Danfoss Aftermarket Workflow Project Creation and Implementation

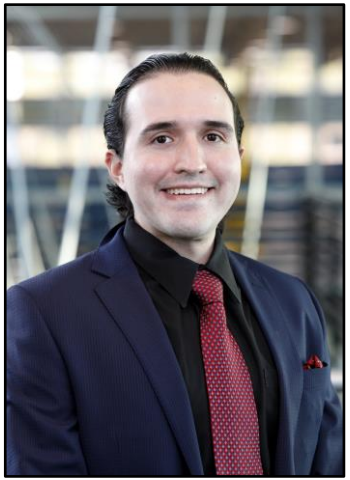
Team: 504

Team Introductions

David Bishop
System Engineer

Alex Wilson
Design Engineer

Kyle Youmans
Design Engineer



Julian Villamil
System Engineer

Julian Villamil

Sponsor and Advisor

Engineering Mentor
Shayne McConomy, Ph.D.
Professor

Project Advisor
Yousuf Ali, Ph.D.
Professor

Engineering Mentor
Stephen Seymore
Operations Engineer Director

Julian Villamil

Project Objective

"The objective of this project is to design an integrated system that generates a bill of materials for a given aftermarket compressor using records provided by Danfoss's investigation and planning team"

Julian Villamil

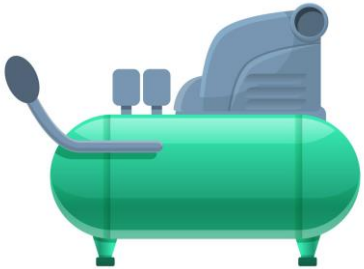
Project Background

Julian Villamil

Project Background

Where we come in

Receive Compressor | Inspection | Planning | Production | Pack & Ship



Julian Villamil

Project Background

- Repair order comes in
- Use compressor model number to look up the static BOM

- Download static BOM from SAP

- Receive repair list from investigations team
- Cross reference this with static BOM

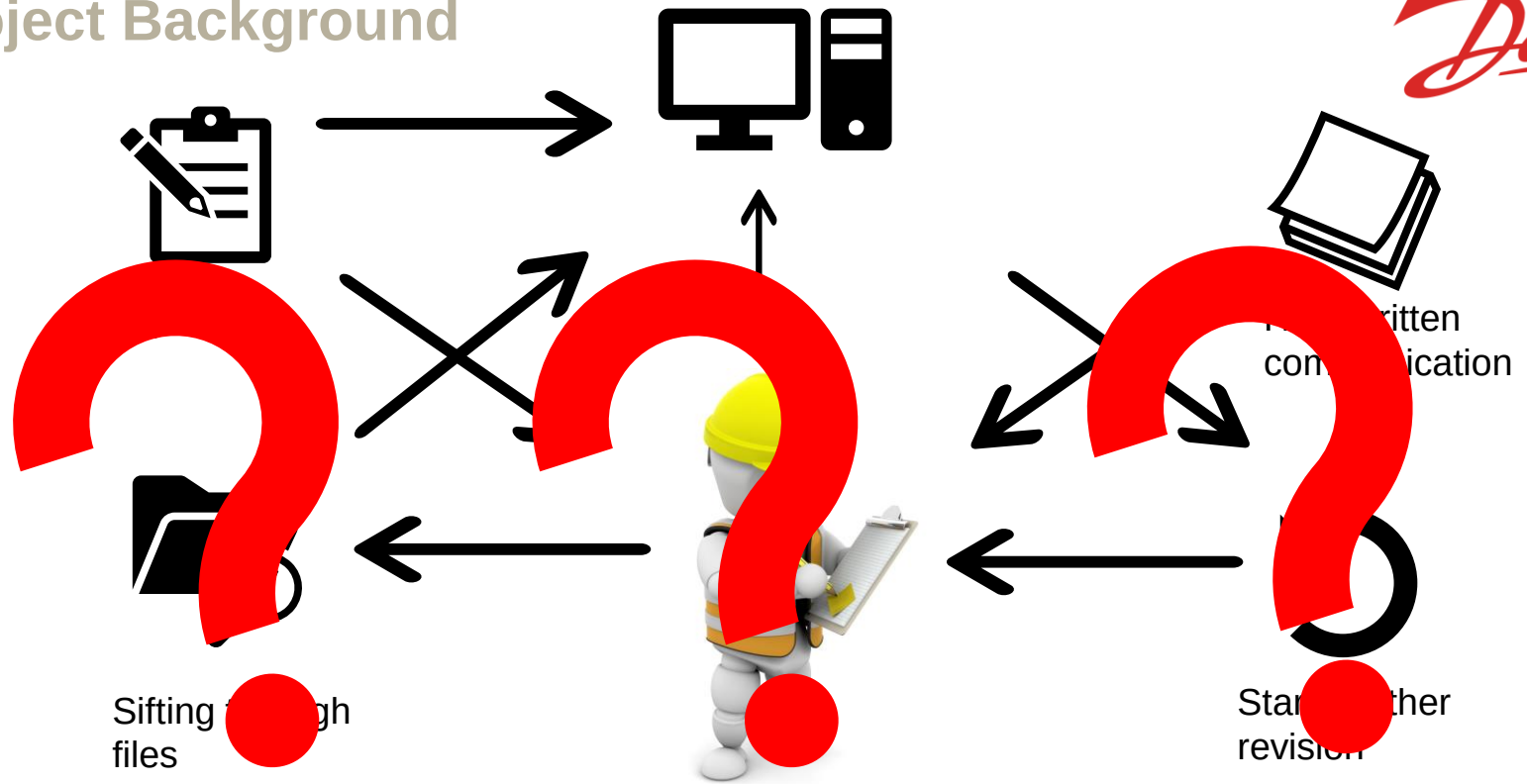
- Receive conditions on 4 main components
- Replace if needed

- Make sure parts are not duplicated
- Make sure parts exist
- Make specific changes to certain components

- Produce final BOM with the repair list and the static BOM

Julian Villamil

Project Background



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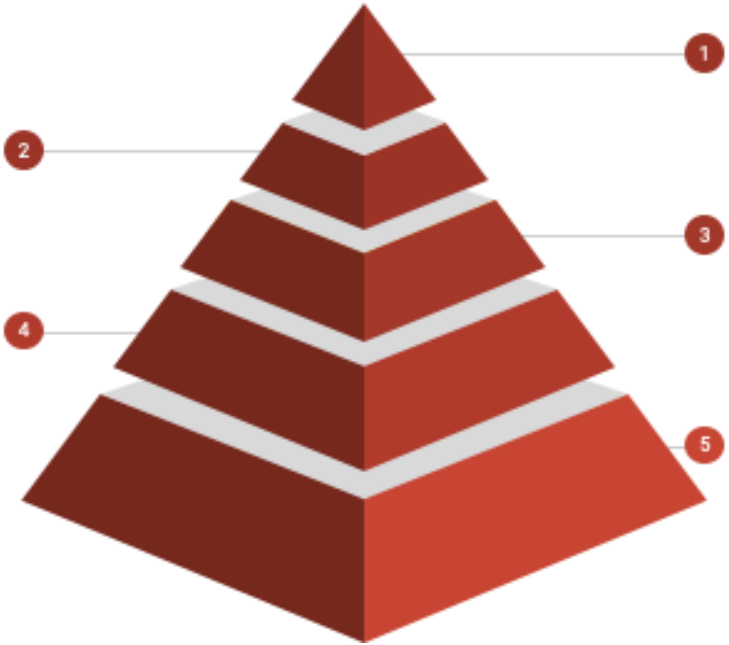
Customer Needs



Automation
The system is more robust than the current process with fewer human errors due to an automated design.

User Experience
System is capable of providing its outputs in a format that is accessible and easily understood by a common audience.

Organization
The system needs to catalog and store data in an organized way.

Quality
Aftermarket compressors are shipped back to their customers at the same level of performance or higher based on the bill of materials generated by the system

Adaptability
System is easily updated as software changes and input information changes

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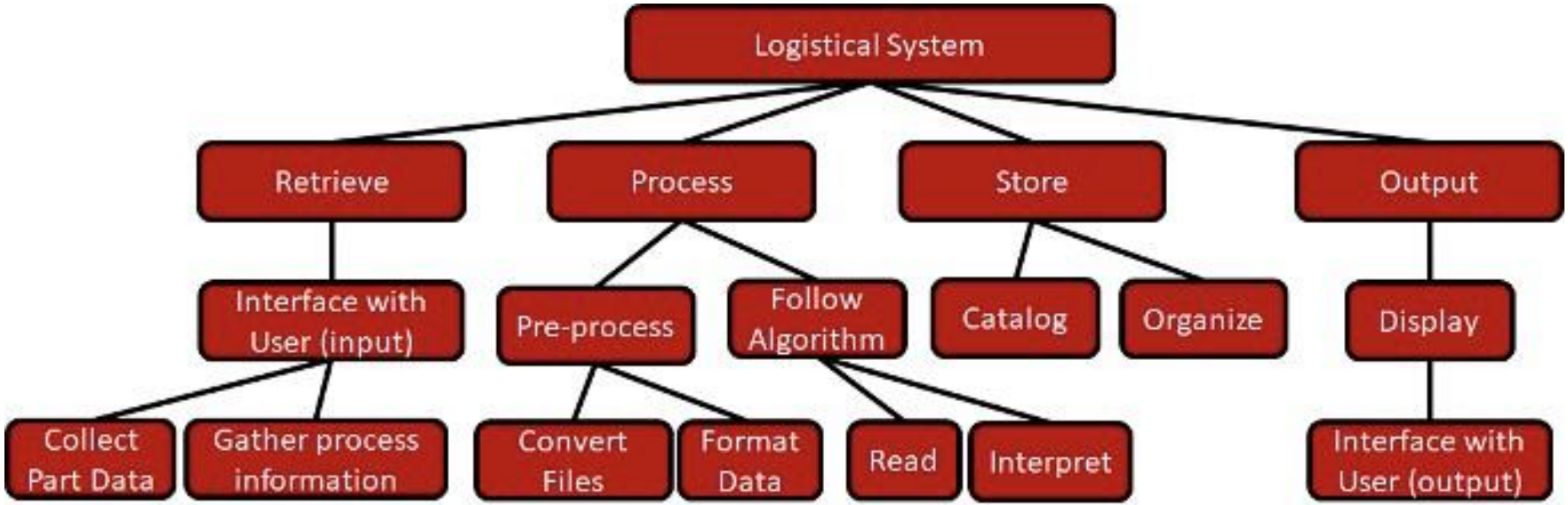
Functional Decomposition



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Concept Generation

Inventory Techniques

- Six Sigma
- Economic Order

Quality Control Techniques

- Controls Chart
- Statistical Sampling
- Histograms

Computing Techniques

- MATLAB
- Python
- C++

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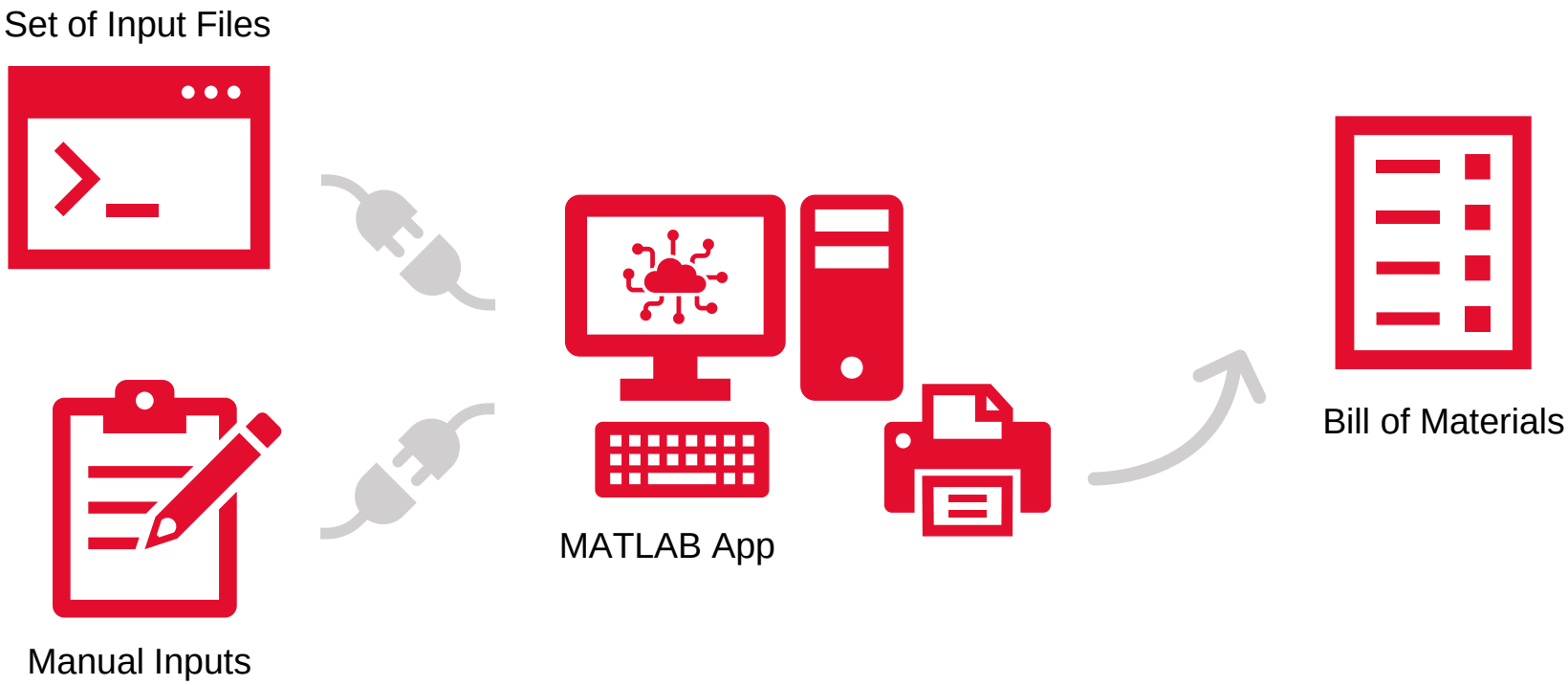
Concept Selection



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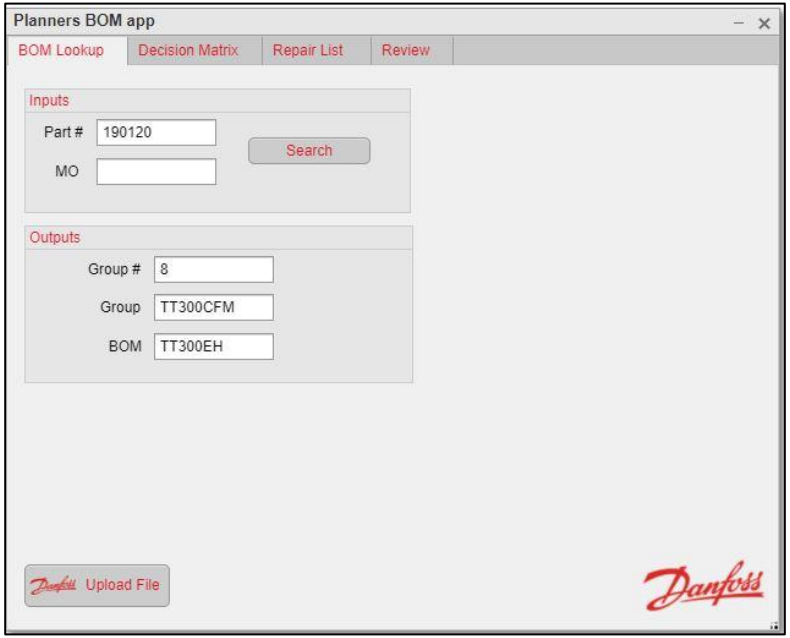
Prototype Tab 1



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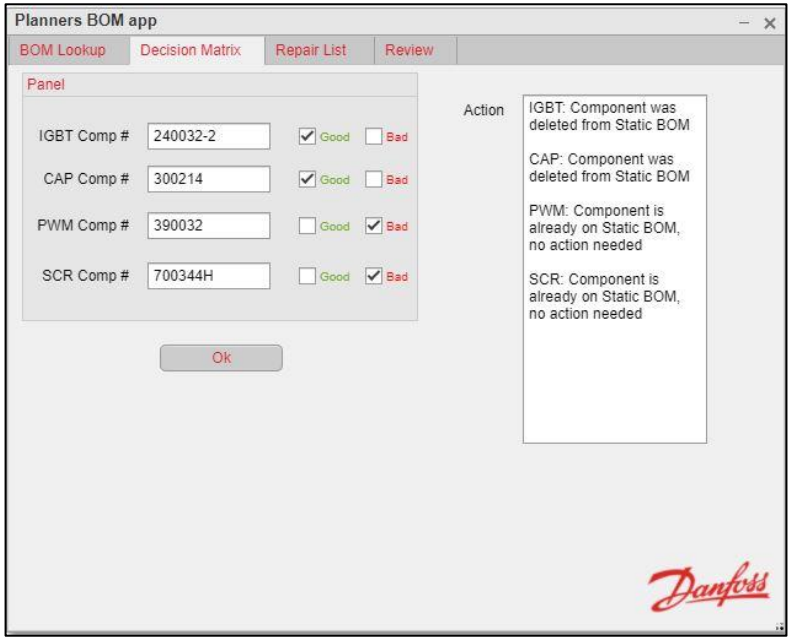
Prototype Tab 2



