Development of visual management system for support to planning and control of maintenance activities

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Abstract

The world is experiencing a global market where supply and demand are subject to constant market fluctuations. The aeronautics sector is a mirror of this reality, where the customer demands quality and rigor at a competitive market price. In this way, scrupulous and faultless maintenance tasks are essential to ensure differentiation in the service offered. This is the markets standard and no company is impervious to this scenario, to which they have to adapt. The lean philosophy met the need for cost reduction and greater flexibility through the elimination of waste in the aeronautics sector. Its implementation was successfully adopted by many companies in the aeronautics sector after the positive results achieved in the automotive field. This dissertation arises from the need to continue the application of the lean philosophy in a Portuguese aeronautical company of MRO (Maintenance Repair Overall). The goal is to develop solutions to increase operational efficiency and reduce waste by applying visual management and other lean tools.
Keywords: lean, MRO, waste, efficiency, visual managment

1. Introduction

In the aeronautical industry, the implementation of lean has revealed great potential for positive results in eliminating the sources of waste and the reduction of costs. Although it has been applied successfully, the particularities of the MRO branch make it necessary for the implementation to be adapted, and some authors even suggest caution in the literal and direct application of the philosophy [12] This dissertation follows on an internship in an aircraft maintenance company, aimed to provide solutions of visual management tools to increase the efficiency and reducing waste in the shopfloor. This increase in the efficiency was achieved by eliminating wastes, such as displacements with no added value. This dissertation relies on the application of a diagnostic of the maintenance process and solutions for improvement, followed by implementation and replication of the solutions achieved.

2. State of the art

Brief history of lean

In order for us to be able to talk about lean today, we have to acknowledge that it all started in Japan with Toyota and the Toyota Production System (TPS). TPS has, as its core philosophy, the "complete elimination of all waste" and aims to achieve more efficient methods of production. This philosophy had its roots in Sakichi Toyoda and his automatic loom in 1924. TPS was developed over the years, after some trial and error, with the aim of improving efficiency by applying methods developed at Toyota. This was made possible with the contributions of people such as Kiichiro Toyoda, founder and second chairman of the Toyota Motor Corporation [1]. As the practices matured, Taiichi Ohno developed the TPS home model[8].

The foundations of this house are:

• Toyota Philosophy: Values and ideas within the Toyota company;

• Visual Management: Use of visual indicators that allow to warn the user about the need for decision making, alert, preventive or control action;

• Standard Process: The work carried out must take into account the organization and the previously established procedures, necessary for its implementation;

• Heijunka : Level production in terms of volume and variety.

On top of these foundations are 2 pillars:

Jidoka: If an anomaly occurs, it should be possible to interrupt production autonomously, ensuring that the defect does not advance in the value aggregation line.

Just in time(JIT): Purchasing, production and transportation. Nothing should be done if there is no need, in order to avoid wastage.

Outside of Toyota, TPS is regularly referred to as lean or lean production since the terms were popularized in the best-sellers: "*The Machine That Changed the World*"[5] and *Lean Thinking* [6]. Both authors enunciate TPS as the starting point for their research in Lean [8].

2.1. Lean Principles

We can define the main purpose of lean as the systematic elimination of waste in order to create value [15]. According to the authors [6] the application of lean is ruled by 5 principles:

- Identify Value

  This is the starting point of any lean operation. We can define value as a chain of different organizations or services (internal / external) that occur for the production of a product or service which the final **client** is willing to pay at that point in time [6].

- Identify Elimination of waste

  3M Model

  The terms **MUDA, MURA, MURI** describe the 3 main types of production disruptions and constraints:

  - MUDA (waste or inefficient use of available resources): characterized by 7 deadly wastes.
  - MURA (variation, inconsistencies or imbalances in the use of resources): sometimes the capacity is higher than the load, others times the load is higher than the capacity.
  - MURI (overload or over resource requirements): load is higher than capacity. Safety and quality problems due to overload.

- Generate Flow (of value for the customer)

  It corresponds to the act of maintaining the movement of the product along the chain of value in a cadence provided since the request is made by the customer until the right moment to deliver.

- Set Pull

  Also referred to as pulled production, this concept presumes the production or replenishment of inventories at the pace defined by demand (customer's needs). The final product should be delivery on the date of need, and in the right amount.

