DfMA and beyond - E+H´s next steps towards Excellence in DfMA

From a managed process to process management

by Dr. Volker Frey, E+H

Senior Strategy Consultant
@ Endress+Hauser Maulburg SE & Co. KG
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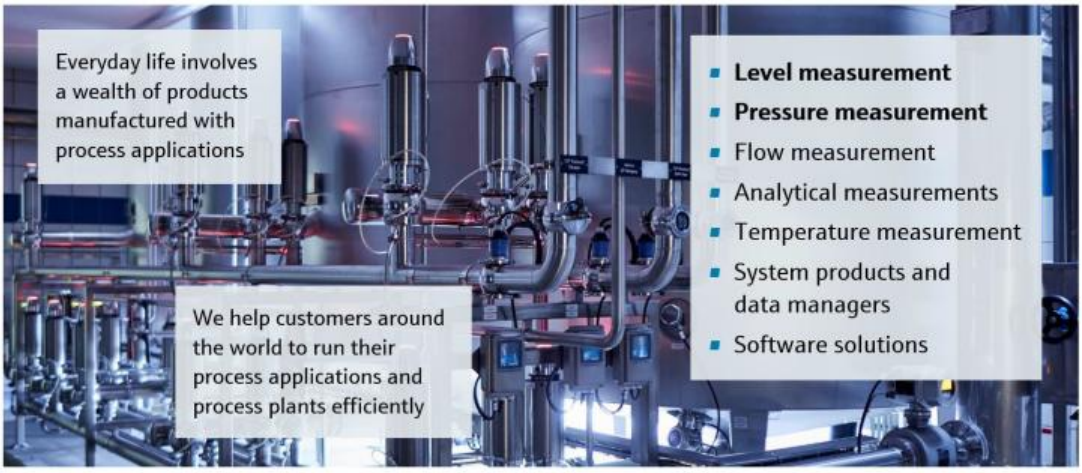
(www.linkedin.com/in/Dr-Volker-Frey)

Agenda:

1 Endress + Hauser in brief

Endress+Hauser is a global player located in each major industrial region. It is a private owned company developing and manufacturing sensors and solutions and providing services for the whole spectrum of Process Industries.

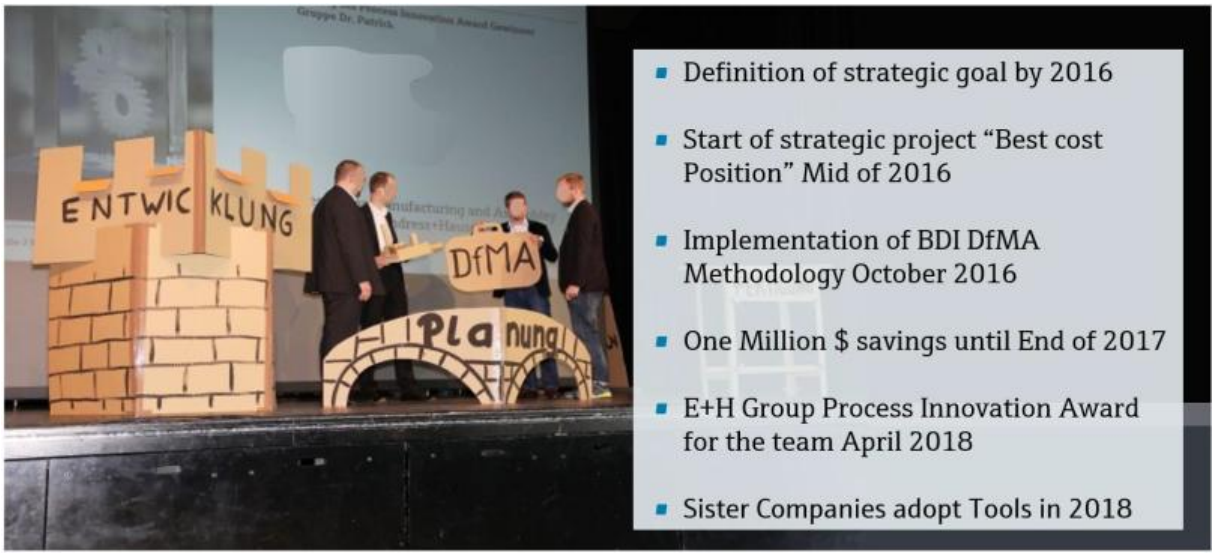


As a family company founded in 1953, we are today 14.000 associates generating a net sale of 2.5 billion € in 2018 with an equity of 70%.

