an innovation process.

Other reasons are:

- This research, its objective and applied methodology and techniques are new for DSBV.
- Proceeding according proposed processes is new for DSBV, several new processes has to be implemented.
- By implementing the (re)designed processes, DSBV will be the first Waste Water Treatment Plant operating business to meet the standards of PAS 55 certification.
- After implementing proposed processes and their adhering changes, it will be possible to implement 'competence management', employees will get different Tasks, Authorization and Responsibilities.

The benefit of implementing proposed processes is control of the M&AM budgets and be able to increase this budget over time due to clear insight of processes, system- and asset performances by monitoring new set kPI's.

7 Recommendations

In order to reach the research objectives several recommendations are formulated from the conclusions and comparison between the current and the proposed situation:

1. Rename all M&AM processes so the name of the process covers the content of the process. This according the existing Quality Management System standards and layouts.
2. Implement the new and revised M&AM processes in the Quality Management System. Use the proposed Activity Diagram to set up the RASCI models.
3. Provide sufficient training and coaching to relevant employees regarding the new M&AM processes and their mutual independencies and the relation to the WvO[16] / WM[17].
4. Edit work instruction for all M&AM processes with the aid of relevant stakeholders of these processes.
5. Determine and implement key performance indicators for the M&AM processes within the existing ICT structures.
6. Provide sufficient training and coaching to relevant employees regarding Reliability Centered Maintenance, Analyzing and reporting methods as Root Cause Analyzing and Pareto analyzing. Implement these methods as standard methods.
7. Provide sufficient training and coaching to relevant employees regarding the existing ICT systems.

It is to be advised that recommendations 1 – 3 are implemented within a short time-frame. These new processes can then be implemented in the new CMMS EAM 8.3 in August - September 2010.

Although recently the key performance indicators are determined during this research process, it is recommended to value and implement these to support the implementation of the processes, particularly process A15 and A16 .

When all M&AM processes are redesigned and implemented it is also recommended that expected benefits are to be controlled after a period of time. This controlling can be done by executing the IO scan and compare the result with the expected improvements from this research.

[16] Wet verontreiniging oppervlakte water
[17] Wet Milieubeheer

8 Personal objectives

This report is written to understand, monitor, control and improve the performance of the M&AM department.

Setting up the research model for approval of the thesis proposal has given me insight how to execute the research and also what the research objectives should be.
After agreeing on the base model of the Demming circle, wherein all M&AM procedures has to be defined, the new situation became clear. From there all relevant PDM[18] techniques were to be adapted and well applicable.

The investigation and redesign of all M&AM processes has given me the opportunity to set up an abstract overview of how the M&AM department has to operate to be part of achieving the company objectives.
With the aim of the content of lectured PDM methodology, used models and techniques, I gained knowledge of how to investigate actual processes and how to alter them positively.

[18] Product Data Modeling

Appendix A Main research and sub questions

The thesis problem / main research question is:

How can a learning M&AM organization be achieved and implemented within DSBV?

In order to answer this question, several sub questions will be investigated:

- Who are the stakeholders in this project?
- Which processes are to be investigated?
- What are the criteria to be used to characterise the status of the relevant processes
- What is the current situation of these relevant processes?
- What is the proposed situation of these relevant processes
- What are the differences between the current and proposed situation?
- What are the appropriate methods to overcome these differences?

Sub question 1: Who are the stakeholders in this project?

- Reason
  To determine which persons are how important for this project.
- Field of Knowledge
  Project management Prince II
- Methods
  The stakeholder analysis will be done according the method described in document "work instruction stakeholder management version 1.1 rjd 100708"
- Desired answers
  An overview of all relevant persons with their impact on the result of this project.

Sub question 2:Which processes are part of this project?

- **Reason**
  To determine the exact scope of this project.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  Desk research
- **Desired answers**
  An overview of all current processes which are subject of this project.

Sub question 3: How are the current processes designed?

- **Reason**
  To get knowledge of current processes in order to determine possible improvements.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  IDEF-0
- **Desired answers**
  A schematic overview of current processes with their mutual relations.

Sub question 4: What data is used during these processes?

- **Reason**
  To determine if the data used in processes is relevant and important and to externalize this data.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  Creating an activity diagram and nonaka diagram
- **Desired answers**
  Overview of activities and data and their mutual relations.

Sub question 5: What is the level of World Class Performance of current processes

- **Reason**
  To determine possible improvements.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  Creating a WCP model
- **Desired answers**
  An overview of current WCP level

Sub question 6: What is the current level of the 'learning organisation'?

- **Reason**
  To determine the possible improvements.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  Integrated design scan
- **Desired answers**
  Overview of current level of Integrated Design diagram

Sub question 7: What are the proposed processes?

- **Reason**
  To investigate the gap between the current and proposed situation and what is necessary to fill this gap.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  IDEF-0
- **Desired answers**
  A schematic overview of proposed processes and their mutual relations.

Sub question 8: What data will be used in the proposed processes?

- **Reason**
  To determine what data is relevant and important for the proposed processes.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  Activity Diagram
- **Desired answers**
  A schematic overview of all activities and data and their mutual relations.

Sub question 9: What is the proposed level of World Class Performance?

- **Reason**
  To investigate the gap between the current and proposed situation and what is necessary to fill this gap.
- **Field of Knowledge**
  Product data modeling
- **Methods**
  World class performance
- **Desired answers**
- An overview of proposed WCP level.

Sub question 10: What is the proposed level of the 'learning organisation'?

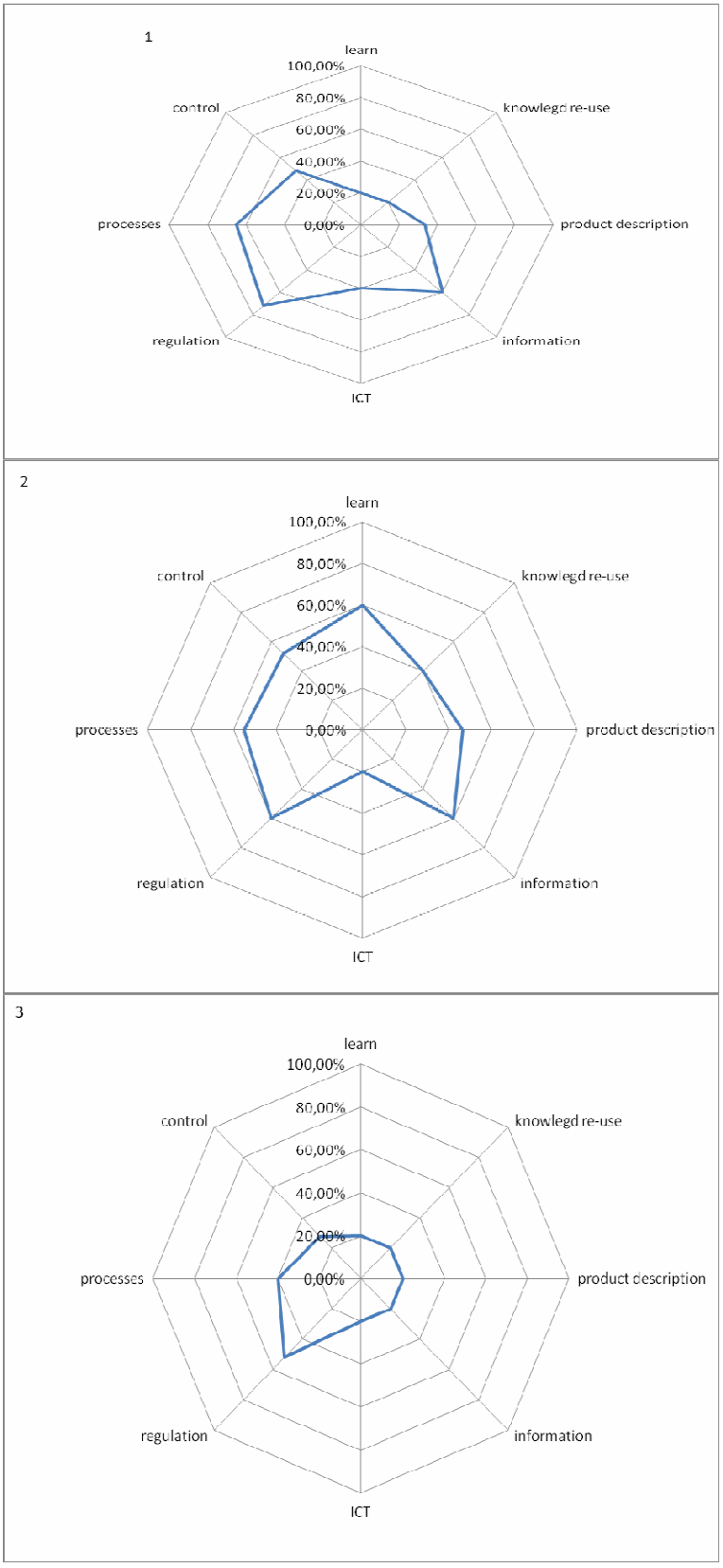
- **Reason**
  To investigate the gap between the current and proposed situation and what is necessary to fill this gap
- **Field of Knowledge**
  Product data modeling
- **Methods**
  Integrated Productivity Scan and ID-scan
- **Desired answers**
  Overview of proposed level of Integrated Design diagram and proposed Integrated Productivity scan.

Appendix B Stakeholder analyze

Stakeholder	Interest	project interest	classification	atttitude	measure	monitoring
N. van Gool	Director Operations	Facilitator time and budget Thesis executive	keep informed	ally	consulting	status reporting
Y. Zuidwijk	Reliability engineer	Responsible for Computerized Maintenance Management System	keep satisfied	ally	involve	status reporting
R. van der Voort				ally	involve	status reporting
C. Ferdinandus	Supervisor Mech. Tech. Dep.	Responsible for execting all maintenance activities	Manage closely	opponent	convince and involve	status reporting
M. Pronk	Supervisor Civil Tech. Dep.					status reporting
A. Polenewen	Supervisor E/I/Pa Tech. Dep.					status reporting
R. Dijkstra	Project Engineer	Responsible for all projects	Manage closely	opponent	convince and involve	status reporting
L. Hollestelle	Purchasing	Technical purchasing	monitor	doubter	convince and involve	status reporting
F. Spaans	Proces Operator	Client of M&AM department	Keep informed	doubter	consulting and involve	status reporting