- Perfection

  This principle concerns the need to make constant and continuous improvements to the first four. The "perfect"state is a process of continuous improvement.

7 MUDAS

The seven deadly wastes categories were identified by Shingo [16] in his study of TPS. Thus, the seven forms of wastes identified are the following [17]:

1. Overproduction: Producing above requirements, or too early without a buyer for the product. It is considered by Ohno [11] as the most serious waste, as it gives rise to the other six wastes presented below.
2. Waiting: Long periods of people or machine downtime resulting in a longer lead time.
3. Transport: Moving the product unnecessarily leads to lost time and increased risk of non-quality or loss.
4. Inventory: Excess inventory (components, raw material, finished products) leads to costs associated with the maintenance and conservation of the stock.
5. Over processing: Reprocessing: Effort spent on the inspection and correction of defects, as well as costs related to lack of quality; Occurs when more than required work is performed in the customer order. This includes the creation of projects and the use of more complex and / or expensive tools than strictly necessary.
6. Motion: The excessive movement of the people during manufacturing.
7. Defects: Production errors that imply additional work lead to increased costs in the short and long term.

Subsequently other authors [2] defined other classes of waste, as observed below :

- The non-use of human potential: It results from having a worker perform a task where he does not use his knowledge, training or acquired experience. "Lean organizations, through the use of the mental power and the will of their collaborators, not only the managers, promote and reward the intervention and creativity of people."[15].
- The waste of the usage of inappropriate systems: "The misapplication of systems and technologies is at the root of great sources of waste

in organizations." [15]. An example of this waste are companies that invest in Enterprise Resource Planning (ERP) management systems, but do not make proper use of or only partially use the system.

- Energy wastes: Refers to waste in energy sources such as: electricity, gas, oil, oil,etc.
- Waste materials: In order to reduce material waste it is necessary to approach the life of the product service. Today, manufacturing and construction activities are not just a matter of profit but also environmental responsibility.
- Waste in services and offices: In the office we can identify wastes previously mentioned, such as unnecessary movement, materials, etc.
- Client time waste: It is considered a waste if the customer is forced to wait for the products / services he needs, or has to go from department to department to acquire what he needs.

Some of the wastes presented above may not be directly related to wastes in the production system, but rather to a macro context of the organization.

2.2. Lean Tools

PDCA Cycle

The PDCA cycle is a sequence of steps that guide continuous improvement. The cycle consists of 4 steps, which should be implemented in the following order[10]:

Plan: An analysis of the current state of the problem or method being studied is made. In this stage data is collected, analyzed and an action plan to improve the current situation is formulated.**Do**: This is the implementation step, during which the plan in the previous step is executed.**Check**: This step verifies the implemented solution and evaluates the results obtained.**Act**: During this stage, if the obtained result is of added value for the organization, proceed to standardize and consolidate the solution found. If this does not happen, restart the cycle.

Ishikawa Diagram

The Ishikawa Diagram, also known as a cause and effect diagram, is a tool that helps identify, separate and visualize possible causes for specific or quality related problems [4].

Five Whys (5W)

The five whys is a diagnostic tool for ascertaining the root cause of the problem. The analysis consists in asking repeatedly WHY when a problem is encountered [11]. This tool can even be used after the Ishikawa diagram to further refine the analysis made by that tool

Pareto Diagram

A graph bar displaying the frequency with which different categories occur, in descending order from left to right. It is used in association with the Pareto Principle in which 80% of the problems are caused by 20% of the causes. It is an empirical rule, which was applied many times, and allows to identify the most important factors in quality [7].

Spaghetti Diagram

Graphic representation technique that uses flow lines to trace the path of people, goods, equipment and activities throughout a process, with the objective of identifying redundancies [15].

Visual Management

The purpose of visual management is to embed the details of the operations through visual devices and visual systems. By applying visual management we are facilitating the decision-making process, and improving quality, safety, and the fight against waste within an organization. [15] [3]. There is a thought cycle when we identify the need for a visual management component. This cycle is composed of:

1st step: Identify a waste.
2nd step: What is the cause of the waste? What triggered this waste?
3rd step: Identify the root cause of the problem.
4th step: Identify the solution and the location where this information is needed.
5th step: Transform the solution found in a visual device.

