

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



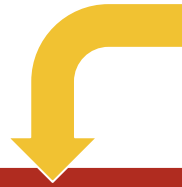
Project Background

Julian Villamil

What's the Process?



Where we come in



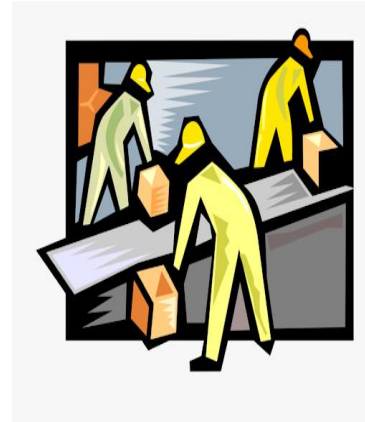
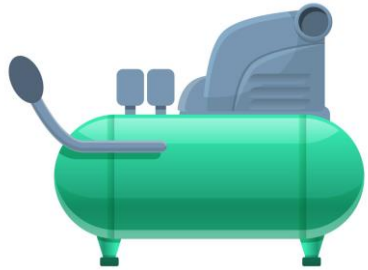
Receive Compressor

Inspection

Planning

Production

Pack & Ship

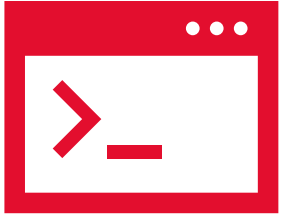


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Solution

Danfoss

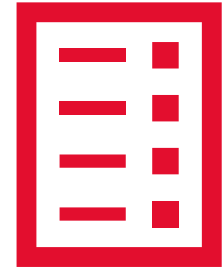
Set of Input Files



Manual Inputs



MATLAB Script



Bill of Materials

Julian Villamil

MATLAB Designer App GUI Template



System Inputs



The MATLAB App GUI is titled "MATLAB App" and contains the following elements:

- Compressor Inputs:** A section with a dropdown menu for "Compressor Type" (options: TT/TG, Mini TT, K-300), and two text input fields for "Serial Number" and "Claim Number", both containing the value "0".
- Plot:** A plot titled "Title" with a y-axis labeled "> 0.5" and an x-axis labeled "X". The axes range from 0 to 1.
- Table:** A table with three columns: "Status", "Main Findings", and "RootCause Concl". It contains four rows of data.
- Button:** A button labeled "Button" located below the table.

Metrics



Decision Making Output



Consolidates compressor part data in one location

Julian Villamil

What the App Looks Like Now



Input Field to get relevant information

Serial Number

Column 1	Column 2	Column 3	Column 4

Allows user to select input file

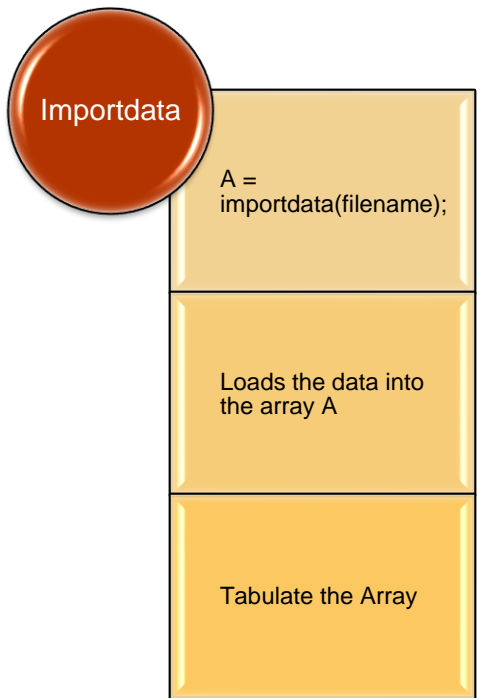
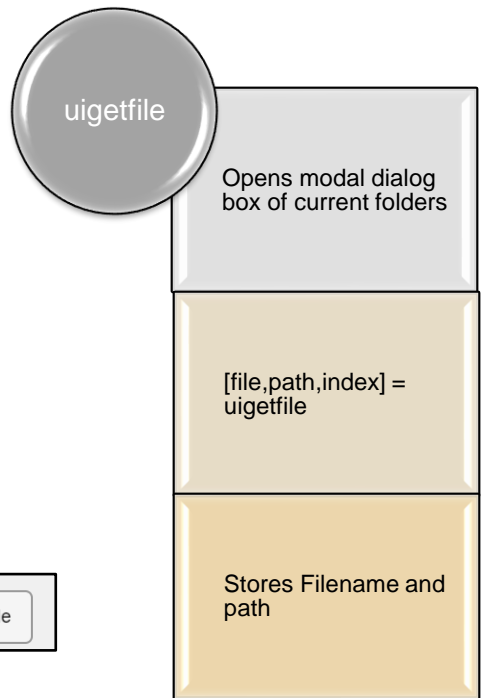
Selects the output path of the BOM