Appendix C Integrated Design Scan

Appendix D Results of the Integrated Design scan



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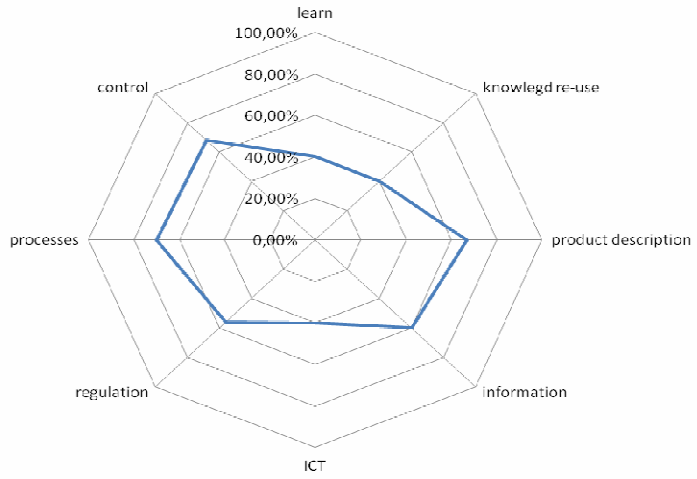
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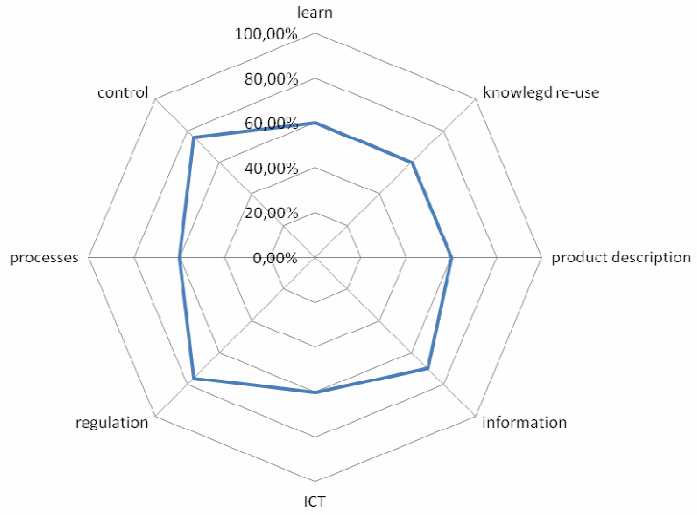
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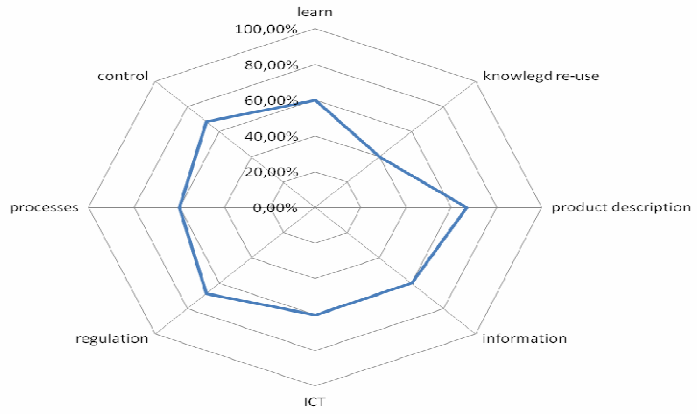
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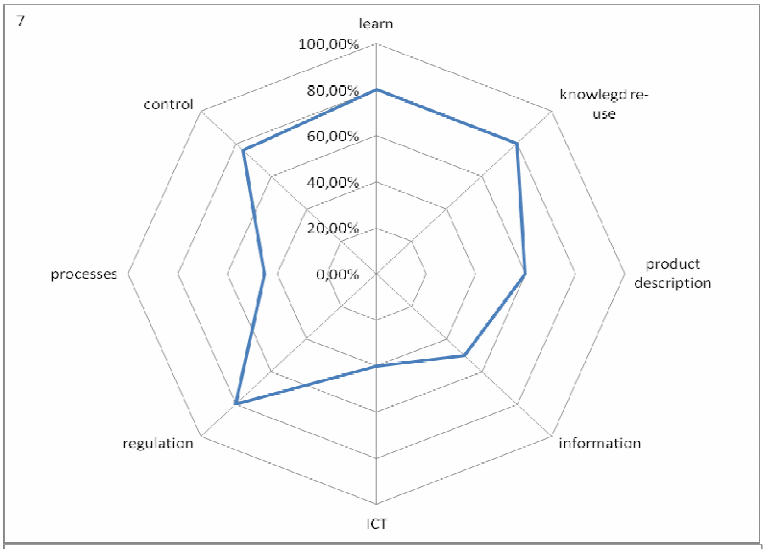
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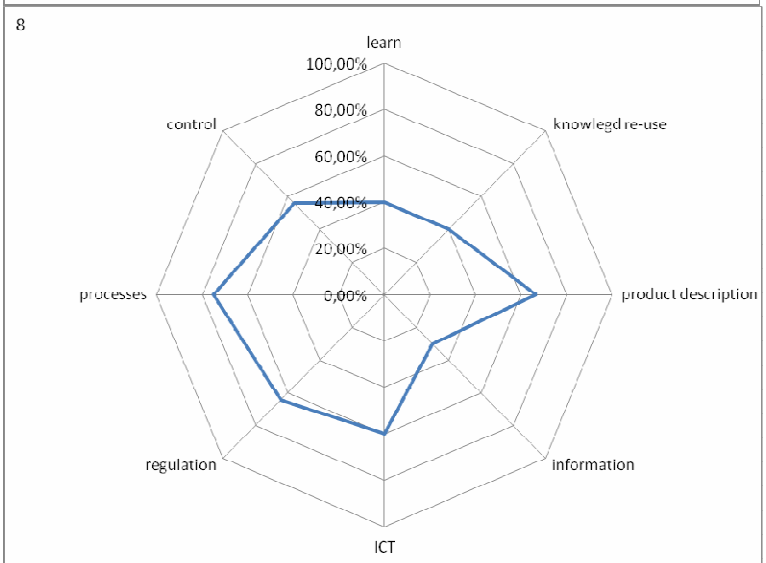
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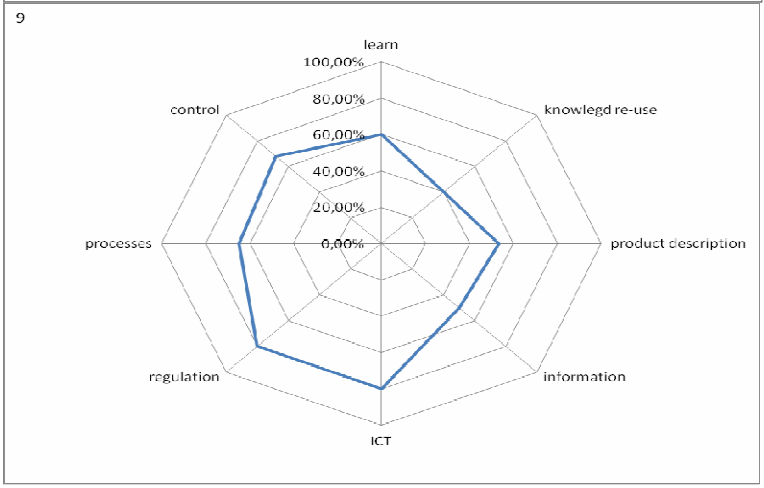
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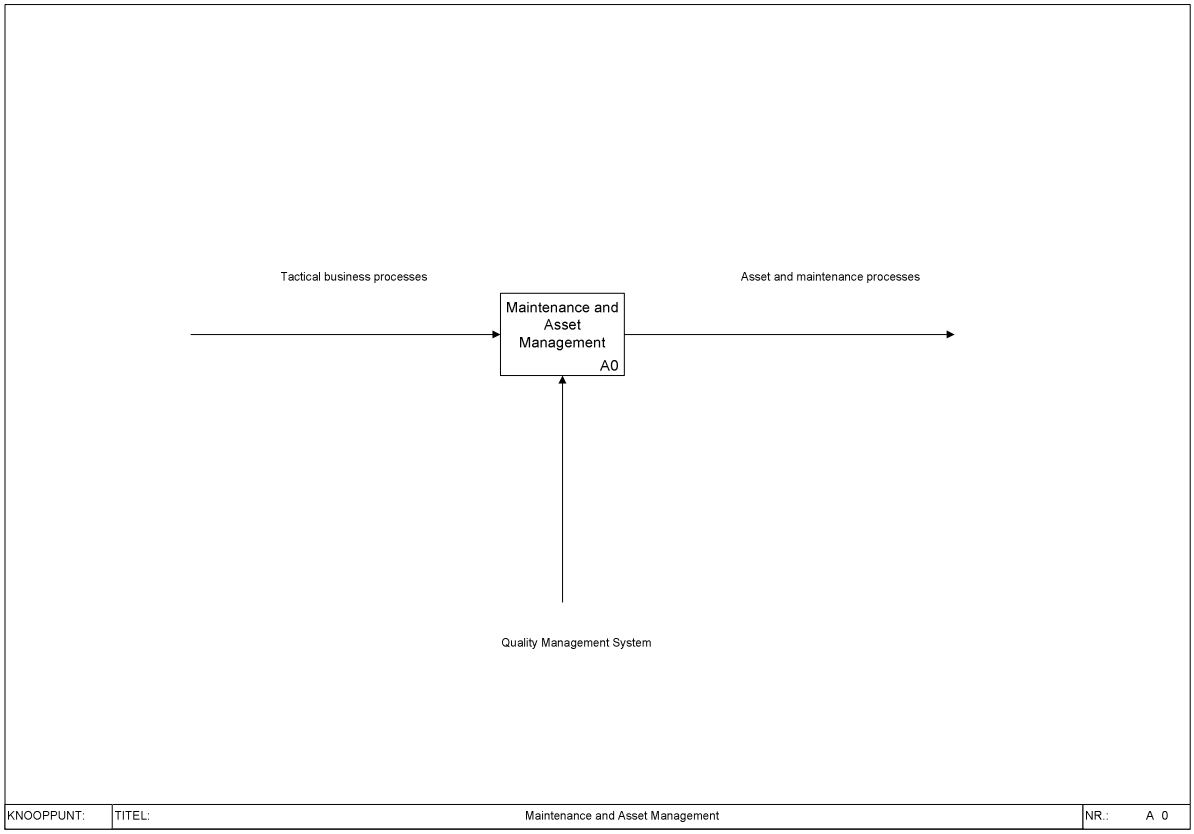
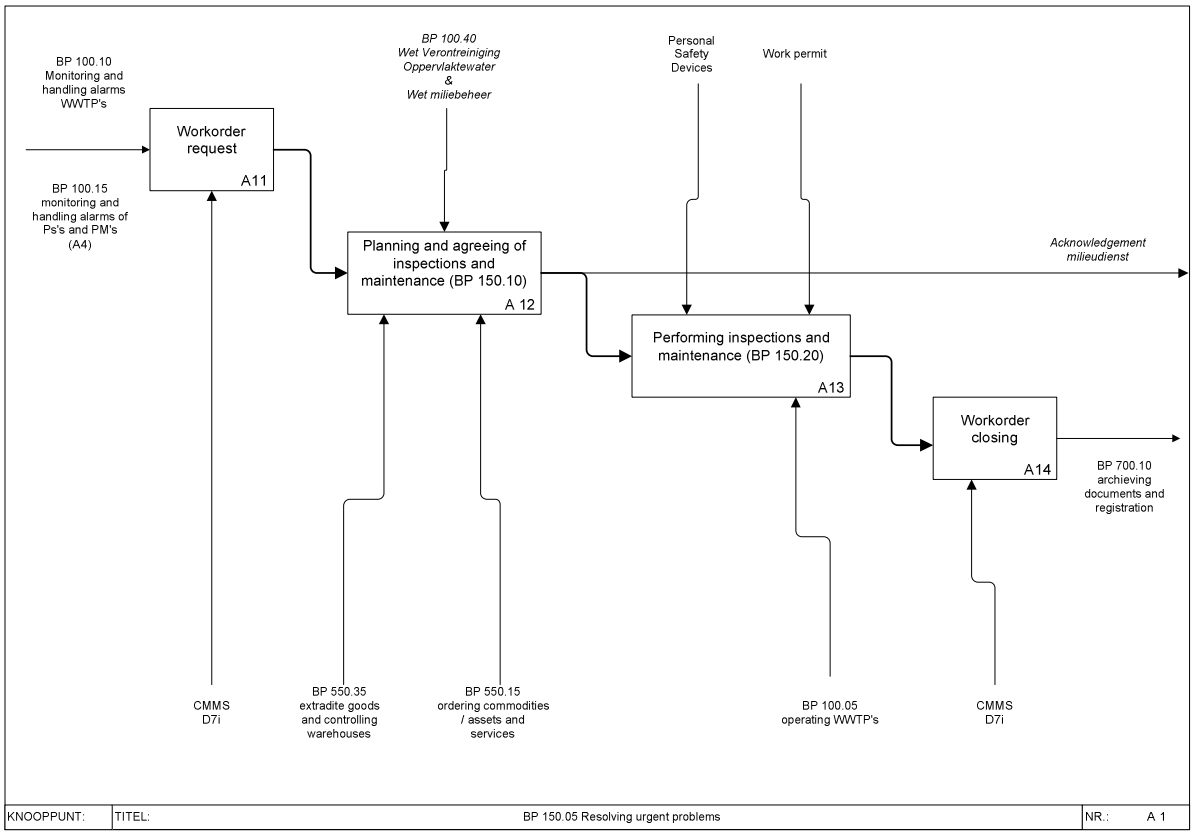
Appendix E IDEF-0 current situation



A 0 Maintenance and Asset Management
This process describes the translation from the tactical policy into maintenance and asset management processes.

