Abstract

This report is the official document to the research assignment that is done to give Terberg Benschop B.V. more insight in the possibilities to increase their production. The following steps are taken.
This research is started with the analysis of the current situation with the aid of a functional and quantitative analysis. After these analysis the possibilities for Terberg on the short term and medium term are explained. These possibilities are based on the attention points found with the two analysis of the current situation. The short term solution are options that can be implemented relatively easy. After the short term solutions are explained the attention shifts to the solution for the long term. This is done by filtering out a concept out of a complete range of possibilities. The filtering is done by using a Paired Comparison Analysis (PCA) to establish a main direction (group selection) and a Multi Criteria Analysis (MCA) to define the best concept in that group. The resulting concept is the setup of a production line in hall 4/5 (see figure 1) and this concept is explained in more detail. To conclude this research there is looked at the option of expansion of the production area.

The company was founded by Johannes Bernardus Terberg in 1869 in a little blacksmith. After the Second World War they started to customize army vehicles and this evolved the division in Benschop into a company with about 280 employees and a turnover of 110 million Euros. These days' tractors are being produced for use on airports and harbors. Trucks are developed for dirt transport. All this is done on the terrain showed in figure 1. It is expected that in the 4 years to come this number will grow to about 1500 vehicles/year. For the long term, the ultimate desired production in Benschop is 2000 vehicles/year.

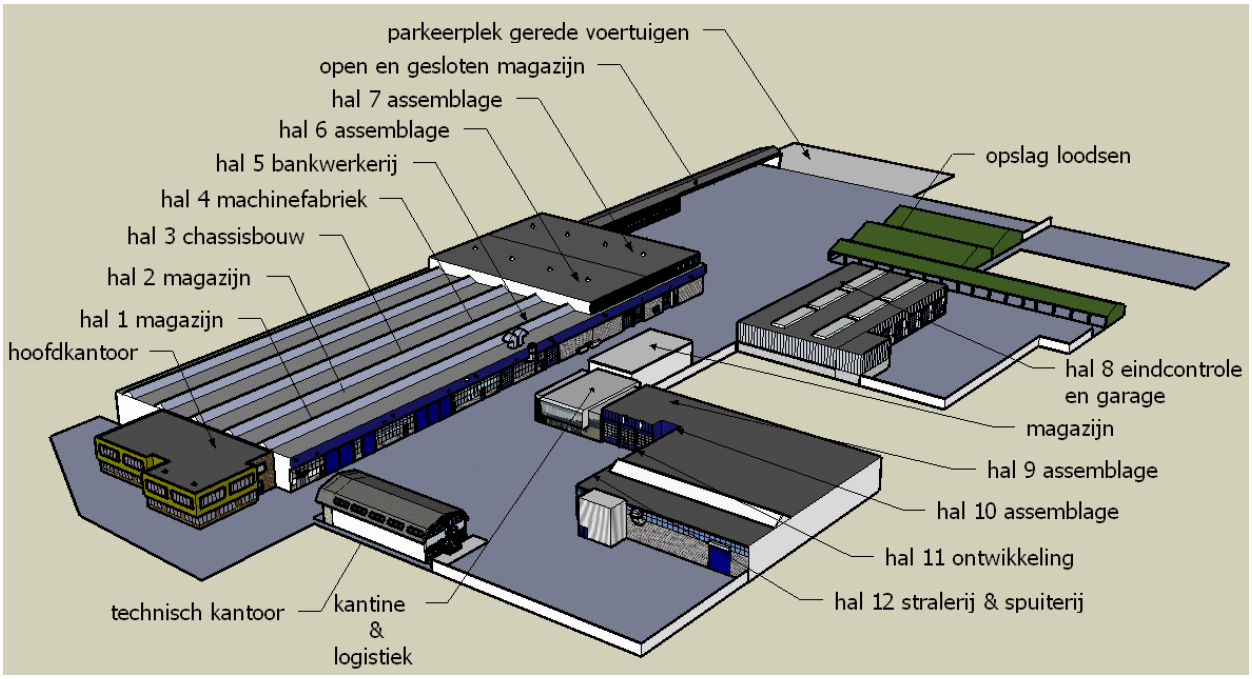

Figure 1 Overview of the Terberg production area in Benschop.

