HIGH RISE WINDOW CLEANING ROBOT

DESIGN FOR QUALITY AND RELIABILITY

Dr. Raguraman Munusamy

MDM18B050 - SREEKIREN.D.S
MDM18B049 - SOORYA SRIRAM
EVD18I001 - A.BALAVIGNESH
ESD18I019 - SRIVATSAN.O

B2 - 43

INTRODUCTION:

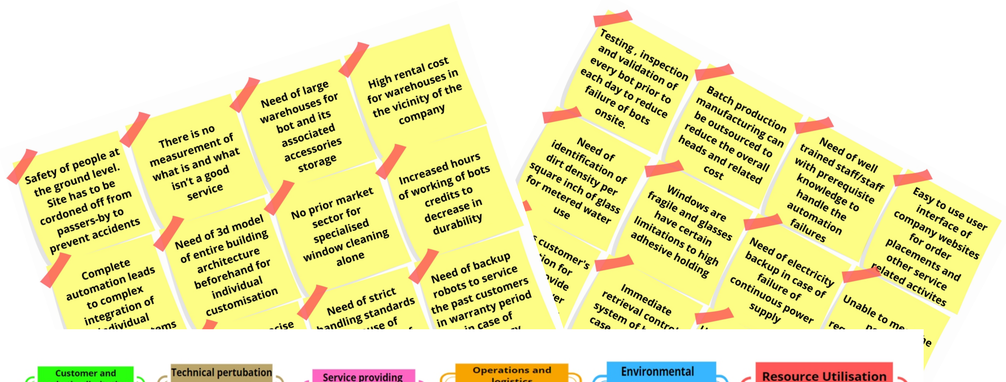
With the ever increasing number of the glass windowed skyscrapers, the demand for their maintenance is also on the rise. Currently platform cleaning methods are being utilized most often, which are operated manually and hence are labor intensive, time consuming, costly and risky. Many solutions have been developed to overcome this problem. The robotic climbing systems proposed to do the job are most often complex in their construction and do not provide for a simple solution . There are many existing systems which make use of this technique to perform cleaning of skyscrapers. However these systems are not totally automated. Our robot aims at providing a cleaning system with maximum automation and minimum cost. The proposed prototype removes human intervention to a maximum extent and implements an effective algorithm that ensures a perfect and clean glass curtain wall of a high rise building.

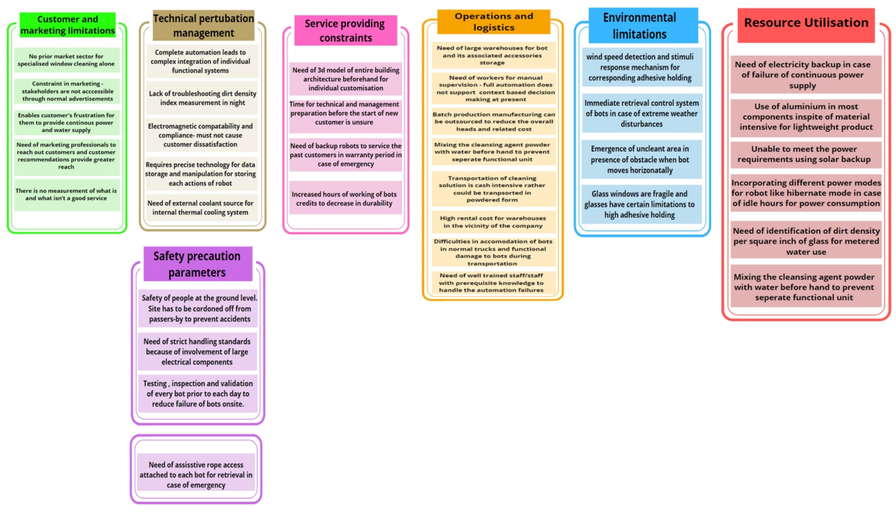
WHAT IS DFSS?

Design for Six Sigma (DFSS), or the Six Sigma DMADV process (Define, Measure, Analyze, Design, Verify), is an improvement system used to develop new processes or products at Six Sigma quality levels. It also can be employed if a current process requires more than just incremental improvement. It is executed by Six Sigma Green Belts and Six Sigma Black Belts, and overseen by Six Sigma Master Black Belts.

