

Consistent Maintenance Management Model: Results of Changes of Maintenance Organisation Structure and Processes

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Number of asset management models, methodologies and tools are available and well known today. However, companies in industry adopt various organizational approaches to the asset management processes. This paper summarizes several examples of maintenance process models and presents a comparison of examples (benchmark) of real maintenance organizational structures. Used examples originate from chemical, petrochemical and automotive industries. On this background, a case study of major maintenance organization change in Unipetrol, a central-european refinery and petrochemical group (part of PKN Orlen), is presented and analysed. The goal of the implemented changes in the company was to increase the overall efficiency of the maintenance organization, mainly in the areas of management, and to achieve the set KPIs. Organizational changes were implemented on the base of the model of a close connection between maintenance and production organizations in the form of a Multi-profession production team, named “Facility team”.

Changes in the organisational structure and asset management processes described in the paper had finally a significant impact on the number of management positions (reduction by 25 %), roles, competences and the asset management process flow. Regarding the quantitative impacts to KPIs in areas fulfilment of process safety requirements and efficiency after implementation of these changes, we notice a positive effect in the horizon of the coming year and the impacts are also evaluated and analyzed in the paper.

Keywords: Maintenance organization, Facility team, Maintenance KPI, Maintenance management

1 Introduction

Currently there are several asset management methodologies and tools available [1]. Even though the term Asset Management is defined through a set of national and global norms [2, 3], in the vast majority of practical cases we see isolated processes and methodologies; even though these are efficient as far as their application and outputs are concerned, they mostly focus only on a single area or sub-process and are not interlinked, they do not form any consistent whole or do not respect the needs or organizational structure of the production plant [4, 5]. This state is usually caused by the isolated development of individual methodologies, which are often commercial products. The time plays also an important role, since individual methodologies and tools were developed in a certain time frame and thus they logically cannot follow up on each other. For example the set of methodologies generally called Risk Reliability Management includes the Reliability Centered Maintenance, Risk Base Inspection and SIFpro© [6] methodologies, whose goals are to generate optimized plans for preventive maintenance based on risk assessment. Individual methodologies generate plans for

preventive maintenance but these plans are in different formats, completely unsuitable for automated or batch transfer to central planning maintenance systems, where data are further processed within the planning and work implementation sub-process.

A frequent representative of such Central Maintenance Management System (CMMS) is SAP – the preventive maintenance administration module [7, 8, 9]. Another factor which reduces the efficient implementation of modern methodologies for asset management is their low adaptability to the organizational structure of the production plant. The imperfect connection of asset management with the production area and with processes supporting the asset management process (such as the purchase of spare parts and consumable material, investments, safety and security, or HR) then leads to imperfect communication flows that reduce the organization’s efficiency and lead to suboptimal asset management costs, reduced availability of production equipment and lower process safety. This could lead, for instance, to imperfect fulfilment of valid legislation requirements, incorrect usage of residual service life of production equipment or low coverage by predictive maintenance.

The facts specified above force us to view the asset

management process as a consistent unit, integrated within the organizational structure of the production plant in a manner allowing efficient communication and goal sharing [10], whereas the real needs of the production facility, the medium- and long-term plans as well as the mission and vision of the company all need to be respected [11, 12].

The goal of the proposed solution spans all parts of the asset management process, from entering requests, their approval and prioritization, system of technical preparation of a job, optimal planning, transfer for implementation, feedback on implementation and final acceptance and closure of a job, whereas emphasis is placed on efficient communication, work quality and utilization of work capacities [13, 14, 15]. Organizationally, it is necessary to setup the process in a way that will ensure that individual decision steps will be carried out on the operator’s side and not on the maintenance’s side. On one hand, this results in an independent approval process with respect to costs management, and on the other this leads to clearly defined priorities by the operator, who is then forced to make decisions not only based on the current operating situation but also based on the costs and indicators for long-term operational availability [16]. As was mentioned earlier, one of the primary tools to achieve optimal decision-making was sharing of goals within key indicator assessment for processes, whereas the operator shares maintenance goals such as maintenance costs, mechanical availability of devices, mean

time between failures (MTBF) and/or efficiency of the maintenance work implementor. On the other hand, the maintenance side shares operational goals, such as operational availability, use of production facilities, energy index, or for instance variable costs [17]. From an organizational standpoint, the solution is based on the structure of a so-called multi-professional team, where a single organizational element has representatives of all key areas required for efficient administration and management of the entrusted production section. In practice, this means that the team includes representatives of production, technology and maintenance, as well as other areas such as reliability and quality management who are responsible for the efficiency of central specialized bodies in given areas. The implementation of a multi-profession team into the organization of maintenance and operation has become the main goal of changes in terms of process settings.

