Summary

Designing a Workspace to Limit Human Error When Torqueing

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VDL ETG is a tier-one-man-manufacturing company that does a lot of work for a big player in the semi-conductor industry. For a new machine of this company an illumination module had to be made. The design of this module is done by an optical equipment manufacturer and VDL ETG will assemble the module. Due to the increasing quality demands in the industry VDL ETG is urged to make no mistakes during assembly of these modules. Therefore VDL ETG invested in automatic torque wrenches of Atlas Copco to fasten the screws. This automatic torque wrench can measure whether a screw is fastened to specification and gives errors if this is not the case.
To use this automatic torque wrench a new workspace had to be designed. This workspace included both the physical (how to store and gather the torque wrenches and bit, how to incorporate a screen in the workspace) and the digital (a digital work instruction and database) environment. The goal of these workspaces was to limit the chance for human error.

The main question of this thesis is: *How should the workspace and software for screwing be designed to help the employees to work ergonomic and precise, while being in a clean room?*

According to the current research and the most accepted theories, humans are not to blame for the errors they make. Humans always try to do the best possible job with what information and tools they are given. The systems they work in enable these errors by faulty design. It can also be assumed that humans never make errors on purpose, they always try to do the best they can. This is called the local rationality principle (Dekker, 2006). Therefore to limit the chances for human errors, the system must give no chances for errors to occur.

To achieve this the current system used at VDL ETG for fastening screws was extensively analysed. First of all a Hierarchical Task Analysis (HTA) was made. Next of each step of this HTA the possible failure and errors were determined. These possible failures and errors were further analysed using a Fault Tree Analysis. Lastly all the previous information was bundled in one Failure Mode and Effects Analysis.
Based upon these analyses a few problems arose that needed solving in the final design. For both the torque wrenches as for the bits for the torque wrenches it should be very hard to pick the wrong one, or place one back in the wrong spot. Secondly, for the physical workspace, a way had to be designed to incorporate a screen in the workspace. For the digital workspace, a system had to be designed that showed the mechanics how to work while constantly checking what they do and giving error notifications if mistakes are made.

For the bit selection a pick-to-light system was deemed the most applicable. This is a system that lights up the correct bit, after which the mechanic can select it. Atlas Copco itself makes a system that has these functions (Atlas Copco bit selector), so this was proposed as the solution for this problem. VDL ETG however did not want to invest in this system on the short term, therefore a temporary solution was made were the bits are placed in a plastic holder. The type of bit will be engraved next to each bit.
To distinguish the torque wrenches colour coding will be used. All the torque wrenches will be placed on a plate, together with their bit holders. Each component will have a shadow of itself displayed on the plate, indicating the location of that component. Each torque wrench and bit holder combination will also have its own colour to distinguish them. The final concept for the front and the back of this plate can be found in figure 1 and figure 2.
The screen will be incorporated in the workspace by using a ridable cart with a laptop holder. In this cart the torque wrenches, bit holder and other tools can also be stored by the mechanic. The idea is that the mechanic will collect all the components he needs and place these in his cart. He can then start to work. A final drawing with all the functions of the cart labelled can be found in figure 3.

Finally the software system will display the work instruction for the mechanics and have a database in which all the data of all the frames can be found. The software will work together with the torque wrenches and the bit selector to check the mechanic for errors. If the mechanic makes an error the mechanic cannot continue in the work instruction until this error has been resolved.

Concluding, the proposed solutions will give VDL ETG a good beginning to eliminate human error during assembly in the new clean room. The proposed solutions are all still a bit rough, so each one will still need some extra work and some more testing. It will be especially important to test the concepts with the mechanics who are going to work with the designs.

