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Reliability Roadmap at 5 Stars Home Appliances

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Abstract

This case highlights how typically the reliability processes are followed in an Indian manufacturing context and what are the problems faced by organizations in doing so. Several reliability tools and software which are used in practice are also described in the case and author believes that such examples will develop the practical knowledge of the students about reliability. The teaching objective of the case is to make students understand the importance of reliability processes in a company, the approaches followed by the organizations and the problems faced by them while undergoing such processes. Suggestions for developing an improved reliability roadmap for the company is expected from the students with a consideration of the constraints that the company has.

Keywords: Annual Maintenance Cost (AMC), Durability, Design Failure Mode and Effect analysis (DFMEA), Reliability, R&D, Warranty

JEL Codes: M11 (Production Management) and O32 (Management of Technological Innovation and R&D)

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Mr. Raina, the R&D head of the Nagpur plant of "5 Stars Home Appliances" was looking very much annoyed in the lunch table. He nodded his head and told, "Mohan, I am afraid that our VP, R&D, Mr. Iyer is really worried about the way things are going on, especially in your department. He directly questioned me about the reliability department of Nagpur R&D today in the morning meeting and let me tell you, this is the first time I have seen him such annoyed!"

Mohan, the Reliability Manager of his company, kept himself silent for a while. He, in fact, knew that, the company was practically incurring a considerable amount of warranty cost every year and the amount was almost constant during present times, if not increasing. Moreover, time spent in the reliability and durability processes during any of the new product development projects was too much as compared to the benchmark practices. Although the reliability of the final product was not so good, a lot of time was being spent for performing the overall process. This, in turn, was hampering the timely development of the prototypes and so, "5 Stars" was sometimes, lagging in terms of the launch of the product as compared to their competitors. Almost all the design and testing teams had already held the reliability team responsible largely for the delay. He then humbly said, "I understood sir. But I am afraid that the root causes are something different. We need a …"

"No, things were not going well and that is why you have been transferred here from the Coimbatore plant with a promotion. I think Dr. Vyas had also told it to you in advance."
"Yes sir, he explained to me something about it and I am working on it since I came here last week. Actually, I am new here and so I need a little more time to get along with the processes which are being followed here."

"Well, I wonder if I might have a meeting with you after a week. The next Friday, I believe, will be a good time to talk. Then you have ten days in your hand to work on it and it is expected that you will be able to give me the whole picture by this time. I am also expecting some suggestions from you for the improvement in the present process".

"Ok sir, I will try my best to find out the issues by this time".

"Not a try, you must do something. My secretary will send you the mail for the details of the meeting. It is a challenge not only for you but also for me. Bye for now, I have some other important fishes to fry." Mr. Raina left the table. Mohan also left for taking the dessert. It was certainly something that worried him. Ownership wise he was indeed answerable for the issue. But the question was how to face Mr. Raina in the meeting? Of course, he knew that the processes used to be too slow at "5 Stars" and not a full proof one, and there were practical constraints for the improvement. But only the explanation of the constraints would not suffice, he was supposed to tell him some improvement plan, too. "Let me chalk it out today itself…." he murmured while he was taking the dessert in the canteen.