We are an innovation driven company, with our major focus on developing new products which fulfil the needs of our customers perfectly and produce and deliver the Sensors customized by our customers in a very short time.

2 Motivation for further improvement

Operating in a global market, the competition is severe and the pressure on cost is omnipresent. Therefore one of our strategic goals is to achieve a best cost position with our products in the market. Here we decided to select DfMA as the strategic approach towards the fulfilment of our goals with tremendous success.



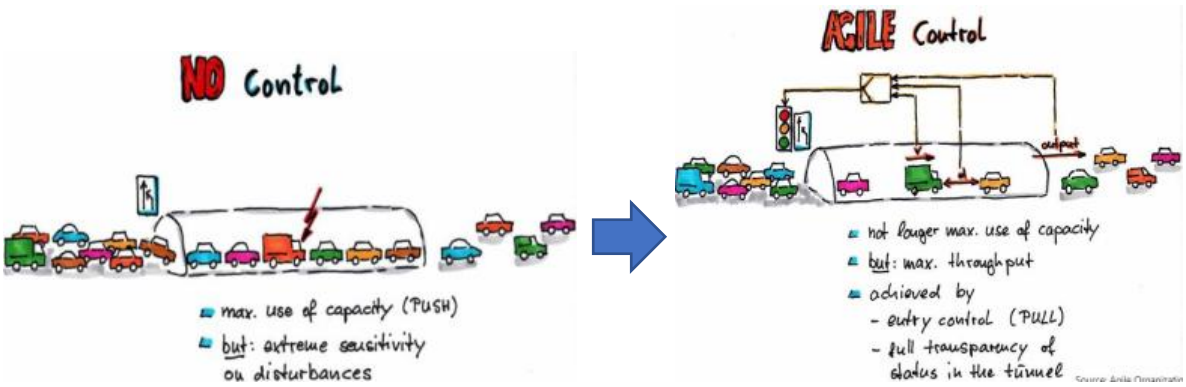
Last year I had the honor to report on our success in Cost Reduction by implementing DfMA into our organization (see report "The One Million Dollar Story - Our Endress+Hauser way to success with DfMA). We also won the "Process Innovation Award" of the year 2018 of Endress+Hauser and two of our three sister companies have already adopted DfMA as an embedded tool into their development process.

The success is ours, why should we change anything?

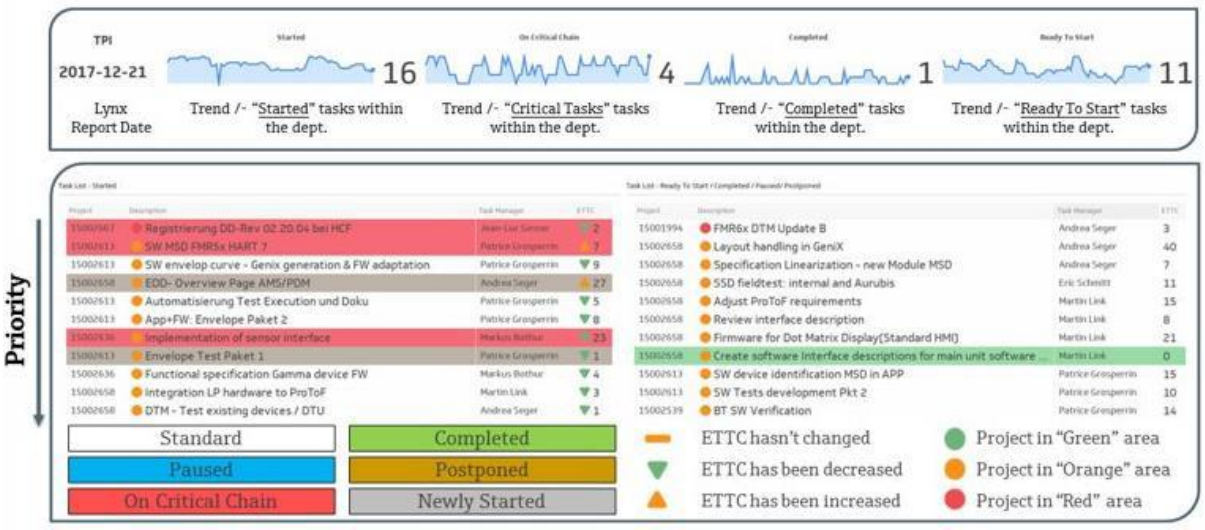
The year 2019 showed that the success was dependent on the commitment and care of only a view people. As soon as even only one team member changed position our initiative on DfMA was significantly weakened.