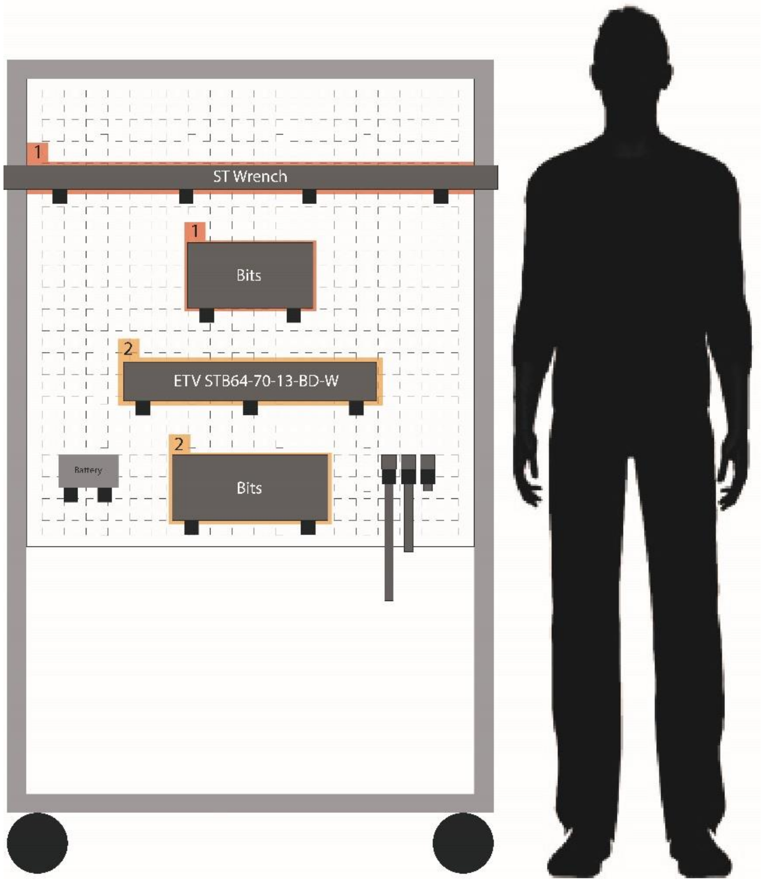

Figure 1 : Final concept torque wrench selection board, front side

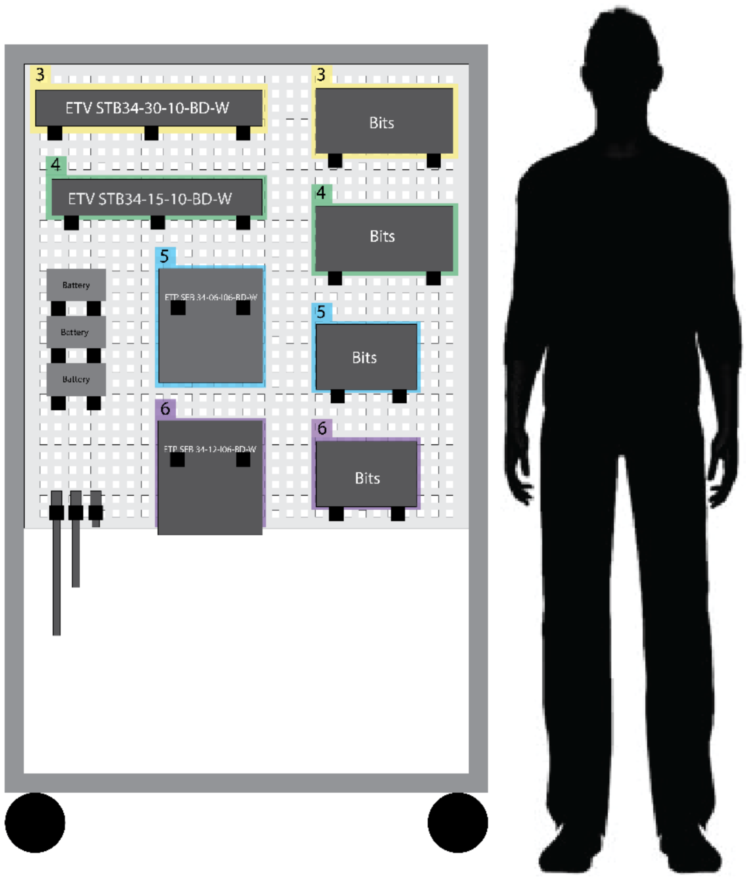

Figure 2 : Final concept torque wrench selection board, back side

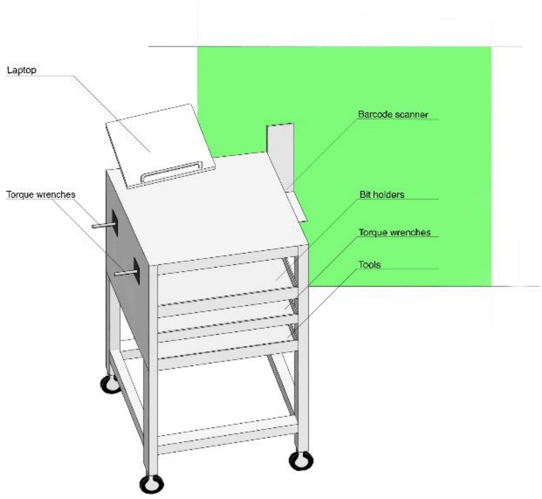

Figure 3: Final concept cart with functions