Flows	
Tactical business processes	all controlling activities necessary in order to fulfil DSBV's mission and vision and translate these into tactical objectives and budgets and be able to control and evaluate operational activities.
Maintenance and Asset Management	This core process describes the process from delivery effluent water and all services to maintain the necessary assets
Quality Management System	Management overview off all systems, cohesion with mission and vision, corporate policy and monitoring and maintaining all these systems. The QMS comply to the standards of ISO 9001 and will be comply to the standards of 14001 and PAS 55.

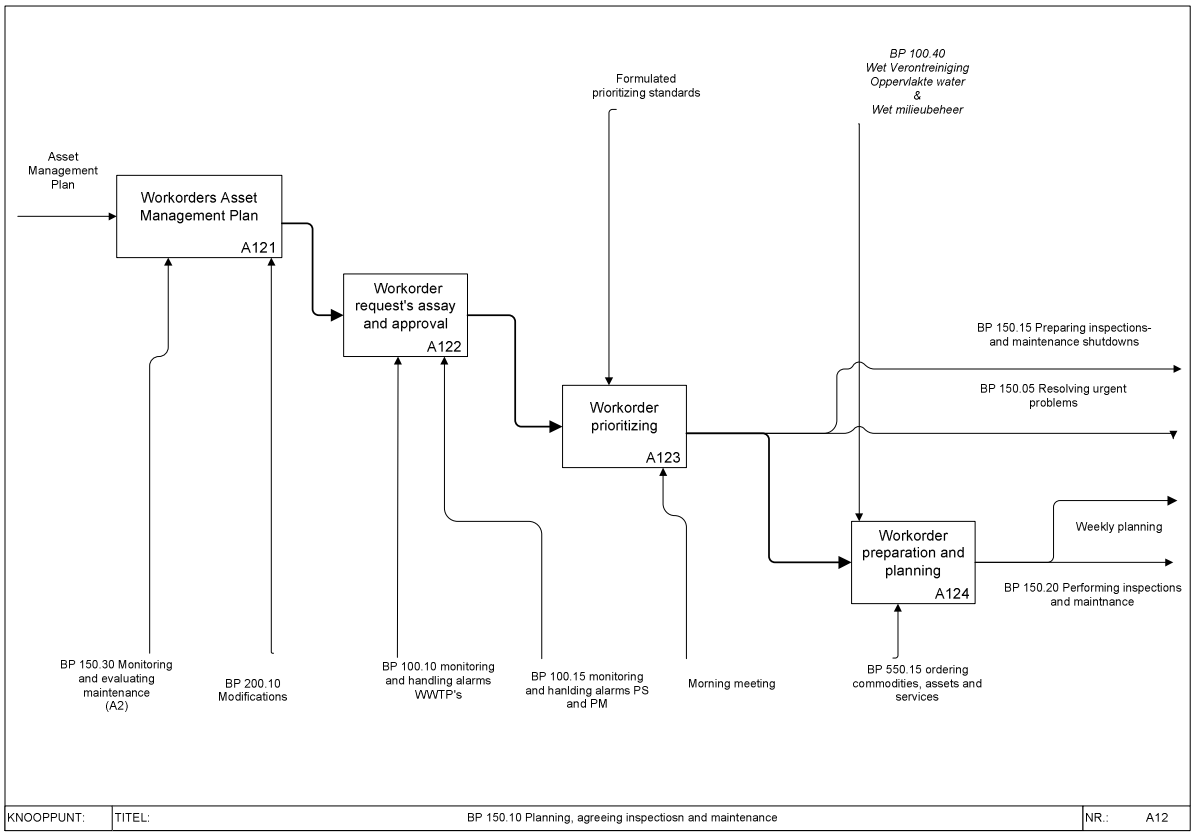


A 1 BP 150.05 Resolving urgent problems

This process describes how to solve urgent failures on the WWTP's, pumping stations and pressure mains.

Processes	
Work order request	The process of requesting for (maintenance) works to be executed within the CMMS D7i
Planning and agreeing of inspections and maintenance (BP 150.10)	The process of planning all maintenance-, modifications- and projects activities agreed by and with all relevant stakeholders
Performing inspections and maintenance (BP 1510.20	The process of executing all activities incl. cleaning activities of WWTP's, PS's and PM's.
Workorder closing	The process of administrative finish of all workorders

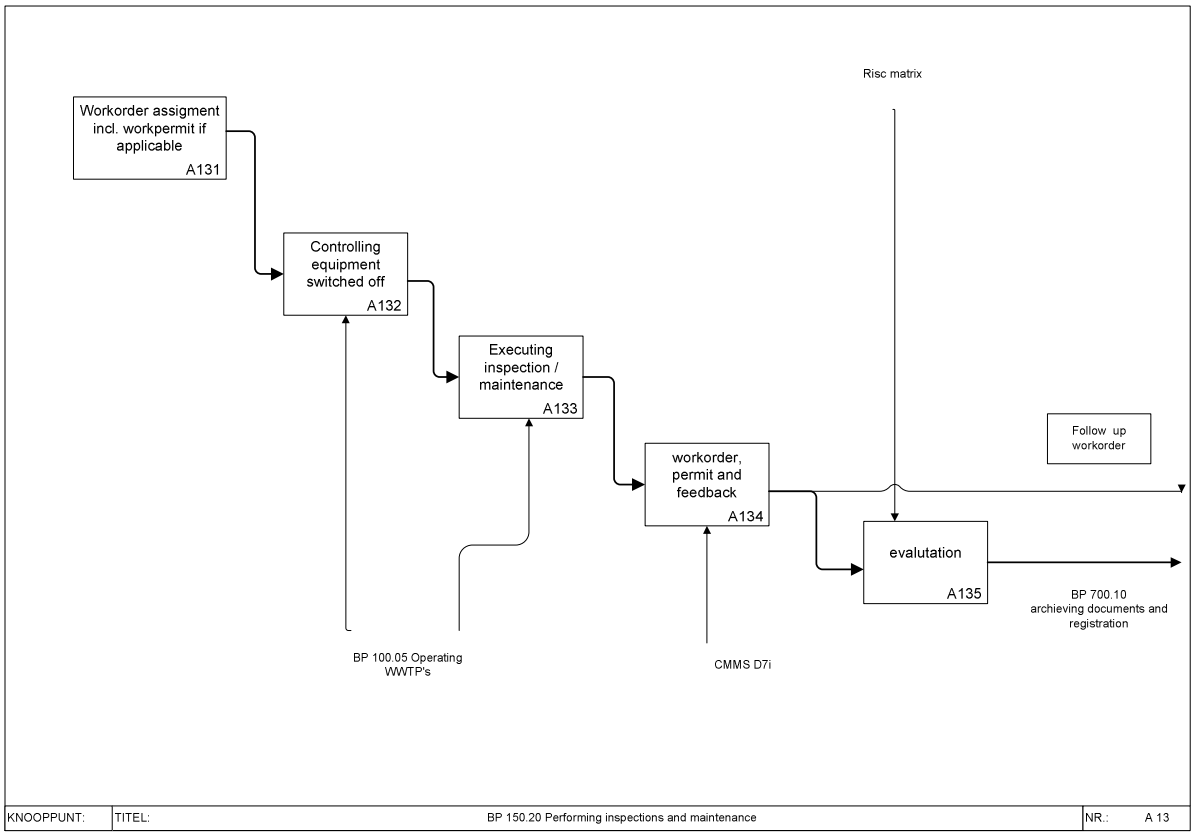
Flows	
Monitoring and handling alarms WWTP's (BP 100.10)	
Monitoring and handling alarms PS's and PM's (BP 100.15)	
Acknowledgement Milieudienst	E-mail to the milieudienst to inform them about inspection and maintenance activities to verify possible complains



A12 BP 150.10 Planning and agreeing of inspections and maintenance
This process describes how work order request results in executed activities.

Processes	
Work orders asset management plan	These are all preventive, predictive maintenance activities as well as modifications
Work order request assay and approval	The work orders are checked on agreed criteria (completeness, correct equipment etc) and will be assigned to departments
Work order prioritizing	The initial prio will be checked and agreed during morning meetings
Work order preparation and planning	Ordering all necessary resources and materials and plan the activities during weekly planning meetings

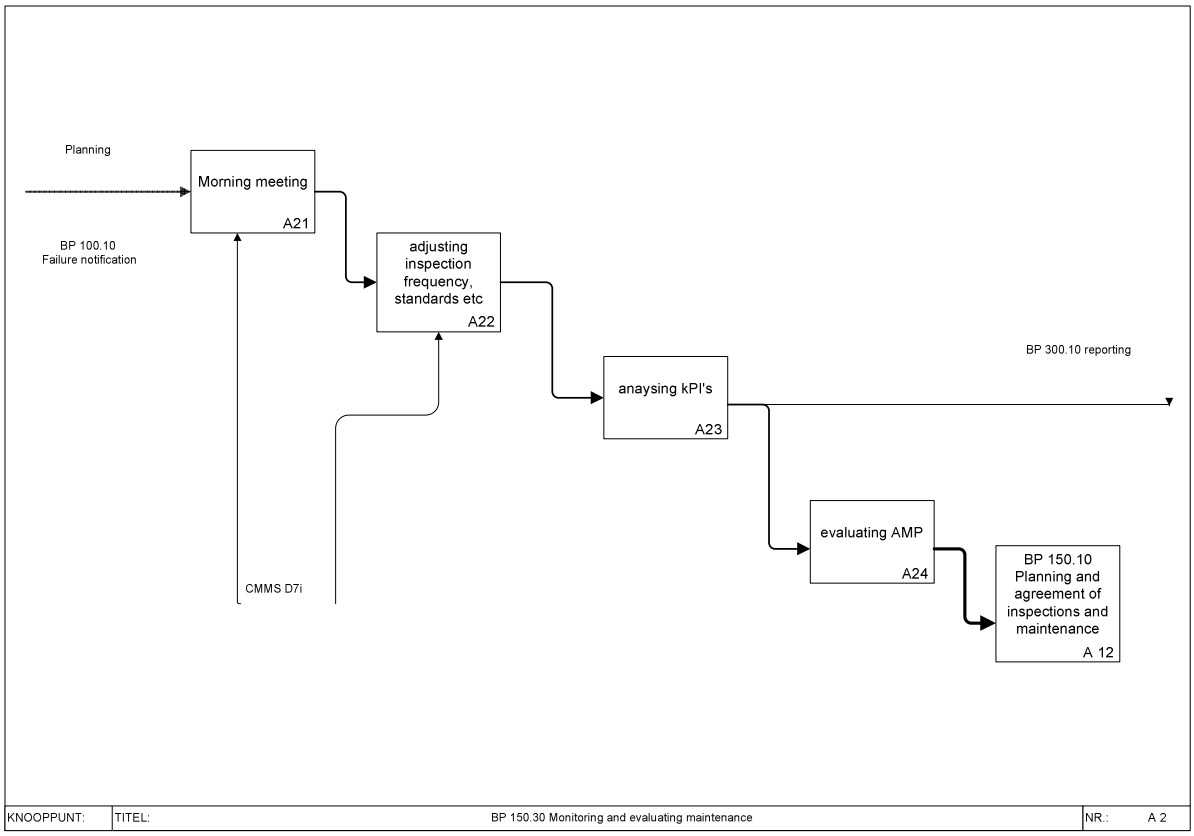
Flows	
Asset management plan	All planned preventive and predictive maintenance activities as result of RCM/FMECA study
BP 150.15 Preparing inspections- and maintenance shutdowns	
BP 150.05 Resolving urgent problems	
BP 150.20 Performing inspections and maintenance	
Weekly planning	Result of weekly planning meeting with all relevant stakeholders, i.e. supervisor, process operators and reliability engineers