One of the key areas that need to be emphasized is the definition of process efficiency indicators for individual management levels, including the definition of key indicators [16]. This set of indicators contains not only basic items such as the aforementioned fixed costs for maintenance, MTBF, or mechanical availability of equipment, but also indicators monitoring process safety of equipment such as Loss of Primary Containment (LOPC), number of process alarms per time unit, success rate of diagnostics of rotary machines etc.

Tab. 1 Master list of harmonized indicators [18, 19, 20, 21, 22, 29]

EN 15341				SMRP			
Indicator No	Indicator Ratio	Metric No	Metric name	Indicator No	Indicator Ratio	Metric No	Metric name
E1	Total Maintenance Cost x100 / Assets Replacement Value	1.5	Annual Maintenance Cost as a percent of RAV	T18	Number of Systems Covered by Criticality Analysis x100 / Total Number of Systems	3.1	Systems Covered by Criticality Analysis
E3	Total Maintenance Cost / Quantity of output	1.3	Maintenance Unit Cost	T21	Total Time o restore x100 / Number of failures	3.5.2	MTTR
E7	Average inventory value of maintenance materials x100 / Asset Replacement Value	1.4	Stocked MRO Inventory Value As s Percent of RAV	O3	Number of indirect maintenance personnel x100 / Number of direct maintenance personnel	5.5.3	Direct to Indirect Maintenance Personnel Ratio
E8	Total internal personnel cost spent in Maintenance x100 / Total Maintenance Cost Value	5.5.5.	Internal Maintenance Employee Cost	O8	Man-hours used for continuous improvement x100 / Total maintenance personnel man-hours	5.7.1	Continuous Improvement Hours
E10	Total contractor cost x100 / Total maintenance cost	5.5.71	Contractor Cost	O10	Direct maintenance personnel on shift x100 / Total direct maintenance personnel	5.5.6	Craft Workers on Shift Ratio
E11	Total cost of maintenance materials x100 / Total Maintenance Cost	5.5.38	Maintenance Material Cost	O16	Corrective maintenance man-hours x100 / Direct maintenance man-hours	5.1.2	Corrective Maintenance Hours
E12	Total cost of maintenance materials x100 / Average inventory value of Maintenance materials Warehouse turnover	5.5.31	Stores Inventory Turns	O17	Immediate Corrective maintenance man-hours x100 / Total maintenance man-hours	5.4.1	Reactive Work
E13	Cost for indirect maintenance personnel x100 / Total Maintenance Cost	5.5.4	Indirect Maintenance Personnel Cost	O18	Preventive maintenance man-hours x100 / Total maintenance man-hours	5.4.2	Proactive Work
E15	Corrective maintenance cost x100 / Total Maintenance Cost	5.1.1	Corrective Maintenance Cost	O19	Condition based maintenance man-hours x100 / Total maintenance man-hours	5.1.6	Condition Based Maintenance Hours
E17	Condition based maintenance cost / Total Maintenance Cost	5.1.5	Condition Based Maintenance Cost	O20	Predetermined maintenance man-hours x100 / Total maintenance man-hours	5.1.4	Preventive Maintenance Hours
E18	Predetermined maintenance cost x100 / Total Maintenance Cost	5.1.3	Preventive Maintenance Cost	O21	Overtime internal maintenance man-hours x100 / Total internal maintenance man-hours	5.5.8	Overtime Maintenance Hours
E20	Maintenance shutdown cost x100 / Total Maintenance Cost	5.1.9	Maintenance Shutdown Cost	O22	Numbers of work orders performed as scheduled x100 / Total number of scheduled work orders	5.4.4	Schedule Compliance - Work Orders
E21	Cost of training for maintenance / Number of maintenance personnel	4.2.1	Maintenance Training Cost	O23	Number of maintenance internal personnel man-hours for training x100 / Total internal maintenance man-hours	4.2.2	Maintenance training hours
T1	Total Operating time x100 / Total Operating time + Downtime due to maintenance	2.2	Availability	O26	Number of the spare parts supplied by the warehouse as requested x100 / Total number of spare parts required by maintenance	5.5.33	Stock outs
T2	Achieved uptime during required time x100 / Required time	2.2	Availability				
T17	Total operating time x100 / Number of failures	3.5.1	MTBF				

The structure of monitored indicators is based on a classical pyramid logic, where the number of monitored items becomes smaller in the direction towards top management [15, 23].