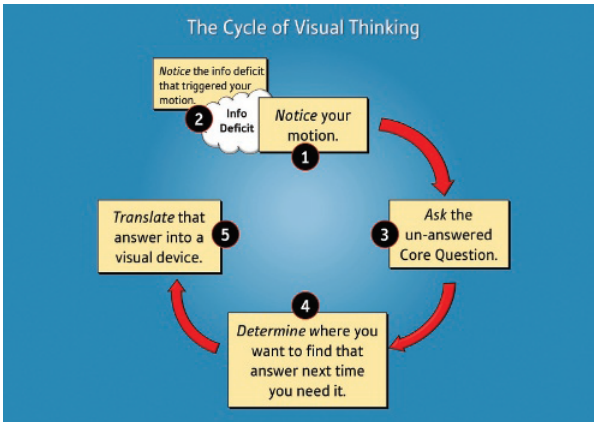


Figure 1: The Cycle of Visual Thinking [3]

10 Steps to implement Visual Management

According to the author [3] to achieve a Visual Enterprise, where visual management is applied transversally within the organization, there are 10 steps to take:

1. **Visual Order**: Establish the Japanese methodology of 5S, a technique of visual housekeeping in the shopfloor, in order to reduce the waste and enhance performance.

2. **Visual Standards**: Establish Standard operation Procedures(SOP) to minimize error.
3. **Visual Displays**: Show and Share of information to avoid stops in operation or unnecessary movement.
4. **Visual Leadership**: Devices that help the leadership with the strategy and control decision making process.
5. **Visual Controls** Tools and techniques to help the user. Shadow boards and kanban systems are examples of this.
6. **Visual Guarantees**: Devices that prevent errors, such as poka-yoke.
7. **Visual Machine**: Mechanisms that promote machine-worker interaction.
8. **Visual Lean Office**: Establish the office as a lean place.
9. **Visual Macro Environment**: Expand the previous steps through the organization.
10. **Visual Enterprise**: Assure the implementation of the 9 steps prior and the robustness of the solutions achieved.

2.3. Lean in the MRO aviation industry

Characteristics of MRO industry

According to the author [13] there are 4 characteristics of interest when studying lean application in the MRO industry. They are:

1. Demand variability: There is inherent variability in the MRO branch. Its possible to schedule preventive maintenance and/or inspections, although sometimes the need for repairs may occur outside the planned range.
2. Uncertainty in work: Due to the nature of repairing, the real scope of the task is determined during the repair process. If the type of task is not found documented with work instructions, it might lead to a trial and error methodology.
3. Uncertainty in the supply of materials: Due to demand variability, the suppliers of materials are also affected. Since The demand for materials is low, suppliers do not maintain inventories, which often results in long waiting times.
4. Cannibalization of components: Cannibalization is the practice of removing components from other aircrafts, which are in usable state, and utilize them to meet the need. This practice usually occurs due to the urgent need for one component.

Limitations

The stochastic nature of the MRO is fundamentally different from a conventional production environment. The biggest challenge faced by the MRO industry is the successful implementation of lean within the global context of the company. According to a 2016 survey done by the author [14], despite the usage of the tools and techniques, the implementation of the lean philosophy fails on the organizational level. The focus of lean application in the MRO industry has been more on the production side and less on the organizational and service factor of companies.

Conclusions

According to the literature consulted, it was concluded that lean has been applied in the aeronautical industry of MRO., However, its application has been focused on tools, while neglecting the management philosophy behind the creation of the tools themselves. The authors consulted referred to the lack of specific literature for the application of lean in MRO context, which motivates its adaptation made by organizations in a methodology of trial and error and continuous improvement [14][13][12].

3. Case study

3.1. Process flow at Avionics department

The figure 2 shows the process flow of a avionic component, since leaving the client until returning.