A 13 BP 150.20 Performing inspections and maintenance

Processes	
Work order assignment incl. work permit if applicable	Prepared work order will be handed over to executing engineer, when necessary a work permit is prepared and will be signed by engineer and process operator
Controlling equipment switched of	Work instruction for switching off equipment in order to work safely
Executing inspection / maintenance	Executing all works according prepared and agreed manor and time. Deviations has to be communicated to supervisors and process operators
Work order, permit and feedback	The process of finalizing the executed works: returning work order including feedback, signing work permit for completion.
Evaluation	Evaluation of executed works regarding plan and actuals

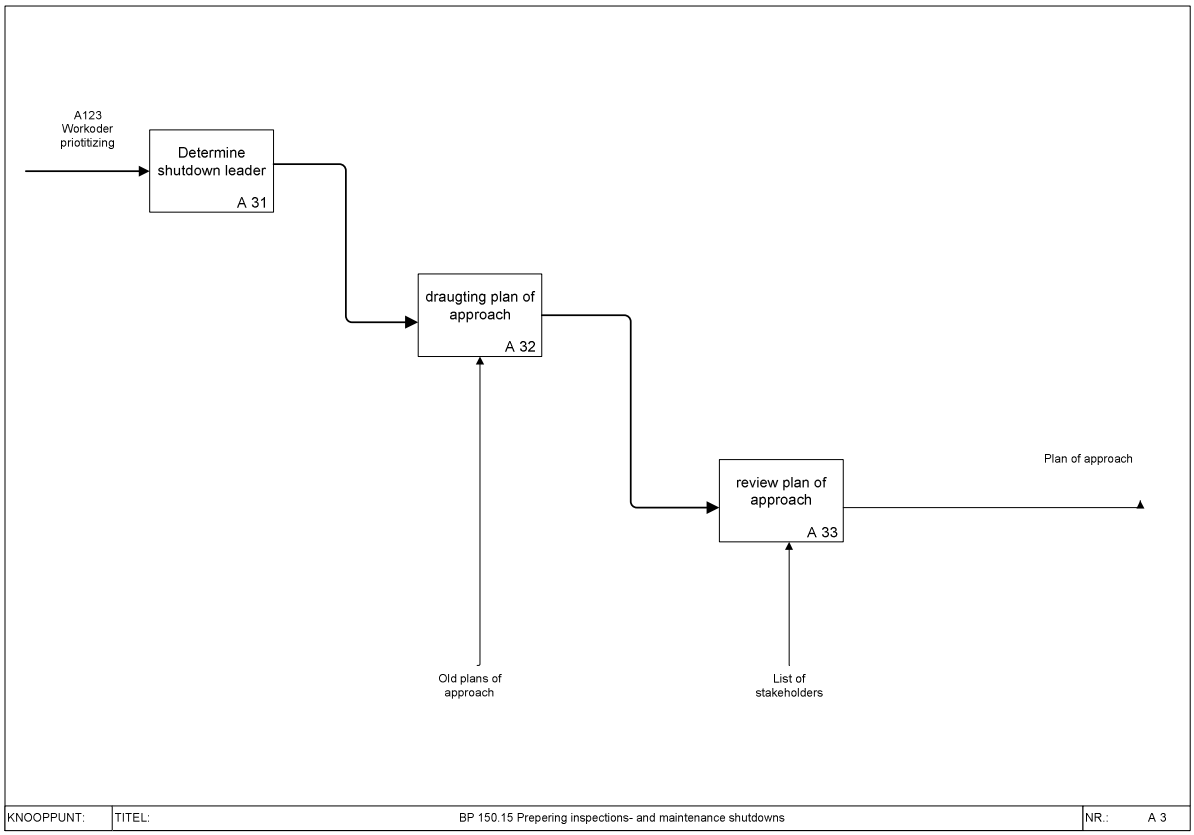
Flows	
Follow up work order	When works are finalized, but needs additional activities, a new work order has to be made



A 2 BP 150.30 Monitoring and evaluating maintenance

Processes	
Morning meeting	During this meeting performed maintenance of previous day will be discussed
Adjust inspection, frequency, standards etc	Depending on the outcome of evaluation of performed maintenance, planned maintenance can be adjusted
Analysing kPI's	Pre – defined performance indicators will be evaluated and planned maintenance can be adjusted
Evaluating AMP	Depending on the outcome of analysing the kPI's the Asset Management Plan can be adjusted
BP 150.10 Planning and agreement of inspections an maintenance	

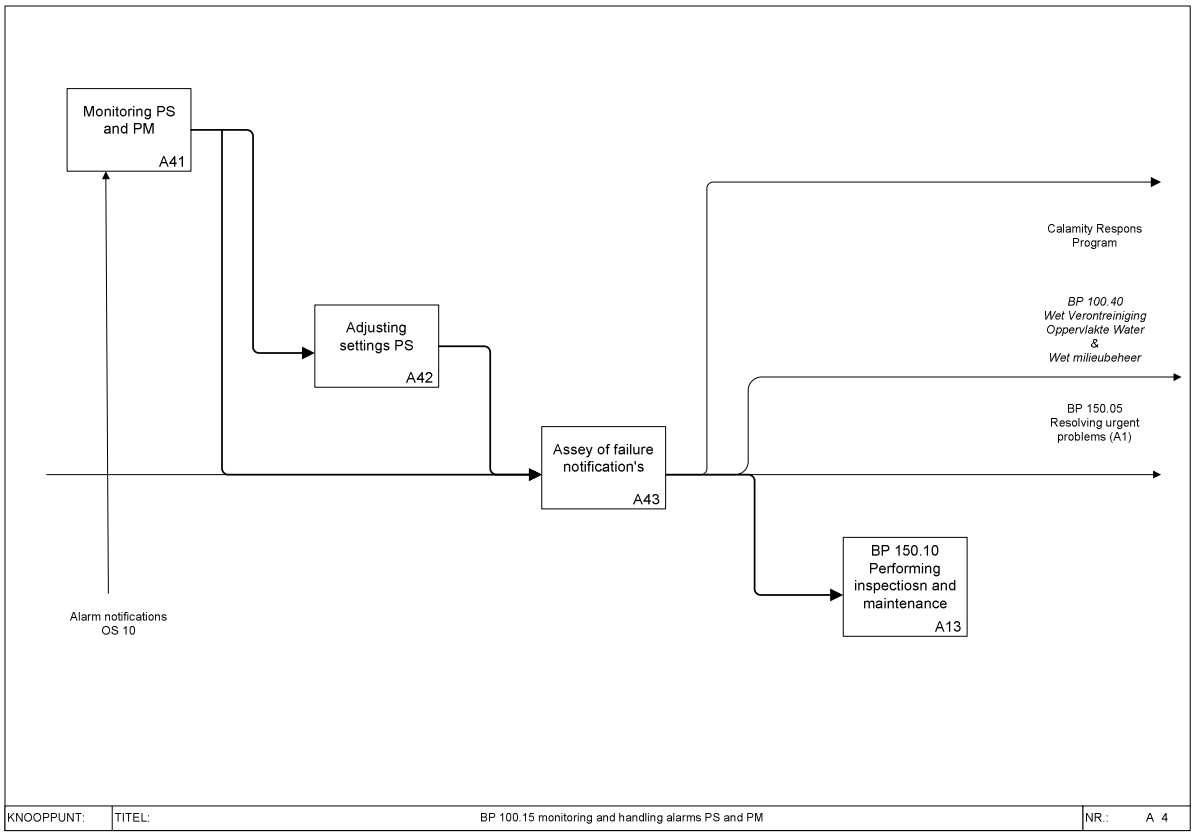
Flows	
Planning	Planning as set up and agreed during weekly planning meetings
BP 100.10	Reporting failures and requesting work order as part of the process monitoring and handling alarms WWTP's
BP 300.10	Draughting periodic report



A 3 BP 150.15 Preparing inspection- and maintenance shutdowns

Processes	
Determine shutdown leader	Depending on the activities, stakeholders and complexity a shutdown leader will be assigned
Draughting plan of approach	The shutdown leader is responsible for draughting this plan and agreement of this plan by all stakeholders and management
Review plan of approach	Feedback of all stakeholders and management will adjust this plan

Flows	
A123 work order prioritizing	As result of this process it will be agreed to plan a shutdown
Plan of approach	Final plan of approach after feedback of all relevant stakeholders