The primary contribution is the creation of an asset management model which will ensure improvement of mutual communication and coordination between individual company bodies [24], improvement of availability indicators for production equipment, optimization of costs for the implementation of maintenance activities, improvement of process safety indicators such as LOPC or number of process alarms. The author intends to demonstrate these improvements based on a real-life implementation of the proposed process solution.

For creation of such an asset management model, it is vital to reflect current problems and trends in maintenance organizational structures. There are two basic forms of maintenance organizational structures: decentralized (area) and centralized. In case of decentralized organization, work control is delegated to individual production areas. On the other hand, in central organization all work orders are controlled from a central shop. (Maynard, 2001) [26]. For smaller maintenance organizations it is typical to use central form, for larger organizations decentralized shop concept is widely used. Combination of both concepts (area - central) might be used for multilevel maintenance, where specialists are assigned to specific areas, maintaining the key equipment. Skills which are not needed on a daily basis are ensured from the central shop when needed.

Organizational structure can be partly described by the maintenance organization ratio and ordinarily it is about 15:1. However this ratio must be set carefully with respect to the skills and daily agendas of supervisors, machine shop dispositions and to the form of production [25].

2 Examples of maintenance process models and maintenance strategy development

One of the main factors for the maintenance organization are the characteristics of the maintenance needs that are generated by the assets.

A possible scenario of a production plant for chemical products can serve as an example.

Originally all the repair works arising out of the maintenance needs (or demand) of the plant were undertaken by local maintenance department personnel. After a major decrease of 40 % in production output due to lack of demand, it was decided by management to reduce the numbers of production and maintenance personnel. The further investigation resulted in two main options to choose between: either completely outsource the maintenance function, or outsource as much as possible. For practical reasons it was decided that a maximum of 50 % of the work had to be done by maintenance department and 10 % by operators undertaking first line maintenance work. So, 40 % of all work was outsourced, in particular all work on building services installations and all the utility equipment. [26]. Scheme of possible organisation is presented on Fig. 1.

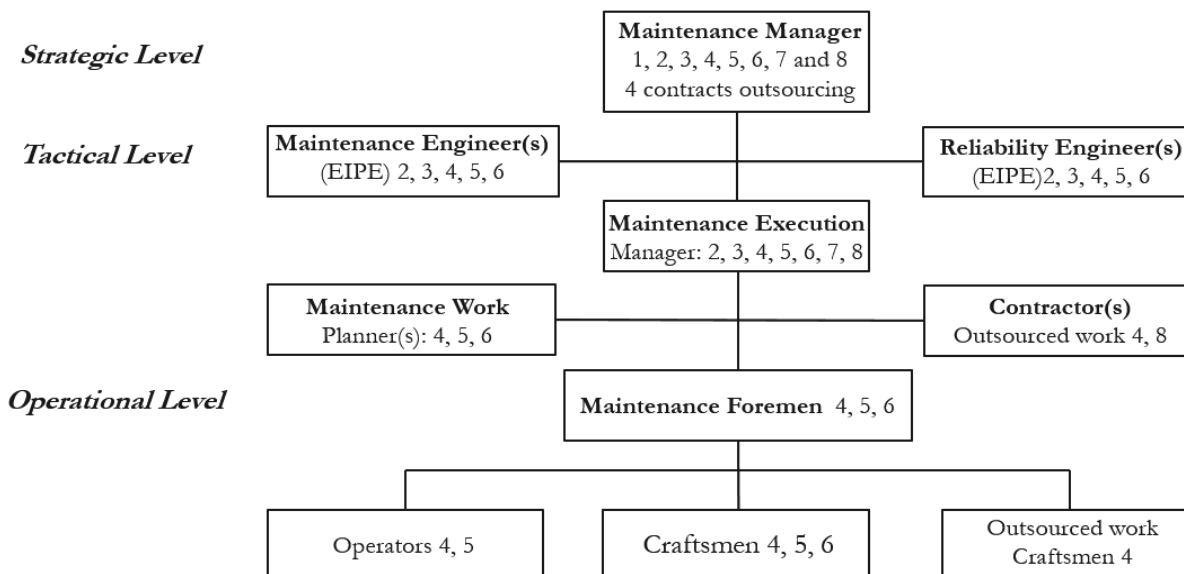


Fig. 1 Possible organization of the maintenance department for a production plant [26]