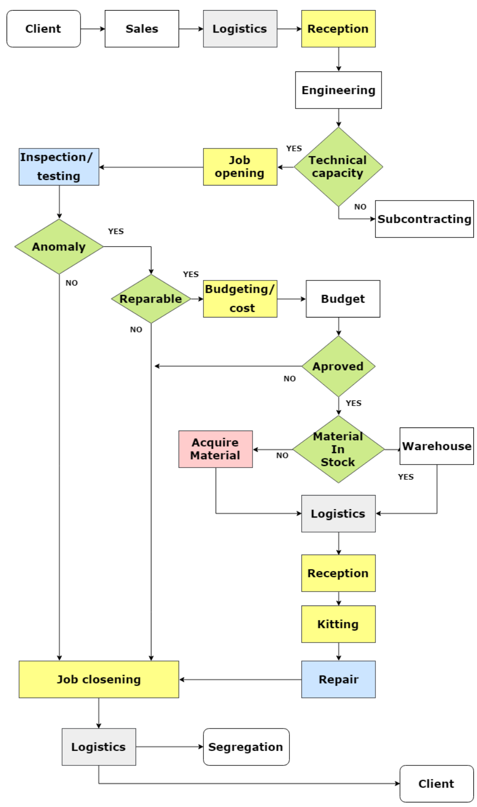


Figure 2: Flux of a product in the avionics shop

Definitions:

Turn around Time(TAT): Time between production milestones.

Overall Time Delivery(OTD): Time required to complete the maintenance process.

The maintenance process milestones are the following :

TC: The component is physically in the shop. Planing department defines works, creates tasks, opens the project and prints the work cards.
T01*: Beginning of an inspection or testing by the production department.
T01: End of the inspection or testing by the production department.
T1: End of budgeting and cost phase. The decision passes to the customer who must decide whether or not to approve the budget.
Tclient: Customer approves the budget.
TK: End of the kitting process. The component is delivered to production by the planning department.
T2*: Beginning of the repair.
T2: Repair is complete with guides, packaging and the annexation of the certificate of conformity. Closing of the job.

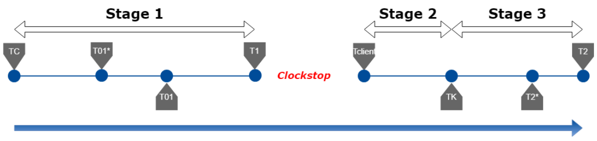


Figure 3: Maintenance timeline

3.2. Visual Managment at the avionics shop

In the avionics shopfloor, the principles of **Visual Order** are implemented through the work stations. They are also **Visual Standards** applied in the form of SOP(Standard Operations Procedures) for machinery, processes and tools. **Visual Displays** can be observed in the form of a white briefing board. For the management, a **Visual Leadership** tool is implemented, in the form of an Excel sheet, to allow controlling of the projects. Lastly, we can see **Visual Controls** in the form of shadow boards for the shops tools.

3.3. SIGMA (ERP system)

It refers to the software used to manage day-to-day activities, such as accounting, human resources, logistics, production management, etc. These systems allow the exchange of information between multiple sources, and transversally within a company, which facilitates communication between departments. They also eliminate data duplication and provide data integrity in a "single source of truth." In the company there is a system like this called SIGMA.

4. Methodology

Firstly, a **state of the art revision** was conducted, on the concepts of lean, specifically on visual management. Since the internship was conducted in an aeronautic company of MRO, additional research on the characteristics of lean in this industry was conducted. Following the research, the objectives of the internship and the subsequent dissertation were defined. Afterwards, after defining the current status, an **analysis** of the system was made, in order to find causes for the wastes and the inefficiency detected in the system. With the **diagnosis** made, the next step was providing **solutions** to the problems found. Some of the solutions were approved for immediate **implementation** by the company, during the internship. The final stage of this methodology was to **monitor** the effectiveness of the solutions and, after reliability was assured, guarantee their **replication**.

5. Diagnostics

5.1. Components

At the avionics shop the variability of the components worked is very high. In order to advance in the diagnostics a representative component to de study need to be chosen. Since the military components are responsible for 95,6% of the work in the shop, this should be the type of component chosen. By analysing the records of production the most intervened component, that at the same time fails most time is OTD is the **Directional Gyroscope**. The OTD for this component is defined as 25 days.

5.2. System

As previously described, the production system is defined between TC and T2. By analyzing the system, we can classify it as a line operating in push production. Systems in which the movement of components is pushed between stages cause problems of overload and variability. During the duration of the internship, it was possible to identify problems of overload and variability in the system, which led to the accumulation of inventory between stages (WIP) and, in some cases, shortage of labour. The accumulation of inventory results in an increase in the OTD of the component, as well as in the intervention time in each productive stage. In figure 4, we can see a scheme of the production line working in pushed production with the accumulation of inventory, marked with a triangle, which occurs in all steps except those referring to the technician, because it can only work a component at a time.