During the same time our company changed its operations method from functional management to process management and we implemented the critical chain project management (CCPM) to reduce our time to market with our development projects.

Our project execution is now based on the methodology of the critical chain according to the theory of constraints from Eli Goldratt described in his book “The Critical Chain” in 1997.



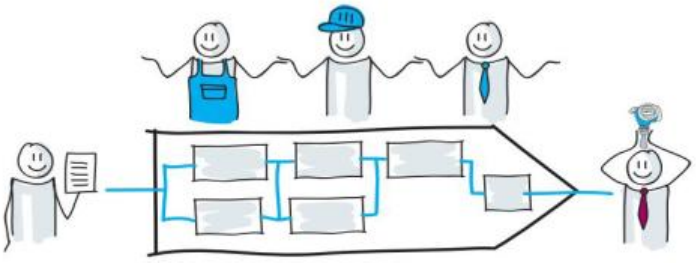
There was a significant reduction of the development time by cutting the project down into small tasks which could be assigned to a single resource needed for its fulfilment. Each task is then released to its resource as soon as the resource is available, and the task has the least impact on the buffer consumption in competition to the other running projects.



In consequence it was hard for DfMA Workshops to keep track with the accelerated process chain of the development projects. We had to adapt DfMA to the changing environment.

Our answer was the change from a managed process (by individuals) towards process management anchored in the development process flow. As a result, the responsibility for the DfMA was released from managers shoulders to the well-defined and documented process of the company. Instead of a leader who cares for the method, the process automatically pulls for the task.

With these objectives we started optimizing the DfA Process first. In a second step we created opportunities to optimize the DfM Workshops and finally we synchronized the DfMA process with the New Product Introduction Process.



3 DfA workshops – from managed processes to process management

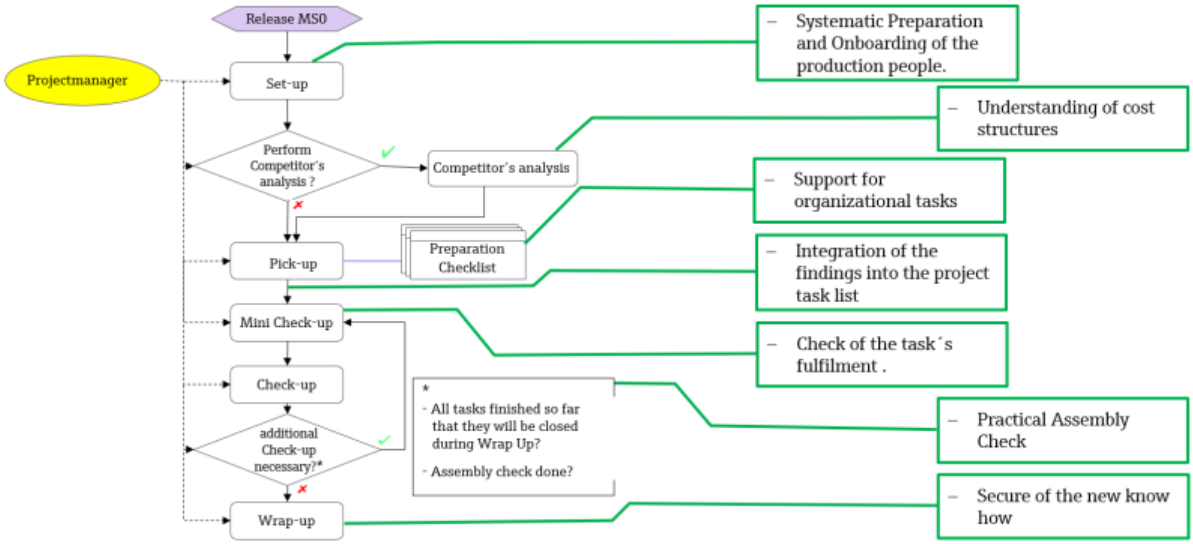
As a first step to improve DfA, we made a stakeholder and employee survey to detect several potentials out of which we picked seven topics which we intended to improve the installed DfMA process with.