Another example of maintenance strategy development is provided by company which decided to create a maintenance model based on the centralized management, as shows Fig. 2. The model helps to avoid

the chaos of diverse demands that can arise in maintenance from day to day. It provides guidance, organization and sense of importance for the company.

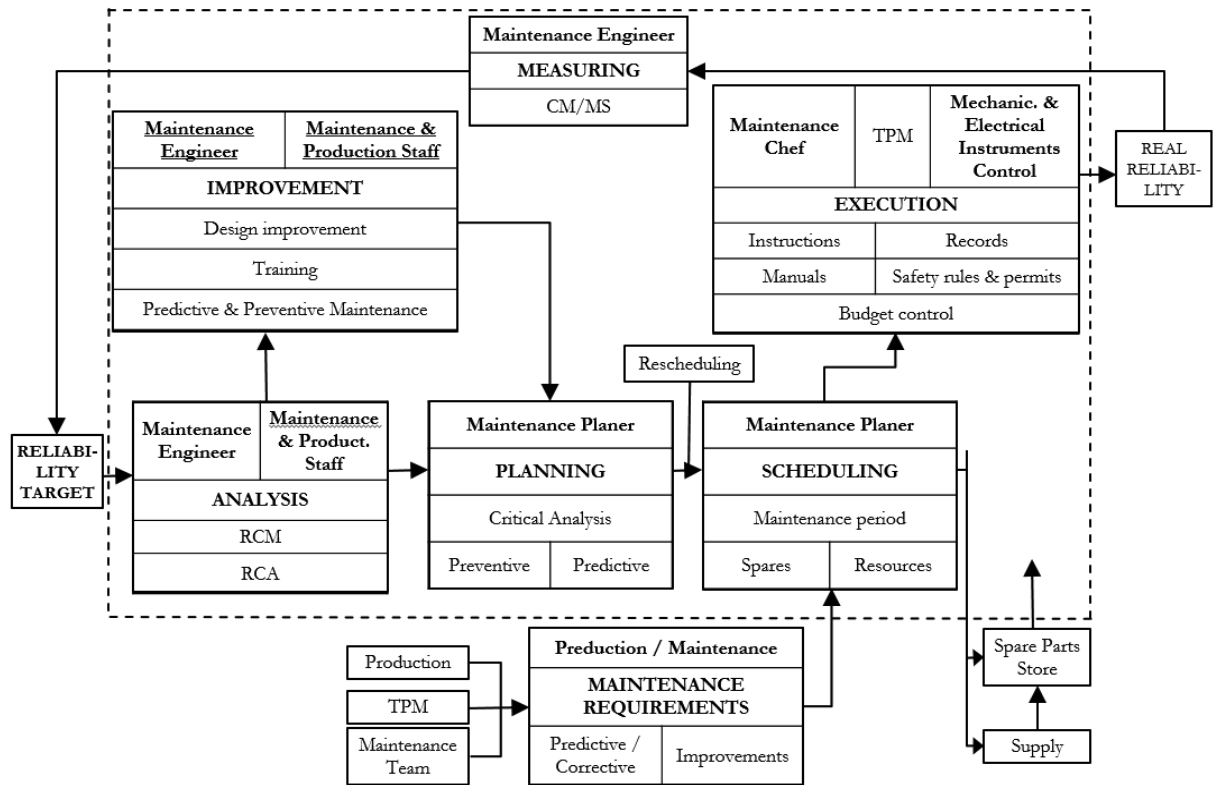


Fig. 2 Example of a maintenance strategy development [27]

Regardless of the organization formal structure and the position of maintenance within the structure, there exist certain generally accepted principles, see example on Fig. 3. Employees must know what they are responsible for and whom they report to. Managers are required to know who is responsible for setting goals and all other activities needed for their

success. The organization structure represents these responsibilities in the simplest and obvious way. The organization structure is clearly perceived on the level where business policy is formulated in the organization, however, it is essential that the organization structure is clearly understood on the level of work execution too [28, 30].