The Company Background

The 5 Stars Home Appliance was a company which manufacturers home appliances like air conditioners, refrigerators, washing machine, microwave etc. The company had been established in 1990 by Mr. Abhinav Chordia and by these years, it had earned a reputation as a renowned player in the Indian home appliance market. The company, at the time when this issue was going on, was having 4 Business Units namely, the 5 Stars refrigerators, 5 Stars ACs, 5 Stars washing machine and 5 Stars small home appliances. All those units were controlled by the corporate office of the company at Coimbatore. There were 5 plants in India from which 5 Stars was rolling out all of their products. The Coimbatore plant was manufacturing both AC and refrigerator, the Baroda plant was solely for small home appliances, the Nagpur plant was making only refrigerator, the Itawa plant was for making washing machine and the Jhargram plant was for AC. Coimbatore, Itawa and Baroda plants were reporting directly to Coimbatore corporate office. But the Nagpur and Jhargram plants were reporting to Coimbatore plant. Actually, from 1990, the Coimbatore plant was manufacturing all the ACs and refrigerators till 2004, whereas the other two plants (Itawa and Baroda) were looking for the washing machine and small appliances manufacturing solely. But as the Indian economy grew day by day, increase in the income level in the small towns of India was observed. This led to an extraordinary demand of AC and refrigerators in almost all the small towns of India and so, the Nagpur and Jhargram plants were opened in 2004, just to cater to the huge demand of AC and refrigerators in other parts of India. Till then, the Coimbatore plant mentors the Nagpur and Jhargram plant, mainly because of the good amount of learning curve which it had. The Exhibit I and II captured the reporting structure of different plants of 5 Stars and that of Nagpur R&D respectively. Everyday teleconference meeting was the way in which the different departmental heads of Coimbatore plant was communicating to the respective departmental head of Nagpur and Jhargram plant.

Abhinav, having a huge experience in dealing with the Indian market knew that Indian customers used to be always cost sensitive and so, he always focused on the cost leadership strategy. He also knew the fact that for customers, cost also includes the maintenance and power consumption rates in case of home appliances. So, the primary focus of the company was not only to make low cost products but also to make products which consume less power and have good maintainability. The timely launch was another “Critical Success Factor” because there were several national and international players in the Indian market and as the market was huge, gaining the first mover’s advantage was extremely necessary to meet the bottom line. So, the policy deployment of the 5 Stars invariably gave importance on two things namely, the low cost & less power consuming products with good maintainability, reasonable reliability and optimum durability and the timeliness in launching products into the market.

The Reliability Processes at 5 Stars:

The Reliability processes of R&Ds of all the plants of 5 Stars were basically derived from the processes which were implemented in the Coimbatore plant by Dr. Vinod Vyas, the head of Reliability. Dr. Vyas was a researcher in the field of reliability and he joined 5 Star's Coimbatore corporate office in 2002, to form a department called reliability in every plant R&D. The processes were applicable for any product and were being followed by all R&Ds of 5 Stars. Reliability manager in every R&D used to report to Dr. Vyas for technical purpose and their respective R&D head for the projects. Mohan was not also an exception. He had got his promotion recently and transferred from Coimbatore plant R&D to Nagpur plant R&D as a reliability manager.

The basic processes of reliability at 5 Stars in Nagpur were varying from project to project. Before defining the processes for different projects, one should have a look on the details of their projects. Projects were chiefly of two types. One was New Product Development (NPD) and the other was the Current Product (CP). Further, the NPD project could be classified into two major type depending on whether the project was having any reference or base platform product or not. Those which were having a base model or precursor were being termed as either improvement or Mix and Match project (MMP). Those were not having any reference and were started from scratch were being termed as Green Field Project (GFP). The diagram of the types of the project has been given in Exhibit III for a better reference.

Reliability processes in 5 Stars mainly were primarily required for the New Product Development Project. The processes consisted of three major steps. They were:

1. Reliability and Durability Target Setting
2. Design Failure Mode and Effect Analysis (DFMEA) and/or Design for Six Sigma (DFSS)
3. Actual testing to find out the Incident per thousand refrigerator (IPTR) and B10 Life of the parts

Step 1: Reliability and Durability Target Setting:

A typical refrigerator consisted of different aggregates. Some of those aggregates were supposed to be performed according to a certain specification and when failed to do so, were to be replaced. Repairing was not possible for those systems. These kinds of aggregates were called endurance systems and for them, the durability target setting was required (i.e. how long they can perform). Generally, durability was measured in 5 Stars with the help of B10 life. Compressors were the examples of endurance parts or systems. Another type of aggregates, those could be maintained to perform according to a certain specification with the help of servicing or maintenance, were called performance parts. Bodies, Door etc. were the example of performance systems. For those systems, the reliability target setting was necessary. In 5 Stars, the reliability

was measured with the help of IPTR. For different New Product Development, the reliability processes followed at 5 Stars have been given below.