The current situation is evaluated with the use of both a functional and a quantitative analysis.
With the functional analysis is mapped out how the current production is done. This is done by zooming in to the details from a very general point of view of Terberg Benschop. The most general point of view is found by stating the main function of Terberg: "Producing special vehicles". By zooming in on this main function new function appear which have to fulfill that main function. This zooming in is done until the fourth level of detail. On this level, enough detail is found to point out different attention points.
The quantitative analysis is done to give a good insight in numbers like areas and how they are used, the number of people per assembly hall (hall 6/7 and 9/10, see figure 1) and the number of vehicles assembled in each hall.
Based on the two analyses, the following points of attention are formulated.

- There is no official planning function. Currently, orders are placed in the "bouwprogramma" or building program which serves as planning. Changes in orders can be made and discussed in the weekly meetings. This planning can be done better, quicker and more active.
- There are very limited options to give feedback. The control loops that are used tend to be very slow.

- To make quantitative decisions, the available information from the different information systems is not sufficiently used.
- To fulfill the main function “Producing special vehicles”, the function “Service and Maintenance” is not needed, but it is present on the terrain.
- The workload is considerable in comparison with the personnel capacity that is available.

When the points of attention are known, a short chapter is added to explain the different base principles that are available to increase production. This is done with the aid of an analogy with a water filled tube. This analogy is used in the rest of the report to clarify what principle is used in the solutions to increase production. The following three base principles are explained.
Option 1: Work faster or more efficient. This is the same as more water flowing through the tube (more work with the same capacity). Working faster can be achieved by using the time more effective. This way there is less waste of time and capacity.
Option 2: Add more capacity. This is the same as increasing the size of the tube so more water can go through. This can be done by attracting more personnel and/or create more workstations.
Option 3: Hire other companies. This is comparable by adding a second tube. Not al the work has to be done by Terberg, which can result in a total increase of work that can be done.

When it is clear what kind of different principle solutions are available, the different solutions for the short and medium term are introduced. These are the relatively easy solutions that can resolve a part of the problem. The different solutions are:

- *More personnel and training*
  By attracting new employees the workload on the current employees can be relieved. By dividing the load over more people, the load per person is lowered. Without adding new workstations, 10 new people can be placed. After these 10 people are added, the bottle-neck in capacity is not the number of people, but the number of workstations. New stations have to be created before new personnel can be added effectively. With these 10 new employees a production increase of approximately 18% is possible to a production of 1200 vehicles/year.
- *Introducing a short term planning*
  With the introduction of a short term planning, a clearly present planning function will be introduced in the company. With the aid of a good planning function, important details can be better controlled to improve and control the quality and time consumption. A short term planning can also help in the systematic and effective improvement of assembly times. The quality can be, even with increasing volumes, better secured and the people get more involved in the planning of the vehicles. This also improves the quality of the work. A short term planning can result in an improvement of approximately 30% which means a production of 1350 vehicles/year.
- *More pre-assembly*
  More pre-assembly is another way of saying there is a need of more capacity. Assembly personnel have no waiting times in which, for example, they have to wait until a machine is ready. They do not have time left which they can use for pre-assembly. This means that pre-assembly has to be done by other (new) employees. The advantage of more pre-assembly is the use of area. Pre-assembly stations are more compact which increases the work density of the halls. More work per square meter is favorable because of the lack of available space.
- *Improve communication*
  The communication between departments and phases (worksteps) can be improved. For now, the communication is sufficient, but when production increases the communication cannot be done the same way. It is possible to react on little mistakes in earlier steps, but this is not nearly as direct as it should be. Also, saving discussed information (in the right place) is an issue. By improving this area, de production and the quality of the products can be much better.

