Concept Generation

Concept Generation Tools

Concept generation and selection are easily the most important steps in the design process as decisions that are made in this step affect the rest of the project. Coming up with 100 concepts is no easy task so a few different methods were employed to assist in this task. These methods are biomimicry, crap shoot, and morphological chart.

Biomimicry involves taking inspiration from nature to come up with design ideas. Crap shoot is making up a design that may seem entirely improbable but could possibly yield valuable insights into the design at hand. An example of this was the design named robotic planner. This doesn't seem feasible because building a robot whose soul task it is to plan compressor rebuilds for Danfoss seems ridiculous. However, it satisfies multiple customer needs: organization, automation, and adaptability. The robotic planner helps visualize what an automated solution may look like on its ability to satisfy the customer needs.

A morphological chart can be used to generate multiple designs by using the power of combinations. An example can be seen in Figure 1 below.

Morphological Chart			
Coding Language	Python	MATLAB	C
Quality Control Method	Pareto Analysis	Stratification	Statistical Sampling
Inventory Control Method	Six Sigma	Drop shipping	Lean Manufacturing

This chart can produce 27 different concepts by finding every possibility of coding language, quality control method, and inventory control method. An example of one concept may be Python – Pareto Analysis – Six Sigma. Another may be MATLAB – Statistical Sampling – Six Sigma. This method helps to generate multiple concepts helping create a larger pool of ideas to decide between.

Selected Concepts

The following eight concepts were chosen from over 100 generated concepts. These eight differ in design but seemed like the most probable out of the designs generated. For all of these concepts it was decided that neither coding language preference, quality control method, nor inventory control method should be an axis of scrutiny. This was decided because these adaptations could be form fitted to any of the designs in theory. Rather than studying what makes the designs similar, variant characteristics were chosen as the focus in these design choices. Using a better coding language or control method could give one design an unfair advantage. Eliminating this as a focus point helps reduce bias.

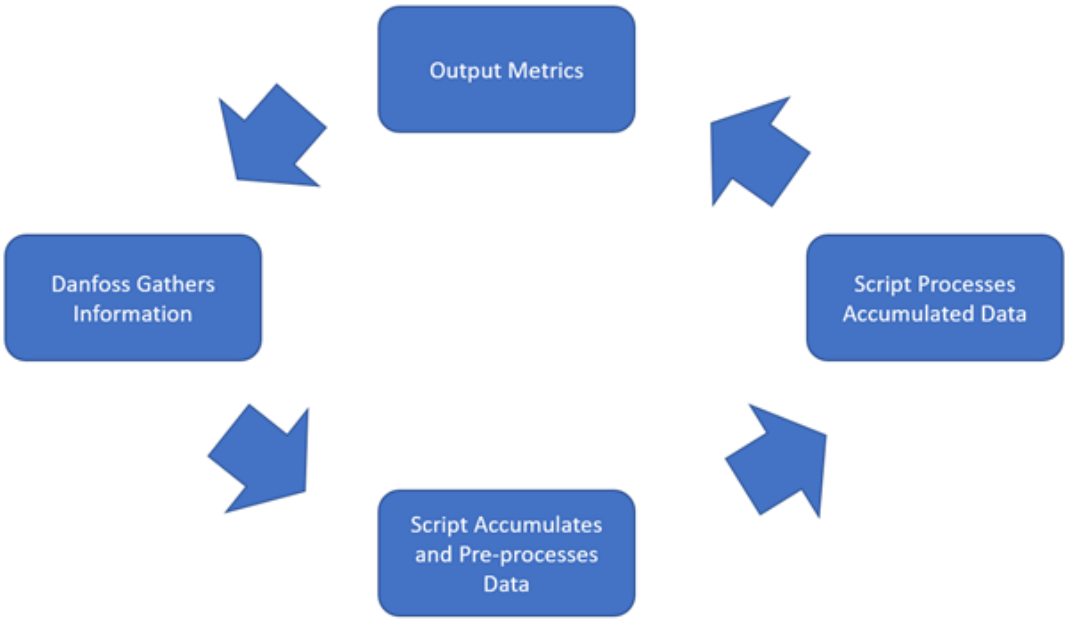
High Fidelity

Concept 1.