Fields for improvement	Potentials
- DfMA Preparation - Tracking and synchronization of defined actions - Anchoring of the DfMA process to the business processes	- Earlier onboarding of the production people - competitors evaluation - Integration of our E+H-Process-Module „Montagefähigkeit“ into the DFMA - cross project utilization of the generated ideas

Individual & anchored → enduring higher value

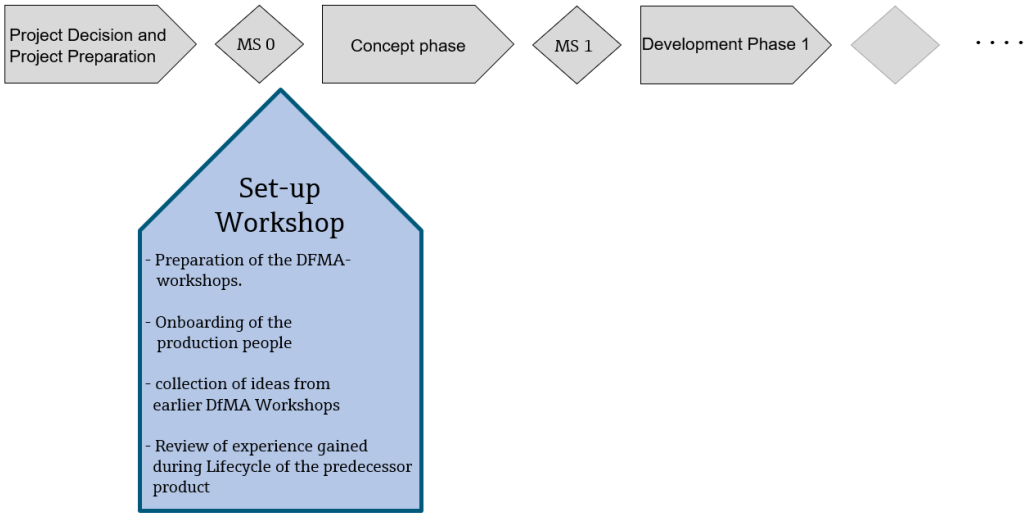
The findings for fields of improvement lead to the identification of improvements like earlier onboarding of the production people into development, the systematic utilization of competitors evaluations and the integration of already existing industrial engineering tools into the DFMA Process.

Based on these findings we created a new process flow for DfA and integrated it into the companies process flow charts, governing all the actions of the company. The following chart shows our newly defined process flow for DfA and in detail the improvements we worked out along the new structured workflow.



Our development process is guided by a series of checklists. We decided to add the relevant phases of the synchronized DfA process into these checklists which must be presented to the management board to fulfil a project Milestone. This is the guarantee that a DfMA is performed for each and every development project.

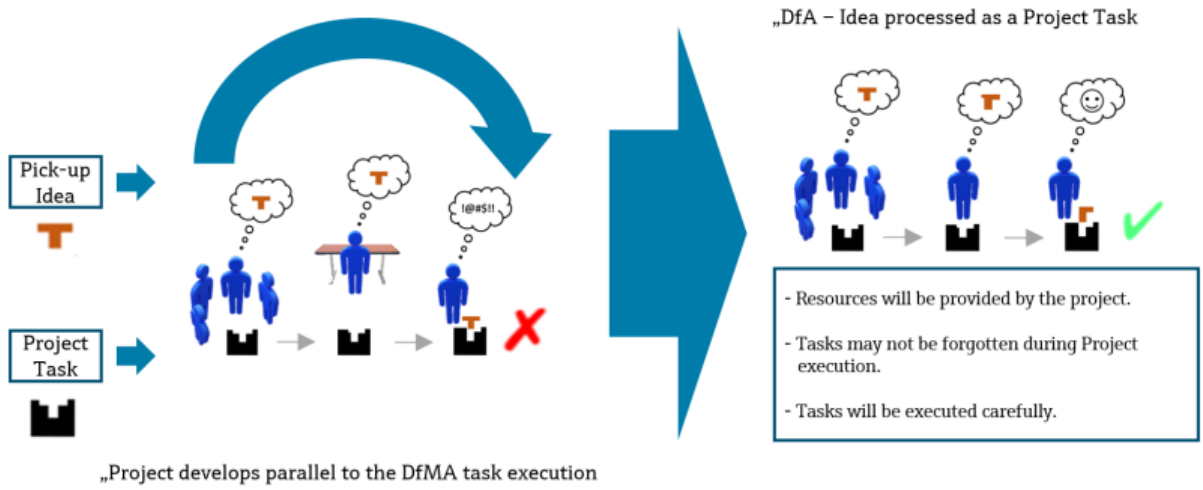
One of the cornerstones of or new process flow is the Set-up Workshop. It is to be done directly after a new project is released for executions and should be done before the concept phase starts.