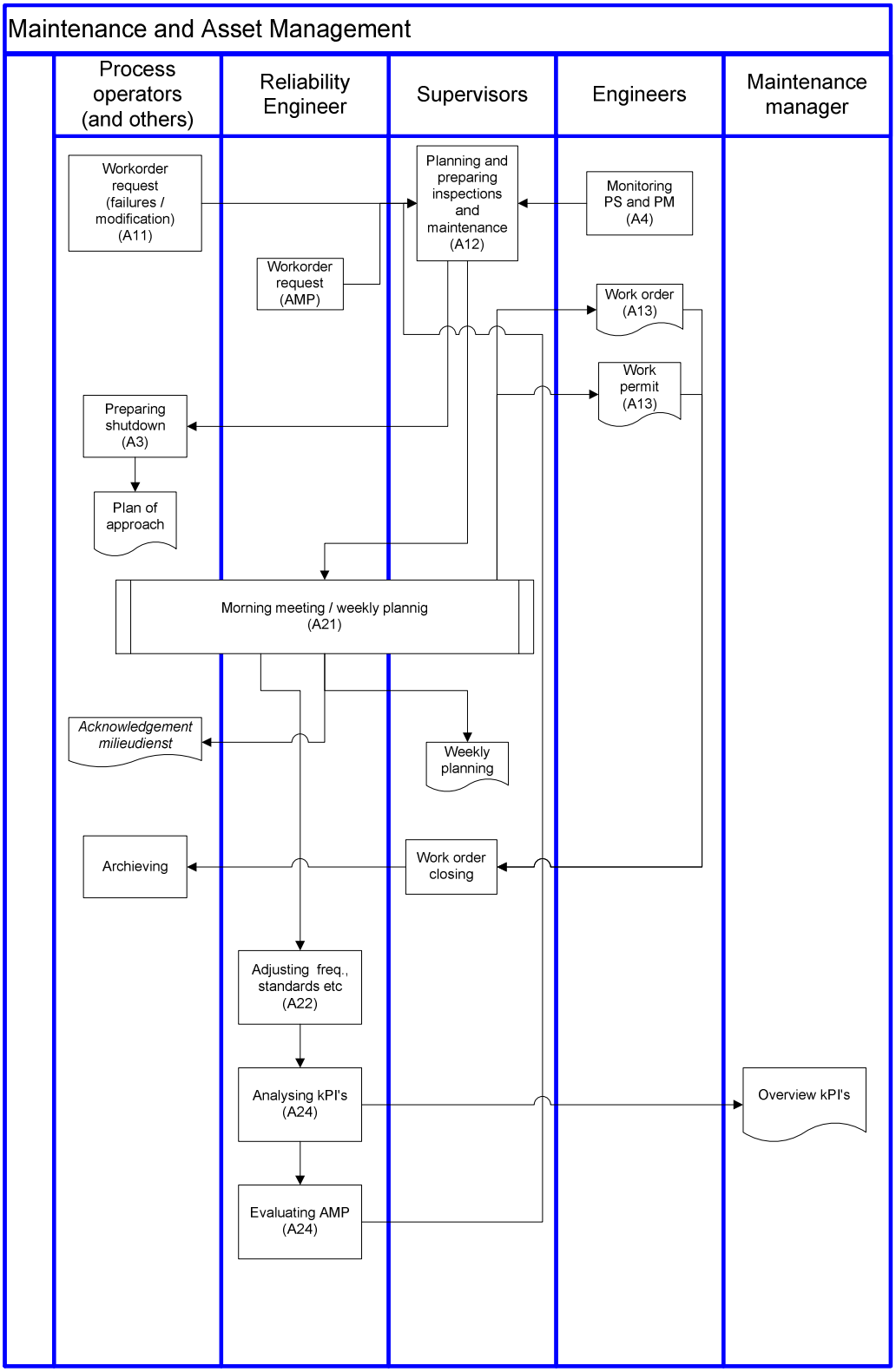


A 4 BP 100.15 Monitoring and handling alarms PS and PM
This process describes how a separate part of maintenance staff have to monitor the performance of the pumping stations and pressure mains, and how to act on alarms.

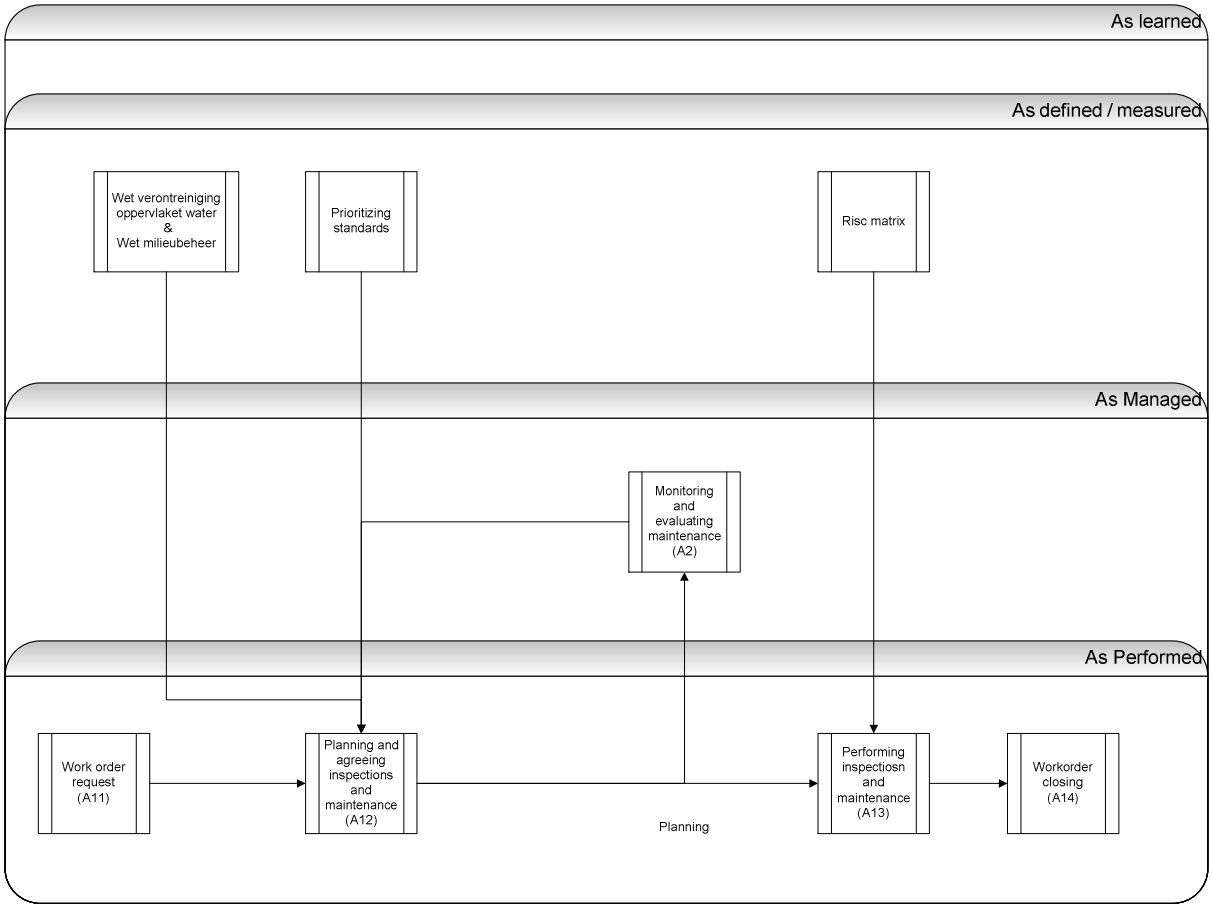
Processes	
Monitoring PS and PM	Daily check of performance of PS and PM within the system OS 10. Daily visiual check of all PS's
Adjusting settings PS	Depending the outcome of all checks, setting can be adjusted
Assay of failure notifications	After failure notification the system will be checked and depending of the failure (immediately) actions will be taken
BP 150.10 Performing inspections and maintenance	

Flows	
Calamity respons program	This process describes all necessary actions and communication when a calamity occurs
BP 100.40 Wet Verontreiniging Oppervlakte Water & Miliebeheer	
VP 150.05 Resloving urgent matters	

Appendix F Activity diagram current situation



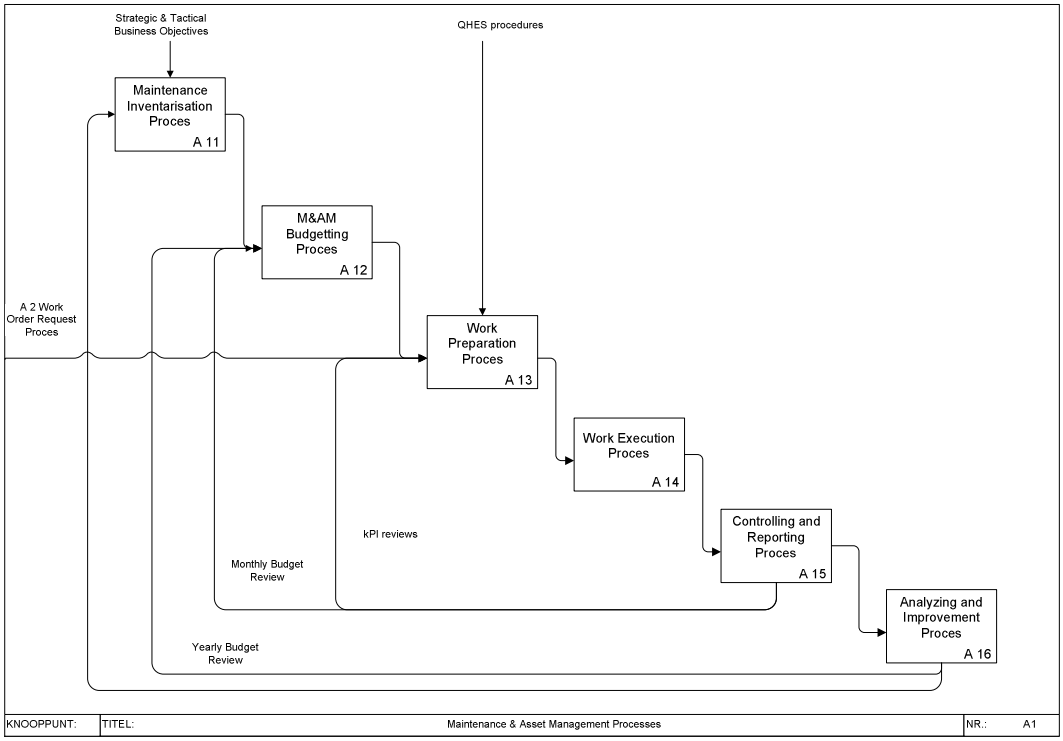
Appendix G World Class Performance Model current situation



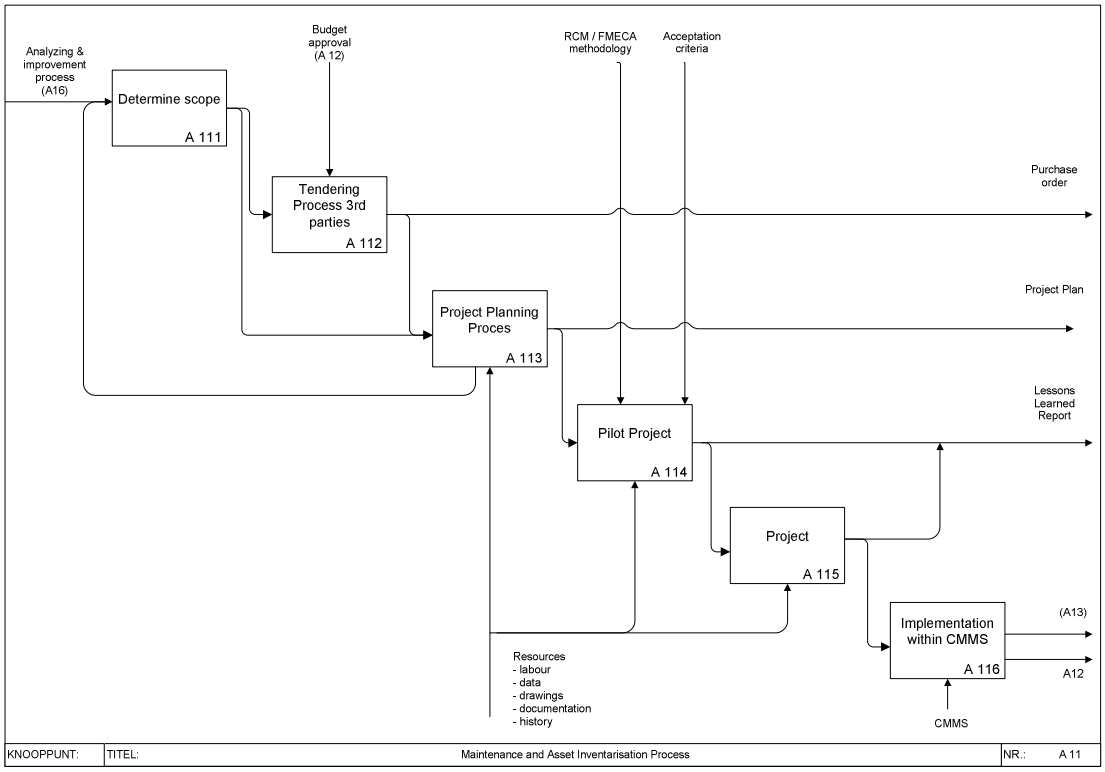
Appendix H Integrated productivity analyze