Beside these main improvements there is a small number of remaining improvements. Perhaps, these are less relevant for Terberg, but they are added to give a complete view into the possibilities. The remaining solutions are:

- *Make workstations of the buffer spaces. Buffers are storage places for the chassis in the assembly halls.*
- *Prevent the occurrence of error*
- *The total workload of the different vehicles should be more evenly distributed across phases*
- *Standardize parts and customer options where ever this is possible*

Beside the short term solutions there are 16 ideas that have relevance on the medium to long term. These ideas are found through interviews with people of all parts of the company. The ideas are divided in 6 groups:
1: Extra construction on the terrain
2: Construction on new terrain
3: Reconstruction
4: Different lay-out of the halls
5: Interchange halls in favor of assembly
6: Use different production methods
A Paired Comparison Analysis (PCA) has been used to decide which group is further explored. This analysis compares all ideas of the groups and the "wins" are counted per group. Group 5: "Interchange halls in favor of assembly" comes out best.
Group 5 contains three ideas that are compared. This is done with the aid of a Multi Criterium Analysis (MCA). To do this analysis right the ideas are detailed in six different concepts to give a clear picture of what the possibilities are. The six different concepts are:

- Exchange hall 4 and 5 with hall 9 and 10, based on current working principle
- Exchange hall 4 and 5 with hall 9 and 10, based on line production
- Arrange hall 3, 4 and 5 for assembly, based on current working principle
- Arrange hall 3, 4 and 5 for assembly, based on line production
- Arrange hall 9,10, 11 and 12 for assembly, based on current working principle
- Arrange hall 9,10, 11 and 12 for assembly, based on line production

With the MCA is found that arranging hall 4 and 5 for assembly based on line production is the best fit for the situation at Terberg Benschop. This concept is detailed.

In the detailing process, attention is given to a range of different aspects.

- Transportation of the chassis is done with carts. Self propelled and guided by rails.
- The workstations will be 6 x 8 meters
- There will be 13 workstations in line. 7 stations in hall 5 and 6 stations in hall 4 (see figure 2)
- De axle pre-assembly and general pre-assembly will both have 3 workstations situated in hall 5 (see figure 2)
- Motor pre-assembly will be done in hall 4 with 6 workstations
- Cabin and dashboard pre-assembly is not done in hall 4 and 5. There is to little room to accommodate this in a good and logical fashion.