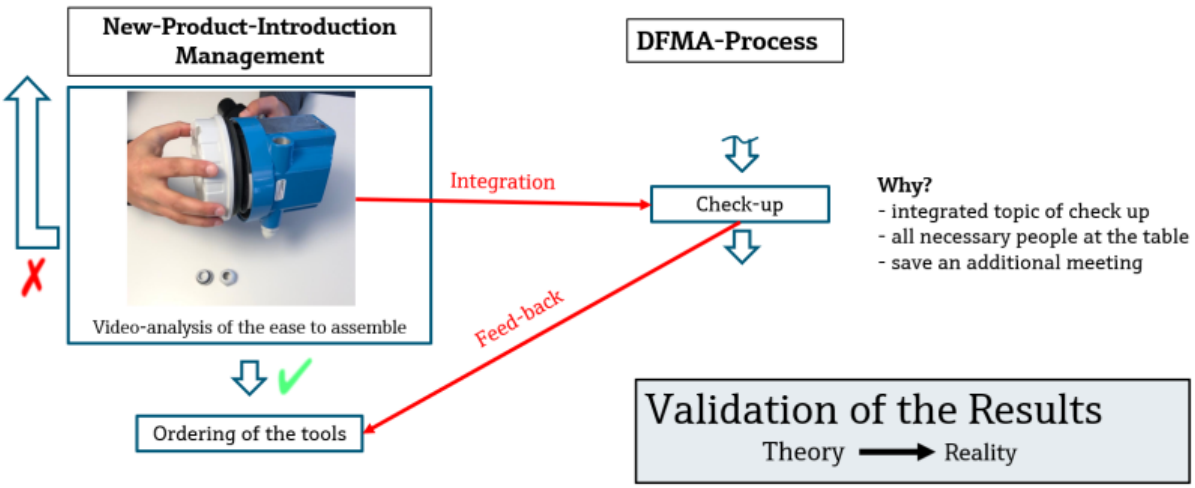
It´s objective is to prepare the DfMA Workshops, select and onboard the right people for the workshop, collect ideas from earlier DfMA workshops and review the existing information about the lifecycle of the predecessor product which we identified as a very worthful source of information.

One of the major weaknesses which we recognized during our first phase of DfMA operaton was the synchronizaion of tasks of the development process with the processing of new ideas out of the DfA workshops. Good ideas were tracked during the pick-up workshops in the DfMA process wheras the project proceeded with its tasks. As shown in the next picture left side, sometimes the basic assumptions of an idea were changed during the development process and the good ideas worked out during DfA processing didn´t fit into the product any more.

To solve this problem, we decided to integrate the idea execution and evaluation of DfA-ideas into the project as equivalent project-tasks performed synchronically in the project. This helped us to synchronize project progress and idea executions to a maximum and ensures the utilization of all ideas created during DfMA Workshops.



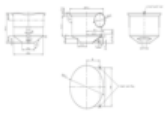
In the very final stage in the series of DfA workshops we integrated an already existing Industrial Engineering task into the DfA process and simultaneously transferred responsibility from the DfA Moderator to the Industrial Engineering. As a final evaluation step, we produce all the designed parts on stereolithographic 3D printers and with these parts we perform an assembly workshop to validate the results of our development and DfA before we order the tools for series production.



In the end of the DfA we end up with a set of good ideas which we decided not to implement into the new product out of several good reasons.

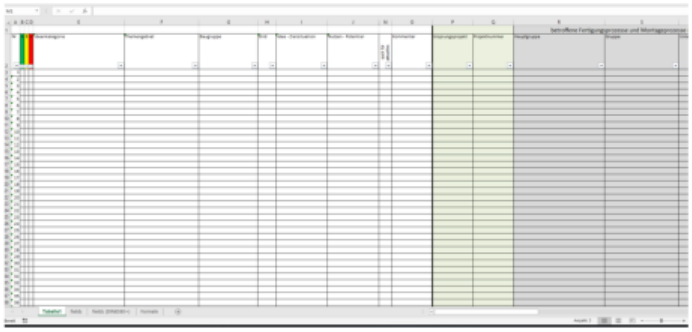
In most of the DfA you would just forget the good ideas probably forever. Here we decided to set up an Idea Database where we want to store the ideas. Just storing them is not enough. Nowadays in the area of AI and Machine learning you must label your data for retrieval reasons. Therefor we created a well-structured clustering scheme shown in the next pictures.