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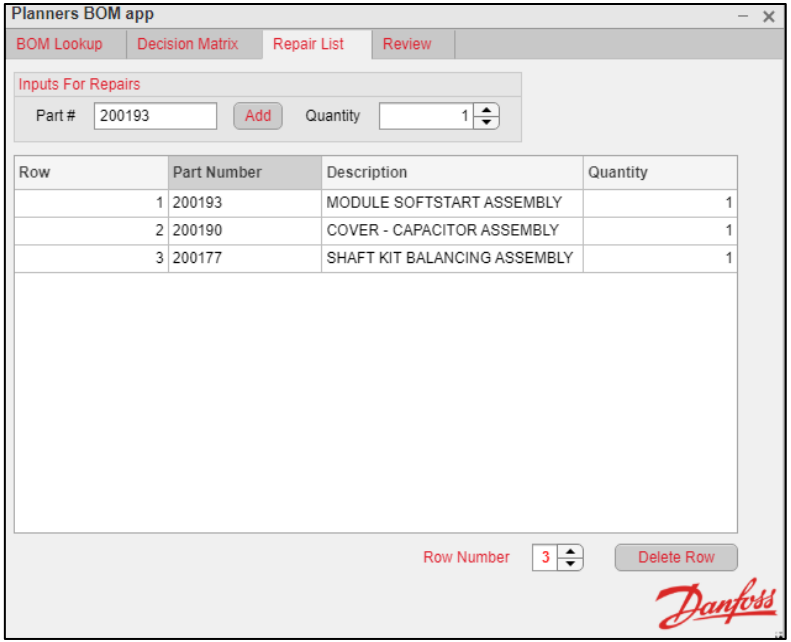
Prototype Tab 3



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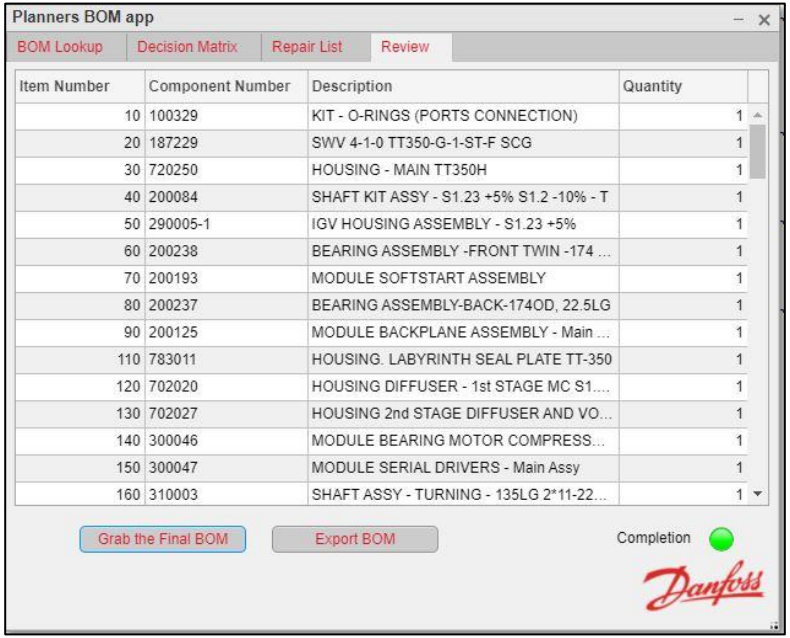
Prototype Tab 4



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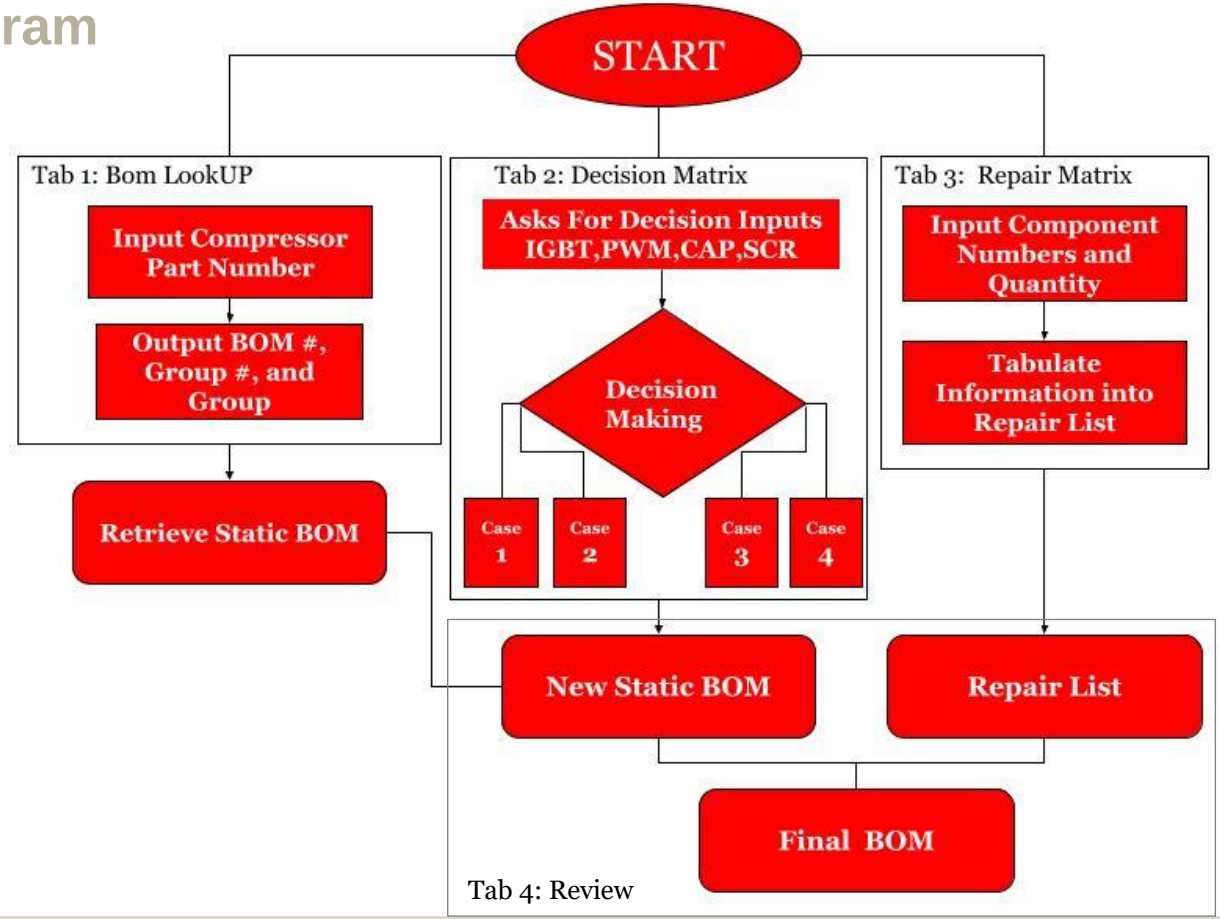
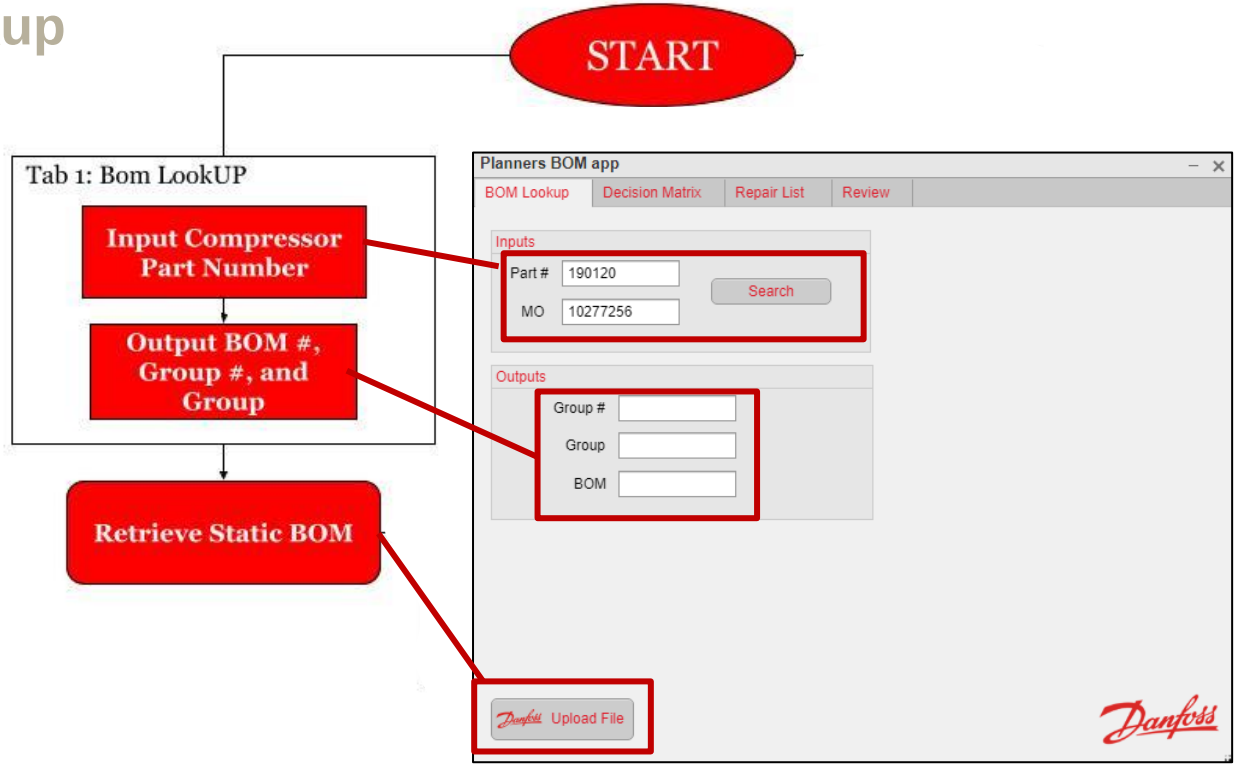
State Diagram



Alex Wilson

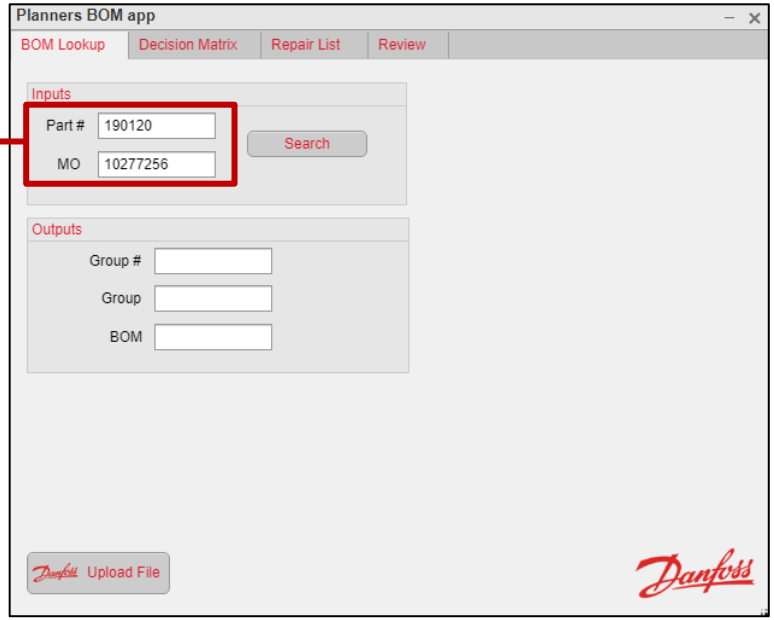
BOM Lookup



Alex Wilson

BOM Lookup

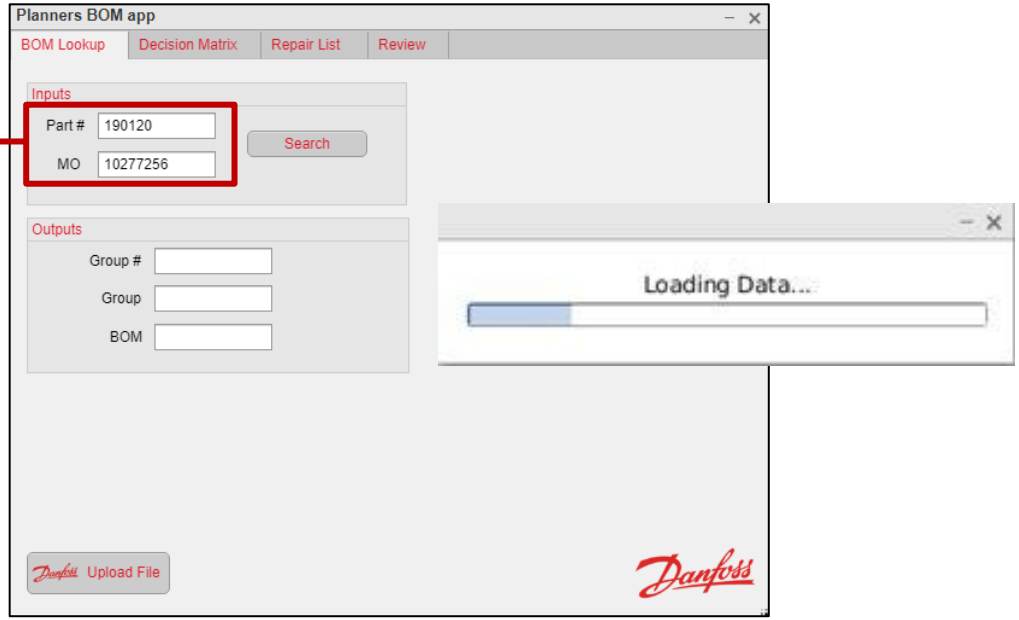
- The compressor Part # determines which static BOM the operator should choose
- The MO or Manufacturing Order Number follows the compressor as it goes down the line
- The MO is not a necessary input for determining the Group, Group #, or Static BOM, but will appear on the final BOM.



Alex Wilson

BOM Lookup

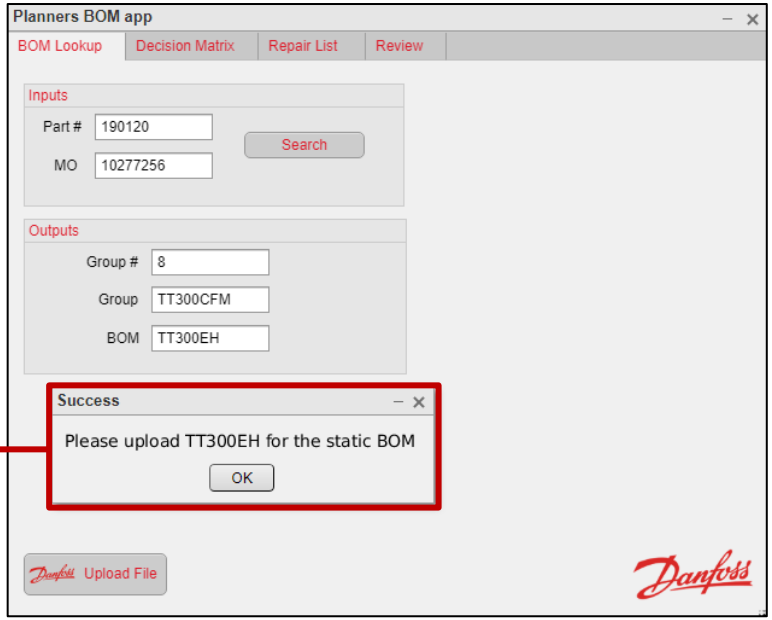
- Once the search bar is pressed the Group #, Group, and BOM are displayed
- A loading bar also appears while you wait so you know that the button press was successful



Alex Wilson

BOM Lookup

- The app then gives the user a notification
- This notifications identifies the next step.
- The user will now upload a file using the upload feature



Alex Wilson

BOM Lookup

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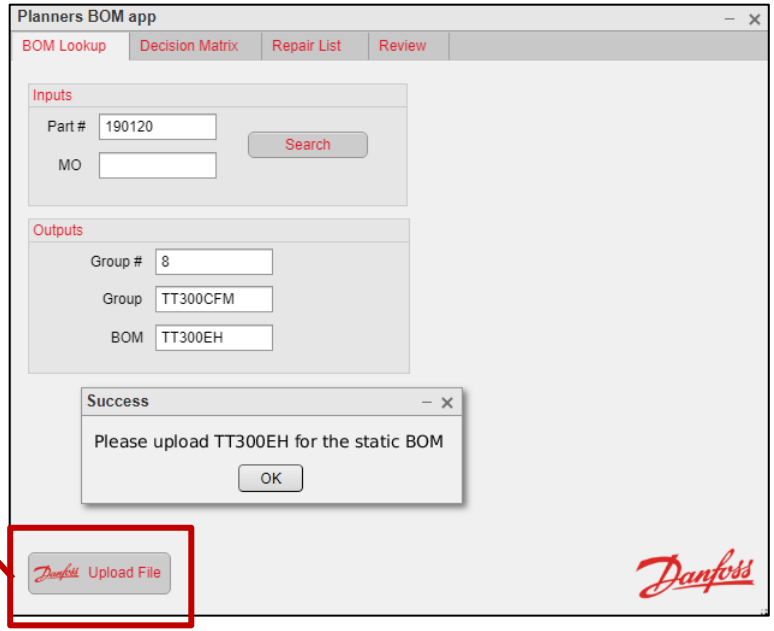
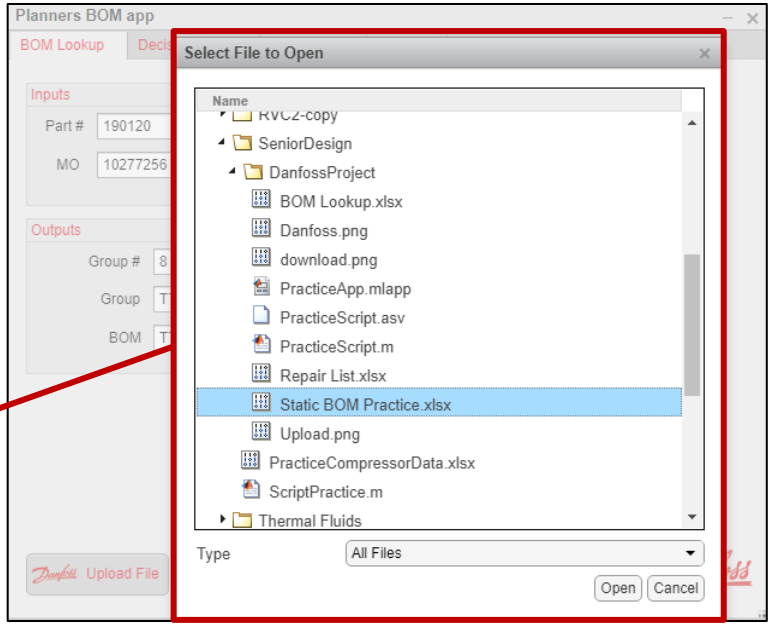