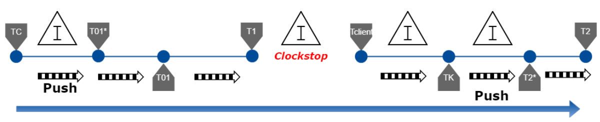


Figure 4: Systems oberved timeline

5.3. **TAT (Turn Around Time)**

Having selected a relevant component, the next step is the analysis of the compliance problems in TAT and OTD, raised in section 5.2. Data was collected from multiple departments including planning, production and materials in which the control unit used is the day. This measure unit is not ideal, as it makes it difficult to control the evolution of the process. However, it does not invalidate the present or future conclusions of this dissertation. Based on the data of 23 Gyroscopes projects and the observation of the inspection and repair proceedings in the shopfloor, we arrive at the following diagnosis of the production stages:

Stage 1(time between **TC** and **T1**)

- Motion waste during the activities of the team leader
- Lack of capacity
- Lack of prioritization of projects
- Unavailable EMP equipment to proceed with the task
- Incomplete use of the ERP system
- Errors in the production database and KPI value

Stage 2(time between **TClient** and **TK**)

- Shortage of material
- Uncertainty in material supply
- Incomplete use of the ERP system
- Errors in the production database
- Incorrect KPI value

Stage 3(time between **TK** and **T2**)

- Motion waste during repair activities by the technician
- Unavailable tools to proceed with the task
- Lack of capacity
- Lack of prioritization of projects
- Unavailable EMP equipment to proceed with the task
- Incomplete use of the ERP system
- Uncertainty in the work scope
- Rework
- Errors in the production data base and KPI value

Analysing the 23 projects in database we obtained the results of default of: Stage 1 52%; Stage 2 17%; Stage 3 91%; OTD 57%.

5.4. **Diagnostic of the Visual Managment Implemented in the shopfloor**

The Visual Order, should be improved since it has identified in the section 5.3 defaults of TAT that occurred due to the lack of an EMP in the shop. As for the Visual Standards they are in use in the tool of Standard Operating Procedure (SOP), however they should include not only technical procedures but repair information to assist unexperienced technician. The Visual Information Display is applied in the shop by means of a white board where performance, quality and other data are displayed. For Visual Leadership the team leader as a Excel sheet that provides a mean of controlling and take decision, base on the data. Although applied, there is a need for improvement in this leadership tool, since it fails to perform correctly. Visual control devices, such as shadowboxes, are applied to the shop, but need improvement. The others steps are not implemented.

After completing the analysis, the visual management was classified. For this the criteria of evaluation was: 0 points if the step is not implemented, 5 points if the step is implemented, but does not perform its function properly, 10 points if the step is implemented and only opportunities for improvement were found.

In the table 1 is a summarize diagnostic of the visual managmet implemented

Table 1: 10 steps diagnostic of the visual management implemented in the shopfloor

10 STEPS	Aplided [YES or NO]	Score [0 a 10]
Visual Order	YES	5
Visual Standards	YES	5
Visual Displays	YES	10
Visual Leadership	YES	5
Visual Controls	YES	5
Visual Guarantees	NO	0
Visual Machine	NO	0
Visual Office	NO	0
Visual Macro Environment	NO	0
Visual Enterprise	NO	0
SubTotal		30
Total		**100**

As we can see the score achived of 30, reflects the deficit in visual management observed.

5.5. Global analysis

When characterizing the system we can verify that the operation is taking place in push production it generates overload and imbalance problems in the system. As a consequence, the OTD deadline is often failed, most commonly in step 3 of maintenance line. When analysing the causes for noncompliance, we can assign them to 6 groups: Machine, Measure, Method, Matters and ERP System. Figure 5 represents an Ishikawa diagram with a total of 11 problems identified in the diagnosis.