1. The example of the Reliability and Durability Target setting for the New Product with Base Platform (the Improvement or MMP) - The Ultra-Cooler X Project.

Reliability Target Setting:

In case of Ultra-Cooler X, generally most or all of the important aggregates were from the base platform i.e. Ultra-cooler series and so, for each of the performance system or part, the database for IPTR was available from warranty data and annual maintenance cost (AMC). These databases provided the customer complains in code and for each compliant code, the 3 monthly, 6 monthly, 9 monthly etc. failure incident data was available. The IPTR for each complaint code was being calculated from the data. For example, the engineer needed to calculate the IPTR of the Door of the base platform Ultra-cooler model from the warranty data. He/she wanted to use the 6 monthly failure data for the same and from the database, he/she found that for 4560 produced refrigerator in 6 months, in 17 refrigerators, the Door failure had been reported. Now the IPTR for the Door of the base platform refrigerator could be calculated as = (17/4560) *1000 = 3.73.

The IPTR for all systems of the base refrigerator could be calculated in such way and the overall IPTR of the refrigerator was = Σ (IPTR of the systems).

While calculating IPTR, the engineer used to prefer to use 6 monthly or 9 monthly data. 3 monthly data were generally not used because they were considered as an early issue (or infant mortality rate) which was very likely for any product. After calculation of IPTR, the reliability target setting was done. If the design of any aggregate was completely the same as that of the base platform refrigerator, generally IPTR target was kept same as the base model. This case was, however, very rare case. In case the design of the aggregate was improved (e.g. the introduction of new compressor etc.), which was very common, the reliability target (i.e. IPTR) was made lesser than that of the base platform refrigerator. Now how much the target would be lesser than the base platform refrigerator target was totally a subjective issue. Generally, the departmental Cross Functional Team (CFT) consisting of designer, reliability engineer and testing engineer take the decision on the same. Designer's opinion was considered vital, but the problem was that the designer, most of the time, used to play safe. A formal sign-off was, however, made at the end of the discussion.

Durability Target Setting:

The durability of the endurance system was measured with the help of B10 life. If the B10 life of an endurance part was specified as x hours, it meant that the maximum 10% of all the parts fitted in the refrigerator would have failed within x hours. In 5 Stars, if the base platform i.e. Ultra-

cooler model data was available, the B10 life was obtained directly from the database. Or else, it was calculated either by actual failure or by censored data analysis. In case of calculating B10 life from actual failure, the data of the durations after which different parts of Ultra-Cooler X failed were being recorded and from the data, the time duration when 10% of all the parts of Ultra-Cooler X failed could be found out (See Exhibit V for an example of B10 life calculation for a refrigerator). In case of censor data analysis, at least 1 failure had to be collected from the failure data and for the other parts, the censored data analysis technique could be used to generate other data points in the Minitab software. Here basically the survival data were being estimated for each of the remaining parts with the help of the Maximum Likelihood Estimator (MLE) and then the joint probability was calculated assuming every failure was independent. Also, they sometimes were using rank regression. In the case of estimation, 5 Stars used to fit the electrical parts into exponential distribution and the other mechanical parts in Weibull Distribution. Then from that, the B10 life could be calculated. Then discussion used to be there in the departmental CFT (same as discussed in the case of IPTR) and the final sign-off was made on the basis of designer's opinion.