Script and Database Design

The main idea of this design is to design a script that can draw from a database of information already gathered by Danfoss to make decisions about how to replace parts. The database would be created by the script drawing from files directories Danfoss currently uses to store information. The script would preprocess multiple files and accumulate the data into one

master excel file for a given aftermarket compressor repair. The script would then use all of the information in this file to make decisions about what replacements are needed for a given compressor model. As the script runs it will also gather statistical data about how often certain parts fail compared to previous cases for quality assurance purposes. It will also create a metric for quantifying how accurate it is at making part change decisions.

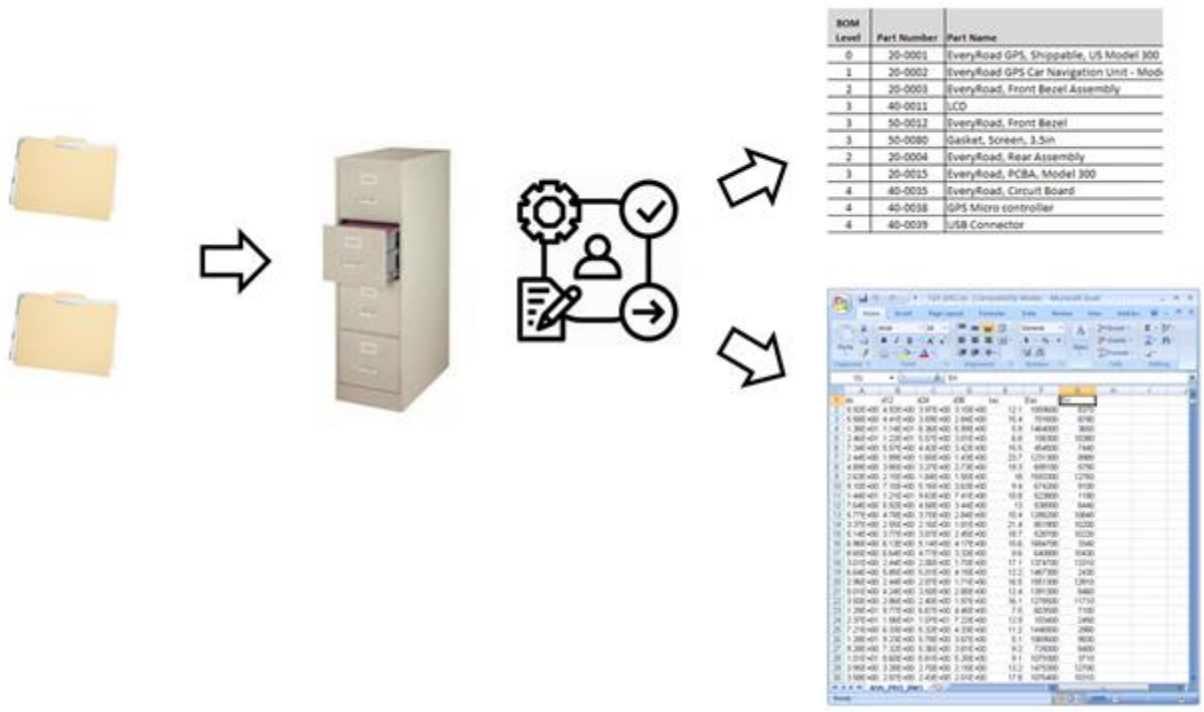


This process is iterative as once Danfoss has all the information they need to plan the compressor build; they will use these outputs to replace these parts on the manufacturing line. If these parts have been chosen correctly then this process gets repeated for the next compressor. However, if this information is chosen incorrectly the script will be given the data that is collected from the failed part replacement to recalibrate its selection algorithm. This is done until, by the script's internal metrics, it is 100% accurate for a given aftermarket compressor model. It will generate report logs that will be stored for Danfoss's quality department.