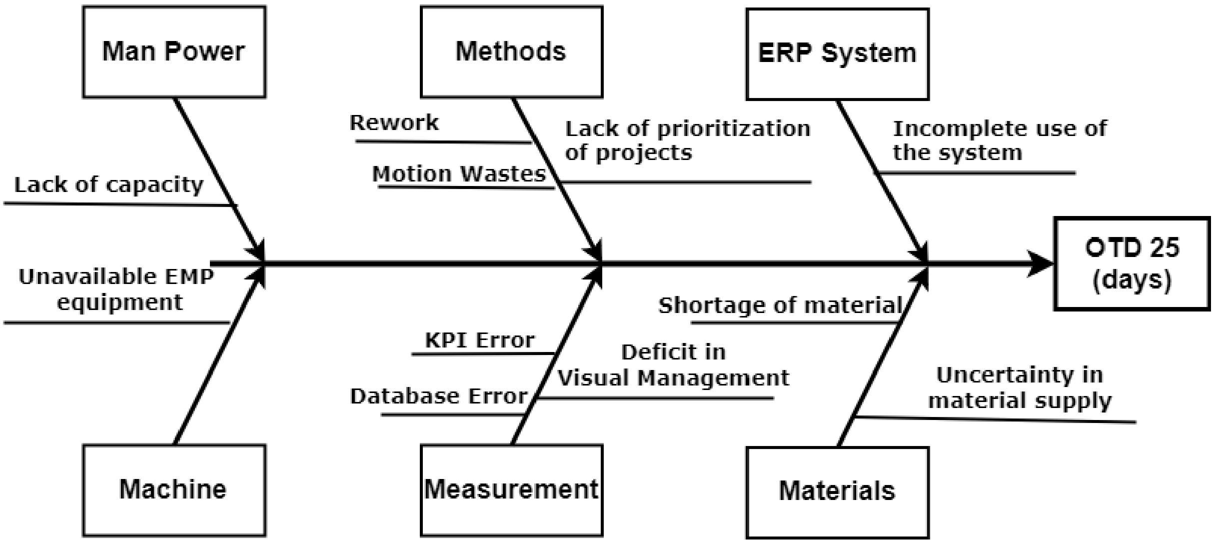


Figure 5: Ishikawa Diagram

6. Solutions

1. **New shoopfloor Layout**

   The aim of this solution is to reduce the waste of movement between tasks during stage 3 of the maintenance process. This will require a modification to the layout of the avionics shop inorder to minimize displacement during repairs. It was observed that during the repair the technician had to move several times to the bench where the press, bench drill and calibration test are located.

   In the repair project observed at the shopfloor it was estimated a 89m displacement during the repair, with this new configuration the same repair is estimated to have a displacement of 57m. A reduction of 36% due to incorporate the press into the clean room, and the bench drill and calibration test closer to the entrance of the same room.

   Benefits: This solution does not imply investment in new equipment or structural modifications to the shop.

   State: The proposed solution is awaiting future implementation by the company.

2. **New shadow boards to the tools**

   The aim of this solution is to eliminate the waste of movement and waiting time caused by by the lack of a tool that was registered during stage 3. The new shadow boards should have a background material of a primary colour (blue, yellow, red) contrasting with the tools support material. This solution allows the perception of a missing tool to be done quickly, avoiding motion waste, looking for the tool later in repair phase, as idle time looking for the tool in the current shadow board.

   State: The proposed solution is awaiting future implementation by the company

3. **Visual control for EMPs**

   The aim of this tool is to prevent the start of a project without the required equipment (EMP) available in the shop. That problem was registered during the diagnostics in stage 1 and 3.

   To prevent this from occurring a individual Kanban for EMP transport should be created. The Kanban should be placed in the shopfloor in a place of easy visualization by the team leader. Each Kanban should contain information on the associated EMP such as: name, number and date of last calibration.

   My suggestion of implementation is the following: The Kanban cards should be place in a board in the shoopflor.Eeach of the Kanban should be of green color. When you remove the Kanban from the board, authorizing the transport to quality department for recalibration, its place in the board (in red color background) will alert for the absent EMP. This solution implies an investment in the creation of the cards, cataloguing and registration of all EMPs present in the shop.

   State: The proposed solution is awaiting future implementation by the company.