2. Reliability and Durability Target Setting for the New Product without the Base Platform refrigerator (the GFP): The Power Saver Project

Power saver was a new brand which 5 Stars was trying to promote in the market, primarily for those customers who were not worried about the price of the product but very sensitive about their power consumption. In other words, these customers, in this case, used to prefer to pay more once to avoid the high electricity cost for their refrigerator. In case of such Green field project, where there was no base refrigerator data available, the basic processes used to remain same as discussed above, but the main problem which was faced by reliability engineer here was the availability of data. But this was very rare that any refrigerator was being totally made without any reference. At least some of the aggregates of new power saver product used to be found either common with some past product or those aggregates with a modification. For the rest of the aggregates, generally, 5 Stars was taking the help of benchmark products of competitors or any other company's product according to the similarity. For the common aggregates, the IPTR data was being collected from the database. For the aggregates which were used in other company's similar product, the data collection procedure was dicey. Generally, 5 Stars used to collect their IPTR data from some common dealers (who was selling both 5 Stars product as well as other competitor's product) and used to update the database. The procedure was actually erroneous because dealer's information was generally having a lot of discrepancies. With the help of those data, then the IPTR and B10 life were calculated using the procedures which were already discussed previously. In case of any improvement in the part, the designer had to take a call on IPTR and B10 life reduction in departmental CFT.

An example may be introduced to illustrate the concept. Suppose, 5 Stars was going to design a power saver refrigerator XYZ for which there was no base platform refrigerator which was

available. In this case, first the reliability engineer would discuss with the design engineer and from the Bill of Material (BOM), it could be found out, how many aggregates were common (or slightly improved) with some other refrigerator in the company. Let us assume that the new refrigerator XYZ was having 20 aggregates out of which 10 aggregates were common or almost common to any of the existing products. So, the corresponding failure data could be used to calculate the reference IPTR and B10 life. For the rest 10 aggregates, 5 Stars used to find out the similar/benchmark product of the competitors first. Say, another company (123) produces a refrigerator ABC, whose all aggregates were found almost the same as XYZ refrigerator. Now the rest 10 aggregate failure data, 5 Stars would collect from common dealers who were selling 5 Stars products as well as company 123's Products (including refrigerator ABC which was already launched).

Step 2: Design Failure Mode and Effect Analysis (DFMEA)

In the reliability process, DFMEA was used in 5 Stars mainly for the following purposes:

- To find out the failure modes of the product/systems
- To find out the root causes of failure
- To find out the detective and prevention mechanism
- To prioritize the failure mode(s) for which actions should be taken.

If any change of the previously used aggregate/systems was made by the designer, DFMEA of the same should have been modified or revised. The ultimate outcome of the DFMEA was the Design Validation Plan or Testing Plan. If the failure modes of the system were captured totally, the testing plan could be designed properly, and this properly designed test plan was used to create the actual situation in which the system or part of the system may fail while it was in operation. It was useful for finding out the correct actual IPTR of the new product.

Suppose the DFMEAs of the door system (Door handle, Door shocker and door) were done to get a feel for the potential failure mode (See Annexure 1 for the DFMEA of the refrigerator Door Handle). Due to these potential failure modes, the door system or any sub-assembly of the door system may have failed in practice. Now the design validation or testing plan (the part which was to be made for door system) should have been made in such a way that the testing of the door system (both as a stand-alone system as well as when fitted in refrigerator) would be performed to make all the potential failure by creating the actual field situation (as close as possible). These failures were very likely in the field condition also. So, from this, whatever IPTR and B10 life had been found would be almost the true representative of the actual IPTR that would be found in the field if the refrigerator was allowed to use actually. Generally, this sort of testing plan should have also included an outdoor testing of the refrigerator also to get almost the similar feel of the field failure. The failure which would be considered to calculate IPTR and B10 life would be mostly as per the failure mode and so, the test engineer was to monitor the no. of times those failures occur while testing.

Step 3: The actual testing for finding the IPTR and B10 Life of the new aggregates which will be used in the new product

Testing or Design Validation Plan was the total list and details of the test which were supposed to be done at prototype level (before the production of the product starts). Ultimately according to the test plan, the testing of newly developed prototype parts was being done (also the proto refrigerator was being tested according to this plan) and the IPTR of the performance systems and B10 life of the endurance systems were being calculated using the previously described procedures. Then these results were being compared with the target that was set in Step 1. The comparison used to be shown to the management in Design Review meeting. From that management generally was taking a call (mainly on the basis of benchmarked refrigerator and on the estimated warranty cost) whether to launch the refrigerator with this reliability or not.
One can see Exhibit IV, to understand the existing overall reliability processes at 5 Stars for any New Product Development.