IO-aspect		Current situation		Proposed situation		Improvements (quality)		Developments (actions)	KPI's
Nr.	features of improvements according ID scan	%	Features current situation	%	Features proposed situation	%	Qualitative improvements	Necessary actions	Key Performance Indicators
1	**Control (developing):** Time spended on controling (steeringcapacity) Teamlearning (knowledge growth) Controlstyle Integrated Design (implementing) Applying (verrichten)	60%	Average degree responibility for own improvements Average degree of knowlegde creation by working in teams improvements by both management and teams / staff Average degree on integrated improvements Average degree of implementing improvements in pilots to develop competences and knowledge	60%		0%			
2	**Learn (knowledgecreation):** - Learning level 1 - Learning level 2 - Learning level 3	30%	Learning by routine, solving problems on experience. Depending on problem solving competences	60%	Learning by the authority to implement and adjust standards due to changing tendencies Creativity and communication are very important!	30%	Learning organization Collective knowledge Knowlegde unlocked	Communication between emlployees Correct use stanards, procedures and instructions	Performance of M&M departments procedures and workflows
3	**Product (integrated):** - Integration of aspects - Integration of productie life cycle - Integration of disciplines	53%	Traditional technical documents Investments based on Life cycle costing / net present value Improvement teams are multi disciplinary, but all technical/operational	53%		0%			
4	**Knowledge (re-use):** - Knowledge re-use	34%	Knowledge in minds, no meaning for colleques. Sometimes information of old projects / problems will be used	60%	inventarisation of knowledge of technical solutions, standards are to be set up. Working princeples, work instructions, options and scenario's to be set up	26%	Re-use of knowledge Implementing standards	Setting up sevaral standards (inspections, reporting, instructions criteria, etc)	Working according these standards
5	**Information:** - Form / shape - completeness	51%	Communication based on digital documents, copiyng / pasting for creating new documents. Necessary information available, completteness needs efforts	51%		0%			
6	**Information architecture (unlocking / opening)** - Integration principles	30%	Own workfiles Island automatization	60%	Data exchange on datalevel, based on specific formats Workfiles are exhangable.	30%	Data is exchangeble and accessible	Correct use of CMMS and related ICT systems	Data input in CMMS
7	**Process (customer focus):** Translation of customer specifications Supportengineering Life Cycle Costing Design review & evaluation	59%	Average degree on translation functional requirements to technical level Average degree on services Average degree in LCC/NPV decisions Restricted degree on reviewing product and processes	59%		0%			
8	**Regulation (targeted):** Level of responsibility (complexity) Process control (maintaining objectives) Standardization (adjusting objectives) Projectcommunication (participation) Managing supply chain (cooperations with external parties)	68%	Own influences on controlling processes and adapt and adjust objectives Several communication protocols adapted	68%		0%			

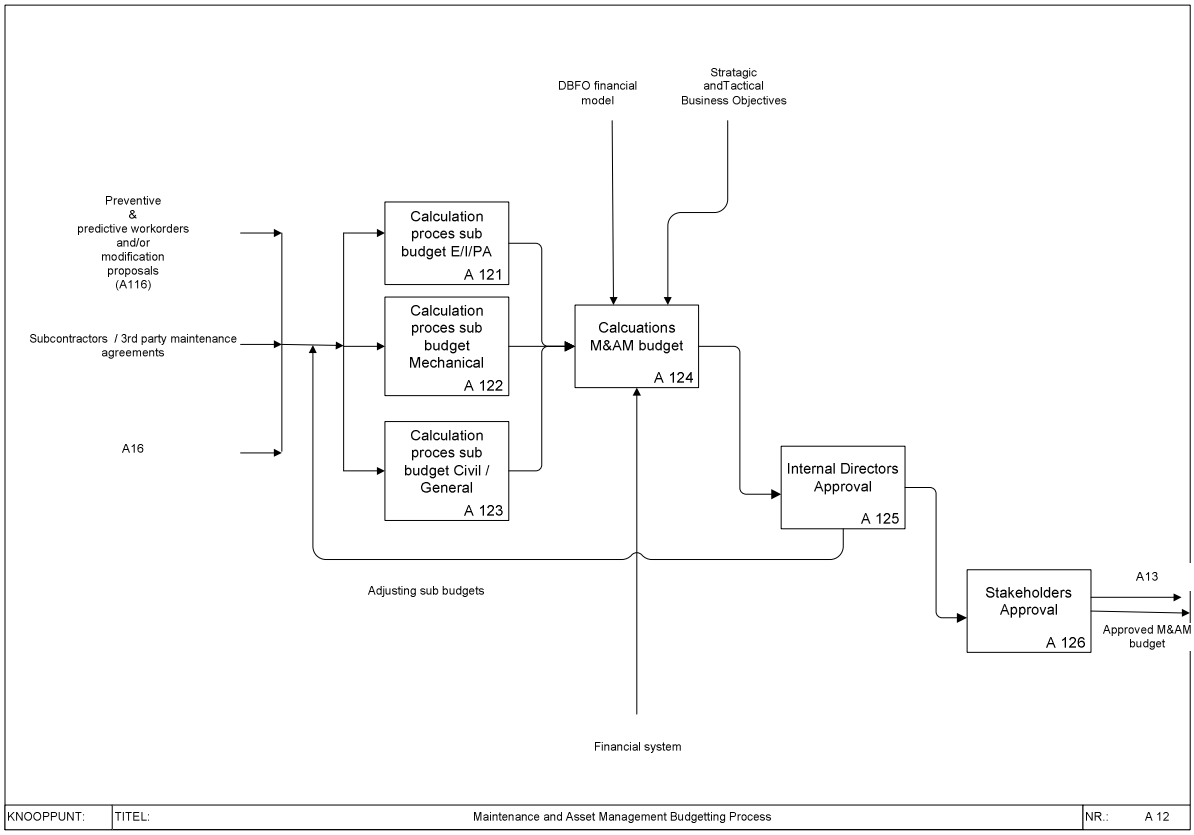
Appendix I IDEF-0 proposed situation



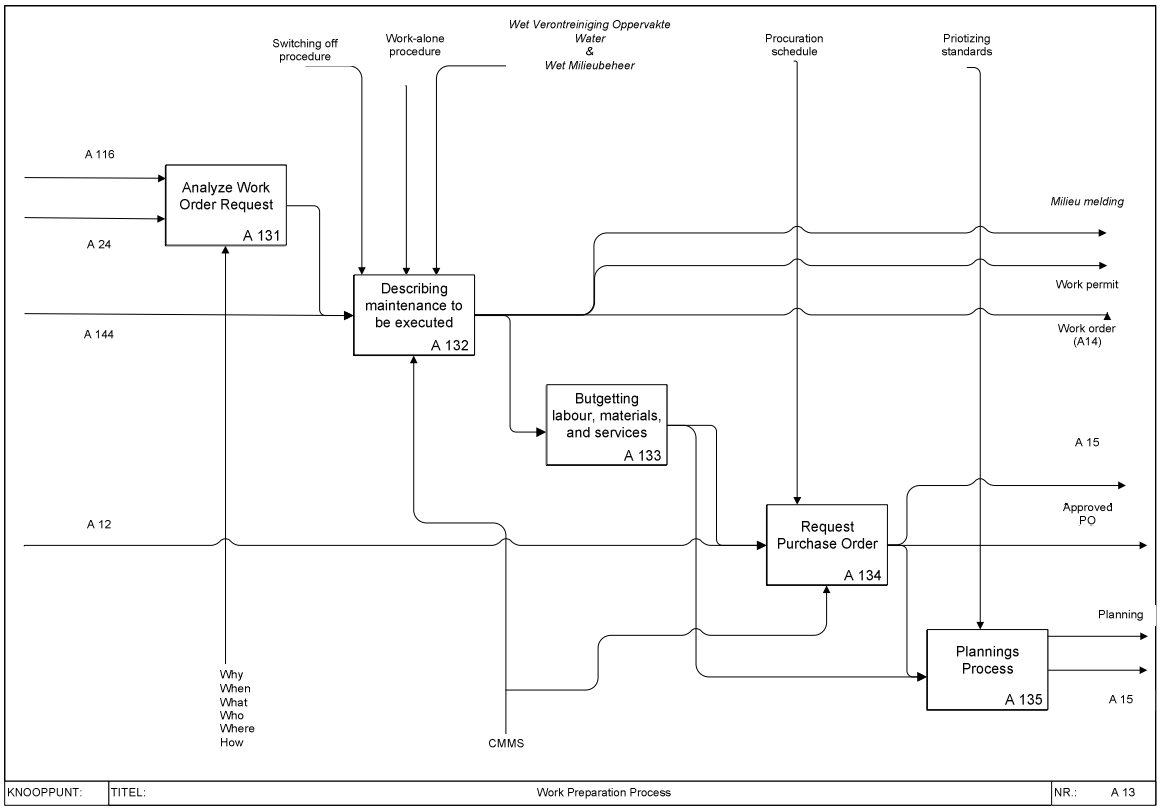
A1 Maintenance and Asset Management Processes	
Processes	
M&AM Inventarisation process	The process to identify all necessary maintenance activities based on the RCM / FMECA methodology as result of the strategic and tactical business objectives.
M&AM Budgetting process	The process to set up an approved M&AM budget, accounting all contractual obligations.
Work order request process	The process to request works structured.
Work preparation process	The process wherein all approved maintenance activities are prepared in order to execute works effective and efficient.
Work order execution process	The process wherein all prepared maintenance activities are executed conform preparation.
Controlling and reporting process	The process after executing works in order to evaluate previous processes of preparation and executing.
Analyzing and improving process	The process wherein all previous processes are evaluated and improvements recommended.
Flows	
Strategic and tactical business objectives	Business objectives determined by Board of Directors and Management
QHES procedures	All procedures regarding ISO 9001 and 14001
kPI review	Review of all approved business performance indicators.
Budget reviews	Overview of sub budget realisations