The final lay-out of hall 4/5 is shown in figure 2

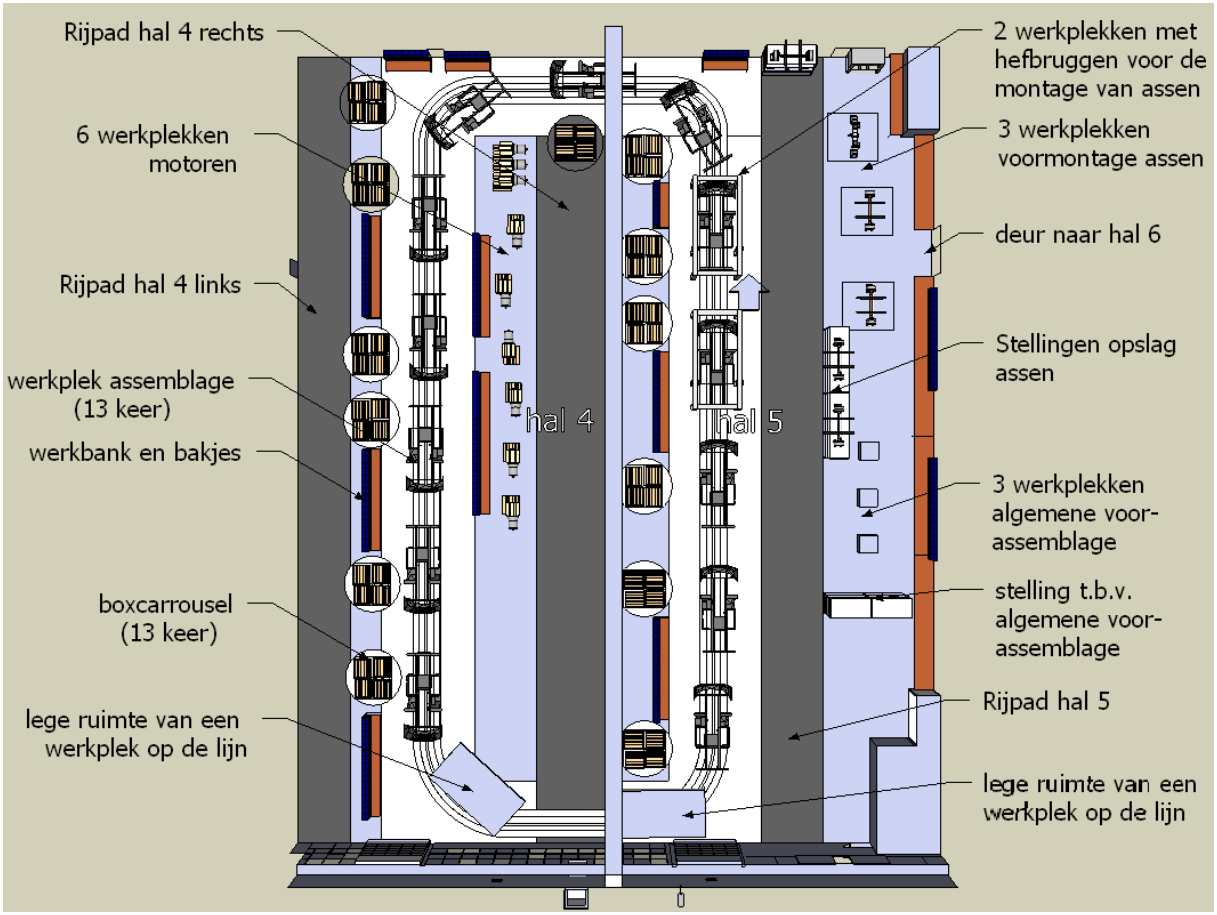

Figure 2. Final lay-out of hall 4 and 5 based on line production

During the detailing phase it became clear that not all pre-assembly functions will fit in hall 4 and 5. This will have to be done somewhere else. It still has to be researched what would be a logical destination. A good option would be to house cabin and dashboard pre-assembly in a new building. Another solution is that other functions move to a new building and cabin and dashboard pre-assembly take their place. Main issue is the lack of free space to place such a new building. The proposed line production can, in combination with the earlier discussed short term planning, be capable of an increase in production of about 70%. This means that a production of 1800 vehicles/year should be possible. The ultimate production of 2000 vehicles/year comes within reach.

As was mentioned earlier, not all necessary pre-assembly is possible in hall 4/5. New construction means expansion of the terrain because it simply will not fit in the current lay-out. If current growth continues, the maximum production on this terrain will be reached eventually. And taking current growth into account, this will not take very long either. That is the main reason the expansion is relevant. This is done in this research to give more insight in the possibilities and obstacles that can be expected. It seems that there is only one option for expansion and that is over the land of Mr. F. de Jong on the Westside of the terrain (in figure 1 above the green “opslag loodsen”). Beside Mr. de Jong there are other neighbors, local government and Terberg itself that are stakeholders. The most difficulty will be found in the fact that all parties have to agree to some sort of compromise. Depending on the plans for the new terrain, these compromises can be very difficult to achieve. As soon as the land becomes available, 2000 vehicles/year is very realistic.

It can be concluded that it is very difficult to increase production with the current production principles. Even with more new employees and expansion of the terrain, large growth is difficult. Considerable growth can be expected if halls are exchanged and Terberg starts using line production. With these alterations, an estimated 70% growth of year production, to about 1800 vehicles/year, is possible.
Before changing to line production is reasonable, a serious amount of work has to be taken care of. The personnel have to be well prepared so that they know what will happen and what will change. Line production involves some serious alteration in day to day work so a proper preparation of the employees is essential. Beside the employees, there is also some attention necessary to the steering and control of the production line. The current working principles are not intended for use in combination with line production. The production

quantity increases and working times become critical. It is absolutely essential that a good control s attained. The proposed short term planning can play a big part in this.

This is the base for the first recommendation. A research is proposed to investigate the possibilities for a system that can provide the certainties that are necessary for line production. A system has to be found that can combine all the available information in the company into a form of information that is usable for an accurate planning. The system has to be robust to cope with continuous changes in priorities and production numbers.
A research assignment that can follow up the first research is the second recommendation. When a good planning tool like this is available the proposed production line has to be reconsidered. Based on that information a more accurate estimations can be made considering production numbers, times and hall lay-out.
The third recommendation is originated in the analysis of the current situation, which revealed that a lot of space is used for the function “Service and Maintenance”. This research did not go into the consequences and possibilities that are available if Service and Maintenance is moved to a different location. Perhaps, this can be done in another research. From the “lack of space” point of view, this could have some very interesting possibilities.