Reliability Processes for the Existing Project

For existing product(s), generally, a detailed reliability procedure was not required. Here the only requirement was to explore the possibility of reducing the IPTR or increasing the B10 life so that the product reliability would increase, and this would help the reliability of any new product because the current product used to be the base refrigerator for some of the future product. To improve the IPTR and B10 life of a system/part the following scopes were there.

1. Analysis of Warranty cost data of existing products from time to time
2. DFSS Project
3. DFMEA improvement or modification from any new failure found from warranty data and/or AMC data
4. Sometimes discussion with current engineering group design engineers to have some improvement in design and conduct a test to check whether any improvement happens or not.

The existing reliability roadmap at 5 Stars, thus, was largely depending on the type of the product.

The Sources of Reliability Data and the Data Collection Procedure at 5 Stars

Data was a vital part of the whole reliability process. 5 Stars was a reputed home appliances company in India and had a good market share in the commercial refrigerator segment. Therefore, the customer base as well as the customer care department was very strong in 5 Stars. So, they had a huge and structured database. The reliability engineers at 5 Stars were primarily, using two types of data for the reliability and durability related estimation and calculation. They were Customer Relationship Management (CRM) data and actual testing data.

CRM Data

CRM data used to include both Warranty data and AMC data. The failure happened within the warranty period was called warranty data. In case of warranty data, generally, the customer care persons throughout the world were collecting such field failure data in the form of field report and uploading them in to the software system which was accessible for R&D and Quality Assurance group of the company. The SAP report was containing complain-report/claim, claim details and production details. The reliability engineers used to download the report as per necessity and use it for their purposes.

The AMC was basically the annual maintenance cost including both warranty cost and non-warranty cost. The company sometimes was financing customer for purchasing the critical system like engine, gearbox etc. even if the warranty period was over. AMC included all such costs. These data were also being collected by the customer care personnel and uploaded to the software system. It was being used by the reliability engineers for finding out the relation between complaint code and failure mode.

Actual Testing Data:

Testing data could be collected by the R&D testing engineers and so, this was an internal database for 5 Stars R&D department. Basically, two types of testing data were available. One was from in-door testing which was generally in terms of the cycle (the cycle was generally multiplied with a suitable multiplier to find out the equivalent usage hr.) and the second type was from out-door testing which was directly given in usage hr. Testing data for precursor refrigerator could be used as a reference and the testing data for a new refrigerator could be used to compare the actual reliability and durability performance of the product with the set target. Testing data could be collected during testing with the help of a data-logger and could be directly saved to a PC or laptop.

Although the database of 5 Stars was very strong, there were several potential sources of contamination in the data. These contaminations in the data used to be a big problem in 5 Stars.

Process or method of calculating the warranty cost with the help of collected data

Like the reliability department, Quality Assurance (QA) department was also having the access of warranty data which were in the software system of the company. The cost for repairing or replacing was also recorded in the reports for all complains which were uploaded by the customer care department. From that QA used to calculate the warranty cost. The process has been described below with the help of an existing model e.g. PQR.

Suppose the production of PQR was 100 in the month of December. Say, total warranty cost which was spent by 5 Stars for the product PQR was Rs. 10000 and this was for a complaint.