BOM Lookup

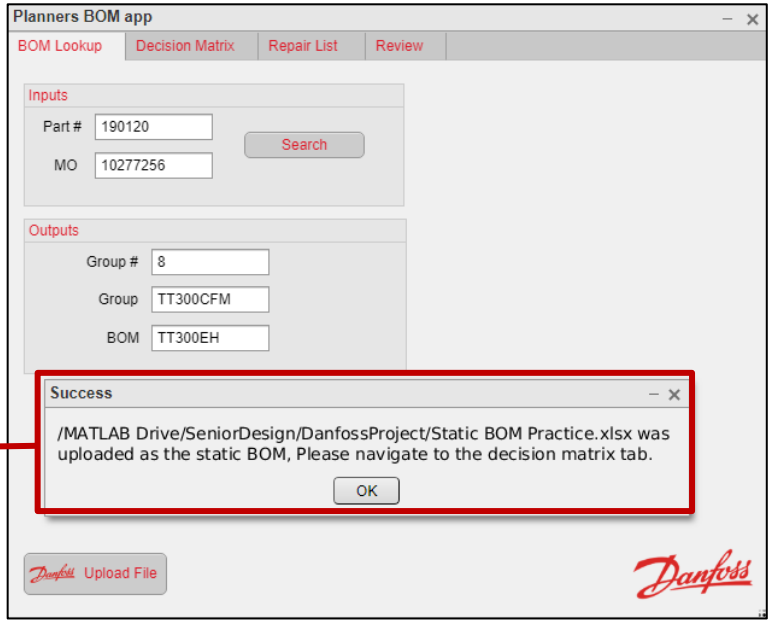
- The app will ask the user for a .xlxs file to upload as the static BOM
- These files are formatted according to Danfoss's proprietary BOM
- These files are downloaded from Danfoss's SAP software



Alex Wilson

BOM Lookup

- After a file is selected the app will notify that the file was uploaded
- It also tells the user that this tab has been completed
- The user can now move on to the decision matrix tab



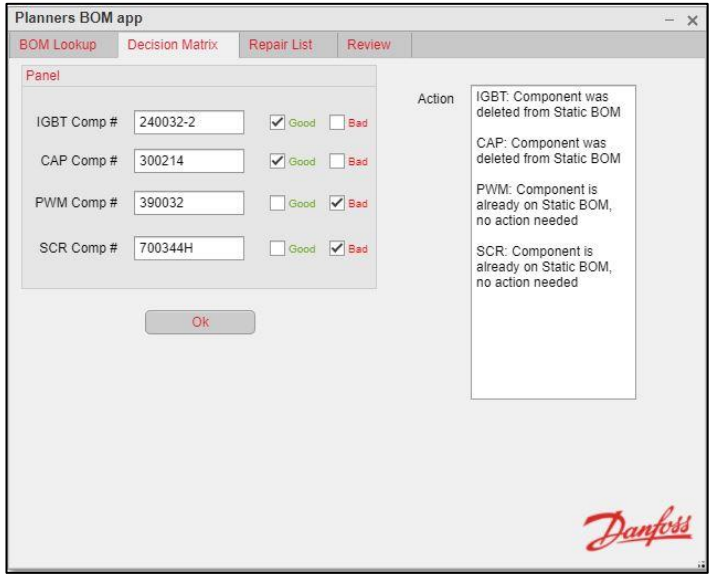
BOM Lookup Code View

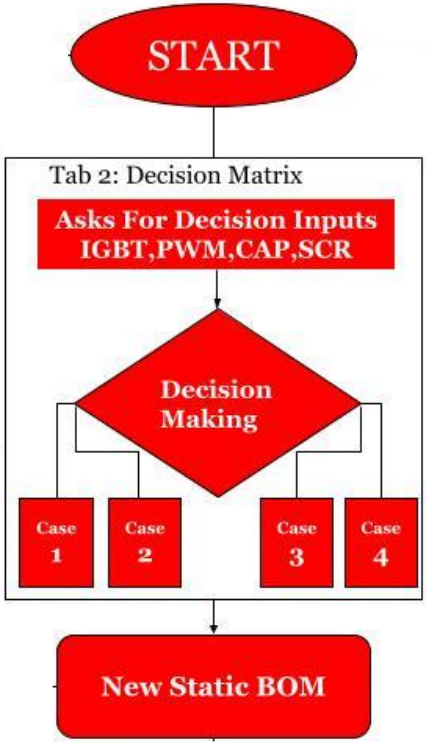
	A	B	C	D	E	F	G	H	I	J
1	Vlookup	Plant	PN	Work Ct	Plant	BusA	Gen TL	GC	T	BOM
2	TT300CFM1	1351	110040	REPAIR	1351	135	TT300CFM	1	A	TT300PG10TD
3	TT300CFM1	1351	110041	REPAIR	1351	135	TT300CFM	1	A	TT300PG10TD
4	TT300CFM1	1351	110042	REPAIR	1351	135	TT300CFM	1	A	TT300PG10TD
5	TT300CFM64	1351	110043	REPAIR	1351	135	TT300CFM	64	A	TT300PGMT11TD
6	TT300CFM4	1351	110045	REPAIR	1351	135	TT300CFM	4	A	TT300PG12TD
7	TT300CFM4	1351	110046	REPAIR	1351	135	TT300CFM	4	A	TT300PG12TD
8	TT300CFM68	1351	140009	REPAIR	1351	135	TT300CFM	68	A	TT300H10T

- Matlab uploads an excel file which contains this sheet
- Contained within it is the associated Static BOM, Group, and Group # for any given TT compressor
- The code simply finds the index of the part number entered and finds the associated Group, Group #, and Static BOM

Alex Wilson

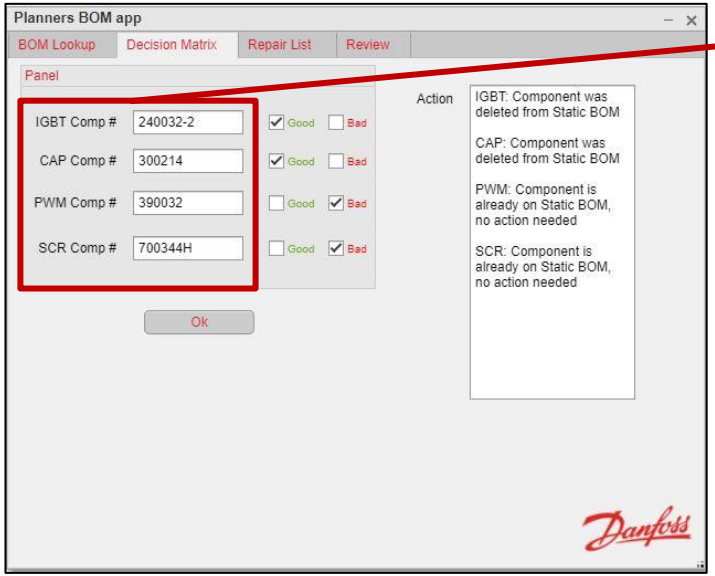
Decision Matrix





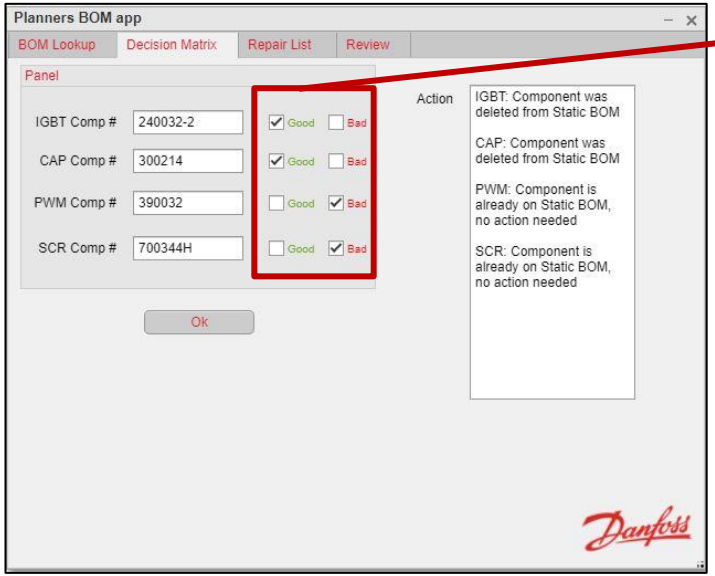
Alex Wilson

Decision Matrix



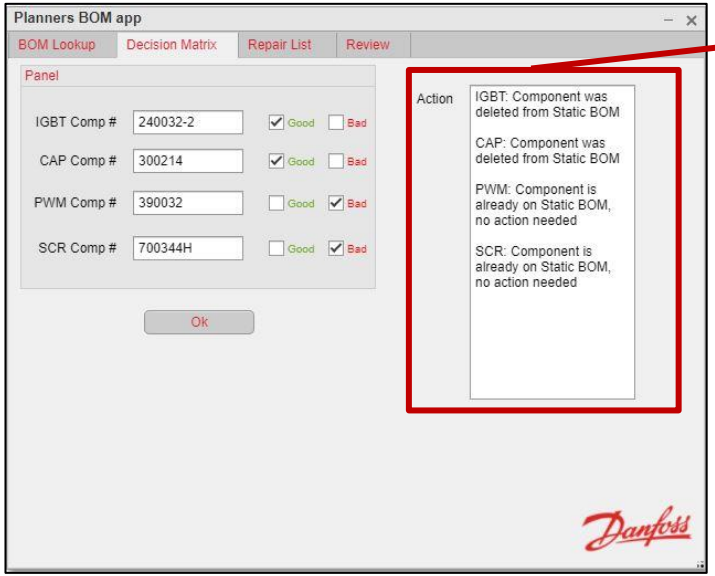
- This pannel includes the four main inputs
- These inputs are part numbers that are notorious for being displayed incorrectly on the static BOM
- The code is responsible for determining if the part number entered matches the one on the static BOM

Decision Matrix



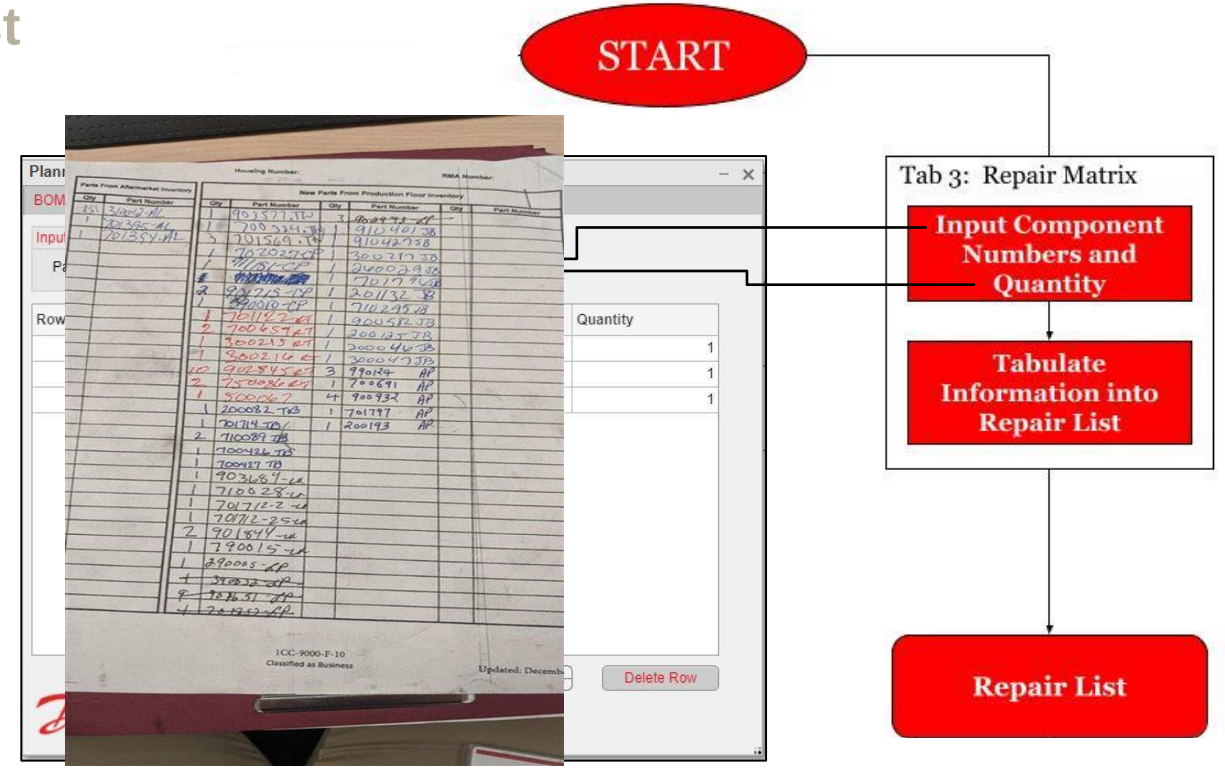
- The check boxes record the structural integrity of each of the components
- The decision here determines how replacements will be made for each of the components

Decision Matrix



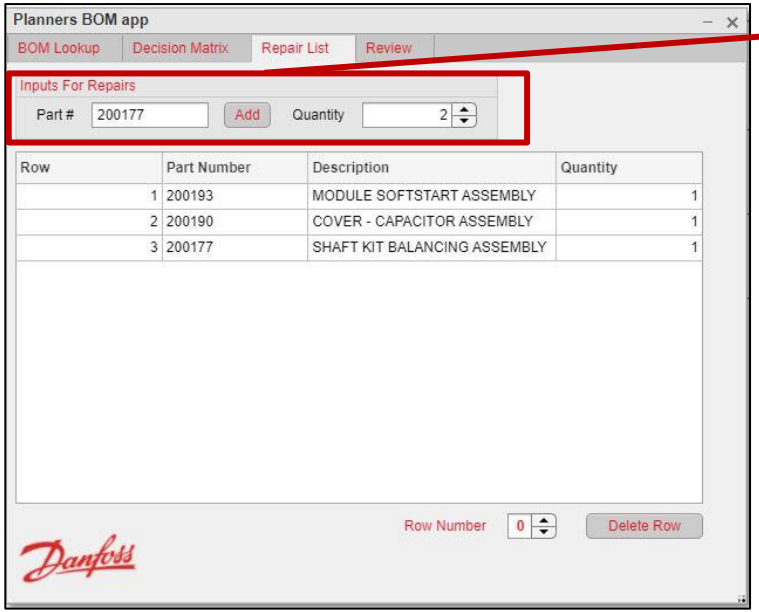
- The action panel displays what action was taken for each of the four components.
- This panel displays the outcome for each of the parts.
- The planner can review this panel to ensure the correct decision was made.

Repair List



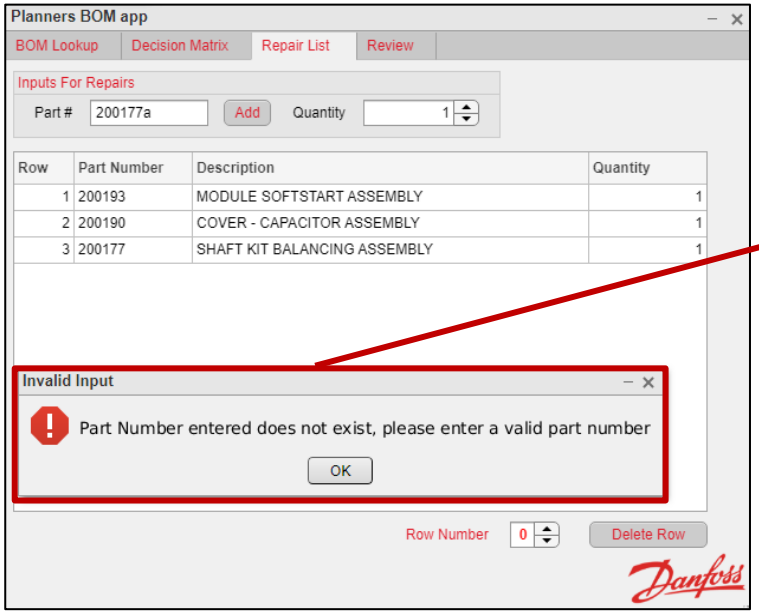
Kyle Youmans

Repair List



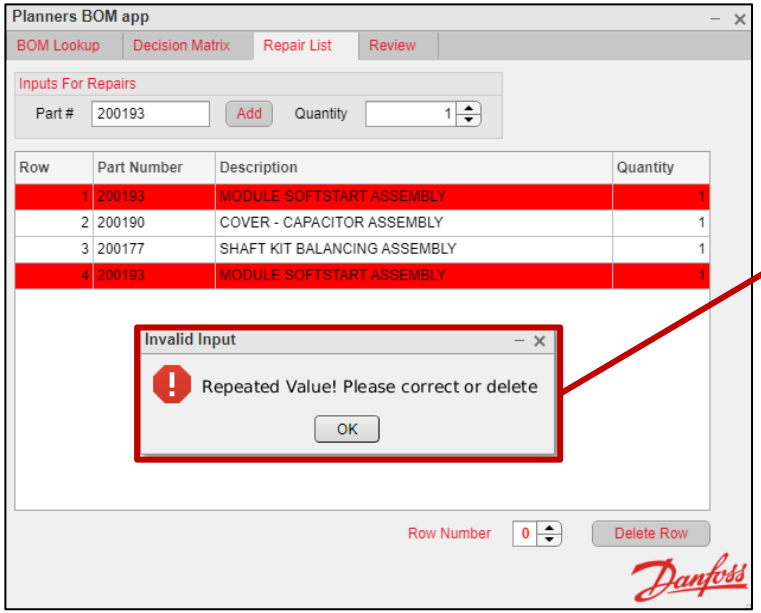
- Inputs consist of part Number and Quantity.
- The script determines if the part number exists.
- If the part exists, then it is added to the list and the description of the part is found using the Vlookup file.