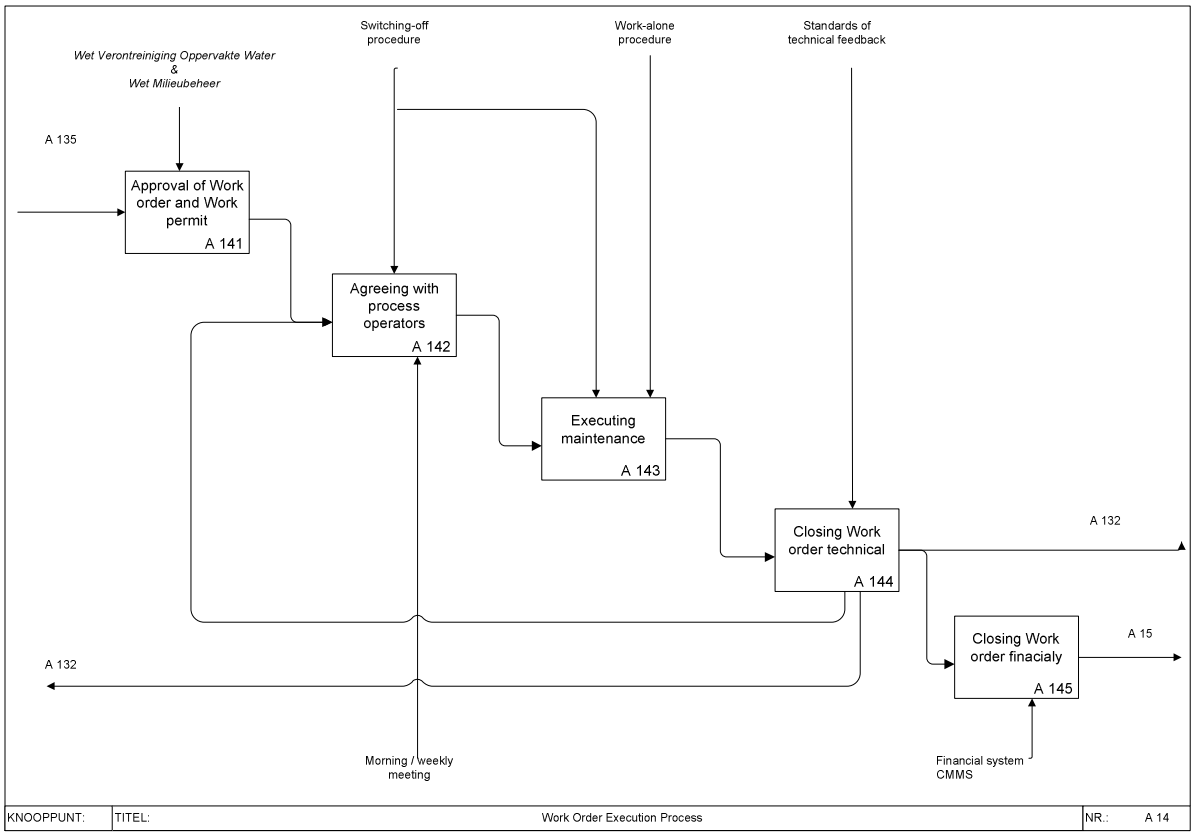
A 11 Maintenance and Asset Management Inventarisation Processes	
Processes	
Determine scope	Inventarisation of the outlines of the process part / location of which the maintenance requirements are investigated.
Tendering process 3rd parties	Separate tendering process to determine to which contractor this study will be outsourced to.
Project Planning Process	Process to set up a planning agreed by all relevant stakeholders.
Pilot Project	Part of the total project in order to identify pro's and contra's of this project.
Project	The maintenance study itself
Implementation process	Process to implement all identified maintenance activities in the CMMS, agreed by the IT staff. Also to eliminate previous implemented maintenance activities which are found unnecessary.
Flows	
RCM /FMECA methodology	Reliability Centered Maintenance / Failure Mode Effect and Criticality Analyse. The adapted methodology for inventarisation of all maintenance activities.
Acceptation criteria	Previous set up standards for acceptation of the project results.
Purchase order	Outcome of the Purchase Process, a sended order to the contractor.
Lessons Learned Report	Outcome of the pilot project
CMMS	Computerized Maintenance Management System



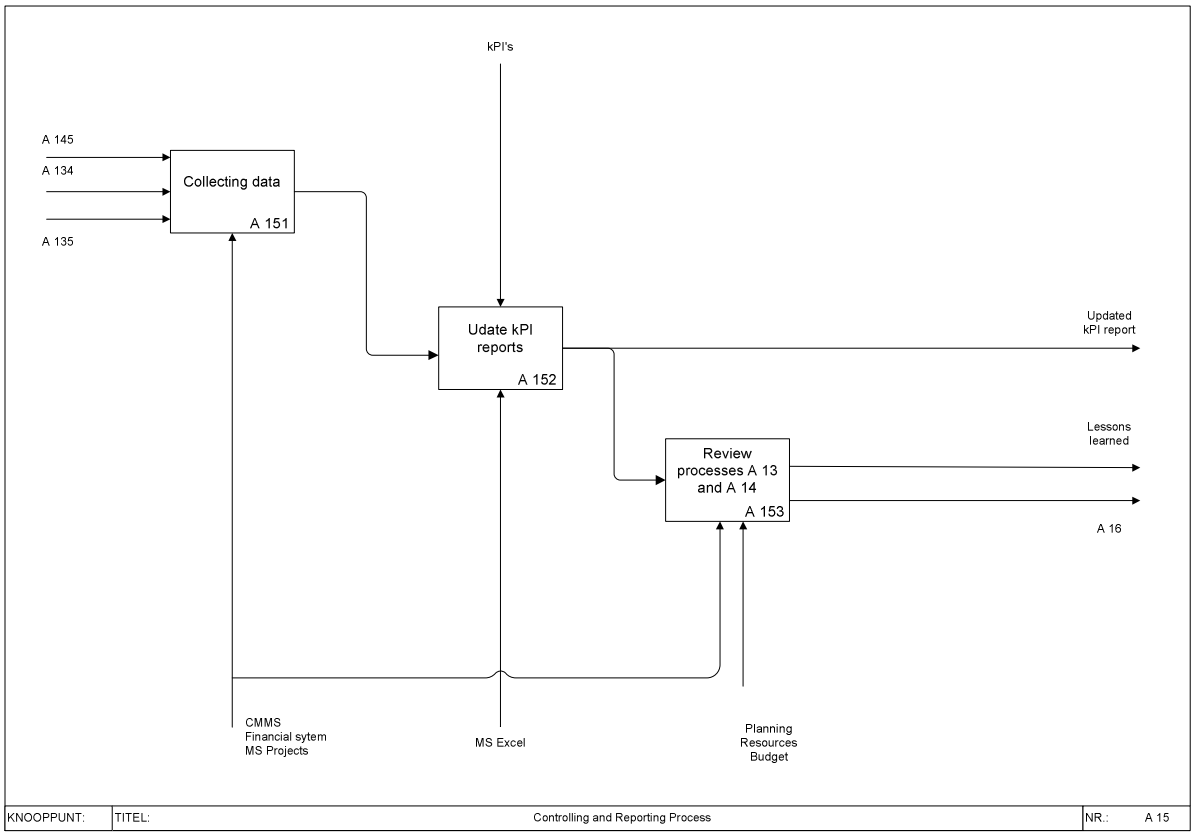
A 12 Maintenance and Asset Management Budgetting Processes	
Processes	
Calculation sub budgets	Inventarisation of all planned maintenance activities, contractors, planned projects and approved modifications and based on previous budget reviews determine all sub budgets
Calculation budget	Aggregate all sub budgets
Internal Directors Approval	Internal approval of board of directors of the M&AM budget
Stakeholders approval	External approval of stakeholders of DSBV's year plan and budget, wherein the M&AM budget is part of.
Flows	
DBFO financial model	Financial agreement for all operating and maintenance activities for the length of the contract (30 years)
Strategic and Tactical objectives	Results of these objectives which have consequences for the M&AM budget.
Financial system	DSBV system for all financial activities MS Dynamics AX



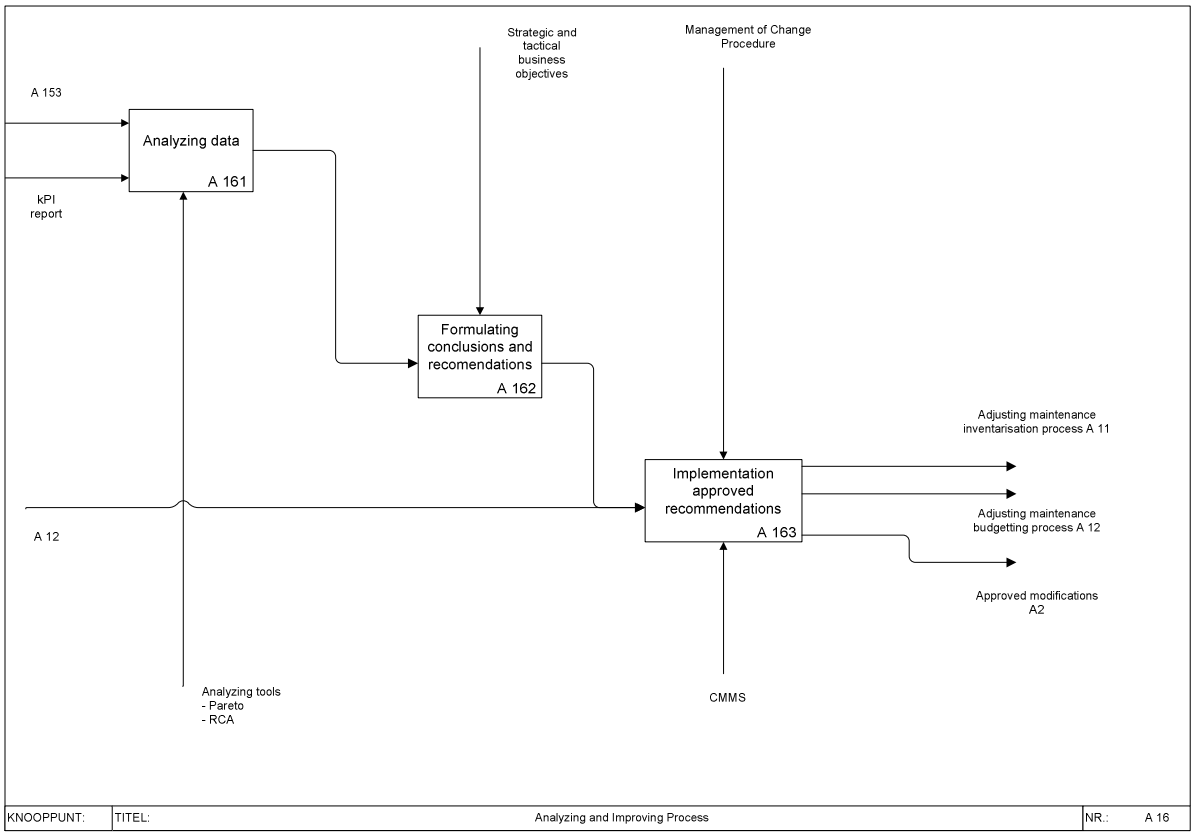
A 13 Work Preparation Processes	
Processes	
Analyzing work order request	Gatekeeping process in order to verify if requested maintenance is described according standards and of added value regarding QHES
Describing maintenance to be executed	Clear description of all activities to be performed
Budgetting labour, materials and services	Inventarisation of all necessary resources to execute the maintenance activities efficient and effective.
Request purchase order	When applicable for buying materials and / or services / 3rd parties
Planning process	Process of agreeing of all maintenance activities during planning meeting.
Flows	
Switching of procedure	Procedure in order to execute maintenance activities safely when electrical power have to be switched off.
Work alone procedure	Procedure which describes the circumstance where under engineers can / have to work alone
WVO /WM	Licenses to operate
Milieumelding	Announcement to the milieudienst of activities to be executed
Power of attornaty schedule	Gradation of budget approvals
Work permit	Permission for engineers to execute their work under prediscribed and agreed safety precautions