Concept 2.

Filing System

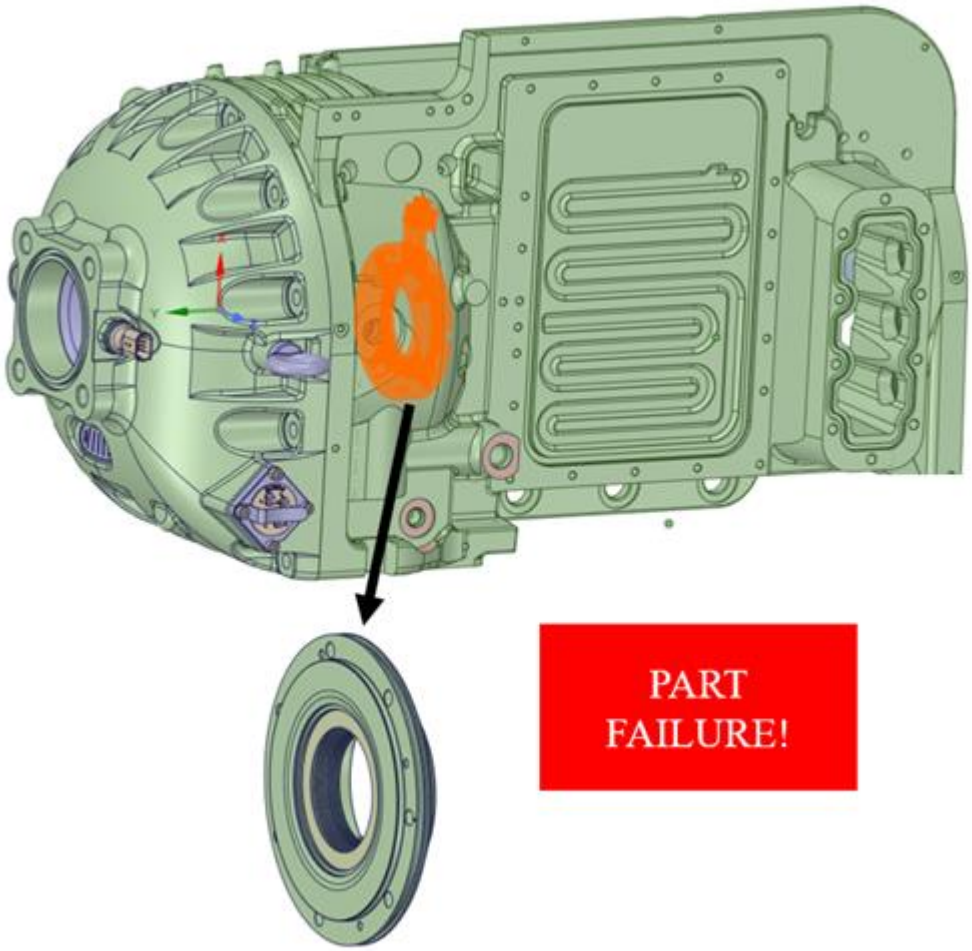
The idea behind this design is to create a more organized workflow for Danfoss's employees by centralizing a filing system. This filing system would contain all the files necessary for the planners to decide what parts to replace. In this new workflow, the investigation team would be required to gather specific information about failing parts, documenting these details in folders. It would then be the job of the planner to compile all this data into one master file. From this file they will make decisions about which parts to replace. The planner will also be required to document the part changes that were made once the compressor is repaired successfully. This itemized part list will be an excel file containing the protocol for how to replace any given part from any given year. After all the parts have been cataloged, this will no longer be the planner's job as the file has now been generated with the procedure for how to replace any part given its part number.



Concept 3.

