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# Visual management system to manage manufacturing resources

LP Steenkamp[a*], D Hagedorn-Hansen[b], GA Oosthuizen[c]

[a]Master student in Industrial Engineering Department, Stellenbosch Univeristy, Stellenbsoch,7600, South Africa
[b]Junior Lecturer at the Industrial Engineering Department, Stellenbosch Univeristy, Stellenbsoch,7600, South Africa
[c]Lecturer at the Industrial Engineering Department, Stellenbosch Univeristy, Stellenbsoch,7600, South Africa

**Abstract**

The next generation of manufacturing will be focused of utilizing lean tools within production industries. Internet of Things (IoT) has made its progress evolvement into the manufacturing industry and has led to improved control when implemented to monitor manufacturing resources. Smart production systems can integrate the virtual and physical worlds and accomplish improved transparency of production processes. These smart production systems will go beyond the traditional means of collaboration to move companies from good to great. In this study a visual management system was developed for resource management research for the Stellenbosch Technology Centre's Laboratory for Advanced Manufacturing (STC-LAM). This system gathers shop floor data and display it in a dashboard. Results and future work was also discussed.


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*Keywords:* Visual Management; Visual Tools; Resource Management; Smart Production Systems; OEE

## 1. Introduction

The future of manufacturing will be influenced by the attitude towards resource management. Maximum profit with minimum capital investment was generally accepted above the more modern approach of maximum value creation with minimum resource consumption [1][2][3]. Manufacturers of the future should, therefore, be focused on the consumer's needs and value creation niches within production [1][3][5][6]. As a result, industries can be forced

* Corresponding author. Tel.:+27721822008
*E-mail address:* 16051505@sun.ac.za


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to have shorter innovation cycles and complex production processes [7]. The importance of this new attitude becomes evident with the emerging popularity of social manufacturing. This new trend in manufacturing which ties into the current production paradigm transformation can be observed in Figure 1 [1][2]. Social manufacturing will be the driving force for the customisation and personalization of products according to the paradigm and in doing so become a smart service for customers [5][6].

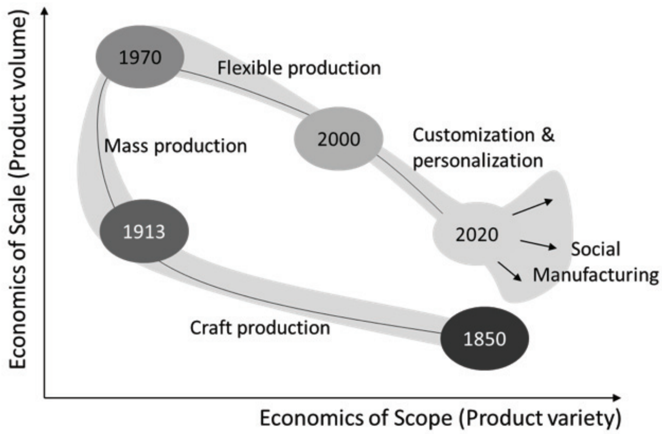


Figure 1: Production Paradigm Transformation [1][2]

In order to adapt to this new paradigm, new visual management systems need to be incorporated into production processes. This can help to promote improved control and performance within the complexity of the new production environment [7][10]. A system of its kind can include, amongst others, a virtual counterpart of a workshop which would generate work packages, schedule them, and track the progress of execution. A visual management system can be implemented within a smart production system environment focused on increased production efficiency and cost reduction. Conversely, it can be implemented on, and customised to, each level of management within a production enterprise. In essence, this system can gather information from multiple sources and use intelligent processing techniques, based on historical operations and future projects, to generate smart resource management scheduling.

To accomplish this feat, a visual management tool unique to a manufacturing process, is necessary. This visual management system must incorporate the entirety of the manufacturing process to promote transparency throughout the company [6][11]. It would serve two purposes. Firstly, it would serve as an access point to collaboration and smart services, where clients, managers or other factories can share resources and secondly, it can be used to enhance resource management techniques through the use of digital visual management tools [10][14].

Therefore, a study into the the implementation methodology of a visual management system will be explored within a production enterprise. This visual management system can significantly help with the business's growth, but for the tool to be implemented correctly, the data gathering scope has to accommodate all the possible activities of the production systems [13][14].