QA then used to calculate the warranty cost per refrigerator i.e. 10000/100 = Rs. 100. The cumulative cost for the month of December was also 100 (because only a single type of failure happened in December). Suppose, in the month of January production of PQR was 200 and for this lot say, warranty cost spent for a particular failure was 2000 and for another failure say the warranty cost spent was 3000. So, the cumulative cost per refrigerator will be [(2000+3000)/200] or Rs. 25. Similarly, for 12 months, the warranty cost could be calculated in an excel sheet and then a trend analysis could be done by plotting a graph of cost per refrigerator against the month. This trend had to be analyzed to find fault in production for a given model. Also, an average of the cost per refrigerator could be calculated for a given year so that management could take a call on how much to reduce the warranty cost. (For a sample, see Exhibit VI and VI a). The warranty cost calculation was carried out by customer care division and the activity was related to the reliability department in 5 Stars by no means.

The Theoretical Reliability and Durability Terminologies used at 5 Stars

The terminologies which were used for reliability in 5 Stars were mainly twofold. Firstly, some terminologies with which the management usually take the decision about the future of the product. Secondly, some terminologies which were used by the Reliability engineers while performing their day-to-day technical activities. The details of those terminologies have been given below.

For any sort of decision related to product reliability, 5 Stars management used to ask for the IPTR of the system/product (as per the requirement) for the performance systems and/or the B10 life for the endurance systems. They did not refer any other terms for the product reliability related decisions. Actually, most of the time management required warranty cost per refrigerator and quality index which were related to QA, not with the reliability.

Reliability engineers in 5 Stars were proficient enough to relate relevant theories with the practice. They used to use Weibull Distribution for all the mechanical systems and exponential distribution for all the electrical systems. So, their knowledge about different distributions was unquestionable. Also, they used to consider the different stages of failure i.e. early issues (infant mortality issues) and mature stage failure. Also, the chance failure and wear-out failure concepts were very much known to the engineers and they used to use the chance failure theory in case of electrical systems and wear-out failure theory for the mechanical systems. Only thing was that they do not combine those two types of failure to avoid complications. After finding out each type of failure (as per applicability) they used to consider all those systems in series and calculate the joint probability. Generally, parallel systems were not present in refrigerator (it was unnecessary and was thought that it would increase the cost of the product). Other theories were also applied as per the necessity.

The Reliability Theories used in 5 Stars:

The 5 Stars reliability engineers were relying mostly on the training given by the company in terms of use of theory and they were using Reliasoft software products for analysis. They primarily used the following theories and tests.

- Life data Analysis (They used mainly Complete and Right Censored Data Analysis using Weibull++ software)
- Experiment design and Analysis (Using DOE++ or Minitab)
- Failure Mode and Effect Analysis (They used to conduct DFMEA Using excel sheet; training was being given; See Annexure 1 for the DFMEA of refrigerator Door Handle)

Another theory, Accelerated Life Testing Analysis (ALTA), was considered very much useful for reliability engineering. But this was not very common in Nagpur plant because of some infrastructure and skill related issues. Also, the Nagpur plant was not using the XFMEA software for conducting DFMEA. But these processes were being used in Coimbatore and Baroda plant.

The Present Situation in the 5 Stars Nagpur R&D:

At the time of discussion, the demand of the refrigerator was on its every time peak and so, the Coimbatore and Nagpur plants were producing day and night to meet the requirement. Each of the plants was running at about 90% utilization. The new product development projects were also huge because marketing was almost every day indicating that there were potential markets in case there were innovative designs. They were conducting surveys which were actually revealing various taste and likings of the customers at a different part of India. So, not only the production and marketing departments were in hurry to roll out new models, the R&D was also in a hurry to build new model's prototype as quick as possible, because until and unless the R&D would not give a green signal (after developing and testing a prototype), the production could not start the production of that product. Now for making a perfect prototype of a new model the R&D department needed to set and test the reliability and durability of those products (and their critical components). First of all, the reliability and durability testing, in practice, used to demand a lot of time which was almost impossible to allow. Secondly, if one had to compromise with the reliability and durability (mainly because of the lack of time), it was contradictory to the policy of the company and most importantly, there would be a chance that the customers were dissatisfied and there was a chance that they may switch to a competitor's product. The third issue was related to warranty cost calculation and estimation of the reliability. The gap between the estimated warranty cost of a new product and the actual amount that the company had to incur after it was sold used to differ every time and the difference used to be significant enough to eat up a considerable portion of the profit that the company expected from the sales. Similar error was present in the reliability calculation of a part or sub-system because of this data error.