Review of the Workshop Results for new ideas:
- Identification of new ideas
- Idea evaluation
- Decisionn to store

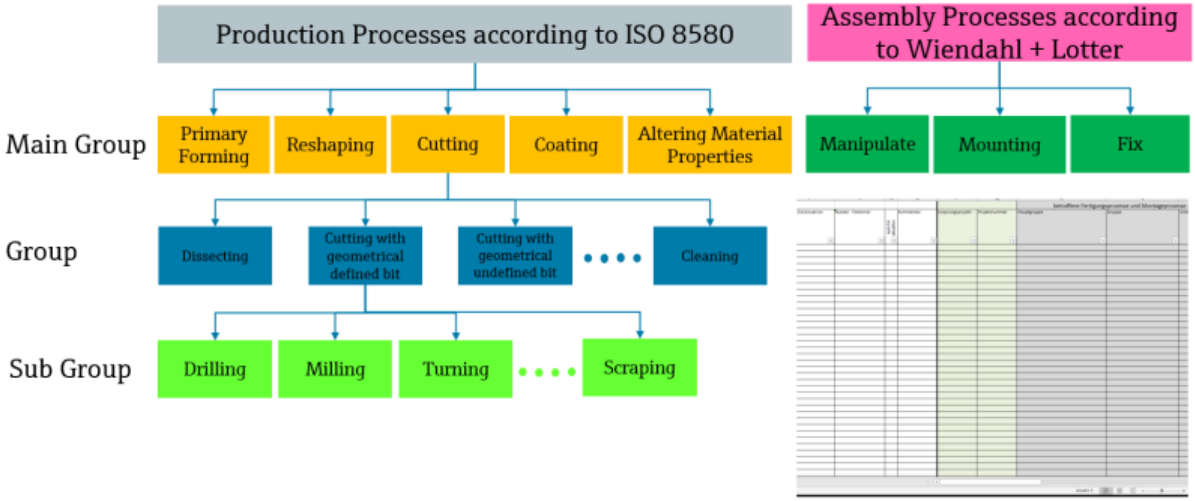


Clustering of the ideas:
- Origin of project
- Subject Area
- Subassembly
- Production & Assembly processes

Storage of the ideas:
- Structured Idea Store
- global access
- Retrieving of Ideas systematically



For the labelling of the production- and assembly processes we relied on existing ISO Standards and on the structuring of the major academic drivers on assembly in Germany Prof. Wiendahl and Prof. Lotter.



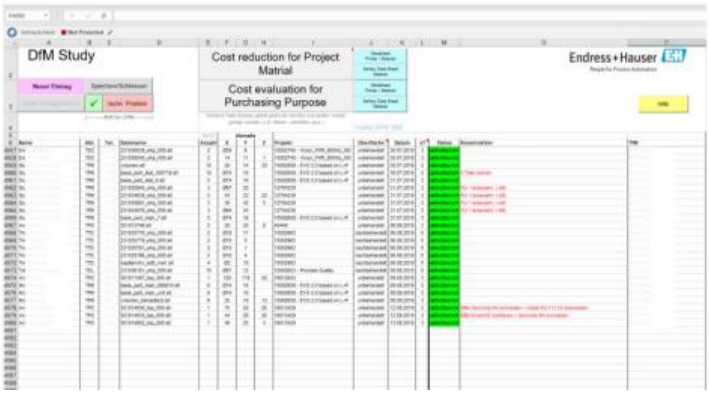
4 Integration and Automation of the DfM process

High focus was also laid on the DfM methodology. We trained 8 associates from production, development and procurement on the methodology. In the case of DfM studies we found several sources where requests for a study came from. The most important is the DfA workshop. However, many more requests for DfM evaluations come from procurement, whenever they want to change a supplier or prepare for annual negotiations. They appreciate the very detailed reports on cost drivers for their parts.