## 2. Literature Study

### *2.1. Manufacturing in South Africa*

Manufacturing, mining and agriculture represent the main industries in South Africa, with manufacturing contributing to approximately 17% of the GDP [15][16]. While the manufacturing industry shows growth potential, the low skill level of workers, and the unreliable electricity supply will eventually make this service become less economical in the future [5][15][17]. The lack of proper management and unsystematic approach within South Africa's manufacturing industries is resulting in products being delivered to clients with a delay [18][19][20]. In a comparison study of South Africa and Germany's manufacturing industry the following was clear: the labour productivity of Germany is nearly three times higher than that of South Africa, but personnel costs are 50% lower within the same comparison [21]. This correlates with the above mentioned, that although South Africa has relatively inexpensive labour, their effectiveness is three times lower than that of Germany's, due to low skill level and lack of experience of the workers [21][22].

## 2.2. Visual Management tools

Visual Management is a management system that attempts to improve performance of an organisation by means of visual stimuli [23][24]. These visual stimuli communicate important information of the organisation at a glance, helping to convey relevant, easy to understand information in context. This management approach relies on the acting on information presented to achieve organisational process transparency [6][25][26][42][53][56]. Manual visual management tools have formed part of industrial information representation: showing schedules, project layout, priority classification, and job deconstructions [23]. But to keep up with modernisation of the industry, we are now moving into an ever increasing digital age where the information collection comes from multiple and heterogeneous sources [11][27]. This information therefore can thus be presented more effectively on digital visual management tools with millisecond refresh rates.

An Example of a visual management tool for resource management is the Haldan MES system which collects Overall Equipment Effectiveness (OEE) data in the factory in order to display relevant and valuable information to the different levels in the enterprise [28]. An example of the visual tool can be observed in Figure 2 below. Haldan MES was initially tested in an automotive part manufacturer called Hansens Engineering [29]. During the testing phase several changes in the company were observed. These changes were: (i) less meetings were needed between the management levels in order to effectively communicate company performance and problems within the company, (ii) shop floor staff were motivated through the constant display of their machine's real-time OEE statistics (Shop floor awareness), (iii) problems within the company structure were promptly revealed through the real-time reports, (iv) strategic and informed decisions for long term investments can be made with the aid of the visual management reports, (v) machine operators and shop floor managers could be held fully accountable when the OEE was not up to standard [28].

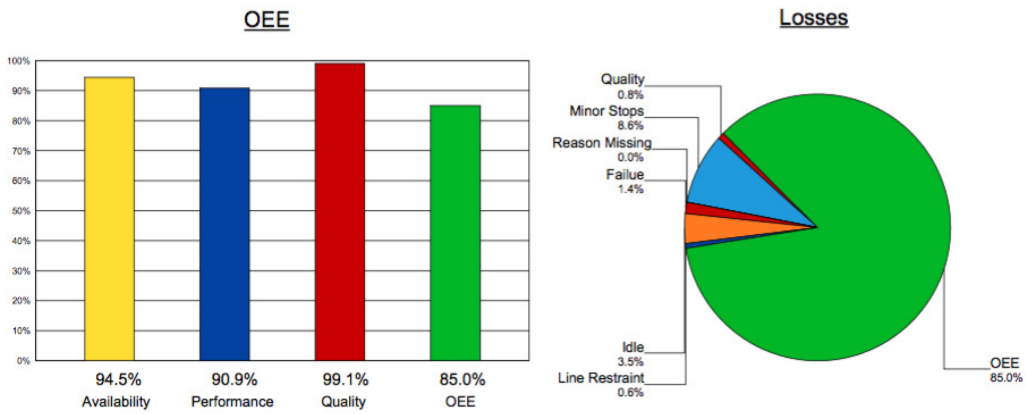


Figure 2: OEE Visual Management Charts from Haldan MES software

## 3. Implementation Framework

### *3.1. Current Automation Pyramid Production IT Architecture*

During recent years, industrial automation witnessed the trends where machine-to-machine communication, machine learning, Internet of Things (IoT) and basic levels of artificial intelligence were introduced within the enterprise operations [13][14][30]. The automation pyramid architecture was then developed to comply with IoT technology and to show how the levels of management can interact with each other [13][14][31]. Figure 3 provides a breakdown of the automation pyramid with its levels of management namely Enterprise Resource Planning (ERP), Manufacturing Execution System (MES), and device or shop floor level. The automation pyramid and an example of how gathered data flows up with processing, becomes valuable information that promotes improved decision making and resource management [3][14][31][23].