Part Failure Graphic User Interface

This concept came out of trying to maximize user experience and usability of the system. This system would have a full CAD model of the compressor as a visual display of part failure. It would highlight all the parts that have failed giving the planner a visual display of what parts need to be replaced. The program will have access to all the CAD models of compressors as well as a list of parts that are still used in circulation on the manufacturing line. Once it knows a particular part has failed, it will cross check that part with other compressor models to see if that part can be replaced with a future model. It will also ensure that the new part will fit the geometry of the old compressor, mating with the other parts with no overlap. If it satisfies these criteria it will add that part to the bill of materials. This gives the planner assurance beforehand that the part will not fail on the line when it goes to assembly.



Medium Fidelity

Concept 4.

Six Sigma

Six Sigma is a method that gives organizations such as Danfoss tools to improve the capability of business processes. Implementing this process often leads to an increase in performance and decrease in process variation. This can yield reductions in defects and improvements in employee morale, profits, and quality. This method relies primarily on using quality management methods such as empirical and statistical methods. Experts of these methods are placed on projects and specific targets are set to improve the overall process at hand. For example, in the case of Danfoss, part replacement quality is the metric of interest. These experts

work with Danfoss's team to improve their workforce making them more efficient at their job. The goal of this concept would be to research these methods and provide an updated procedure as to how the current process should be run to improve the process performance. This may result in the emergence of new roles or responsibilities of Danfoss employees to carry out the aftermarket repair process more efficiently.

Concept 5.

Virtual Compressor Logs

This concept involves creating a virtual workspace and user environment where employees from different departments can interact during the investigation and repair process to streamline information gathering. This platform will allow the planners to post what information they need in modules that the investigations team can fill out. The platform will act like a live script, updating real time to give the teams all the information they need in one place accessible to all. The investigation will not be considered complete until all the action items in the information

gathering stage have been completed by the investigations team. This will help enforce better record keeping during the investigation phase as well as help the investigations team know what information the planners need to make their decisions. A report will only be submitted by manager approval of all the action items listed within the modules keeping both departments accountable. This is both a management solution as well as a technological solution.

Concept 6

Artificial Intelligence (AI)

The purpose of this concept is to use the capabilities of AI to gather and store relevant data that normally may be hard to retrieve. This is especially useful in the aftermarket compressor repair process as there is information needed that is not easily accessible in Danfoss's file directories. An example of this is written reports provided by the investigation team. These written reports could be read using AI algorithms and the information is synthesized and stored. This information could then be called upon by a script to exchange parts within the compressor. After a database is accumulated this data could then be fed into the AI algorithm. This will help to train the AI, helping it to make future predictions. Once it has seen