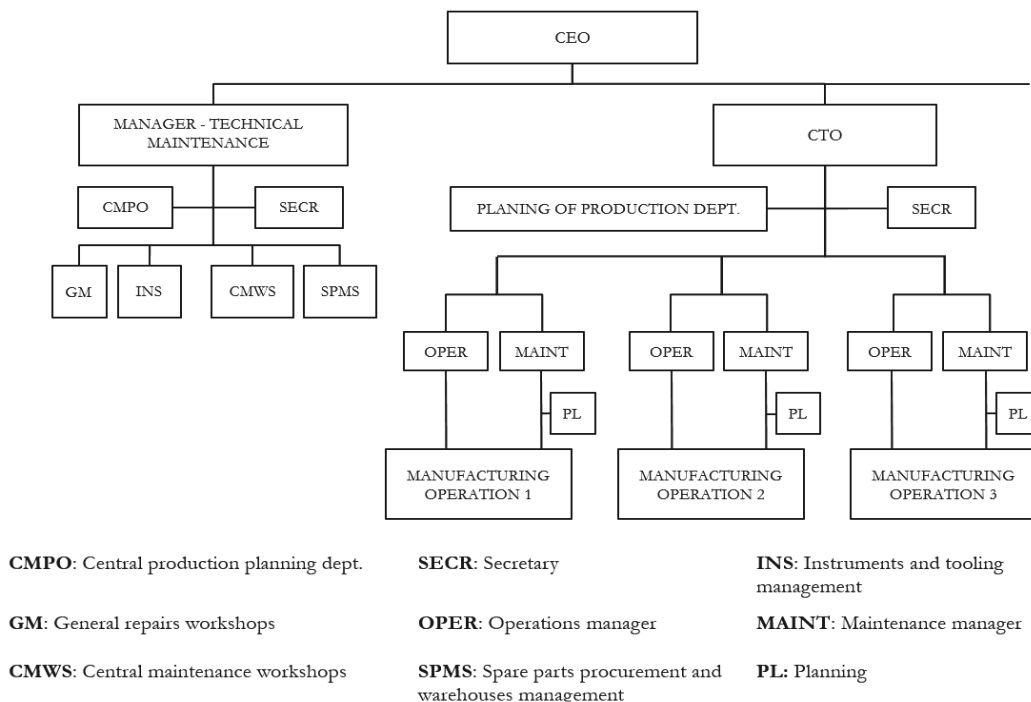


Fig. 3 Example of organization structure of combined maintenance [29]

3 Examples of real maintenance organizational structures

Useful tool for determination which organizational structure should be used, is benchmarking of maintenance structures. Basic benchmarking of 5 similar

maintenance organizations in automotive industry was conducted for comparison. It should be considered, that organization structure is strongly affected by the level of outsourcing, scale of operation and technology type. This assumption was generally confirmed by the results of the benchmarking presented in following Tab. 2 and diagrams.

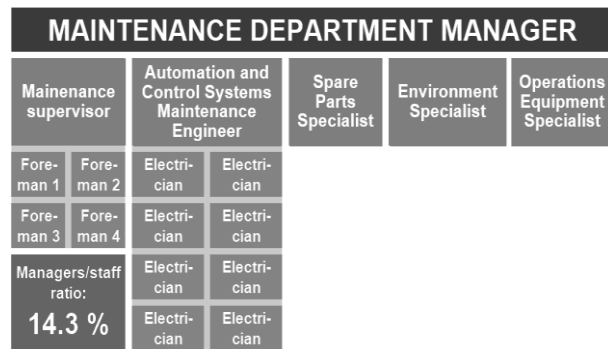
Tab. 2 Benchmarking of five similar maintenance organizations in automotive industry

Automotive industry maintenance	Cars/day	# shifts	Total head-count	Level of outsourcing	Manager/Staff Ratio
Assembly line A	1 000	2	42	medium	14.3%
Assembly line B	1 500	3	50	medium	13.0%
Assembly line C	580	3	28	high	21.0%
Bodyshop-welding	1 400	/	48	high	12.5%
Paintshop	2 000	/	91	medium	13.2%

This table sums up the following graphics:

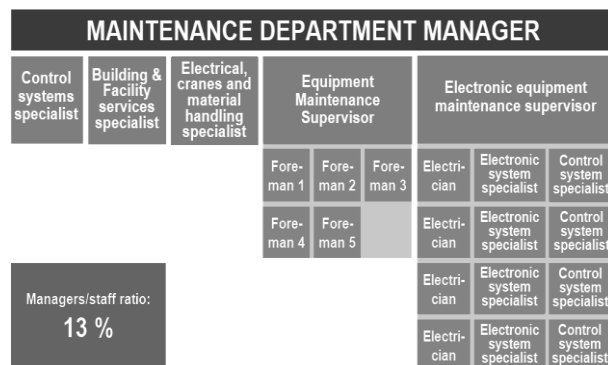
Automotive, Assembly line A

Production: 1 000 cars/day, 2 shifts operation, Total headcount: 42, Level of maintenance outsourcing: medium



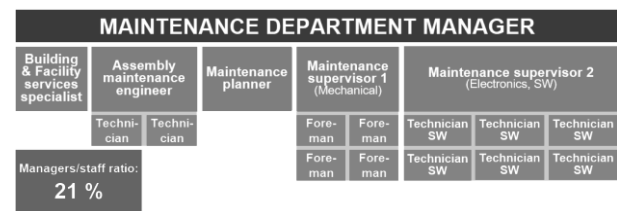
Automotive, Assembly line B

Production: 1 500 cars/day, 3 shifts operation, Total headcount: 50, Level of maintenance outsourcing: medium



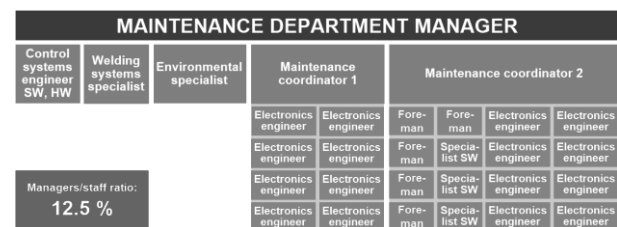
Automotive, Assembly line C

Production: 580 cars/day, 3 shifts operation, Total headcount: 28, Level of maintenance outsourcing: high



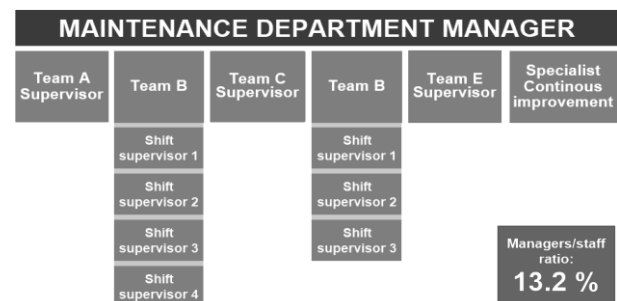
Automotive, Bodyshop – welding

Production: 1 400 cars/day, Total headcount: 48, Level of maintenance outsourcing: high



Automotive, Paintshop

Production: 2 000 cars/day, Total headcount: 91, Level of maintenance outsourcing: medium



4 Maintenance organization change in Unipetrol

The decentralized (area) maintenance model was applied over a long period for individual production

plants in Unipetrol in the past. It was during times when the company had its own in-house executive maintenance including workshops and machinery. Change occurred in the nineties, when the company underwent privatisation and almost all service activities were split off and further used in the outsourcing form. At that time, changes in the organisational structures of maintenance were also accelerated, it was necessary to adapt to a different model of operation. Over next fifteen years many changes occurred, when organisation of maintenance settled on the decentralized model with a specific small role played by centralised services which constituted the basic service for individual maintenance operations. The central part included technical diagnostics, cost reporting and basic administration of the maintenance process. No central technical engineering existed at that time as well as no system of uniform strategic management, for example in the field of reliability, inspection, risk management, planning and strategy for preventative maintenance. The interconnection with the field of production differed for various production units. This model of maintenance management required a large number of management employees and ensured only minimal option for unified management of maintenance strategy.

In 2014, the company decided to implement the organisational model of Facility Teams across the board for management in the field of production. This concerns a multi-professional team which is responsible for comprehensive management of a defined

production unit and which also allows the close connection with organisation of maintenance.