Julian Villamil

Upload Function



Allows user to select input file



Julian Villamil

What the App Looks Like Now



Inputs to get the static BOM

Serial Number

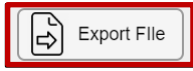
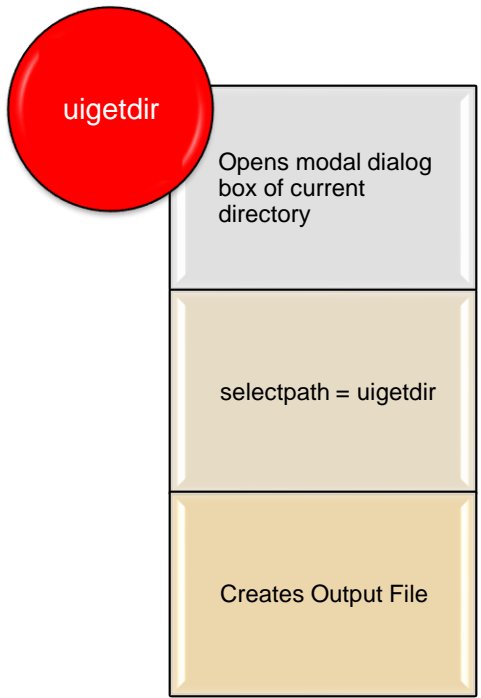
Column 1	Column 2	Column 3	Column 4

Allows user to select input file

Selects the output path of the BOM

Julian Villamil

Export Function



Selects the output path of the BOM



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What the App Looks Like Now



Inputs to get the static BOM

Serial Number Search

Column 1	Column 2	Column 3	Column 4
----------	----------	----------	----------

Allows user to select input file

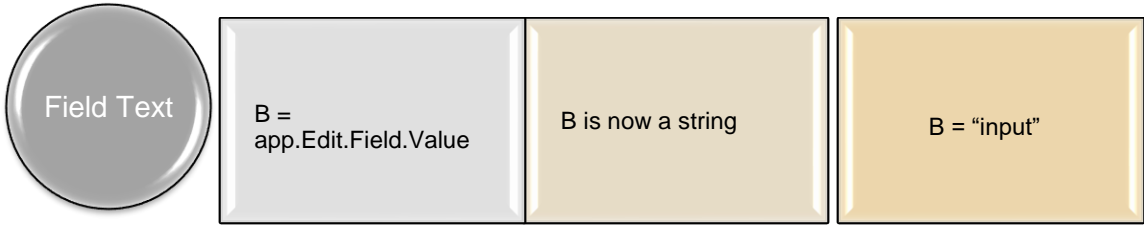
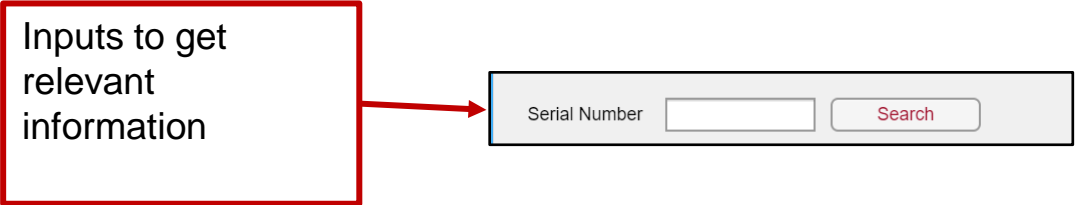
Upload File