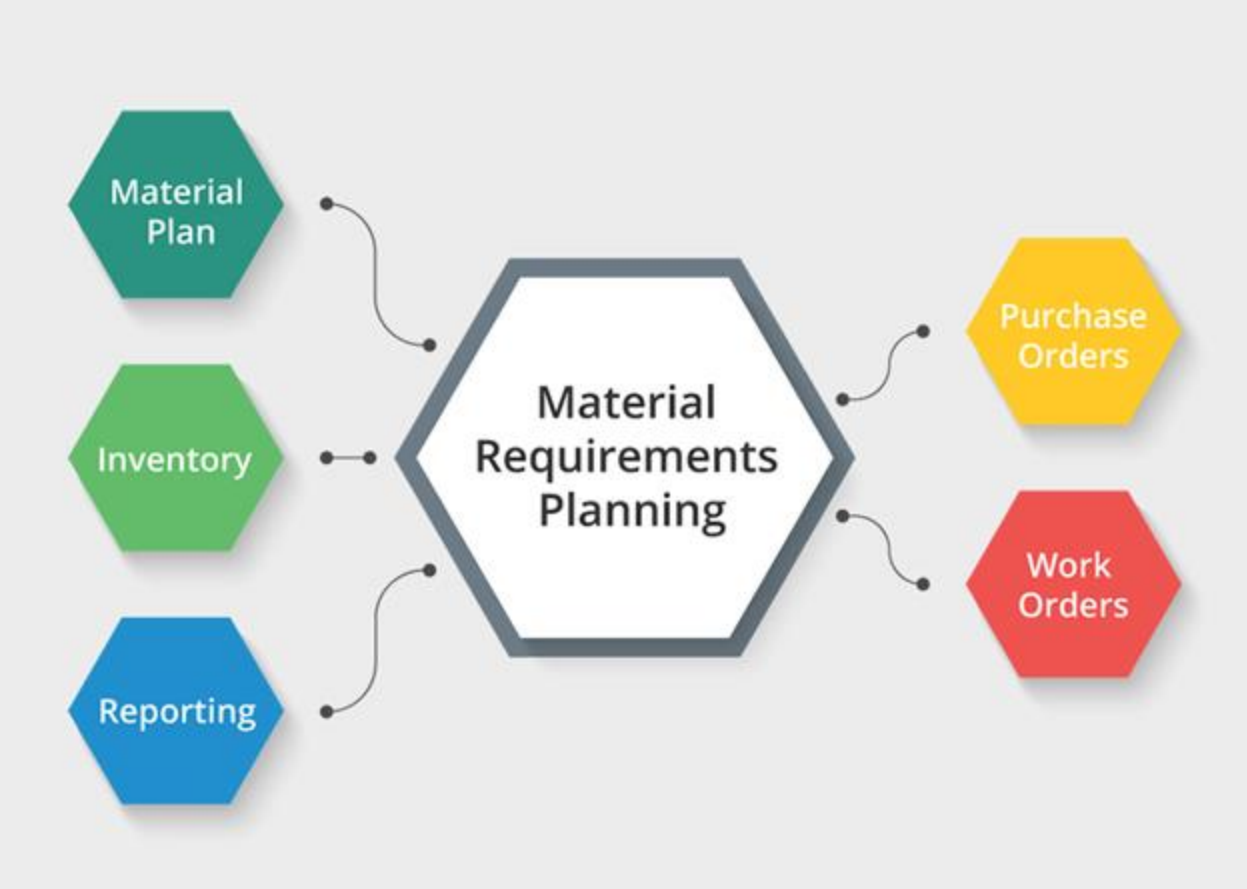
thousands of compressor repairs, it will get more accurate about making future part replacements. By storing all the information regarding its failures as well as its successes, it will know how to improve its own performance.

Concept 7

Material Resource Planning System (MRP)

The idea behind this system is to assist in production planning, inventory control, and manufacturing process management. MRP ensures that parts are available for production. It also assists in maintaining the lowest possible material and product levels in the facility. It is especially useful when planning manufacturing processes. Since Danfoss already uses this software there would be no transition to a different technology. The tools within this software could be utilized to gather information needed to make decisions about part

replacements. MRP's internal database could be called upon to get real time metrics into which parts are available, and which part needs to be replaced. Creating a process within this resource would provide Danfoss with a solution that will not cost a significant amount in upgrades or other technologies. It will also save time since the information will be stored internally in the MRP database requiring no transfer of data from outside files into MRP. The combination of real time inventory control, material planning tools, and reporting software make MRP a valuable resource and potential solution for Danfoss's aftermarket repair process.



Concept 8

Digital Part library

The digital part library is a system designed to be like a search engine. The user will have a search bar at the top of the program and can search any part from any compressor model. The library will then take the user to a webpage where all the information about that part as well as its known replacements will be stored. As new discoveries are made about which part replacements work for which compressor, that information will be updated by Danfoss's staff with easy to use features. After searching a certain part number, alternative search bars will be available within that to refine the search further such as is the display features in craigslist or google shopping. This database will help Danfoss to make informed decisions about how to replace a given part. It also helps reduce the workload on the other teams to explain to the planners what parts need to be replaced for a given compressor.