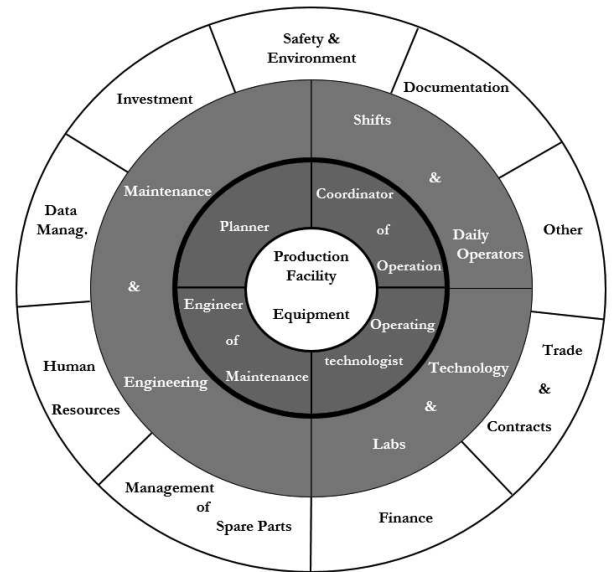


Fig. 4 Facility Team

Apart from the position of production technologist and energy technologist, the Facility Team is made up of a Reliability Engineer, Main Maintenance Engineer, Operations and Maintenance Coordinator and Scheduler Fig. 4. Thanks to these positions the close interconnection with organisation of maintenance and its suppliers is ensured.

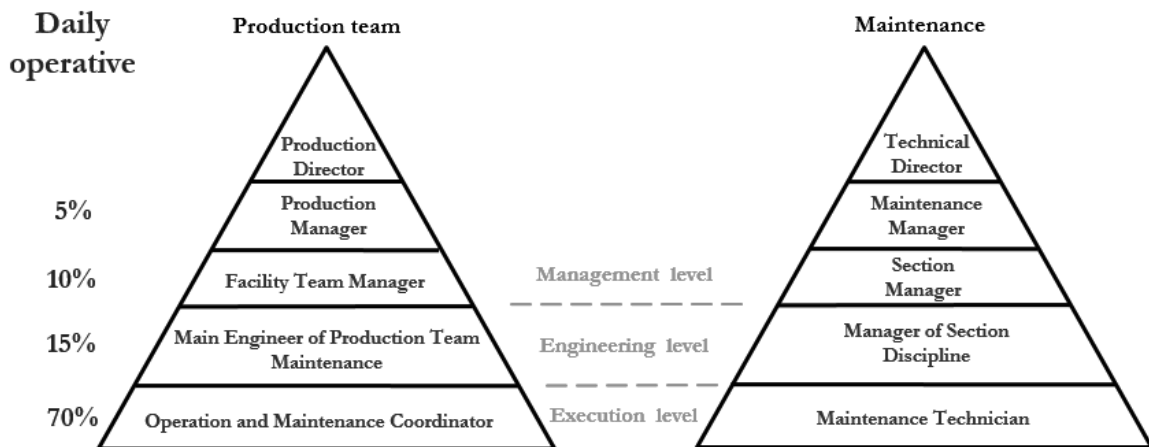


Fig. 5 Pyramid

In order to ensure that responsibilities and communication between in-house production and maintenance are clearly defined, transition to Facility Teams required a change in the organisational structure of maintenance Fig. 5. These changes were

at the same time used to ensure more complex changes in organisation of in-house maintenance, whereas centralisation occurred in the executive part of maintenance and the level of technical engineering was created, allocated to departments according to technical expertise Fig. 6.