Export File

Selects the output path of the BOM

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Insert Field Text Function

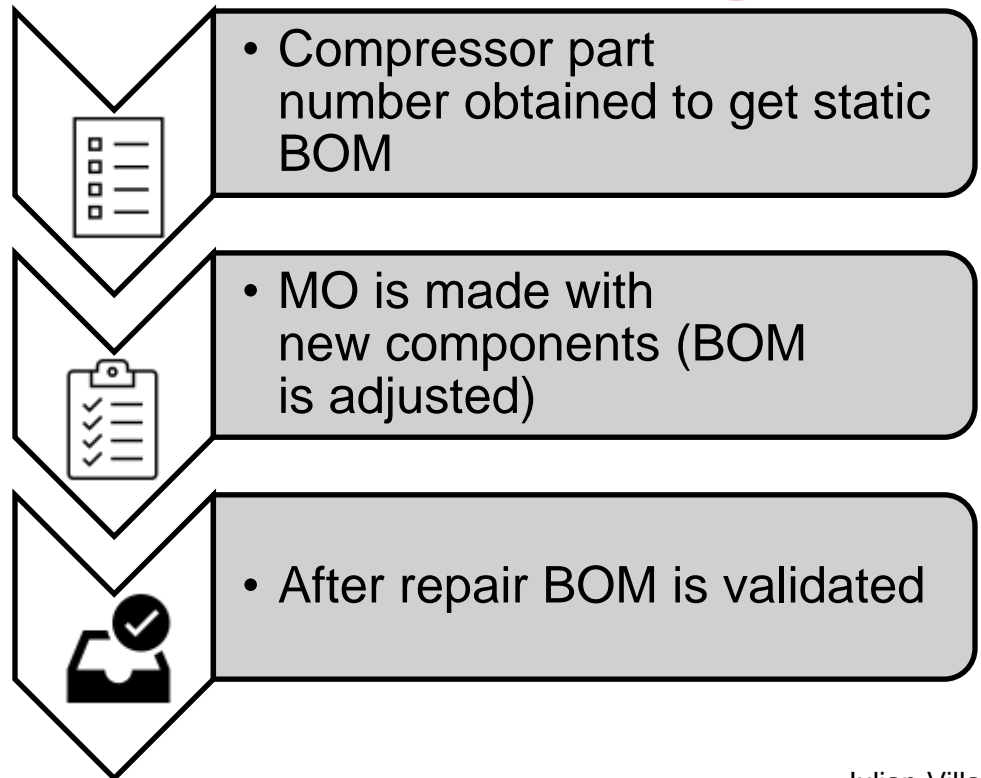
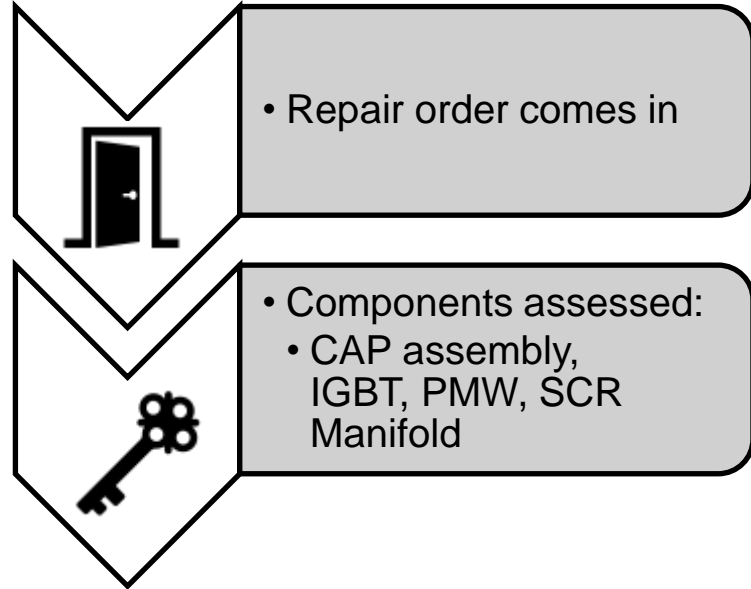


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Conversation with Planner



Steps for replacement:

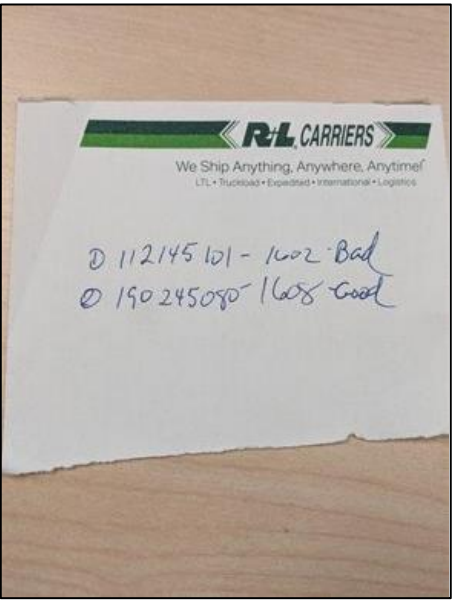
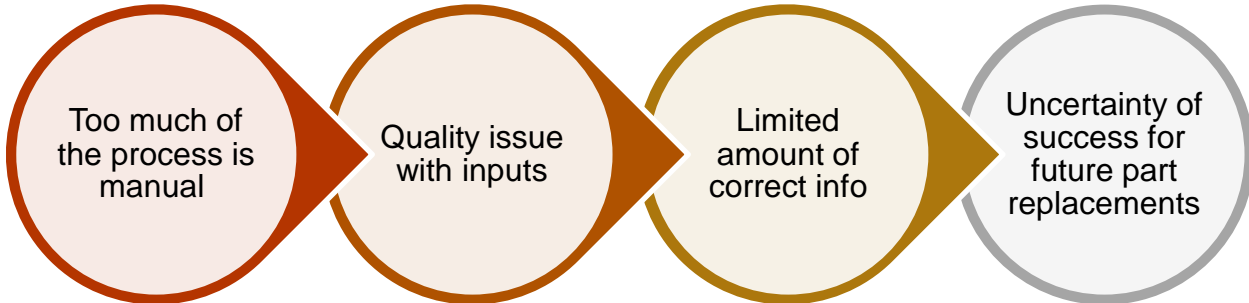


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Conversation with Planner



Problem's the planner faces:



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The program consists of several steps:



Manual Inputs



Input Files



Logic/Processing



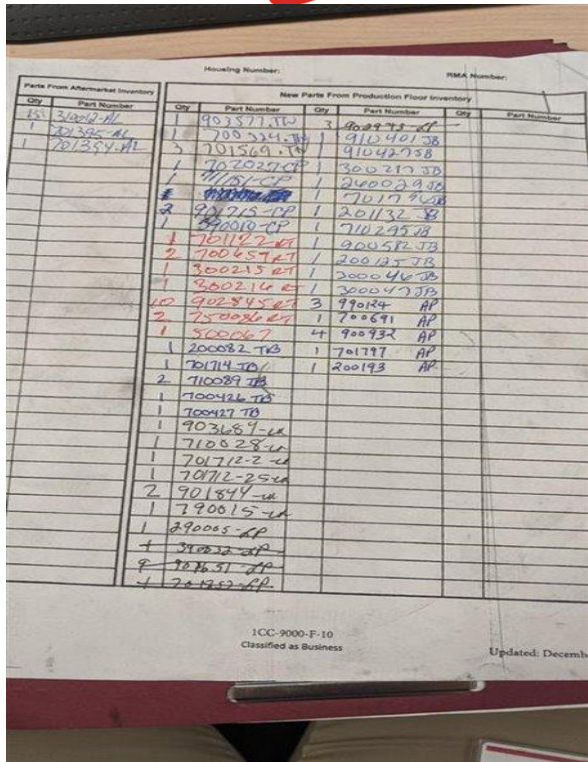
Output File

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



- 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

- The code requires two separate inputs files:
 - SAP 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 TTS350AH52M010X0X5XXX
 Sys.Status: CRTD MANC FRC 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	TTS300DGS2M010X0X5XXX			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

Alex Wilson

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

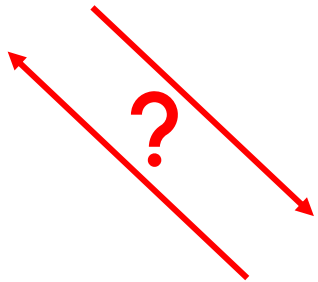
	A	B	C	D
1	Vlookup	Gen TL	Ctr	TL Descr.
2	TT300CFM1	TT300CFM	1	TT300PG10TD
3	TT300CFM2	TT300CFM	2	TT300EHMT
4	TT300CFM3	TT300CFM	3	TT300DGS
5	TT300CFM4	TT300CFM	4	TT300PG12TD
6	TT300CFM5	TT300CFM	5	TT300EF
7	TT300CFM6	TT300CFM	6	TT300EHS
8	TT300CFM7	TT300CFM	7	TT300PG10T
9	TT300CFM8	TT300CFM	8	TT300EH
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