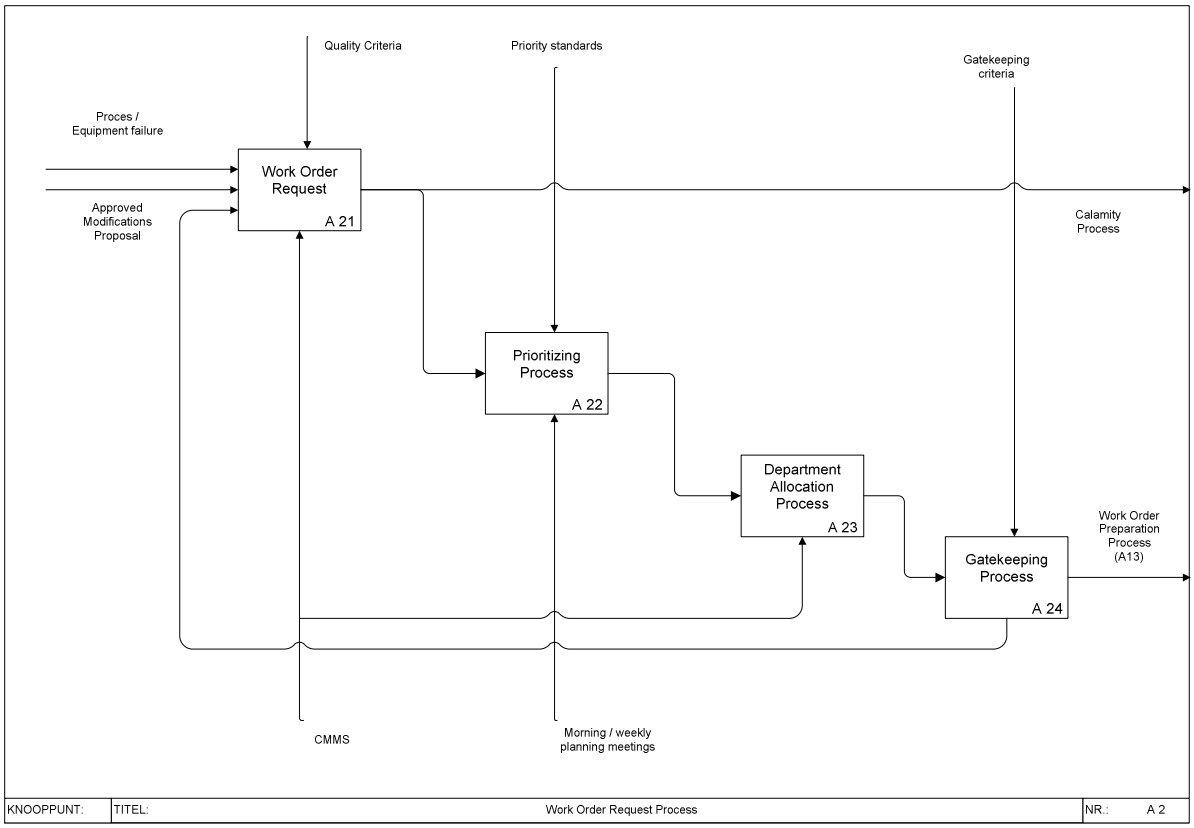
A 14 Work order execution process	
Processes	
Approval of work order and permit	Process of handing over prepared work order to the executing engineer
Agreeing with process operators	Final agreeing on the maintenance activities to be executed
Executing maintenance	The actual performing of the maintenance
Closing work order technical	Changing the status of a work order in the CMMS to 'technical accomplished' after accounting all spent labour hours, material and findings, incl. feedback about work order preparation
Closing work order financial	Changing status of a work order in the CMMS to 'financial accomplished' after controlling all administrative obligations
Flows	
Standard of technical feedback	Agreed standards for closing a work order technical in order to be able to set up reports for analysing and improving.



A 15 Controlling and reporting process	
Processes	
Collecting data	Process of collecting and judging relevant data from several systems (CMMS, financial system)
Update kPI's	Process of updating standard kPI's for formal reporting
Review processes A13 and A14	Reviewing maintenance preparations and executing for improvements of these processes
Flows	

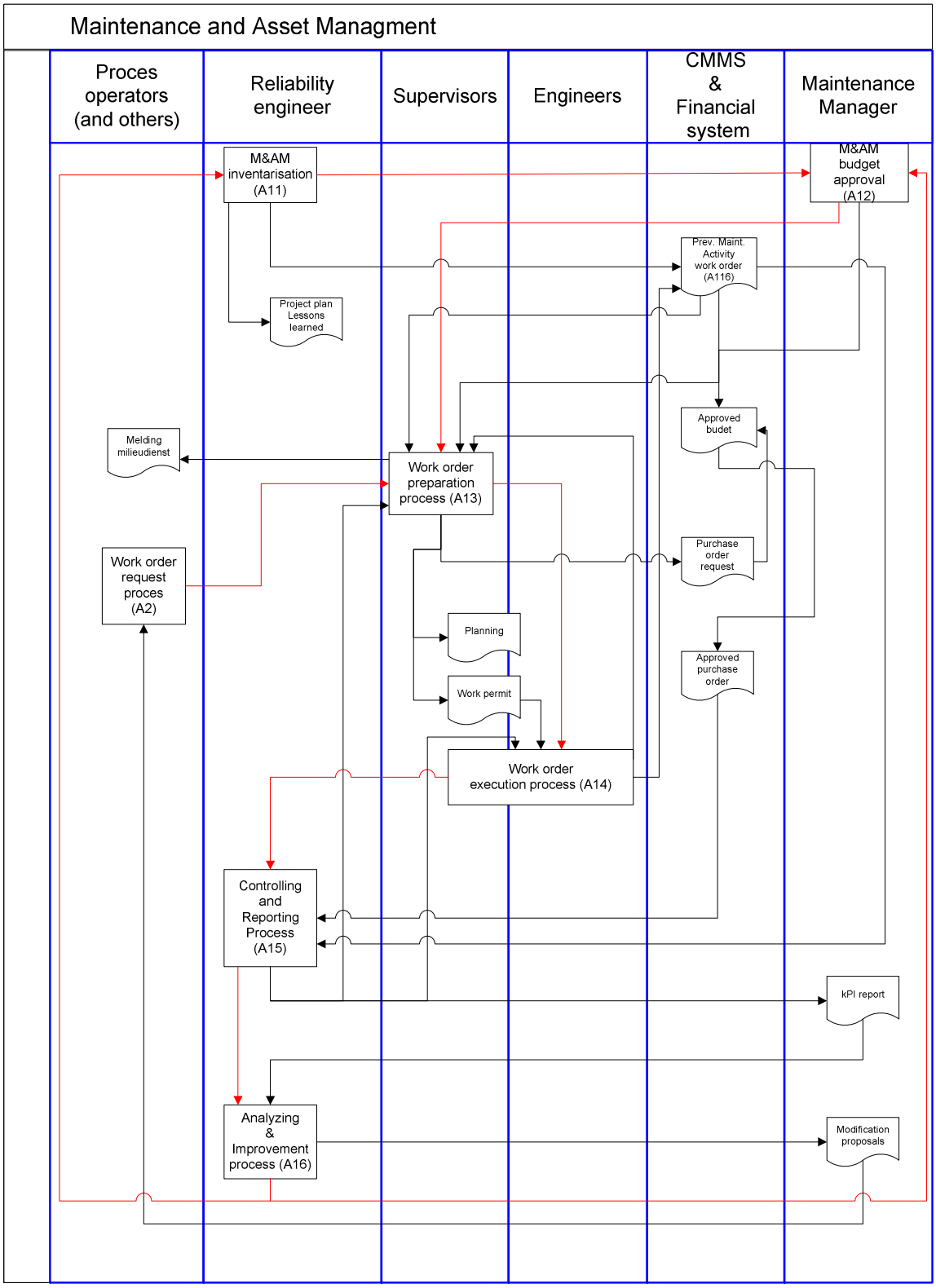


A 16 Analyzing and improvement process	
Processes	
Analyzing data	Review of all relevant data by using the Pareto, RCA etc methods.
Formulating conclusions and recommendations	Setting up business cases for improvements, technical or procedural in according with the business objectives
Implementation of recommendations	Process of implementing by the business process of changes and modifications (management of change processes)
Flows	

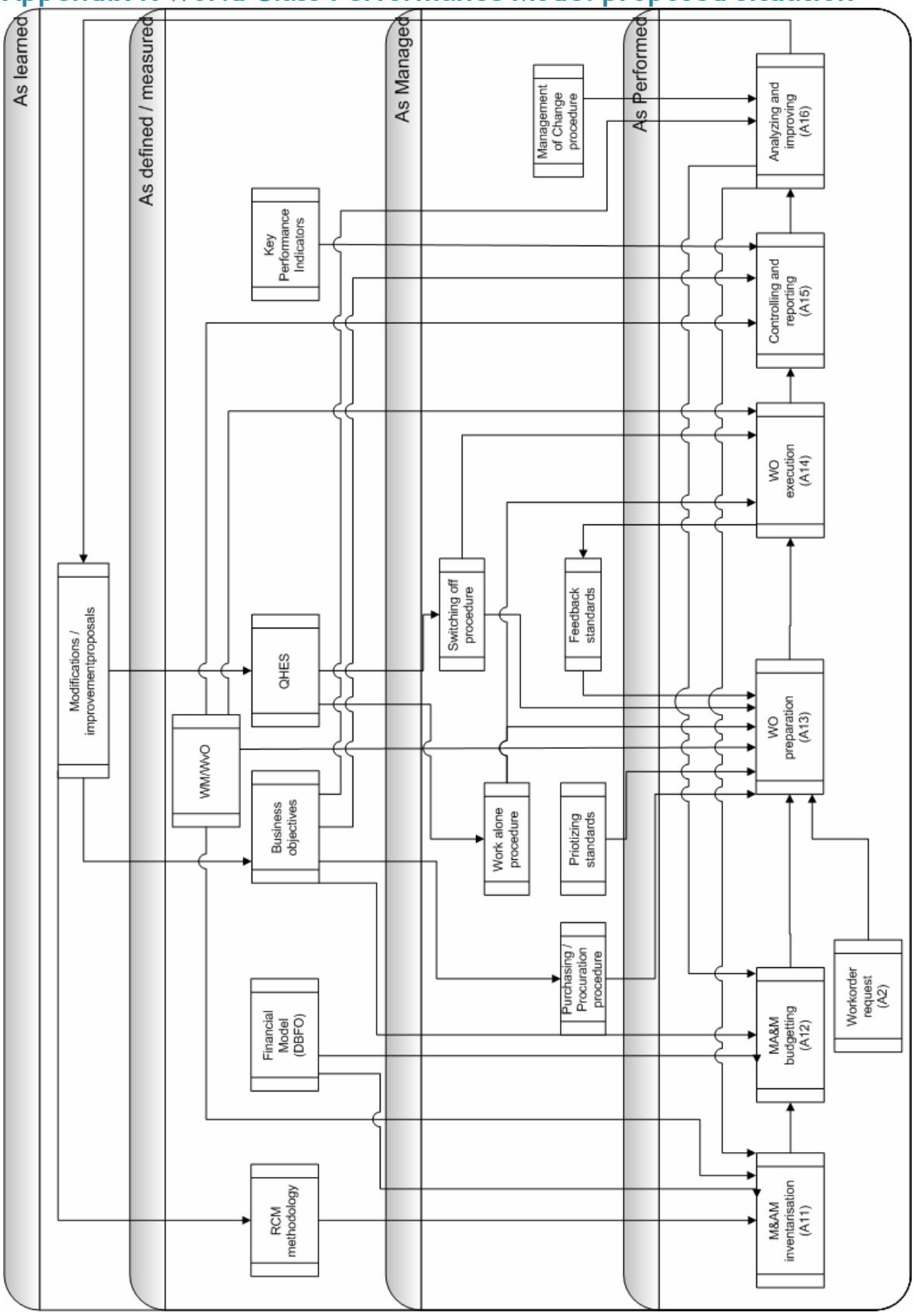


A 2 Work order request process	
Processes	
Work order request	A structured manor of requesting for works to be done according predefined standards
Prioritizing process	Process wherein all work orders are prioritized according to predefined standards.
Department allocation process	Process of determine which department is leading executive.
Gatekeeping process	Process of review of work order regarding added value to process, maintenance and QHES
Flows	

Appendix J Activity diagram proposed situation



Appendix K World Class Performance Model proposed situation



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- Activiteiten diagram
- Positioneren van de werkplak
- Analyse van de werkplek
- World Class Performance Model
- Ondernemersmodel
- IDEF-0 model
- Methodisch innoveren
- Integraal Ontwerp Scan
- IO - landkaart

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