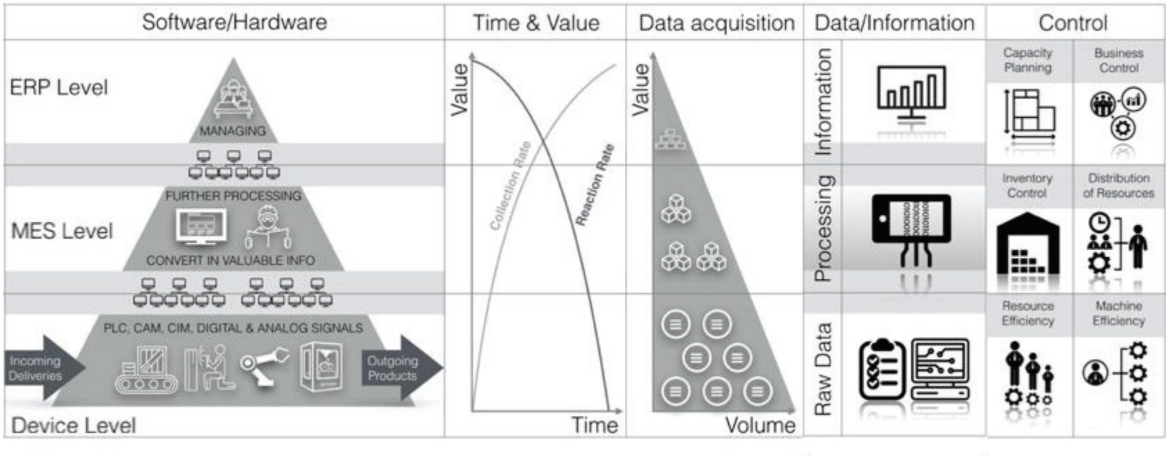


Figure 3: Automation pyramid with visual management tools elements

Figure 3 compares the amount of data gathered by each level to the reaction rate achievable on the processed information. The graph suggests that the faster the information on a low level is processed, the faster a response can be implemented for improvement adjustments. Due to this relation between the response rate and the amount of processed information, a suggested hypothesis can be made that if a correctly implemented visual management system can be achieved, it can significantly improve efficient resource allocation planning and scheduling [30]. This visual management system can significantly help with the business's growth, but for the tool to be implemented correctly, the data gathering scope has to accommodate all the possible activities of the production systems.

### *3.2. Visual Management System Implementation Framework*

To add perspective to the improvement of the automation pyramid architecture, examples of information gathering, processing with the addition of visual tools will be added. The use of visual management tools per level of the automation pyramid is an exemplary model that displayed where scheduling and control functions can be implemented in corresponding system elements. The data collecting devices are displayed, on the left of Figure 3, that grows progressively into informative information that can be incorporated for scheduling purposes. Over on the control side, right side of Figure 3, the information is extended to a visual management system that can display current tracking and future activities and therefore promote improved resource management [23].

Through a process of analysis, process mapping, processing and categorising of incoming data, the resulted information generated can display manufacturing KPIs. The generated information can then be stored in a database to help with future decision making processes by comparing current activities to historic ones. According to Lee et al (2014), the visual management tools would be capable of receiving data and information, generate smart predictive information that would help with transparency and productivity [11]. Therefore, a study was conducted to determine the readiness of the technology and implemented within a South African context using open source, online software.

## 4. Case Study

### *4.1. Introduction*

The Department of Industrial Engineering at Stellenbosch University has many services that it offers through projects such as the Institute for Advanced Tooling (IAT) and the Rapid Product Development laboratory (RPD) to university students, industry and other institutions. Stellenbosch Technology Centre's Laboratory for Advanced Manufacturing (STC-LAM) was formed when the decision was made to incorporate internal and external projects as to make the laboratory a centre that would provide the opportunity to create research opportunities around manufacturing and provide multiple projects where data could be collected. The STC-LAM is an institution that now provides excellent quality products in small quantities with high precision machinery. This institution was therefore chosen as a case study to demonstrate a visual management system that focus of implementing Lean tools and resource management within the production process.