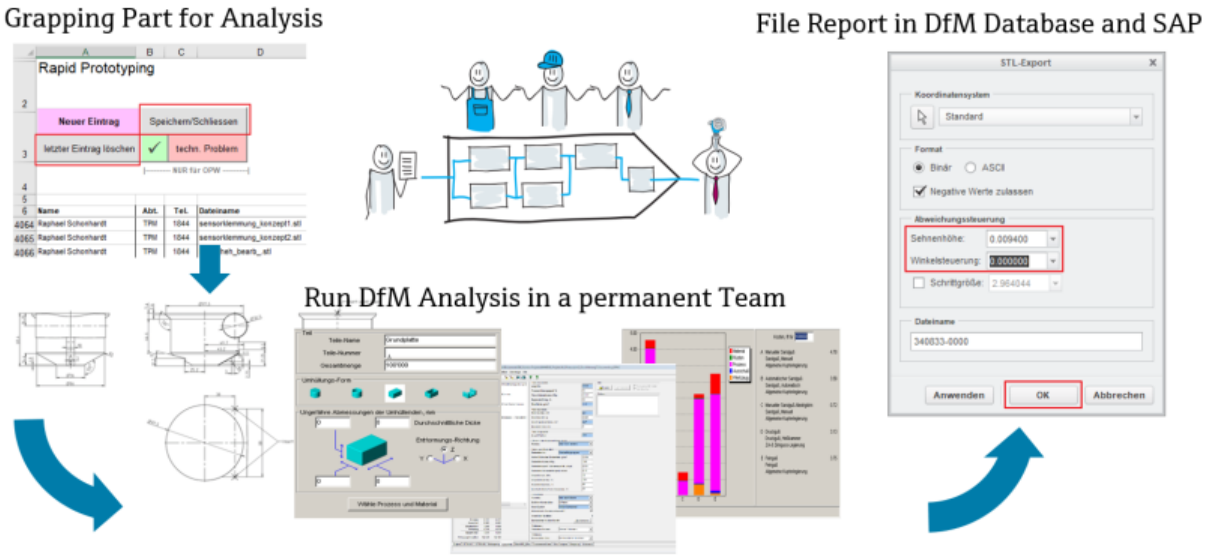
Also, our change management is a thankful customer of DfM studies whenever they must change a part for several reasons. Our approach to fulfil the requests was to implement weekly meetings of the DfM team.

To change from a manually managed process to process management, we are on our way to design work flows and negotiate with the departments to add these workflows in the company's business process management system.

To provide a structured and well-ordered input, we created a central order-table where the requestor can put his order in. Based on a checklist he must provide several predefined information which we identified as a necessary input to run a DfM study.



The coordinator of the team will then review the data and decide on a proposed date when the study will be finished. This is also documented in the central order-table as a part evaluation report too. All the results are stored in the central DfM database and can be picked by the requestor whenever he needs. With this method we can provide a valuable input for our colleagues from procurement and development in a well-organized process.



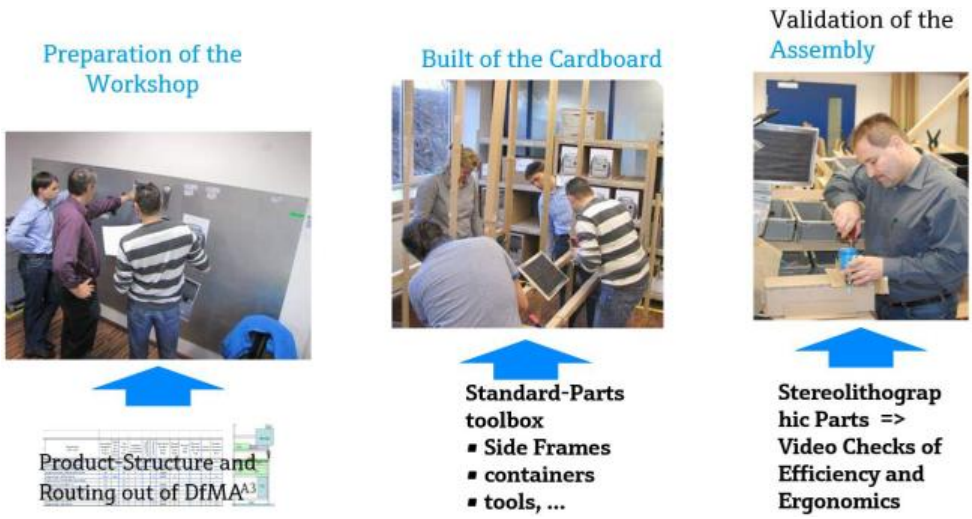
5 Improvement of the New Product Implementation Process by Tools resulting from DfMA

Once we have successfully preformed the DfMA workshops and studies, further important questions arise: How to design the production system based on the output of the DfMA and how does this fit to human abilities and ergonomics. To address this very important issue, we designed a set of tools and methodologies to help our industrial engineers in their daily work. It´s all about the further extension of methodologies towards the successful joining of product and production system.