Alex Wilson



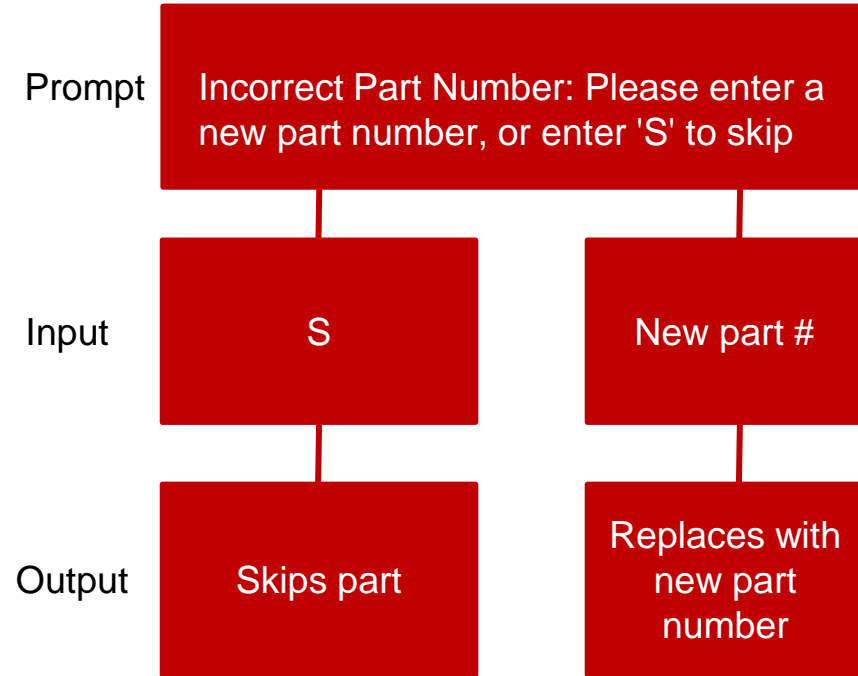
- Existence:
 - Does the component exist?
 - Did the inspector write down the component number correctly
 - Did the script operator copy it over correctly
 - If the component does not exist:
 - The correct component needs to be found
 - This is done by contacting the operator
 - Or by referencing a previously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