Repair List



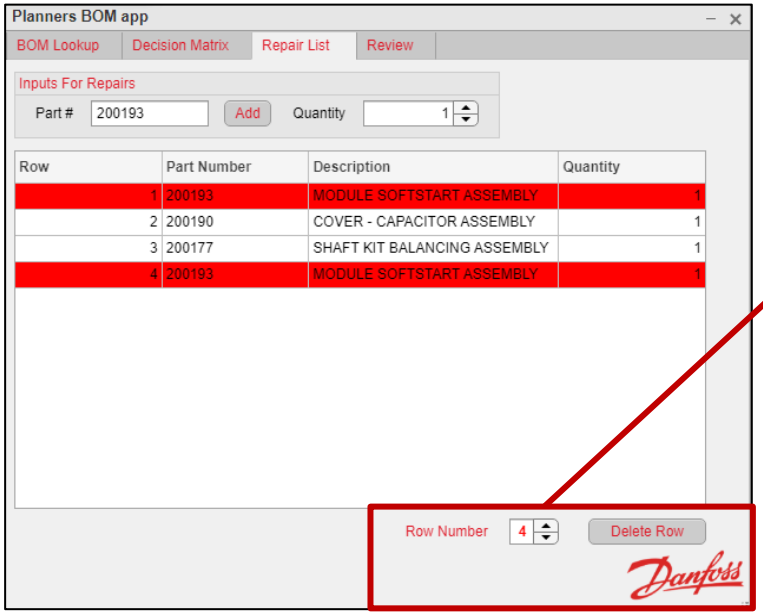
- If the part does not exist in the vlookup file, then the part is considered invalid
- In this case an error message is displayed as follows

Repair List



- If the same component is put on the list twice, then it will be highlighted red
- The user must then use the row delete feature to delete one of the two repeated components

Repair List



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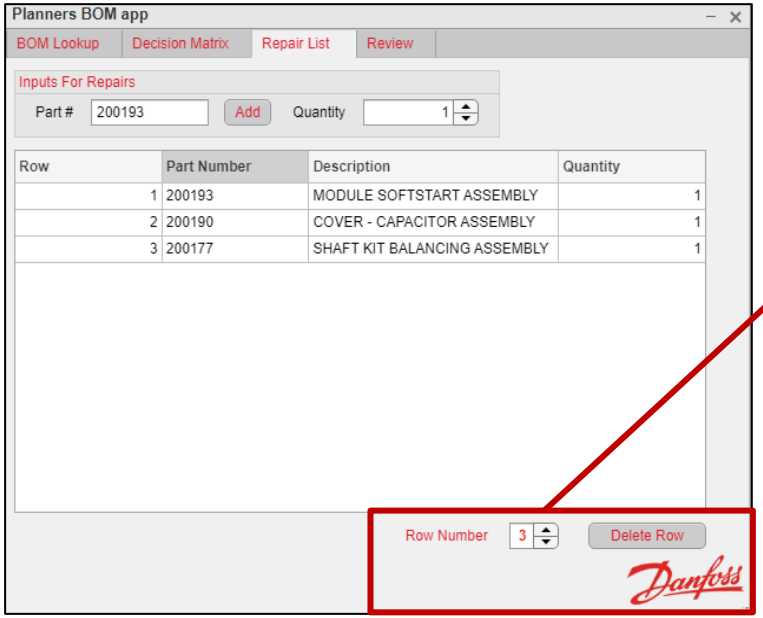
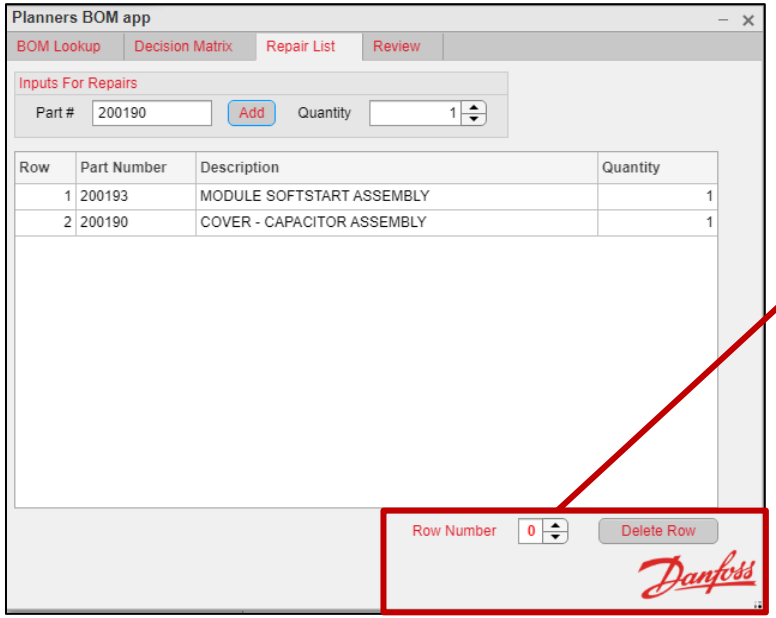
Repair List



- The user can also select any row number they wish to delete
- This ensures that if there is a mistake the component can be deleted

Repair List



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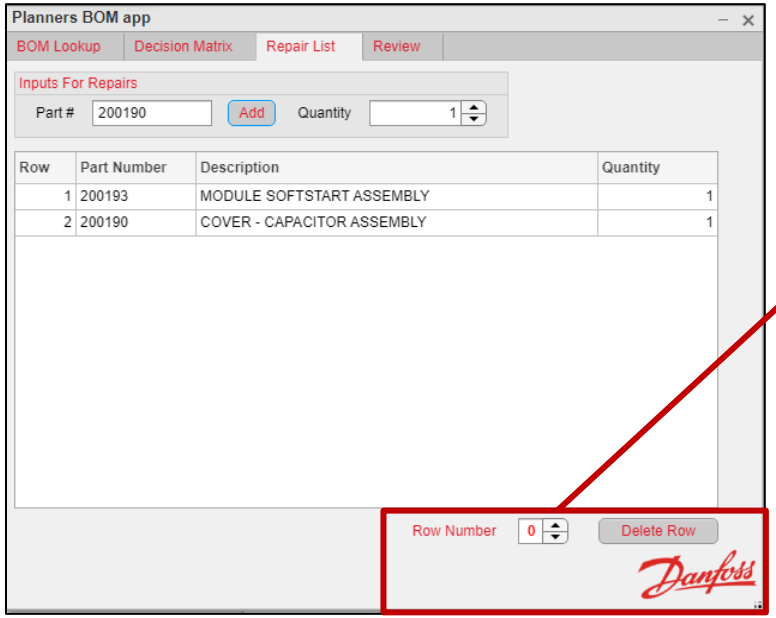
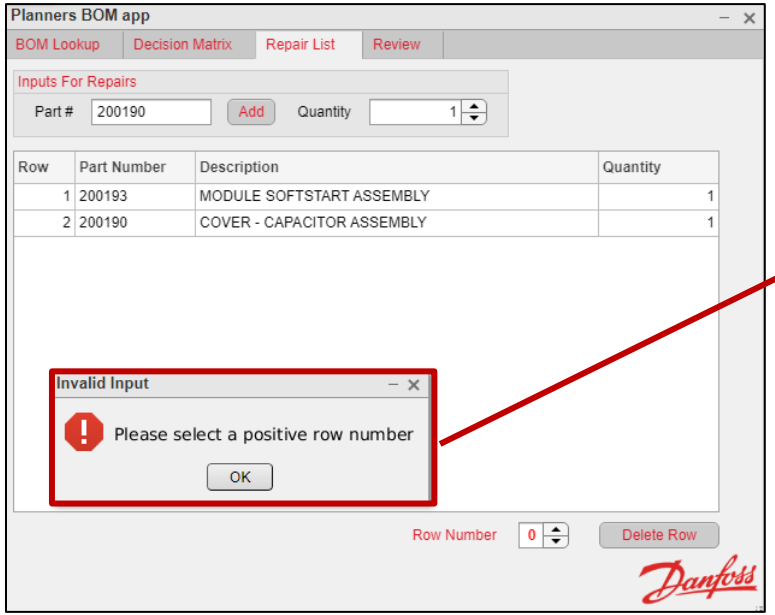


- If the user enters either a negative or 0 row number
- An error message appears

Kyle Youmans

Repair List



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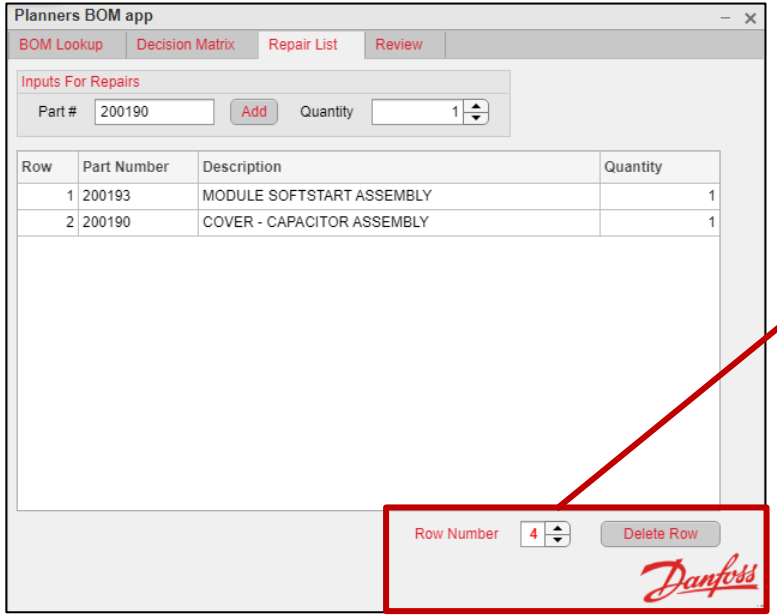
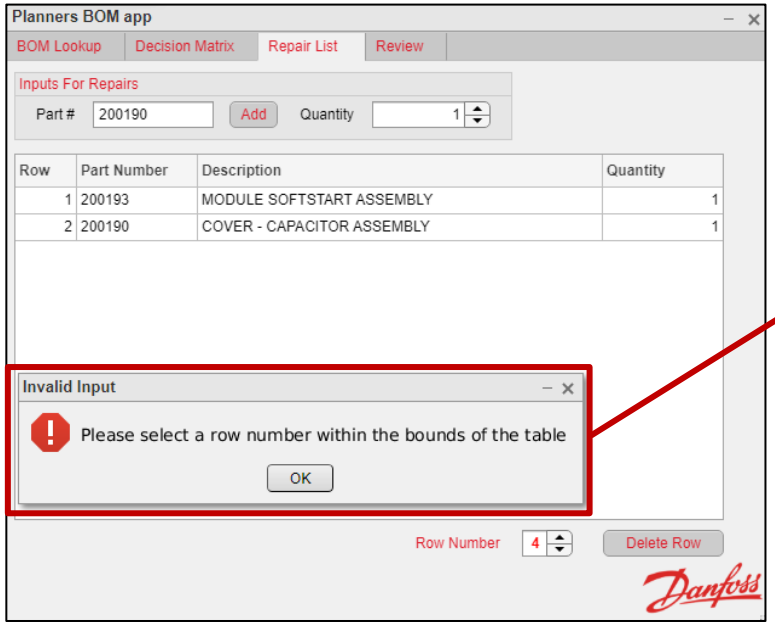


- If the user enters a row number that is outside the bounds of the table
- The interface displays an error message

Repair List



- If the user enters a row number that is outside the bounds of the table
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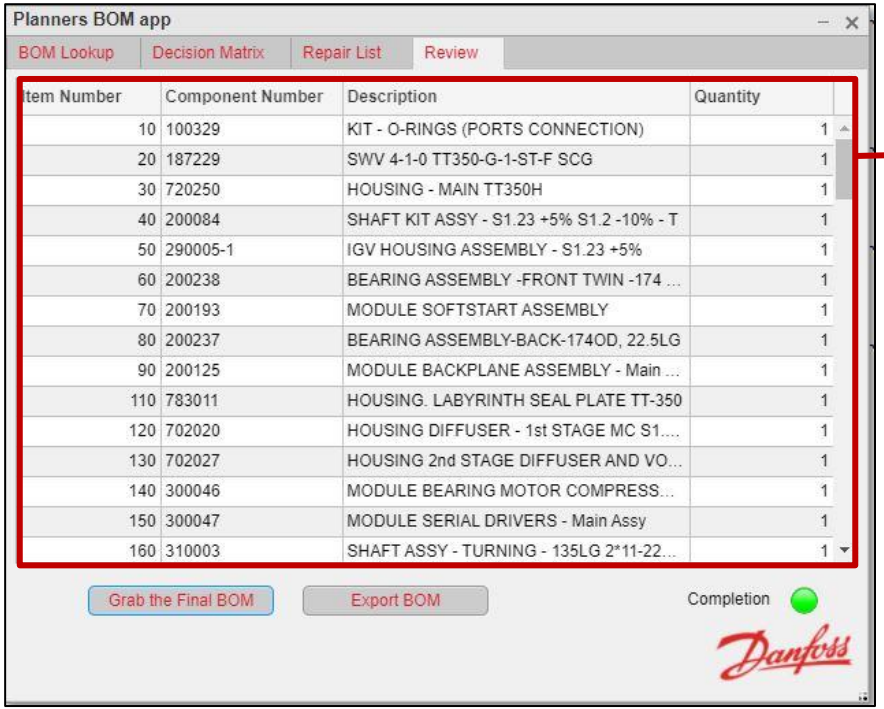
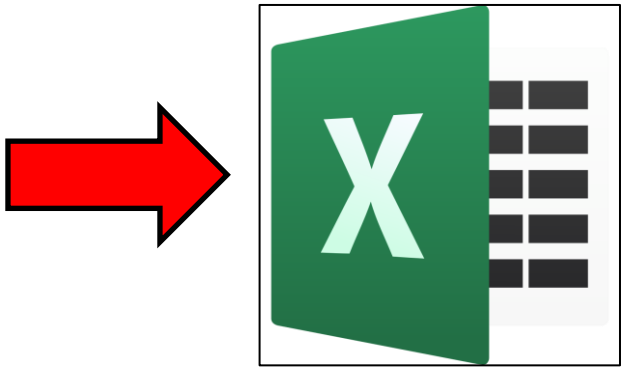
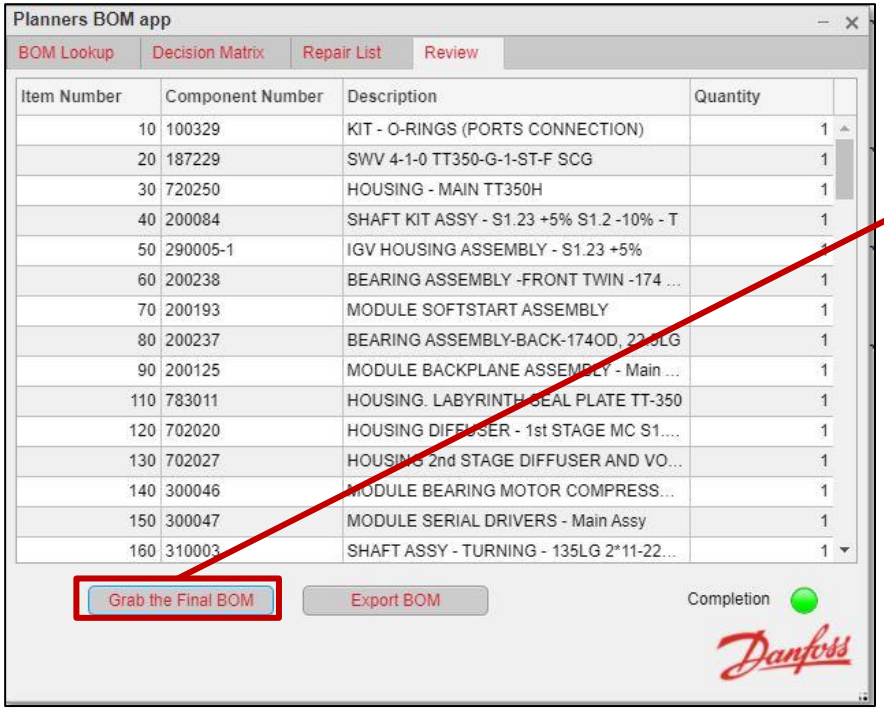
Final Review Tab



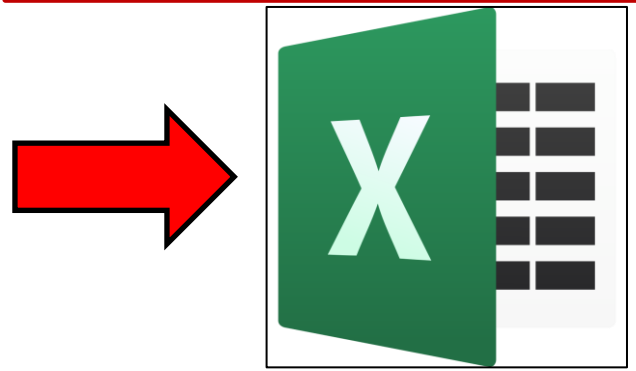
- Visual Display of the Final BOM with the item number, Component Number, Description and Quantity.



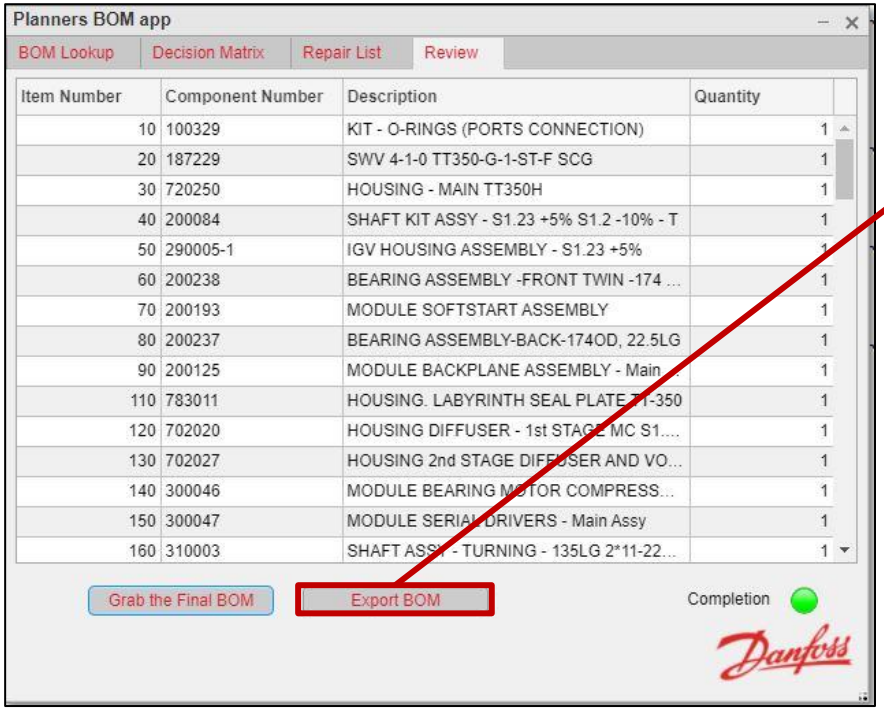
Final Review Tab



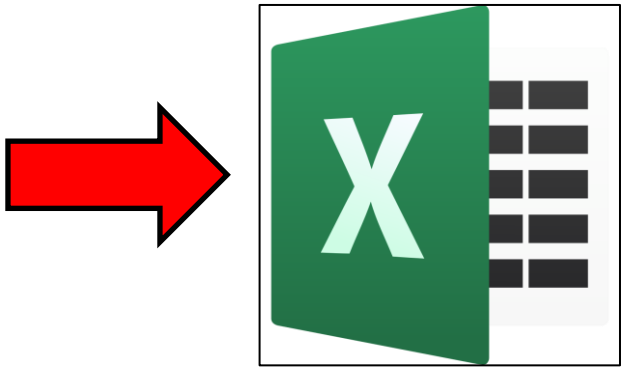
- This button gathers information from the decision matrix and repair list tabs
- The information is added together and put in the final BOM



Final Review Tab



- This button exports the table to a xlsx. file and stores the file in the directory that they are currently working in.