DEFINE : concept generation & correlation parametrisation

AFFINITY DIAGRAM





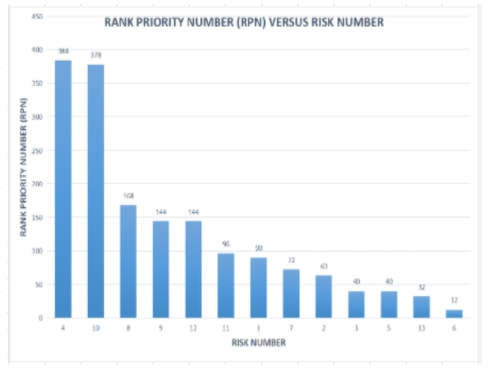
Bases on the affinity diagram where the generated ideas are group together for concept generation and application the result is broadly defined into 7 subdomains namely: Operations and logistics,Resource utilisation,Environmental limitations,Customer and marketing limitations,Safety precautionary parameters,Technical pertubation management Service providing constraints

ANALYSIS:

FMEA

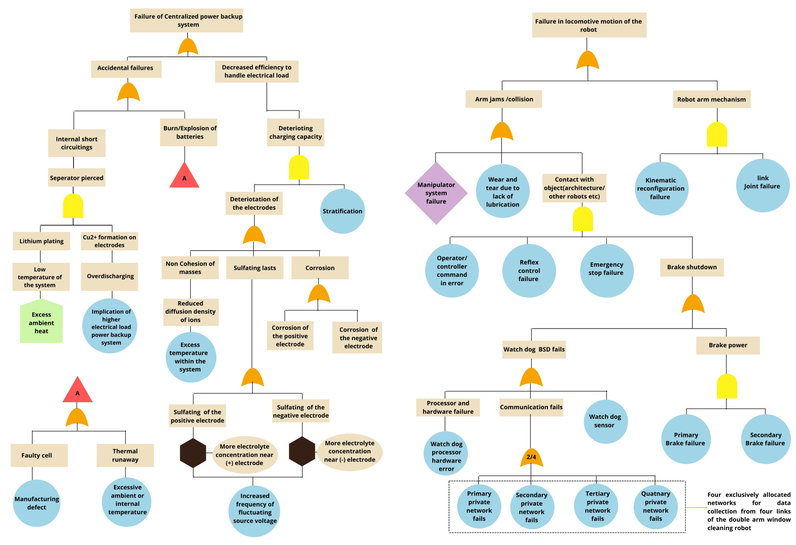
FAILURE MODE EFFECT ANALYSIS OF INDIVIDUAL COMPONENTS