1	Component Number
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

Alex Wilson

- 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

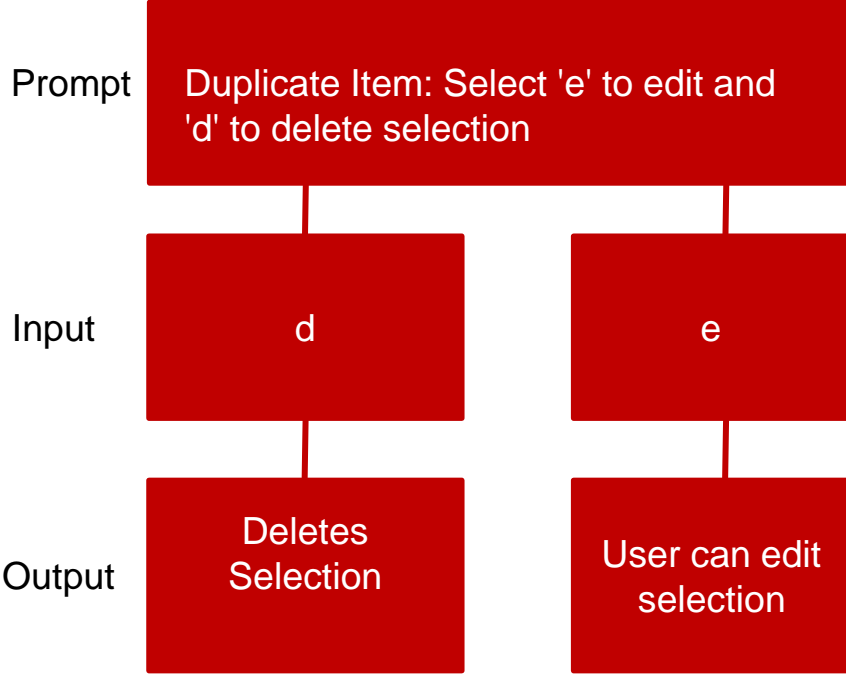


Alex Wilson



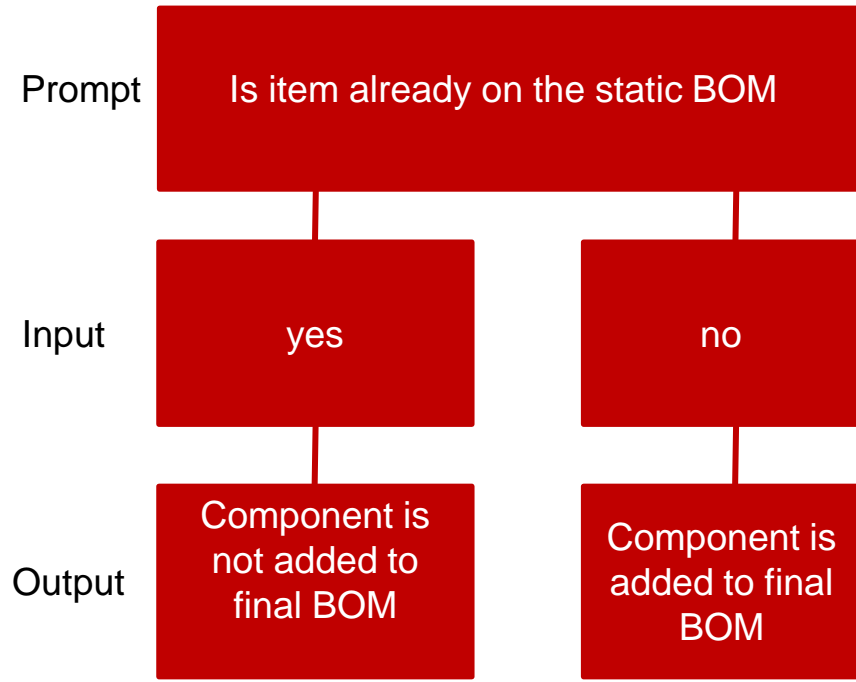
- The code will alert the user when they have entered duplicate items.
 - It will allow the user to edit the selection
 - Or it will allow them to delete the selection if it is a duplicate.

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



Alex Wilson

- 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



Alex Wilson

- 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		

Alex Wilson

- Automate the manual inputs by changing the process
 - Could scan in the parts instead of writing them down by hand
 - Use scripting feature in SAP to automatically export the correct static BOM when requested
- Implement existing logic into code
- Write a process manual
- Need to validate script with correct BOM
- Review changes with Guido

Alex Wilson

- [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/10284000000061346>
- [4] Seymore, Stephen. (2020). Special Compressor Process. Danfoss Turbocor®. [PDF file]. Retrieved from <https://3.basecamp.com/3939307/buckets/18515621/uploads/3119943196>

Alex Wilson

Questions?

Danfoss

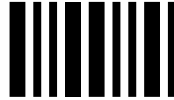
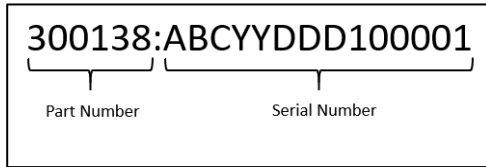


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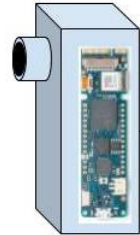