Examples of Heuristics in Our Design

errordlg

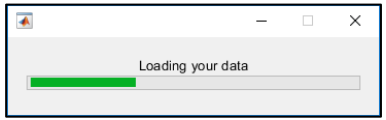
Creates dialog box. Pushbutton must be pressed to make box disappear

```
errordlg('Please enter a valid compressor part number','Invalid Input')
```

waitbar

Creates dialog box with load bar, a message and a time frame

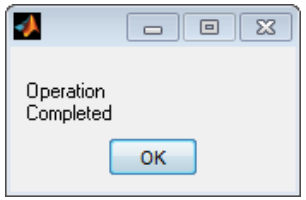
```
F = waitbar(time,message)
```



msgbox

Creates dialog box with message

```
F = msgbox(message)
```



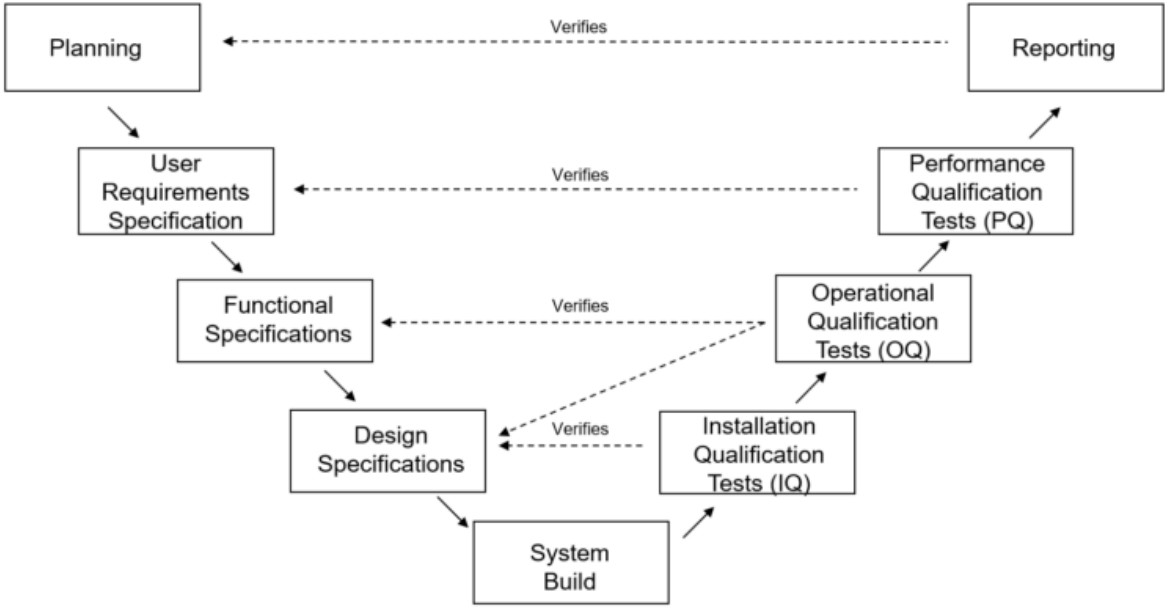
Lamps

Lamps are app components that indicate the state using color

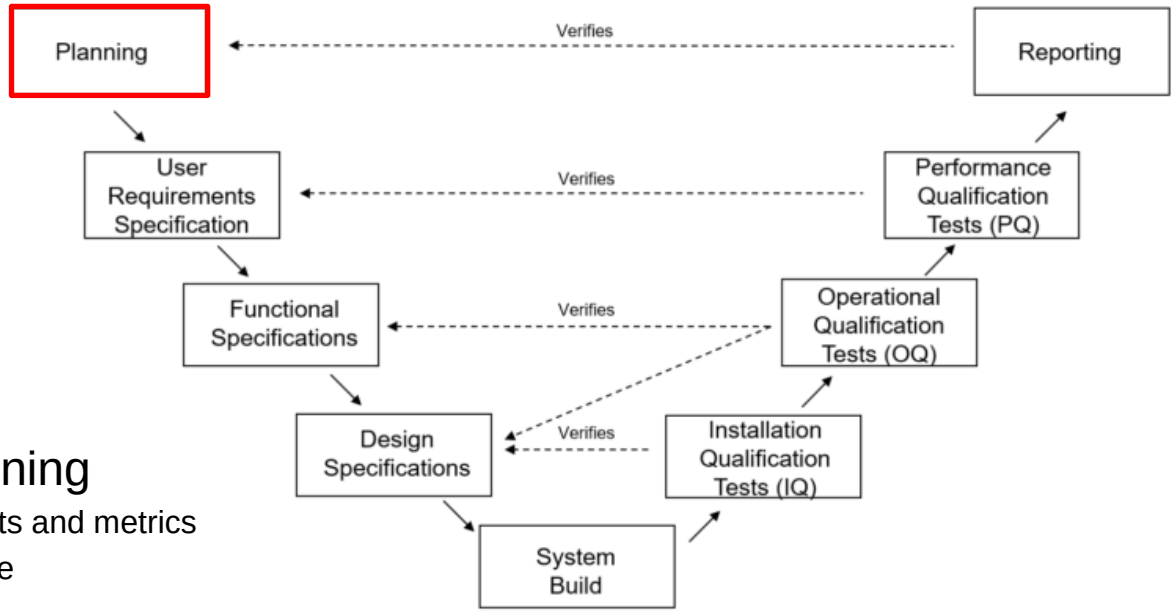
```
Fig = uifigure;
Mylamp = uilamp(fig);
Mylamp.Color = [R G B];
```

Kyle Youmans

Validation


Planning
Verifies
Reporting
User Requirements Specification
Verifies
Performance Qualification Tests (PQ)
Functional Specifications
Verifies
Operational Qualification Tests (OQ)
Design Specifications
Verifies
Installation Qualification Tests (IQ)
System Build

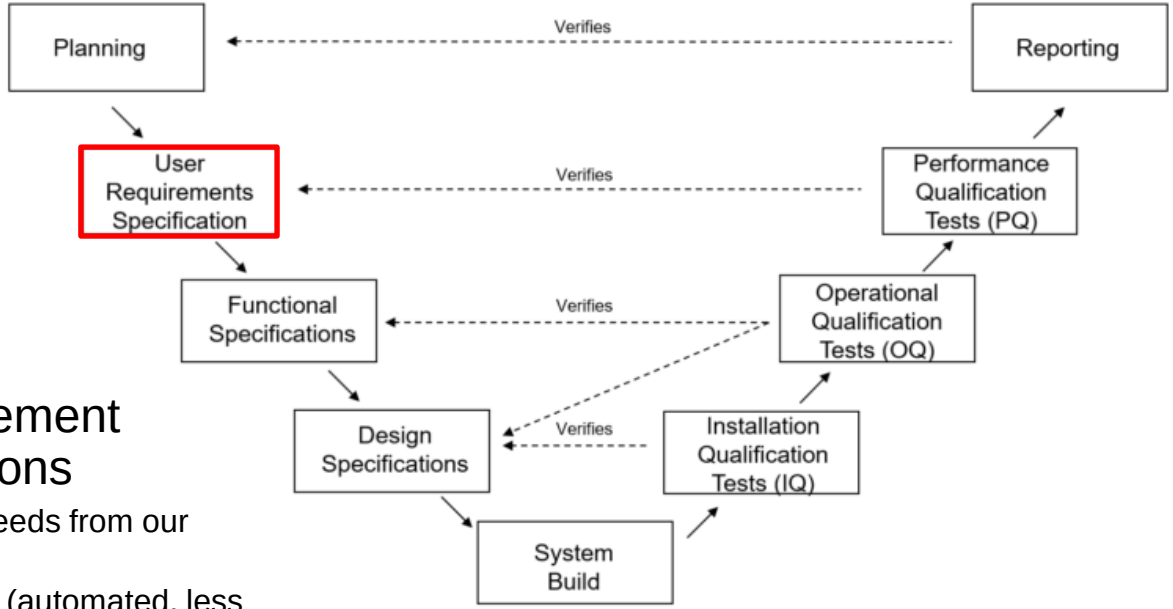
Validation



Planning

- Creating targets and metrics
- How to validate

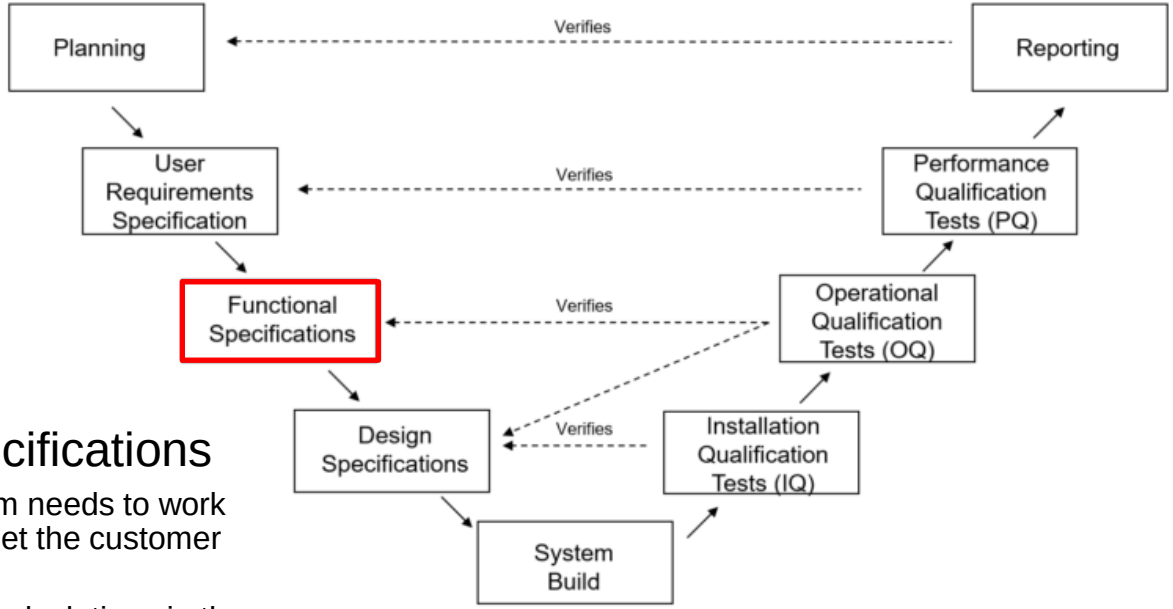
Validation



User Requirement Specifications

- What Danfoss needs from our system
- Customer needs (automated, less error, etc.)

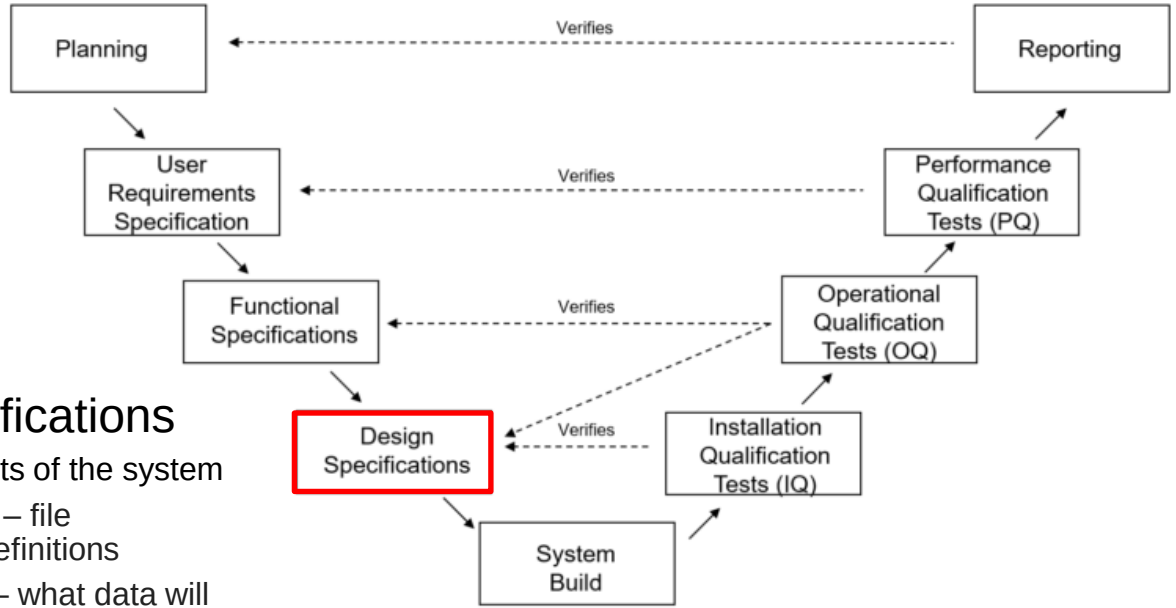
Validation



Functional Specifications

- How the system needs to work and look to meet the customer needs
- The logic and calculations in the system as well as how the system displays information

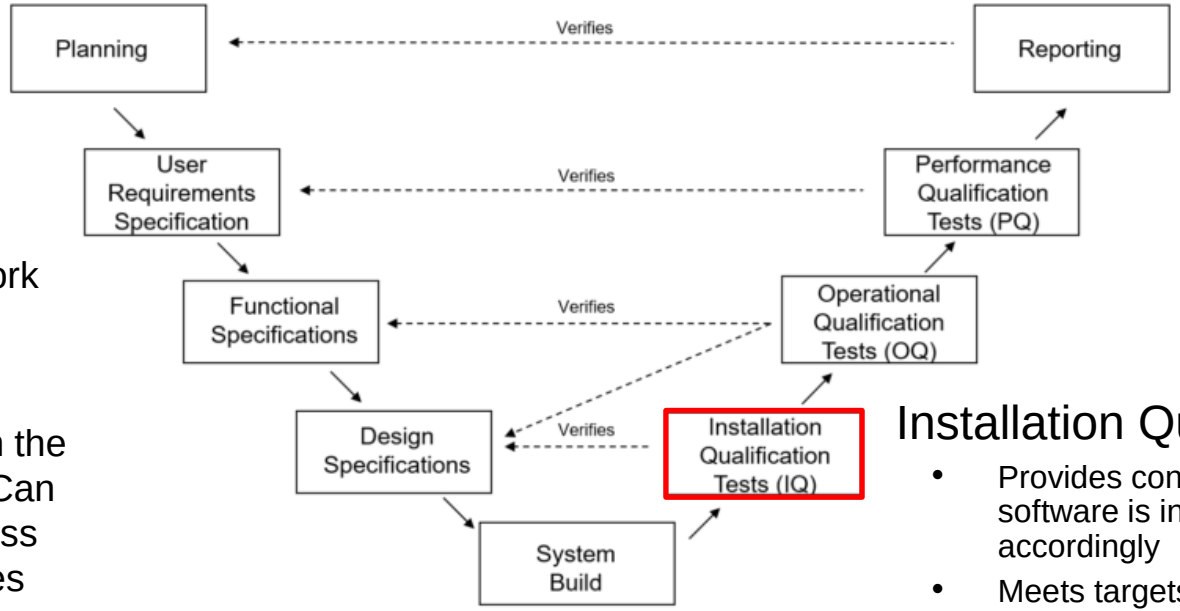
Validation



Design Specifications

- Technical elements of the system
- Database Design – file structures, field definitions
- Interface Design – what data will move from one system to another; how and how often, and failure handling

Validation



Iterative process. Need step A to work to get to step B

Binary. Are files in the correct location? Can it be run on Danfoss computer? Are files accepted into the script?