Risk No.	Part/Feature	Function	Potential Failure Mode	Potential Failure Mode Effect	SEVERITY	Potential Failure Mode Cause	OCCURRENCE	Detection of potential failure mode/cause	DETECTION	RPN (S x O x D)	Recommended Improvement Activities	Action Owner
1	Servo Motor	Angle Manipulation - Arm movement	wear and tear of the gears	Immobility	10	lack of lubricants	3	Field mode-Immobility, Inaccuracy in	3	90	Frequent lubrication	Heavens Roar's electro-mechanical technician
2	Vacuum suction pump	Adhesion to wet/ dirty surfaces	Wear and tear of the suction cups, Unclean surface causes lack of adhesion	Falling and tilting, Weight Imbalance	9	Sedimentation of impure dust affects adhesion	7	Field mode-Falling and tilting	1	63	regular inspection, maintainance and repair	Heavens Roar's electro-mechanical technician
3	DC Motor	Cleaning movement - Rotating Brushes	Demagnetisation/misorientation of the coils	No cleaning	10	improper biasing of the motor, full damage	4	Field Mode - Improper/no cleaning	1	40	frequently checking if the connection is intact	Heavens Roar's electro-mechanical technician
4	Brushes	Cleaning - 360 degree cleaning	Corrosion and Poor Surface Finishing	Improper cleaning	8	repeated use without proper maintainance	8	Field Mode - Improper/no cleaning	6	384	Periodic inspection	Heavens Roar's electro-mechanical technician
5	Microcontroller	Main control of the robot	High voltage/current in the circuit, unwanted state changes	Robot will stop working and might fall off when its working	10	Electrical noises, leakage currents, bouncing states of switches	7	Field Mode - uncharacteristic behaviour of the robot	2	40	deploying noise filters and use of over voltage and current protection circuit	Heavens Roar's electro-mechanical technician
6	Indicator(LED)	Indicate the state of the machine (ON/OFF)	High voltage/current in the circuit	No indicators about the state to the supervisor and the customer	3	Electrical noises, leakage currents	4	Field Mode - No indications	1	12	deploying noise filters and use of over voltage and current protection circuit	Heavens Roar's electro-mechanical technician
7	Over ride switches	Manual control over the bot	Max result in start up failure and randomly shuts down the robot	loss of manual control	8	exposure to adverse environments	6	Stalling the cleaning process	3	72	Removal or temporary stoppage of override switch	Heavens Roar's electro-mechanical technician
8	Bio degradable filter	Filter the unclean overhead tank water before cleaning	Corrosion due to hardness in water leading to wear and tear	Dirty water will be used to clean	6	harmful chemicals coming in contact with the filter	4	Colour of water/ Mixture of dirt and sand with the water	7	168	Periodic inspection	Heavens Roar's electro-mechanical technician
9	Cleansing agent	Cleaning/ Removing the dirt from surfaces	Solidification/ Solid soap particles doesnt dissolve properly	Clogging the pipes	8	adverse environmental conditions	9	Field mode - Soapy water due to improper mixing	2	144	Interior sedimentation is checked against inner surface of pipe. Soapy window surfaces can also be checked	Heavens Roar's electro-mechanical technician
10	Proximity sensor	Obstacle detection and prevention of interference with bots nearby	Incorrect sensing of birds and insect, high voltage/current in the circuit	collision with obstricles and other working robots	7	Environmental interference/Electrical noises, leakage currents	9	Field Mode - Clashes with nearby robot	6	378	sealing appropriately and use of over voltage and current protection circuits	Heavens Roar's electro-mechanical technician
11	Image Processing Camera	Maximum area coverage for dust density identification	Scratching of glass, high voltage/current in the circuit, shutter failure	Unregulated use of water	6	Electrical noises, leakage currents, Lack of light and poor positioning	4	Incorrect data gathering	4	96	Structural similarity is checked at regular intervals	Heavens Roar's electro-mechanical technician
12	PVC pipes	Pipes used to restrict/ausre water within the heated robot	Cracks and leakages causes shorting of internal electric components	wastage of water	8	High pressure due to inflow of overhead water	2	Field Mode - Wethrough inside bot	9	144	Unscrew the base and check internal components	Heavens Roar's electro-mechanical technician
13	Body - Stainless Steel	Lightweight body for maximum payload carrying capacity	Crack/ Rupture on outer surface	Imbalance of weight, might scratch the glasses	8	External impact(Eg. Stone) or weather conditions, repeated dropping	1	Field Mode - External Damage	6	32	Checking the body at the end of the day's service	Heavens Roar's electro-mechanical technician