### *4.2. Developed Visual Management System for Resource Management*

The methodology to develop a visual management system firmly consists of collecting data, processing the data and then making decisions based on the information that was compared to historic trends. Thus a digital data input point had to be developed to accomplish these tasks. The collection of data was achieved by utilising an online application generating online program AppSheet [32]. The application was a simple project number generating app, where the information about the project can be entered in by the client and then stored in an online spreadsheet to be used by the STC-LAM to be edited and updated by the project manager. The application screenshots, Figure 4, shows online project adding application used for data capturing.

The stored information was then processed before a visual management system can be incorporated to represent the generated information and Google Sheets was used for this purpose [33]. Google Sheets provides an online spreadsheet that can be published to the web. Providing a platform where multiple data collecting devices can collaborate on one or multiple spreadsheets and add data to the sheets in real-time to be processed and stored. An exert of the page can be viewed in Figure 4. These combined functions can improve the collaborate of IoT devices and heterogeneous data collecting sources. This function therefore can promote enhanced definition of operations within the production enterprise. The published data can then be used in creating a visual management system as seen in Figure 4, where a dashboard, created on Freeboard.io, is displayed [34]. This serves as a proof of concept as proposed by Lee et al of functional information displaying [11].


Figure 4: Visual Management Tool in Stellenbosch Technology Centre's Laboratory for Advance Manufacturing (STC-LAM)

*4.3. Results*

The main objective of the dashboard was to display important manufacturing KPI's collectively. To improve on the dashboard's functionality, the dashboard had to be easily accessible, fast reacting and display the KPI's in a fashion that is quick and easy to comprehend. Freeboard was a powerful tool and achieved these elements with ease. It has multiple input methods and uses visualization techniques that is easily programmed to achieve colourful and eye catching displays.

The dashboard displays information regarding the power consumption of the shop floor, power consumption regarding all the machinery on the shop floor and the efficiency of the human resource management. The efficiencies were split and were represented in a line graph that shows previous, current and a target efficiency levels. The power consumption visualisation tool consists of gauges that stretches to the maximum amount of power in kW. The projects in progress are displayed showing their title, the date submitted, the estimated completion date and a sketch of the completed project. A progress gauge that indicates the completion percentage of the project can change colour as the level of completion reaches 100%.

This project adding tool was used to demonstrate proof of concept that forms part of a framework of online data adding tools that can revolutionise the resource management within a smart production system. Data collection and processing can enable enterprises to have higher levels of control over their production resources. These higher level of resource management control can have positive influences throughout the entirety of sub-sequential processes within the enterprise. The effect of time, cost, quality, and waste can each be influenced positively through the use of visual management tools by creating a more transparent and informative environment.

Future objectives will be to provide information that can link human resource that is responsible to a project completion progress, the client's name, contact details, and expected completion date. This information can then be linked to a project manager to improve the documentation and scheduling inside the enterprise. Future security should be upgraded to a more secure platform. The robustness of the online platforms should be tested. The collaboration of multiple applications will be added to the research for greater data collection within the production processes for more elaborate and accurate information visualisation system.

## 5. Conclusion

The implementation methodology of a visual management tool was explored. The use of visual management systems for improved resource management was discussed when incorporated into production enterprise that was simulated by the STC-LAM. A new visual management system was developed using open-source programs and information was displayed from the collected data. With the enabling vision of Lee et al (2014), a visual management system was developed which is capable of receiving data and by processing it, generate smart predictive information that would improve process transparency and productivity. The visual management tool was developed to show proof of concept and deployed within the STC-LAM. The tool used Appsheet to gather data, Google Sheets as the database and processing platform, and Freeboard to display the processed information. All these platforms being free, open-source, online tools. The online dashboard displayed important manufacturing KPI's collectively to improve transparency and productivity on the shop floor. This system focussed on the control and scheduling aspects within a manufacturing enterprise to enable better resource management and therefore overall management improvement through process transparency. Improved resource management regarding production processes was discussed along with future work.

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