Installation Qualification Tests

- Provides confirmation that the software is installed and setup accordingly
- Meets targets that regard how it is installed

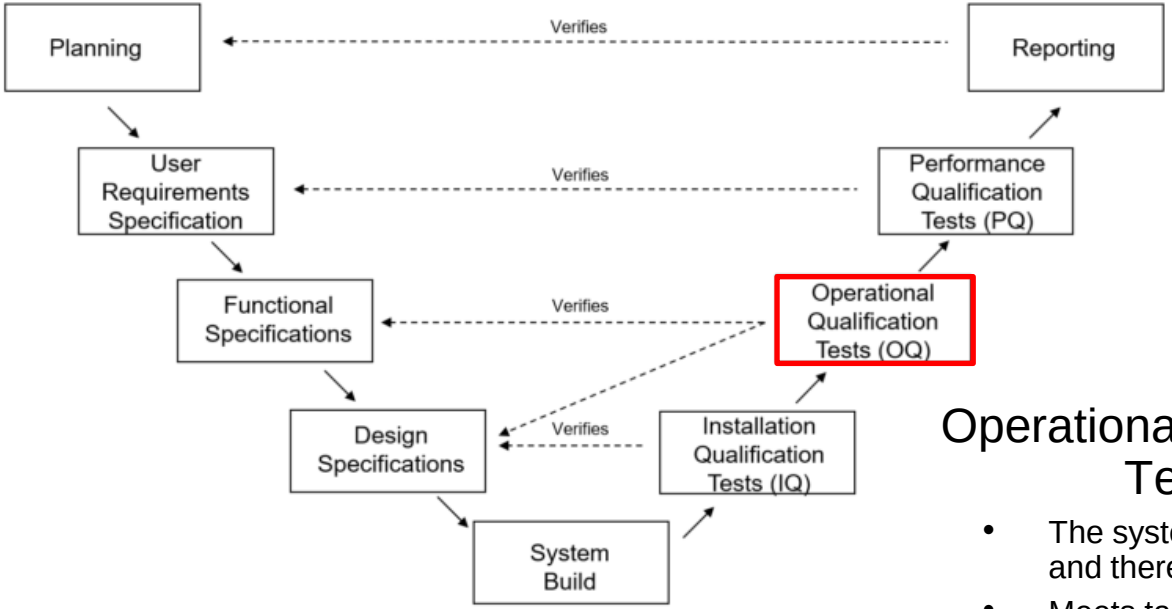
David Bishop

Validation

Computational Speed: TIC TOC function

Functionality (100%): number of working functions/total functions

Reliability (93%): number of times script runs successfully/total runs



Operational Qualification Tests

- The system functions correctly and there are no bugs
- Meets targets that the code will run correctly

Validation

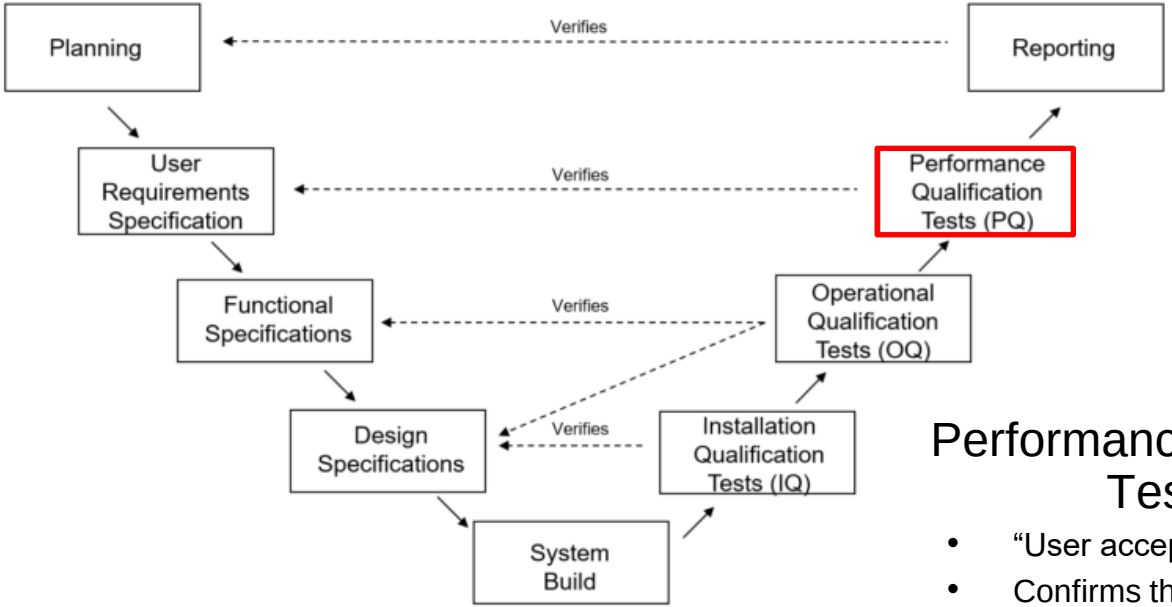
Overall accuracy (100%): correct replacements/total number of replacements

Time: our system is faster to use than current system

Ease of use: number of clicks

Effectiveness (95%): tasks completed successfully/total number of tasks

Customer satisfaction survey: aesthetic appeal, organization, final BOM quality, code complexity (can someone at Danfoss modify this?)

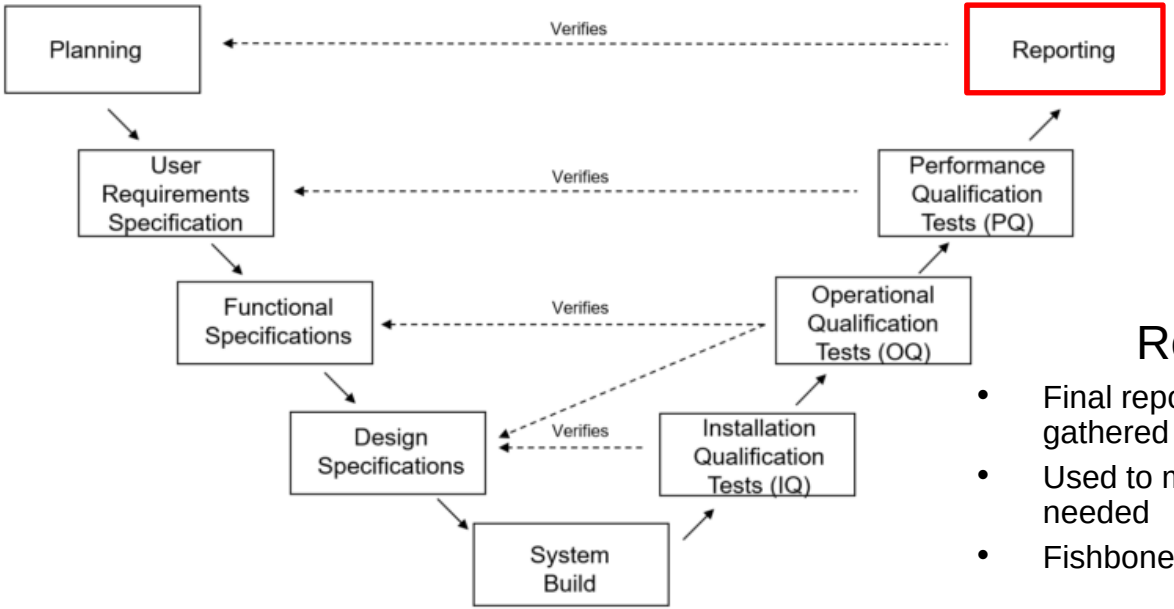


Performance Qualification Tests

- "User acceptance testing"
- Confirms that the system meets the customer's needs

David Bishop

Validation



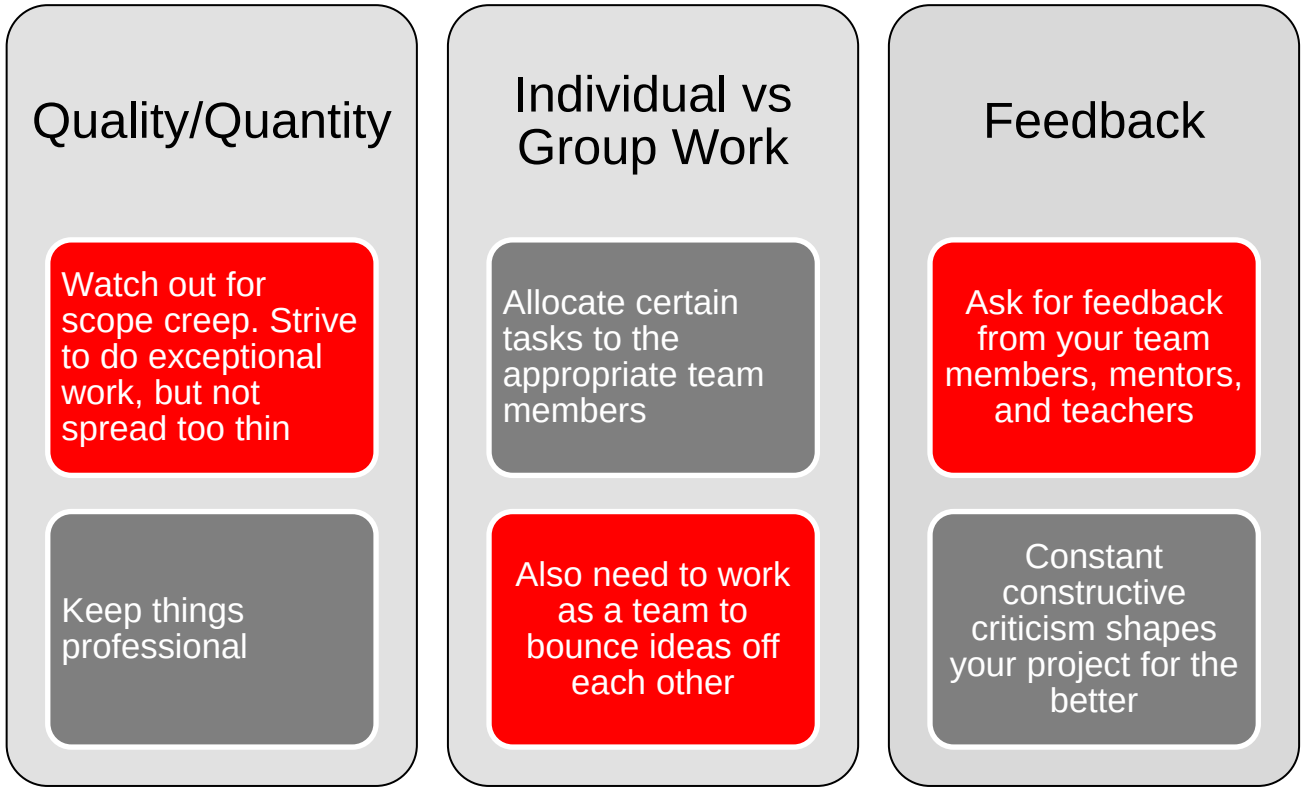
Reporting

- Final report of all the data gathered from validation testing
- Used to make adjustments where needed
- Fishbone diagram

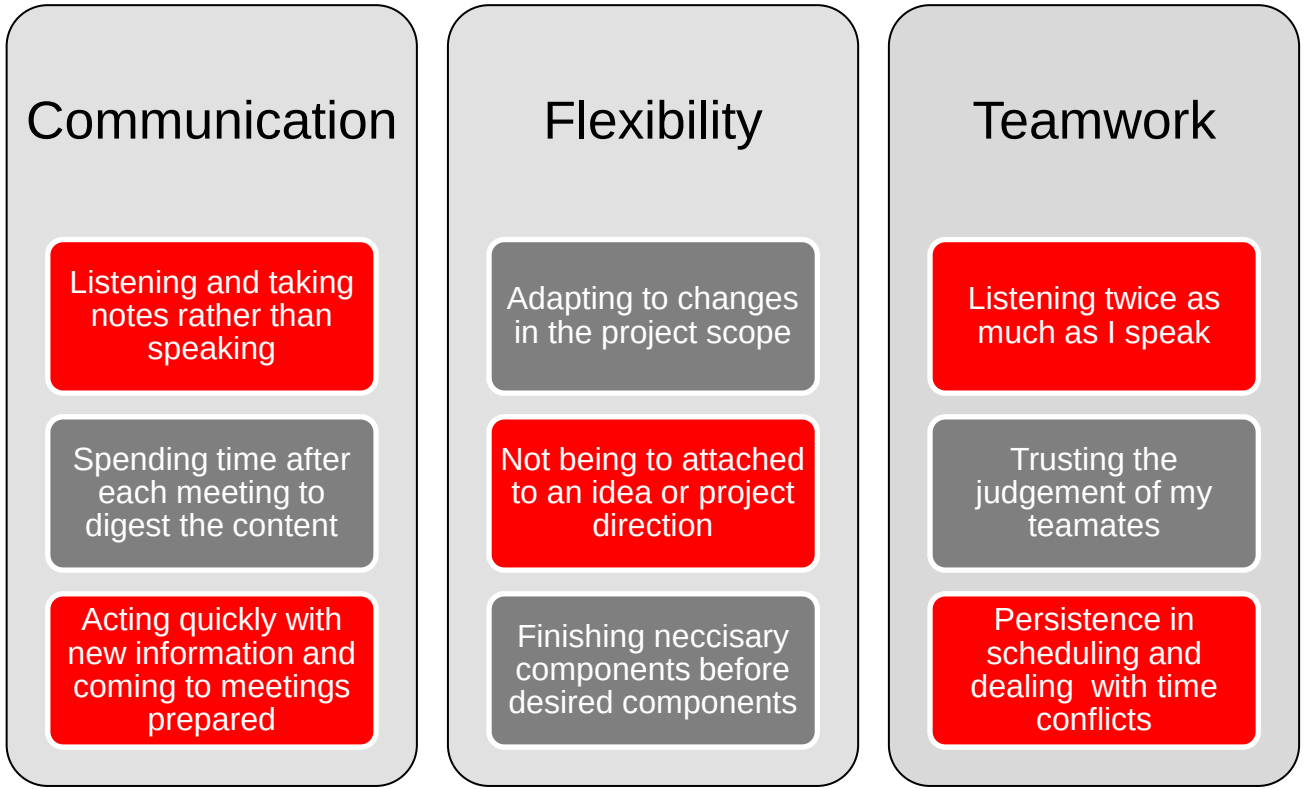
- Future Work
  - OCR (Optical Character Recognition) converts handwritten data into txt file
  - Adding an ISBN scanning system to the script so handwritten data is no longer needed
  - Validation and Revisions
  - Review the finalized results with Stephen Seymore our project sponsor and Dr. McConomy.

David Bishop

Lessons Learned



Lessons Learned



Alex Wilson

Lessons Learned

Technical Skills

- Procedural vs Object Oriented Coding (Basics)
- Heuristics In Software
  - Create guard rails so that app doesn't crash
  - But give the user flexibly and freedom to veer of course

Work Experience

- Talking with Danfoss Upper management and
- Lean Manufacturing Techniques

Other Cool Features

- Optical Character Recognition (OCR)
- Scanner Technology

Kyle Youmans

Lessons Learned

Working with Sponsor

- Preparing for meetings
- Interpreting needs vs wants

Project Experience

- Software skills (MATLAB)
- Professional skills

Team Experience

- Zoom Communication
- Delegation of tasks

Julian Villamil

Summary

The objective of this project is to design an integrated system that generates a bill of materials for a given aftermarket compressor using records provided by Danfoss's investigation and planning team.

- A MATLAB App was designed to assist planners and streamline aftermarket production.
  - Four main tabs were made to organize the process.
  - Results are exported to an excel file.
- Future work includes validation
  - Having a planner step through the new process.
  - Presenting results to Stephen Seymore.
  - Working with Optical character recognition (OCR) to reduce the number of steps needed by Danfoss personnel.

Reference

[1] Seymore, Stephen. (2020). Aftermarket Services Danfoss Turbocor® Compressors. [PowerPoint slides]. Retrieved from https://3.basecamp.com/3939307/buckets/18515621/uploads/3119943154

[2] McConomy, Shayne. (2020). Aftermarket Workflow Project 2020. [Word document]. Retrieved from https://3.basecamp.com/3939307/buckets/18515621/uploads/3078752695

[3] Bishop et al. (2020). SD T504 201106 Concept Generation and Selection. [Word document]. Retrieved from https://famu-fsu-eng.instructure.com/courses/4476/assignments/18861/submissions/102840000000061346

[4] Seymore, Stephen. (2020). Special Compressor Process. Danfoss Turbocor®. [PDF file]. Retrieved from https://3.basecamp.com/3939307/buckets/18515621/uploads/3119943196

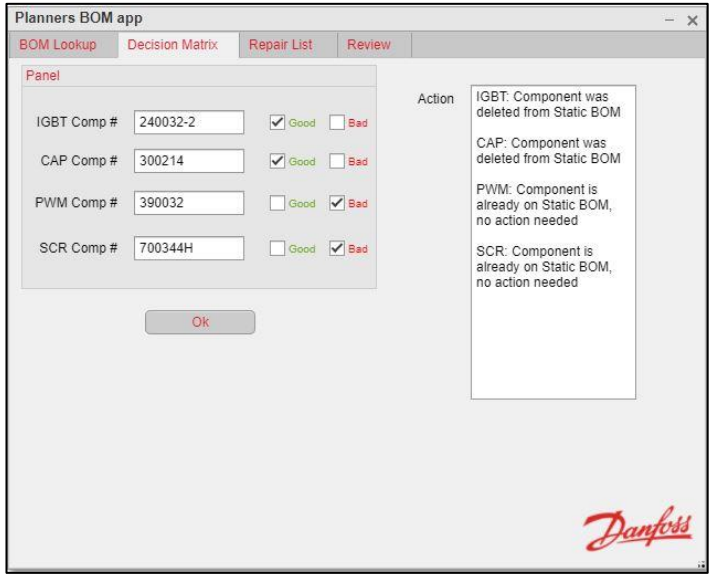
Questions?

Alex Wilson

Backup Slides

- Lessons Learned (David)
  - Striving for quality over quantity
  - Divide and conquer vs group work
    - Allocate tasks to the appropriate people
  - Ask for feedback
    - Constructive feedback betters your work

Decision Matrix



Case 1

- Part is good and the part number is not on the static BOM.
- Therefore, no action is needed for that component

Case 2

- Part is bad and the part number is not on the static BOM.
- Therefore, this component is out of date with the static BOM
- A replacement for this part will be added on the repair list tab.

Case 3

- Part is good and the part number is on the static BOM.
- Therefore, component is deleted off the static BOM.

Case 4

- Part is Bad and the part number is on the current static BOM.
- Therefore, no action is needed for this component.