Backup Slides

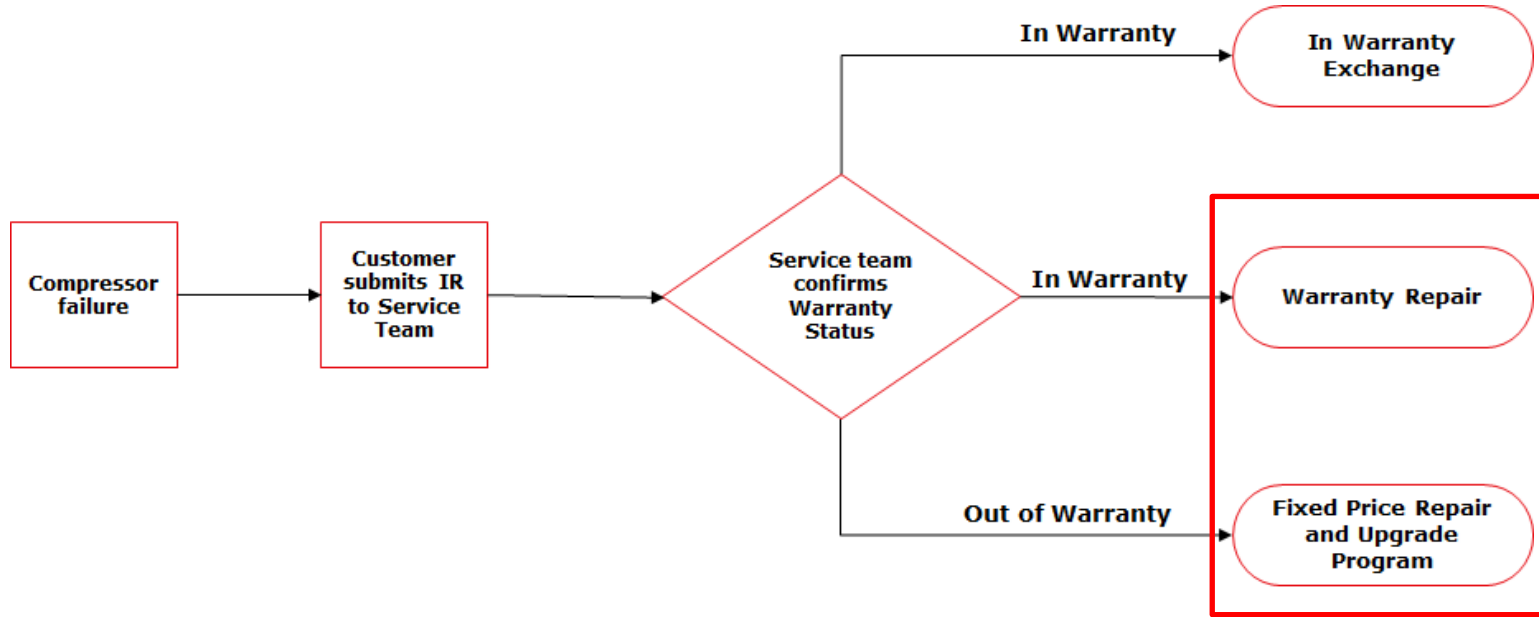
Scanner System



- 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
Adaptable	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

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

$\lambda=8.562$

$CI= (\lambda-n)/(n-1) = (8.562-8)/(8-1)=.0803$

$CR= CI/RI=.0803/1.4=.0574$

$CR < 0.1$

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

$$\lambda=3.138$$

$$CI= (\lambda-n)/(n-1) = (8.562-3)/(3-1)=.069$$

$$CR= CI/RI=.0803/0.52=0.132$$

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

$\lambda=3$

$CI = (\lambda - n) / (n - 1) = (3 - 3) / (3 - 1) = 0$

$CR = CI / RI = 0 / 0.52 = 0$

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

$\lambda=3.137$
 $CI= (\lambda-n)/(n-1) = (3.137-3)/(3-1)=0.069$
 $CR= CI/RI=0.069/0.52=0.132$

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

$$\lambda=3.039$$

$$CI= (\lambda-n)/(n-1) = (3.039-3)/(3-1)=0.019$$

$$CR= CI/RI=0.019/0.52=0.037$$

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

$$\lambda=3$$

$$CI= (\lambda-n)/(n-1) = (3-3)/(3-1)=0$$

$$CR= CI/RI=0/0.52=0$$

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

$$\lambda=3$$

$$CI = (\lambda - n) / (n - 1) = (3 - 3) / (3 - 1) = 0$$

$$CR = CI / RI = 0 / 0.52 = 0$$

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

$$\lambda = 3.137$$

$$CI = (\lambda - n) / (n - 1) = (3.137 - 3) / (3 - 1) = 0.069$$

$$CR = CI / RI = 0.069 / 0.52 = 0.132$$

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

$$\lambda=3$$

$$CI = (\lambda - n) / (n - 1) = (3 - 3) / (3 - 1) = 0$$

$$CR = CI / RI = 0 / 0.52 = 0$$

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