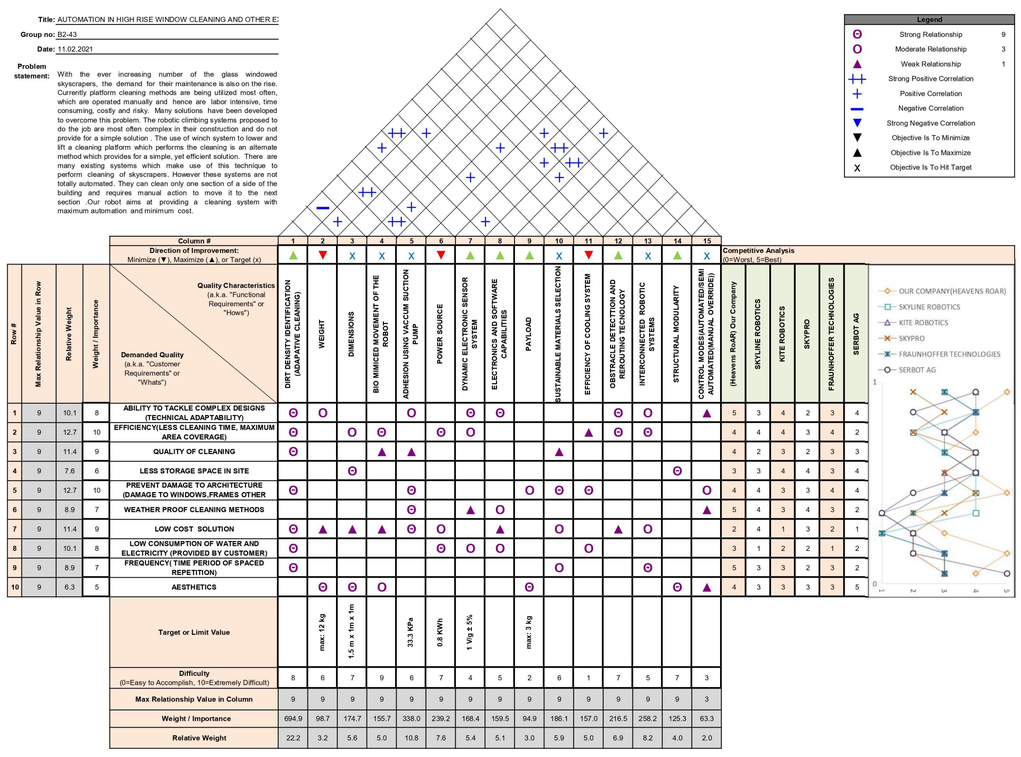
Based on the analysis done using FMEA at both product and component level risk associated towards brushes and proximity sensor bags the major importance .THis can be improvised using periodic inspection and with appropiate code and use of over voltage and current protection circuit similiary based on the ranking order the risk has to be rectified according with their respective improvement activities.

FAULT TREE ANALYSIS



THe entire high rise window cleaning system is divided into number of subsystems and considering this as collective model FTA analysis is perfomed where the mst of the electronic components are dominanatly affected by battery management failures,sensor failures and other weight failures which is detailed in a seperate pdf.

QUALITY FUNCTION DEPLOYMENT (QFD)



Heavens Roar, is a unique robot that fits and cleans any engineering building irrespective of its complex architecture and is not restricted to any specific structure. The use of vacuum pumps helps for easy adhesion to glass surfaces and S shaped cleaning mechanism is implemented for easy cleaning. The QFD analysis has been done taking into the consideration the various competitors developing a completely new robotic cleaning system. The weightage of dirt density index or adaptive cleaning is very high since that is one of our differentiating factors. Factors that are integral to our product's formulation and prototype are power source, obstacle detection and rerouting and interconnected robotic systems which would make our product stand out in the market and to our consumers.

PUGH CHART

Pugh Matrix Template

Critical Quality	Weight (1 being least important, 10 being most important)	Concept 1 our product	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6
Weight	4	-1	1	1	-1	1	1
Area cleaned	8	1	0	-1	1	-1	-1
Power consumption	5	1	1	1	-1	0	1
Water consumpition	9	0	-1	0	1	-1	0
Efficiency	9	1	0	1	1	-1	-1
Cost	6	1	0	1	-1	1	1

Summary Table

Total "1s"	4	2	4	3	2	3
Total "0s"	1	3	1	0	1	1
Total "-1s"	1	1	1	3	3	2
Total Weighted Score	24	0	16	11	-16	-2

PRODUCT DESIGN AND OPTIMISATION

The entire model is optimised using mathematical model of governing all the subsystems seperately hence making the design optimisation process modular and since the differentiating feature adapting to different complex architecture.According the concepts with higher conceptual mathetical probability of success is embedded into the system after iterative process of system thinking of design

VERIFICATION AND VALIDATION

The quality of the high rise window cleaning is mainly determined by key performance indicators like efficiency of cleaning where we introduced the concept of dust denisty identification where the amount of cleansing solution depends on the amount of dust present per square inch of area.This is validated using appropiate image processing techniques and other movement and internal colling systems and other extended subsystems are validated using Intelligent systems monitoring

CONCLUSION

THe possible suggestions from brainstorming sessions were collected and grouped into related paramters for providing seperate attentions towards classified problems for developing a customer centric desing and based on the above analysis the interrelation between each parameters were analysed using QFD and the risk associated with the product and each subcomponent was briefed using FMEA and cause these each risk formualted was found through FTA.Based on the above methodology looping different possibilities provide different concept model from which the best needs to be chosen hence weighted pugh chart analysis was undergone to chose the best model that is sustainable,qualtiy centric and reliable product