Alex's Slides

- Setting up meetings with Danfoss (point of contact)
- Allocating Danfoss resources to project
- Setting up structural components of the code
- Reviewing Assignments and allocating team resources
- Responsible for understanding all the nuts and bolts of the project and how they fit together
- Worked with Kyle on the BOM lookup, Decision Matrix, Repair List and Review Tabs

- Lessons Learned (Kyle)
  - Heuristics when it comes to software
    - Less clicks the better
    - Let the user know something is happening (waitbar,and error dialogue)
    - Balance between user freedom while constraining them to guidless so the app doesn’t crash
  - Object Orientated coding (basics)
    - Creating Properties and methods that correspond to a component on the app (input fields, buttons, uitables)
  - Lean Manufacturing techniques
  - Lots of cool MATLAB functions and features
    - Waitbar
    - Error User Interface diolouge box
    - OCR

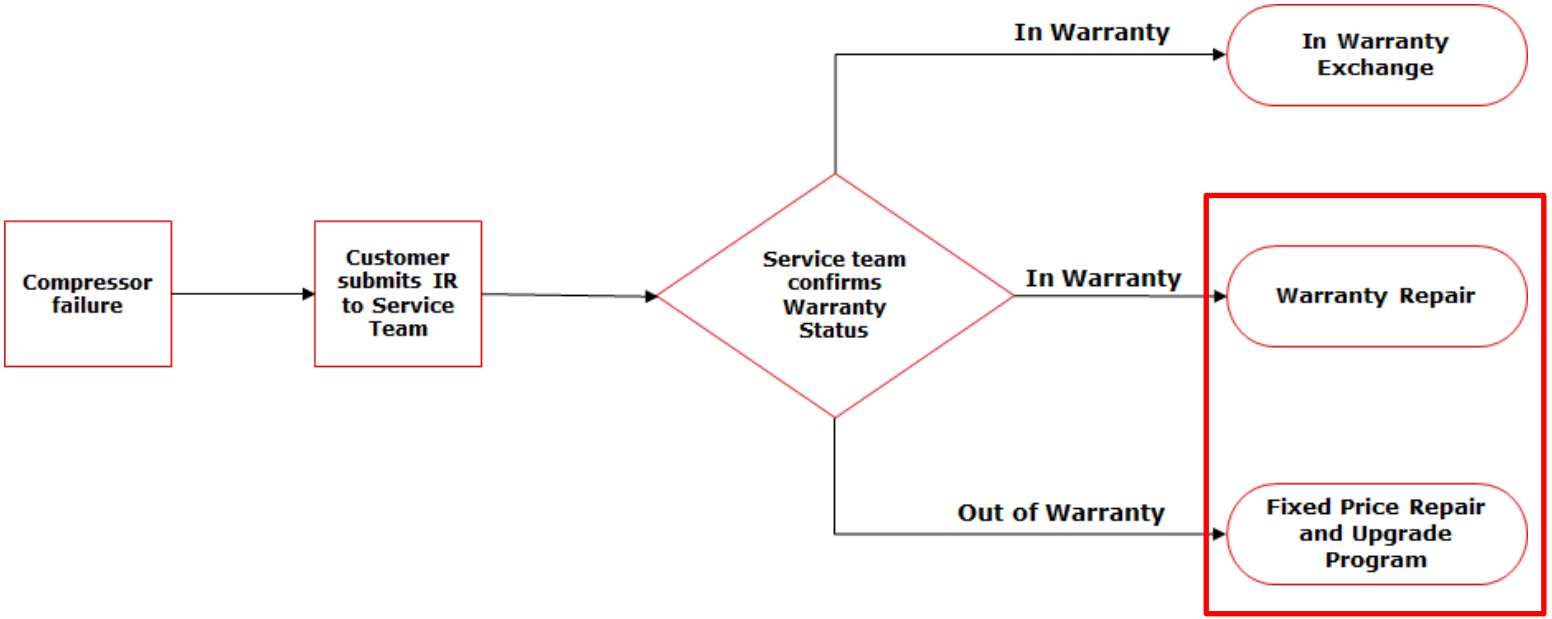
Scanner System

300138:ABCYYDDD100001

Part Number Serial Number

- Danfoss has a current scanning system
- Danfoss also has a quality control department

Future Aftermarket Repair Programs



David Bishop

Morphological Chart

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

Binary Pairwise

Binary Pairwise Graph

	1	2	3	4	5	Total
1. Organization	-	1	1	1	1	4
2. Automate	0	-	1	1	1	3
3.Quality Control	0	0	-	1	1	2
4. User Experience	0	0	0	-	0	0
5. Adaptability	0	0	0	1	-	1
Total	**0**	**1**	**2**	**4**	**3**	**10**

House of Quality

House of Quality									
		Engineering Characteristics							
Improvement Direction		↑	↑	↑	↑	↑	↑	↑	↓
	Units	sec	byte	%	n/a	n/a	n/a	n/a	%
Customer Requirements	Importance Weight Factor	Speed	Storage Capacity	Accuracy	Usability	Aesthetic	Maintainability	Simplicity	Reliability
Organizes	5	1	3	9	1	1	3	1	9
Automate	4	1	0	1	9	0	9	1	3
Controls Quality	3	0	1	9	1	0	3	3	9
Interacts with User	2	0	1	1	9	9	0	3	1
Adaptible	1	0	3	1	9	1	9	3	3
Raw Score (391)		9	23	79	71	24	69	27	89
Relative Weight %		2.30%	5.88%	20.20%	18.16%	6.14%	17.65%	6.91%	22.76%
Rank Order		8	7	2	3	5	4	6	1

First Pugh Chart

Selection Criteria		Concepts							
		1	2	3	4	5	6	7	8
Speed	Datum (Current Method)	+	+	+	+	+	+	+	+
Storage Capacity		+	-	-	S	S	-	+	+
Accuracy		+	+	+	+	+	+	+	+
Usability		+	+	+	+	+	+	+	+
Aesthetic		+	+	+	S	+	+	+	+
Maintainability		+	+	+	+	+	+	+	+
Simplicity		+	-	-	+	+	+	+	+
Reliability		+	+	+	+	+	+	+	+
Pluses		8	6	6	6	7	7	8	8
Minuses		0	2	2	0	0	1	0	0

Second Pugh Chart

Selection Criteria		Concepts 1	4	6	7	8
Speed	Datum (Concept 5)	+	S	+	+	+
Storage Capacity		+	-	-	+	S
Accuracy		+	-	+	+	+
Usability		+	-	+	+	+
Aesthetic		+	-	+	+	+
Maintainability		+	-	+	+	+
Simplicity		+	-	+	+	+
Reliability		+	-	+	+	+
Pluses		8	0	7	8	7
Minuses		0	7	1	0	0

Third Pugh Chart

Selection Criteria		Concepts		
		1	6	8
Speed	Datum (Concept 7)	S	+	-
Storage Capacity		S	-	S
Accuracy		+	+	S
Usability		-	+	S
Aesthetic		S	S	S
Maintainability		-	+	+
Simplicity		+	-	+
Reliability		+	+	S
Pluses		3	5	2
Minuses		1	2	1

Target Catalog

Metric	Target
Storage Capacity	0 < x < 10 Megabytes
Ease of Use	Number of clicks by user 1
Aesthetic Appeal	1-5 (customer satisfaction survey) 5
Information Obtained to Total Information Needed	100%
Processing Speed	2 GHz to 4.0 GHz
File Conversion Accuracy	Files converted to files requested 100%
Data Format Accuracy	File matches column and row assigned Binary (1-0)
Part Conversion Efficiency	Ratio of parts exchanged correctly to total parts exchanged 100%
Reliability	Below 7% average failure rate
Code Complexity	1-5 (customer satisfaction survey) 5
File Location Accuracy	Files placed in the correct location Binary (1-0)
Organization	1-5 (customer satisfaction survey) 5

Customer Survey

Customer Satisfaction Survey					
Question 1 = unacceptable 2 = poor 3 = satisfactory 4 = good 5 = excellent	Order of Satisfaction				
	1	2	3	4	5
How aesthetically appealing is the display of the product?					
Is the code readable, organized, and reproducible?					
How does the product compare to the previously used method?					

Criteria Comparison Matrix [C]								
	Speed	Storage Capacity	Accuracy	Usability	Aesthetic	Maintainability	Compactness	Reliability
Speed	1	3	5	3	0.33	5	3	5
Storage Capacity	0.33	1	5	0.33	0.20	3	1	3
Accuracy	0.20	0.20	1	0.33	0.20	0.33	0.33	1
Usability	0.33	3	3	1	0.33	3	1	3
Aesthetic	3	5	5	3	1	5	5	5
Maintainability	0.20	0.33	3	0.33	0.20	1	0.33	1
Compactness	0.33	1	3	1	0.20	3	1	3
Reliability	0.20	0.33	1	0.33	0.20	1	0.33	1
Sum	5.60	13.87	26	9.33	2.67	21.33	12	22

Normalized Criteria Comparison Matrix									
	Speed	Storage Capacity	Accuracy	Usability	Aesthetic	Maintainability	Compactness	Reliability	Criteria Weight (W)
Speed	0.179	0.216	0.192	0.321	0.125	0.234	0.250	0.227	0.218
Storage Capacity	0.060	0.072	0.192	0.036	0.075	0.141	0.083	0.136	0.099
Accuracy	0.036	0.014	0.038	0.036	0.075	0.016	0.028	0.045	0.036
Usability	0.060	0.216	0.115	0.107	0.125	0.141	0.083	0.136	0.123
Aesthetic	0.536	0.361	0.192	0.321	0.375	0.234	0.417	0.227	0.333
Maintainability	0.036	0.024	0.115	0.036	0.075	0.047	0.028	0.045	0.051
Compactness	0.060	0.072	0.115	0.107	0.075	0.141	0.083	0.136	0.099
Reliability	0.036	0.024	0.038	0.036	0.075	0.047	0.028	0.045	0.041
Sum	1	1	1	1	1	1	1	1	1

AHP

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={Ws}./{W} Consistency Vector
1.932	0.218	8.854
0.834	0.099	8.393
0.298	0.036	8.274
1.087	0.123	8.841
2.986	0.333	8.969
0.417	0.051	8.221
0.844	0.099	8.553
0.345	0.041	8.391

λ=8.562
CI= (λ-n)/(n-1) = (8.562-8)/(8-1)=.0803
CR= CI/RI=.0803/1.4=.0574
CR < 0.1

AHP

Speed Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.091	0.130	0.048	0.090
A.I.	0.455	0.652	0.714	0.607
Digital Library	0.455	0.217	0.238	0.303
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.272	0.090	3.031
1.965	0.607	3.238
0.954	0.303	3.145

λ=3.138
CI= (λ-n)/(n-1) = (8.562-3)/(3-1)=.069
CR= CI/RI=.0803/0.52=0.132

AHP

Storage Capacity Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.143	0.143	0.143	0.143
A.I.	0.714	0.714	0.714	0.714
Digital Library	0.143	0.143	0.143	0.143
Sum	1.000	1.000	1.000	1.000

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.429	0.143	3
2.143	0.714	3
0.429	0.143	3

λ=3

CI= (λ-n)/(n-1) = (3-3)/(3-1)=0

CR= CI/RI=0/0.52=0

AHP

Usability Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.231	0.217	0.333	0.260
A.I.	0.692	0.652	0.556	0.633
Digital Library	0.077	0.130	0.111	0.106
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.790	0.260	3.033
1.946	0.633	3.072
0.320	0.106	3.011

λ=3.137
CI= (λ-n)/(n-1) = (3.137-3)/(3-1)=0.069
CR= CI/RI=0.069/0.52=0.132

AHP

Accuracy Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.143	0.2	0.077	0.140
A.I.	0.429	0.6	0.692	0.574
Digital Library	0.429	0.2	0.231	0.286
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.427	0.140	3.049
1.853	0.574	3.230
0.897	0.286	3.133

λ=3.039

CI= (λ-n)/(n-1) = (3.039-3)/(3-1)=0.019

CR= CI/RI=0.019/0.52=0.037

AHP

Aesthetic Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.2	0.2	0.2	0.2
A.I.	0.6	0.6	0.6	0.6
Digital Library	0.2	0.2	0.2	0.2
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.6	0.2	3
1.8	0.6	3
0.6	0.2	3

λ=3
CI= (λ-n)/(n-1) = (3-3)/(3-1)=0
CR= CI/RI=0/0.52=0

AHP

Maintainability Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.2	0.2	0.2	0.2
A.I.	0.6	0.6	0.6	0.6
Digital Library	0.2	0.2	0.2	0.2
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.6	0.2	3
1.8	0.6	3
0.6	0.2	3

λ=3
CI= (λ-n)/(n-1) = (3-3)/(3-1)=0
CR= CI/RI=0/0.52=0

AHP

Compactness Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.231	0.429	0.2	0.286
A.I.	0.077	0.143	0.2	0.140
Digital Library	0.692	0.429	0.6	0.574
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.897	0.286	3.133
0.427	0.140	3.049
1.853	0.574	3.230

λ=3.137
CI= (λ-n)/(n-1) = (3.137-3)/(3-1)=0.069
CR= CI/RI=0.069/0.52=0.132

AHP

Reliability Comparison Norm				
	Script and Database	A.I.	Digital Library	Design Alternative Priorities
Script and Database	0.2	0.2	0.2	0.2
A.I.	0.6	0.6	0.6	0.6
Digital Library	0.2	0.2	0.2	0.2
Sum	1	1	1	1

Consistency Check		
{Ws}=[C]{W} Weighted Sum Factor	{W} Criteria Weights	Cons={WS}./{W} Consistency Vector
0.6	0.2	3
1.8	0.6	3
0.6	0.2	3

λ=3

CI= (λ-n)/(n-1) = (3-3)/(3-1)=0

CR= CI/RI=0/0.52=0

Final Rating Matrix								
Selection Criteria	Speed	Storage Capacity	Accuracy	Usability	Aesthetic	Maintainability	Compactness	Reliability
Script and Database	0.090	0.143	0.140	0.260	0.2	0.2	0.286	0.2
A.I.	0.607	0.714	0.574	0.633	0.6	0.6	0.140	0.6
Digital Library	0.303	0.143	0.286	0.106	0.2	0.2	0.574	0.2

{W} Criteria Weights
0.218
0.099
0.036
0.123
0.333
0.051
0.099
0.041

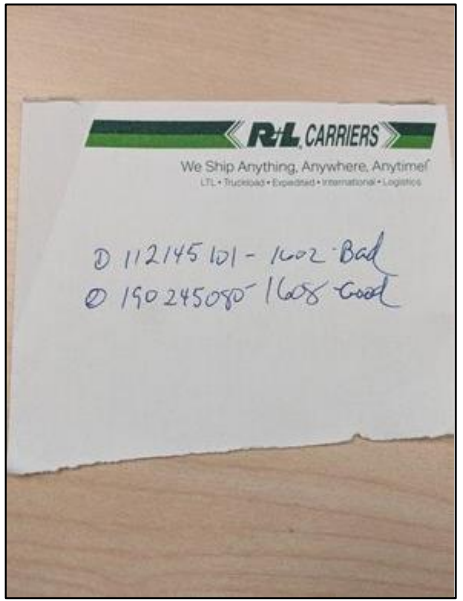
previously appraoved

Concept	Alternative Value
Script and Database	0.184
A.I.	0.571
Digital Library	0.245

Conversation with Planner

Problem's the planner faces:

- Too much of the process is manual
- Quality issue with inputs
- Limited amount of correct info
- Uncertainty of success for future part replacements



MATLAB Functionality

The program consists of several steps:

 Manual Inputs

 Input Files

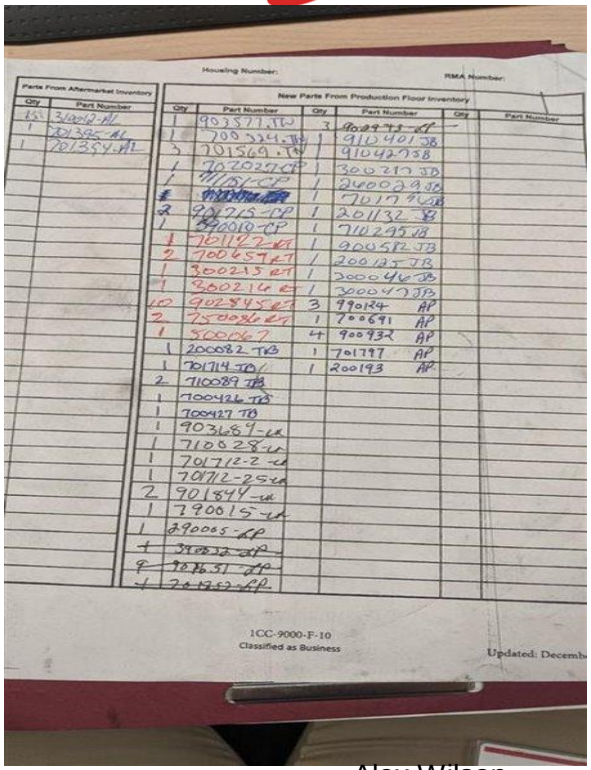
 Logic/Processing

 Output File

Alex Wilson

MATLAB Inputs

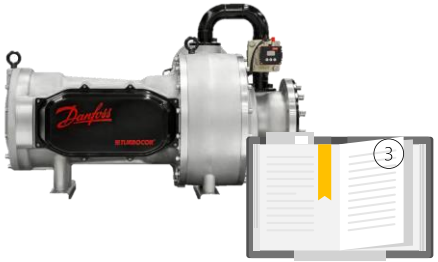
- Component Numbers
  - These are the part numbers associated with each individual part found on the compressor
  - These numbers are typically written down by hand and must be entered into the script manually
- Component Number Quantity
  - Each component has an associated quantity
  - Entered manually alongside the component numbers



Alex Wilson

MATLAB Inputs

- Manufacturing Order Number:
  - The way of tracking the manufacturing changes
  - Follows the compressor down the line
- Compressor Part Number:
  - Determines what Static BOM is to be used
  - This helps determine how the script functions



Alex Wilson

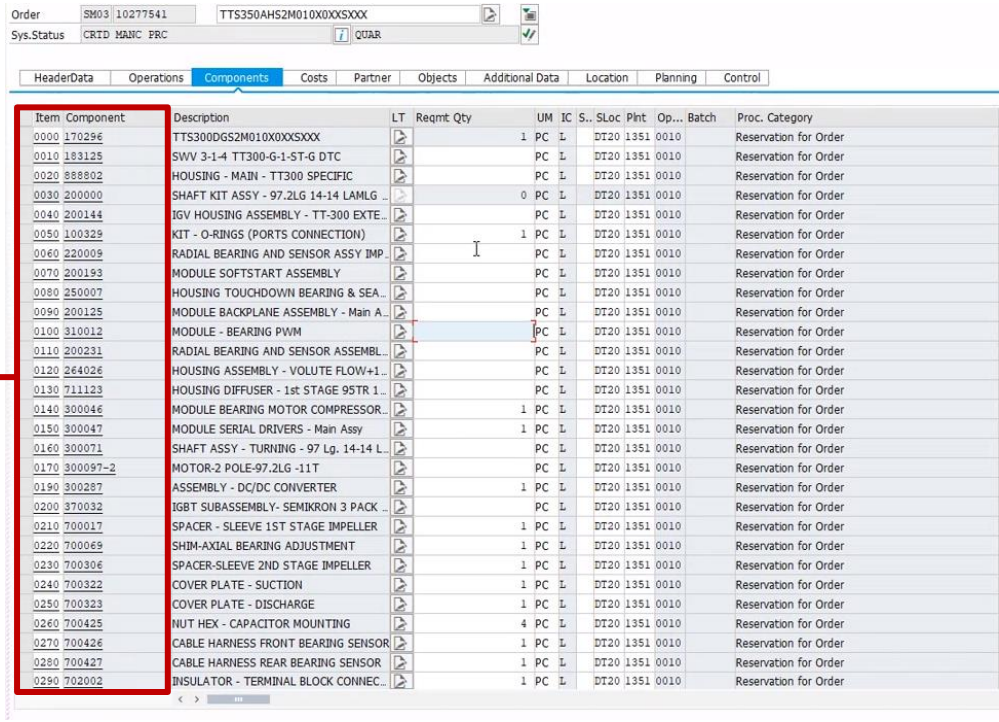
Input Files

- The code requires two separate inputs files:
  - Static BOM input file
    - A bill of materials that comes stock for a given compressor repair.
    - These are parts that will get replaced regardless
    - Downloaded from SAP
  - BOM Lookup input File
    - Contains a list of all possible parts
    - Comments about part replacements
    - Compressor part numbers with their associated Static BOM