As soon as the project has advanced that far that we have some detailed information on the projected assembly we are able to produce prototypes of all parts on our 3D polymer printers as the input of our DfA evaluation.

Meanwhile the industrial engineers made a concept for the production line. Together with the operators they built the projected line in our cardboard rooms.

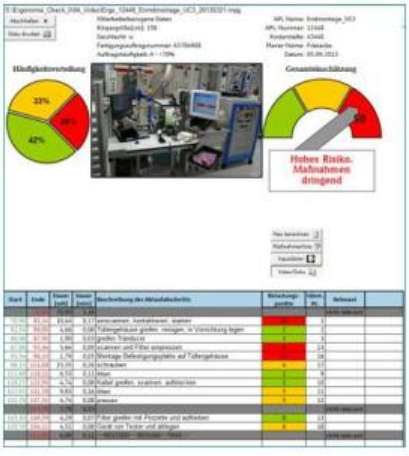
On this cardboard then we evaluate the product – production ecosystem according to several aspects.



First, we do an assembly check where we - in a last check - validate the results of the DfMA and the now synchronized development process to prove that theory and practice fit together.

As with our high number of variants we are not able to automate our assembly processes. The main handling is manually operated however the processes are fully automated. In this human centric assembly, we must make sure that our employees receive the best fit workplaces we can provide. To assure this we developed a semi-automated ergonomic check based on a video where we track the movements of our workers during the assembly of the products.

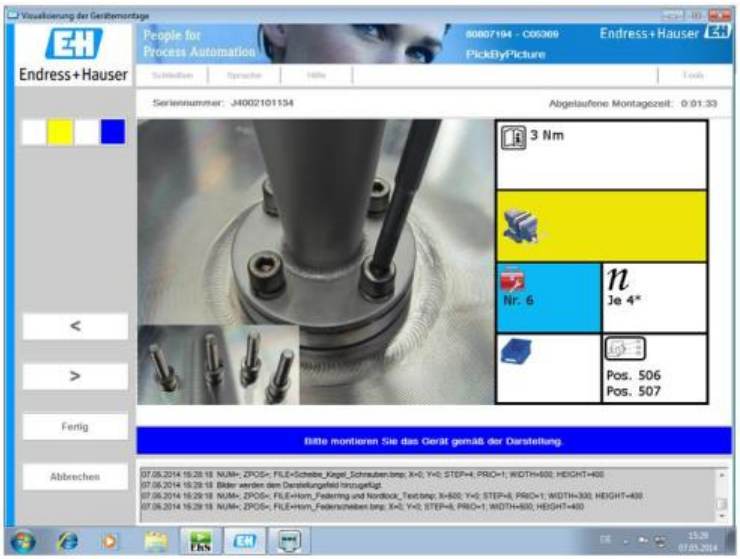
- Based on the automotive methodology EAWS
- Adapted to the needs of Video Analysis and to E+H
- Similar to DfA the movements of the people can be selected
- The tool evaluates the movements and calculates the stress factor for the people based on tracked parameters
- Measures can be attached directly to the process sections with the highest stress factors



Based on the standard EAWS-From V1.3.3 which was designed and used by the automotive industry we evaluate the movements registered and identified on the video and label them. The result of the

evaluation of each movement will then be summed up and it expresses the value of ergonomic design in a workstation. With the same tool we are also able to calculate the process times for our major variants offline and before we release them to the production.

Our high variance in the product lines (up to 33 million variants per product line) we need to help the operators with the assembly instructions. As we are a global company producing in many different countries, we have to provide the assembly instructions in different languages. Our approach here is an automated language neutral picture-based “work instruction next generation”. All necessary information is provided step by step as the workflow proceeds and is reported back as seen in the following picture.



6 Summary

With our approach we succeeded to implement DfA and DfM into the business process management environment of our company. This made the process more independent for individuals and builds the basic of an automated procedure which pulls for DfM and DfA rather than manager to watch and push.

With our extension of the idea of DfMA into the New Product Implementation Process where the new product joint into the production environment we could reduce the time to market furthermore and reduce the number of issues which come up in the early phase of the production lifetime of a new product.