4. **Tool for data input in Excel sheet**

   The aim of this solution is to provide the team leader with correct data in the visual leadership tool present at the shopfloor, to avoid decisions made from incorrect data. The Excel database was diagnose containing incorrect data and generating wrong KPIs in all stages of production

This new application should cover two key points: Direct import of data from SIGMA system and error prevention mechanisms. The direct importation of data prevents the human error in the manual introduction of data. As for the errors, poka-yoke devices should prevent mistakes and invalid data. If errors are found in the data, two types of poke-yoke can be activated: control(if the user is prevented from moving forward and entering incorrect data) and warning(if the user is warned for missing data). The introduction of data occurs in the several milestones of production, so this tool should also let introduction of data throughout all stages.

A suggestion to implement the proposed solution is a form for introducing data. The implementation suggestion is made using the Excel capabilities of software, since Excel is already used to control projects currently in the shop.

Benefits:

As the implementation suggestion is made in the same software already in the shop, implementation and easier and without the cost of acquiring new software licenses.

State: The proposed solution was implemented during the intership in the company

5. **Development of TAT monitoring tool**

The aim of this solution is to provide support for the lack of prioritization in projects detected in stage 1 and 3. This can be achieved through a visual monitoring and alerting tool, for the TAT of a project along the maintenance timeline. The tool should discriminate the projects in three groups: within TAT deadline, at risk of TAT default and out of TAT deadline.

We can see in figure6 an implementation suggestion using Excel software capabilities. It was created a table that gather the projects registered in Excel leadership tool by TAT status within each milestone of production. Each project is classified as : <u>OK</u>: The project is within the set deadline of TAT(marked in green); <u>RISK</u>: The project is at risk of non-compliance with TAT,(marked in yellow); <u>NOK</u>: The project is outside the deadline of TAT(marked in red).

The application should alert the user for risk of non compliance with 2 days lead time, because was considered adequate to take preventive measures(urgent ordering of equipment, need for overtime, cannibalization of components) to meet the deadline, or in last case renegotiation with the client the date of delivery. The double-click on the cell of interest and the user is redirected to the Excel sheet containing more detailed information on these projects.

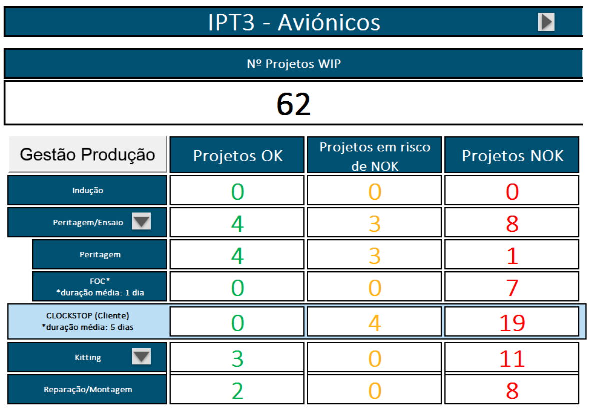
Benefits:

Since the implementation suggestion is made in the same software already in the shop, implementation is easy and without the cost of acquiring new software licenses. Another advantage is the possible interconnection with the Visual Leadership Excel tool already in the shop to access project data.

Disadvantages:

There is, however, a limitation to this table it is dependent on the discipline of introducing the data from all the departments.

State: The proposed solution was implemented during the internship in the company. The company faced with the lack of prioritization, decided to create a queue management tool within SIGMA system. The proposed solution above will be part of this tool, with the prioritization criteria being improved with the introduction of other decision factors such as: manpower and machine availability and project duration.


IPT3 - Aviónicos

Nº Projetos WIP

62

Gestão Produção	Projetos OK	Projetos em risco de NOK	Projetos NOK
Indução	0	0	0
Peritagem/Ensaio	4	3	8
Peritagem	4	3	1
FOC* *duração média: 1 dia	0	0	7
CLOCKSTOP (Cliente) *duração média: 5 dias	0	4	19
Kitting	3	0	11
Reparação/Montagem	2	0	8

Figure 6: Diagrama de Ishikawa

6. **KPI for TAT monitoring**

The aim of this solution is to correct the deficit in visual management, more precisely in the step of visual leadership. By creating a KPI for monitoring the number of projects that fail TAT, and number of projects at risk of fail TAT, it provides the supervisor with a tool that allows the long-term analysis of performance trends.