Alex Wilson

Static BOM

Item	Component
0000	170296
0010	183125
0020	888802
0030	200000
0040	200144
0050	100329
0060	220009
0070	200193
0080	250007
0090	200125
0100	310012
0110	200231
0120	264026
0130	711123
0140	300046
0150	300047
0160	300071
0170	300097-2
0190	300287
0200	370032
0210	700017
0220	700069
0230	700306
0240	700322
0250	700323
0260	700425
0270	700426
0280	700427
0290	702002



Order SM03 10277541 TTS350AHS2M010X0XXSXXX

Sys.Status CRID MANC PRC QUAR

HeaderData | Operations | Components | Costs | Partner | Objects | Additional Data | Location | Planning | Control

Item	Component	Description	LT	Reqmt Qty	UM	IC	S..	SLoc	Plnt	Op...	Batch	Proc. Category
0000	170296	TTS300DGS2M010X0XXSXXX		1	PC	L		DT20	1351	0010		Reservation for Order
0010	183125	SWV 3-1-4 TT300-G-1-ST-G DTC			PC	L		DT20	1351	0010		Reservation for Order
0020	888802	HOUSING - MAIN - TT300 SPECIFIC			PC	L		DT20	1351	0010		Reservation for Order
0030	200000	SHAFT KIT ASSY - 97.2LG 14-14 LAMLG		0	PC	L		DT20	1351	0010		Reservation for Order
0040	200144	IGV HOUSING ASSEMBLY - TT-300 EXTE			PC	L		DT20	1351	0010		Reservation for Order
0050	100329	KIT - O-RINGS (PORTS CONNECTION)		1	PC	L		DT20	1351	0010		Reservation for Order
0060	220009	RADIAL BEARING AND SENSOR ASSY IMP			PC	L		DT20	1351	0010		Reservation for Order
0070	200193	MODULE SOFTSTART ASSEMBLY			PC	L		DT20	1351	0010		Reservation for Order
0080	250007	HOUSING TOUCHDOWN BEARING & SEA			PC	L		DT20	1351	0010		Reservation for Order
0090	200125	MODULE BACKPLANE ASSEMBLY - Main A			PC	L		DT20	1351	0010		Reservation for Order
0100	310012	MODULE - BEARING PWM			PC	L		DT20	1351	0010		Reservation for Order
0110	200231	RADIAL BEARING AND SENSOR ASSEMBL			PC	L		DT20	1351	0010		Reservation for Order
0120	264026	HOUSING ASSEMBLY - VOLUTE FLOW+1			PC	L		DT20	1351	0010		Reservation for Order
0130	711123	HOUSING DIFFUSER - 1st STAGE 95TR 1			PC	L		DT20	1351	0010		Reservation for Order
0140	300046	MODULE BEARING MOTOR COMPRESSOR		1	PC	L		DT20	1351	0010		Reservation for Order
0150	300047	MODULE SERIAL DRIVERS - Main Assy		1	PC	L		DT20	1351	0010		Reservation for Order
0160	300071	SHAFT ASSY - TURNING - 97 Lg. 14-14 L			PC	L		DT20	1351	0010		Reservation for Order
0170	300097-2	MOTOR-2 POLE-97.2LG -11T			PC	L		DT20	1351	0010		Reservation for Order
0190	300287	ASSEMBLY - DC/DC CONVERTER		1	PC	L		DT20	1351	0010		Reservation for Order
0200	370032	IGBT SUBASSEMBLY- SEMIKRON 3 PACK			PC	L		DT20	1351	0010		Reservation for Order
0210	700017	SPACER - SLEEVE 1ST STAGE IMPELLER		1	PC	L		DT20	1351	0010		Reservation for Order
0220	700069	SHIM-AXIAL BEARING ADJUSTMENT		1	PC	L		DT20	1351	0010		Reservation for Order
0230	700306	SPACER-SLEEVE 2ND STAGE IMPELLER		1	PC	L		DT20	1351	0010		Reservation for Order
0240	700322	COVER PLATE - SUCTION		1	PC	L		DT20	1351	0010		Reservation for Order
0250	700323	COVER PLATE - DISCHARGE		1	PC	L		DT20	1351	0010		Reservation for Order
0260	700425	NUT HEX - CAPACITOR MOUNTING		4	PC	L		DT20	1351	0010		Reservation for Order
0270	700426	CABLE HARNESS FRONT BEARING SENSOR		1	PC	L		DT20	1351	0010		Reservation for Order
0280	700427	CABLE HARNESS REAR BEARING SENSOR		1	PC	L		DT20	1351	0010		Reservation for Order
0290	702002	INSULATOR - TERMINAL BLOCK CONNEC		1	PC	L		DT20	1351	0010		Reservation for Order

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BOM Lookup File

	A	B	C	D	E
1	PN	Comment			
2	700344	Changed to 700344H			
3	701569	Also add 901868 (x3)			
4	902268	Changed to 902815			
5	900272	Changed to 902881			
6	902038	Changed to 902806			
7	901021	Changed to 902838			
8	901115	Changed to 902885			
9	900041	Changed to 903684			
10	900043	Changed to 902862			
11	900915	Changed to 902857			
12	902655	Check snubber			
13	790013	Changed to 790013K			
14	760019	Changed to 760020 on 350&400			
15	783011	Changed to 783012 on TT350			
16	782012	Changed to 782013 on TT400			
17	902381	Should be 027H9122			
18	400053	Has been replaced by 300186 on VTTs			
19	600051	Has been replaced by 300186 on VTTs			
20	902569	Has been replaced by 300186 on VTTs			
21	770936H	SCR not used on tt300 anymore			
22	260029	Not being purchased - 702998 - also remove 510002			

Comment Section

	A	B	C	D
1	Vlookup	Gen TL	Ctr	TL Descr.
2	TT300CFM1	TT300CFM	1	TT300PG10TD
3	TT300CFM2	TT300CFM	2	TT300EHMT
4	TT300CFM3	TT300CFM	3	TT300DGS
5	TT300CFM4	TT300CFM	4	TT300PG12TD
6	TT300CFM5	TT300CFM	5	TT300EF
7	TT300CFM6	TT300CFM	6	TT300EHS
8	TT300CFM7	TT300CFM	7	TT300PG10T
9	TT300CFM8	TT300CFM	8	TT300EH
10	TT300CFM9	TT300CFM	9	TT300FH
11	TT300CFM10	TT300CFM	10	TT300DG
12	TT300CFM11	TT300CFM	11	TT300PH9T
13	TT300CFM12	TT300CFM	12	TT300CHE
14	TT300CFM13	TT300CFM	13	TT300GH
15	TT300CFM14	TT300CFM	14	TT300EG
16	TT300CFM15	TT300CFM	15	TT300CGRS
17	TT300CFM16	TT300CFM	16	TT300DGRS
18	TT300CFM17	TT300CFM	17	TT300DH
19	TT300CFM18	TT300CFM	18	TT300GHS
20	TT300CFM19	TT300CFM	19	TT300FGS
21	TT300CFM20	TT300CFM	20	TT300FH1
22	TT300CFM21	TT300CFM	21	TT300EHE
23	TT300CFM22	TT300CFM	22	TT300EHM
24	TT300CFM23	TT300CFM	23	TT300GG1
25	TT300CFM24	TT300CFM	24	TT300GG2
26	TT300CFM25	TT300CFM	25	TT300PG11TS

Static BOM Lookup

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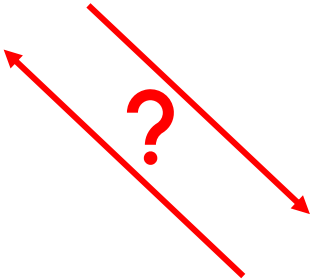
Logic/Processing



	Component Number
1	
2	034L0025
3	034G5050
4	034G5130
5	034G2323
6	034G4252
7	130B1107
8	130B0264
9	130B9990
10	176F6445
11	176F6446
12	176F6447
13	176F3155
14	176F3157
15	176F3159
16	176F3160
17	176F3161
18	176F3162
19	176F8529
20	176F8530
21	176F8534
22	176F8318
23	176F8320
24	176F8323
25	176F8335
26	176F8342

- Existence:
  - Does the component exist?
    - Did the inspector write down the component number correctly
    - Did the script operator copy it over correctly
  - If the component does not exist:
    - The correct component needs to be found
    - This is done by contacting the operator
    - Or by referencing a previously approved part list of the same compressor part number

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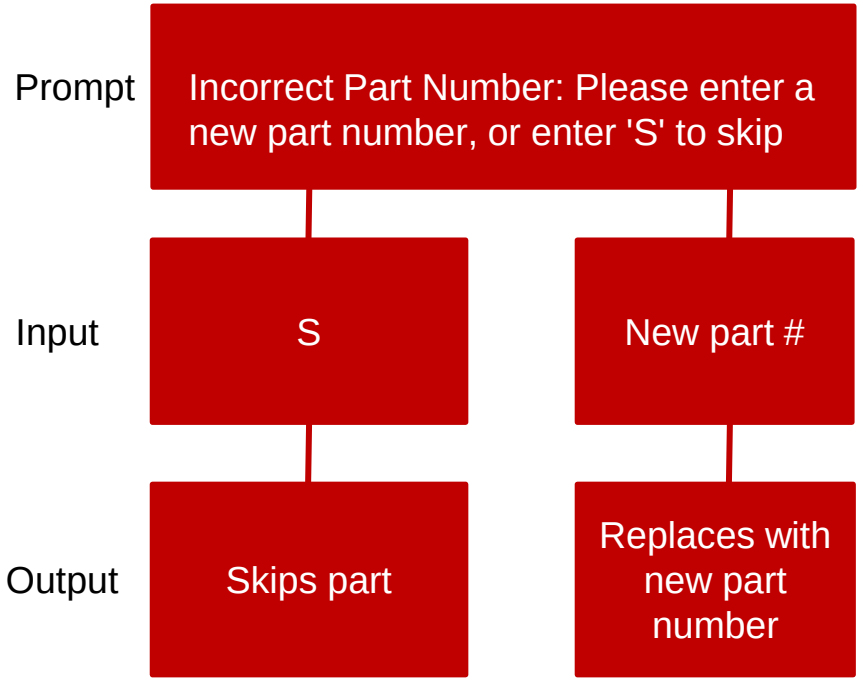
Logic/Processing

- Alert the user when an incorrect component number is entered.
  - Prompts the user to enter the correct value
  - The user can enter or skip and continue entering other parts.
  - In the output file, incorrect parts are displayed in the notes



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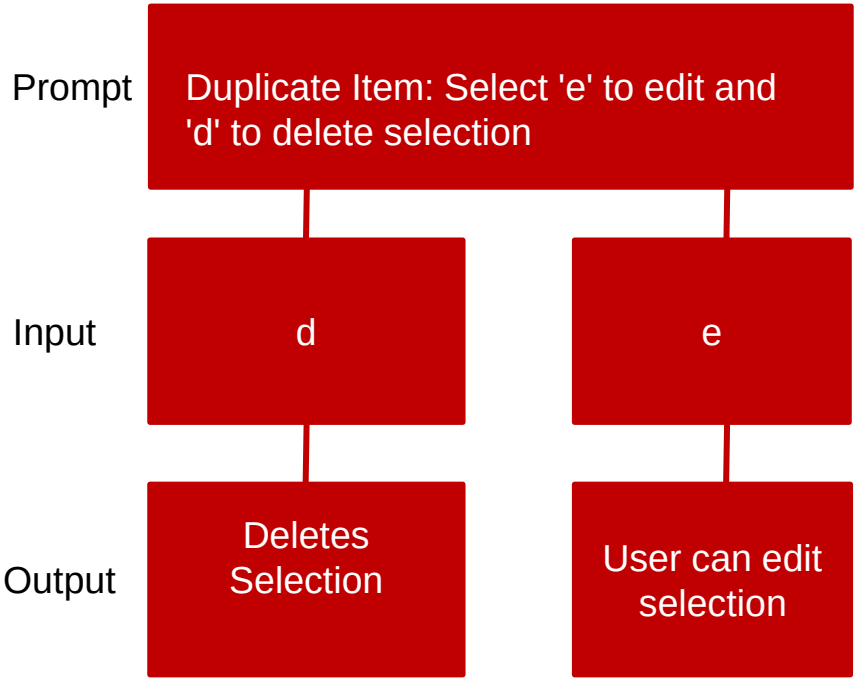
Logic/Processing

- The code will alert the user when they have entered duplicate items.
  - It will allow the user to edit the selection
  - Or it will allow them to delete the selection if it is a duplicate.

Repair Sheet			
Component number	Qty	UM	IC
200000	1	PC	L
200193	1	PC	L
250007	1	PC	L
250007	1	PC	L
310012	1	PC	L
711123	1	PC	L
300071	1	PC	L
700426	1	PC	L
700427	1	PC	L



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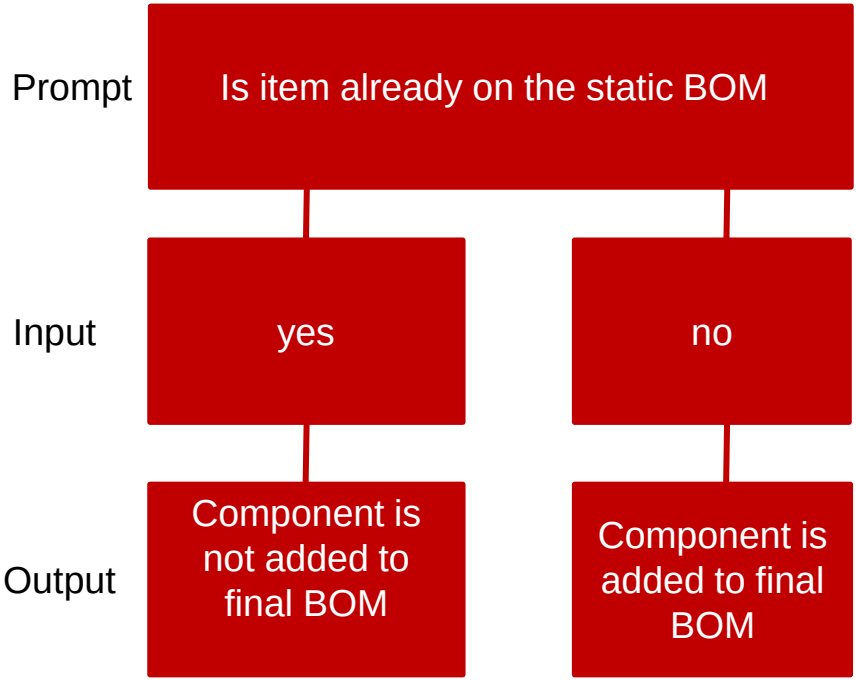
Logic/Processing

- Lookup tool determines if an item is already on the static BOM.
  - If so, the component will not be added to the final BOM
  - If not, it will be added



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Output

- Finally, the code will export the bill of materials
  - Exported as an excel file
  - Contains component numbers of static BOM + added components

BOM:	xxxxx	MO:	xxxxxx	Compressor #:	xxxxx
Component Number	Qty	Item Number	Comments		
700069	3	220	#N/A		
370032	1	200	#N/A		
300287	1	190	#N/A		
710250	1	20	#N/A		
200000	1	30	#N/A		
200144	1	40	#N/A		
220009	3	60	Also add 901868 (x3)		
200193	1	70	#N/A		
250007	1	80	#N/A		
200125	2	90	#N/A		
310012	10	100	#N/A		
200231	2	110	#N/A		
300071	2	160	#N/A		
700306	1	230	#N/A		
700322	4	240	#N/A		
700323	1	250	#N/A		
700425	3	260	#N/A		
700426	1	270	#N/A		
700427	1	280	#N/A		
702002	1	290	#N/A		
710557	1	330	#N/A		
750206-1	1	340	#N/A		
880188-1	1	350	#N/A		
902870	1	360	#N/A		
900032	1	370	#N/A		
900034	1	380	#N/A		
900257	3	390	#N/A		
902881	1	400	#N/A		
900555	1	410	#N/A		

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Future Work

- Automate the manual inputs by changing the process
  - Could scan in the parts instead of writing them down by hand
  - We could also use OCR
- Implement existing logic into code
- Write a process manual (done)
- Need to validate script with correct BOM (in progress)
- Review changes with Guido (in progress)

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Targets and Metrics

- Accuracy (target of 100%)
  - Does the app accurately add and delete parts to the final BOM as compared with completed BOM's
  - Measured as ratio of parts amended correctly to parts amended
- Reliability (target of 93%)
  - Does the app need to be run more than once to get correct results?
  - Number of times run successfully over the number of times run total
- Customer Satisfaction Survey (1-5 scale)
  - Measure's aesthetic appeal, code complexity, and organization.

Targets and Metrics Cont...

- Processing Speed (50% faster)
  - How long the previous method took to the current method
  - Measured using a timer
- Ease of Use (25% less clicks)
  - Number of clicks using old method divided by number of clicks using current method
  - Measured by reviewing recorded footage of old process and counting number of clicks with our current method
- Functionality of Each task