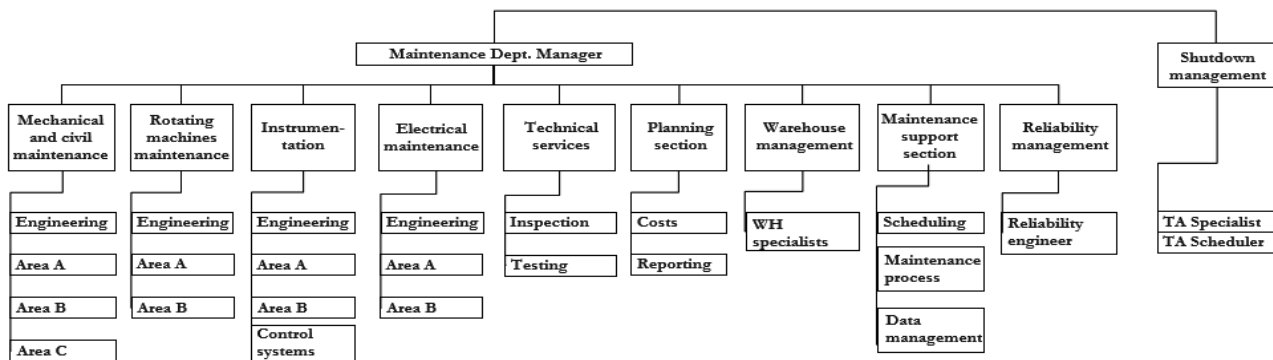


Fig. 6 Organisational chart

5 Evaluation of the change – impact to KPIs

Changes in the organisational structure described above had an impact on the number of employees in management positions, bringing a reduction in their number from 12 to 9, i.e. by 25 %. However, the reason behind these organisational changes was not reduction of the number of jobs, but increase in the specialist abilities in the field of technical engineering and

setup of organisation in such a way that competences and flow of information are clearly defined within the framework of interconnection between organisation of production and organisation of maintenance. Within one year from implementation in 2014, the implemented changes began to have a positive effect on the trends of key indicators of the process safety and planning effectivity, as can be seen on Fig. 7.

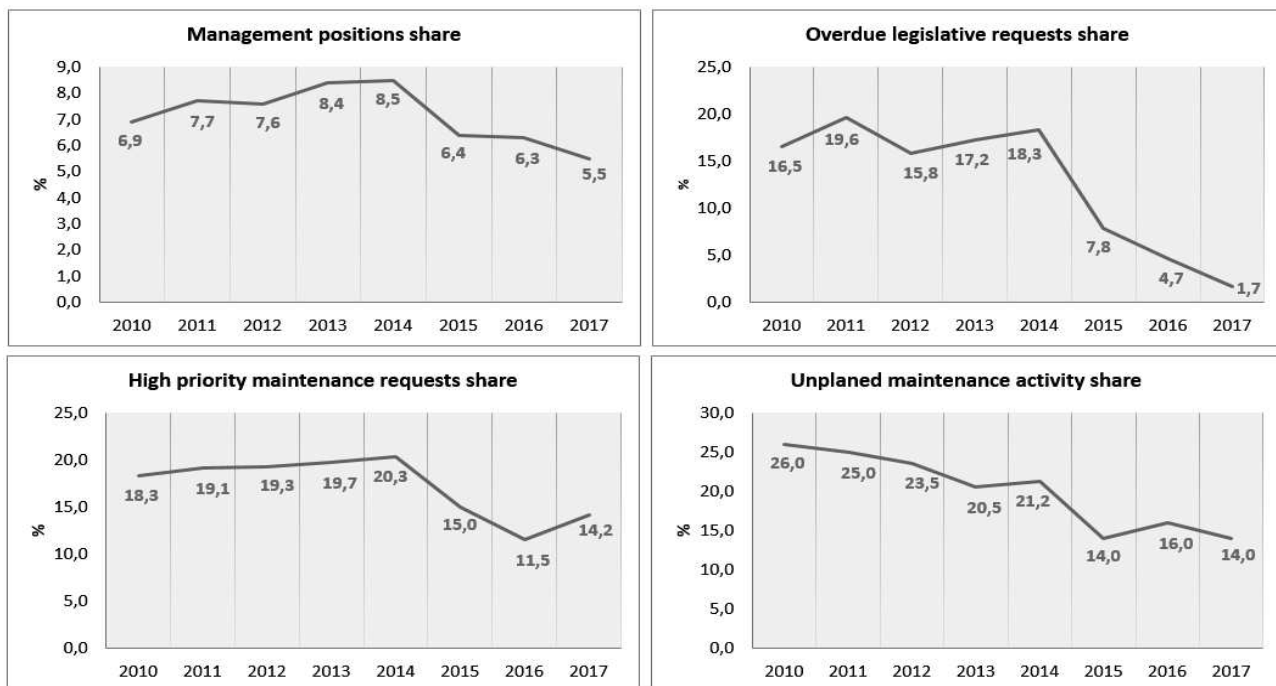


Fig. 7 Trends of maintenance KPIs after organisational change implementation in 2011

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