As an implementation suggestion, the data provided by the TAT monitoring tool(figure 6) can be compiled to generate a KPI. This data collection should be sent them to the supervisor, before the daily meeting with the team leader of the avionics shop.

Benefits:

This solution takes advantage of existing software in the shop, and encourages updating discipline of data and assertiveness. It also allows long term scope for the supervisor.

State: The proposed solution was implemented during the study in the company.

7. **Application for production control in the ERP system**

   The aim of this solution is to fully use the capabilities of the ERP system, since it was diagnosed during all stages of production the incomplete use of this tool.

   The application to be developed should allow the production department to feed the data of current projects directly to the SIGMA system. This solution should allow the department to access, provide and manage is projects in tool inside the ERP system.

   As an implementation suggestion, the application in SIGMA should mimic the functions of the current Excel sheet in the shop. It should also be integrated the solutions mentioned earlier in this chapter such as: data input tool, TAT monitoring tool and KPI. Integration allows the department autonomy in relation to other departments, as well as production data would be available to other departments.

   Benefits:

   This solution allows the flow of information across the enterprise and eliminates the duplication of data.

   Disadvantages:

   This solution implies an investment in the ERP system, to create a tool. Since the current resources are scarce at the company applications department, subcontracting may be a option.

   State: The proposed solution is awaiting future implementation by the company.

6.1. Impact of implemented Solutions

Reevaluation on the visual management

After the implementation of the solutions regarding visual management, and with the same rules that in the section 5.4, the new diagnostics brings a score of 60 in 100 since the steps in visual order,visual leadership an visual controls where improved.

KPI for TAT monitoring

After implementation of the suggestion provided, the supervisor started receiving KPI data via email prior to the daily meeting with the team leaders. Later this KPI was added in the whiteboard KPI dashboard of the supervisor(the daily meeting occurs in from of the whiteboard). This measure had a positive impact on the discipline and assertiveness of the team leaders updating the data and monitoring of the status of projects in WIP. We can see a general trend throughout the first month of implementation in the decrease of projects that failed TAT delivering date.

Replication of the implemented solutions

After verifying the robustness of the implemented solutions, they where replicates to other shops such as: electric, accessory and valves.

7. Conclusions

At the end of the internship it was possible to conclude that the production system of the line observed was classified as push production that caused overload and imbalance problems in the line. As a result, the OTD failed in 57% of a total of 23 projects studied. The following step was to decompose and analyse each of the stages of production and identify the waste and inefficiencies present. By doing that, it was possible to identify 11 causes of problems for the failed OTD. The following step was providing solutions to the 11 causes of problems discovered after the diagnosis was concluded.

After that, a diagnostic assessment was made, on the current state of visual management in the shopfloor. It made the flaws of the visual management present clear and scored 30 in a 100 evaluation. The diagnostics concluded there was a deficit in the current visual management installed.

The diagnostics concluded the need to provide the 7 following solutions: **New shopfloor layout**(it would reduce the waste in motion in a estimation of 36% during the repair stage), **New shadow boards to the tools**, **Visual control for EMPs, Tool for data input in Excel sheet, Development of a TAT monitoring tool**, **KPI for TAT monitoring** and **Application for production control in the ERP system**.

When presented with the solutions for the avionics shop, the company immediately approved some of the suggested application methods. After the implementation in August 2018, a tendency in decrease in the number of projects that default the TAT was observed in the avionics shop. This observation was made by analyzing the KPI graph during the month of August. As for the visual management, it was reevaluated after the implementation of the solutions and it scored 60 due to the improvements in visual order, standards, leadership and control.

The decrease of the projects that default the TAT also means a decrease in projects that failed the final OTD. It can be stated that, due to the implemented solutions, an increase in the efficiency was achieved by successfully eliminating wastes and problem sources. This results where achieve after improving the visual management present at the shopfloor.

Future work

- Global scope of the company OTD

  As a suggestion for future work, the factors that influence the OTD should be considered in a global company scale. That can strengthen the performance of the company, which will result in a better service to the client.

- Industry 4.0

  The concept is associated with promoting the computerization of production and productive systems, allowing the systems to establish communication between themselves and humans, across the value chain in real time [9].In the future the company should take steps implementing this concept, a example can be the substitution of the white boards where meetings occur for interactive devices that allow data updates in real time as a cloud computing device.

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