The concern had already been noticed by Mr. Iyer, VP, R&D, who was sitting at the Coimbatore

plant. In company's every day morning teleconference meeting, he had indicated it to the R&D head of Nagpur plant, Mr. Raina. Mr. Raina committed to him that very soon he would arrange a meeting with his reliability manager, Mohan to figure the problem out following by a quick solution to the problem. Consequently, Raina conveyed the same to Mohan informally and indicated also that most probably they need to sit for a meeting where Mohan was supposed to explain the present roadmap of the reliability process and the possible improvement that could be done as well.

The Constraints

The first and foremost constraint was that the reliability team in Nagpur was facing a shortage of skilled manpower. Two employees had already left and there was no recruitment happened till date in those vacant posts. It was very difficult for Mohan and his junior Harish to take care of all the projects. Mohan repeatedly told this to Mr. Raina as well as to Dr. Vyas but still, now no steps had been taken. Rather both the bosses told Mohan that the company was not in a position to hire new employees for reliability department at present situation. Undergoing training programs required to develop skills were also very rare for Mohan and Harish because Dr. Vyas used to say that new training and subsequent installation of new software particularly for reliability could not be afforded by the company at present because the vision of the organization was to produce cheap home appliance products for price sensitive customers in less time. For the same, they were instructed to learn how to perform quickly under the cost and resource constraints.

The second constraint was rather most strategic. In the meeting always, the designer used to take a lead and whatever he/she used to tell ultimately becomes final. The sign-off meeting was more of a fuss in terms of decision making. The designer always took a safeguard and so the target setting was always poor. Mohan had tried several times to convey the message that they should have taken high reliability and durability target but designer always told that with the constraint of low cost product, it could not be possible. Obviously, the policy that low cost products would be produced with a competitive reliability and durability target should have been forced properly so that designer could not escape.

The third issue was related to technicality. Mohan had sometimes thought of changing the whole roadmap because he felt that there were some loopholes. He made an improved road map also. But for that, he needed a meeting with all the reliability managers of other plant and of course with Dr. Vyas. For this, he had mailed Dr. Vyas a few times but still, no initiative had been taken from his part.

The fourth issue was unnoticed by the management till recent when Dr. Vyas interviewed the Customer Care Head. It was related to the complaint code that the customer care persons used to use while uploading the field failure cases. For same or similar kind of complaints, different customer care persons (in different area and regions) was using different complaint code.

Because of this, the warranty cost calculation by the customer care department and the estimation of IPTR, Failure Mode etc. by the reliability department both were being affected. This erroneous picture proved to be quite detrimental to the company in the long run.

Conclusion

Mohan understood that the main dilemma was all about improving the reliability process and making it quicker with the constraints of budget. It was quite evident that the management would not provide them with new trainings, software or extra manpower. Still, they need to make the reliability processes better and faster. He, however, made the present reliability roadmap in a small power point presentation for the meeting with Raina. He also pointed out the constraints and indicated some of the possible modifications for reducing the time of the reliability process and improving the accuracy of the process. But the question was the implementation of the same. He knew that his improved plan may be very relevant but to implement this new roadmap in the company, Mr., Raina should talk to Dr. Vyas and Mr. Iyer. And a proper management intervention with effective coordination would be necessary. However, He decided to show Mr. Raina his new thought. This discussion could be a milestone for setting an improved Reliability Roadmap in 5 Stars.

The Details of Some Terminologies used:

Censored data analysis, Maximum Likelihood Estimation (MLE), Rank regression **(details of these terminologies can be found in Weibull.com website)**

Exhibit I: The Reporting Structure of Different plants of 5 Stars

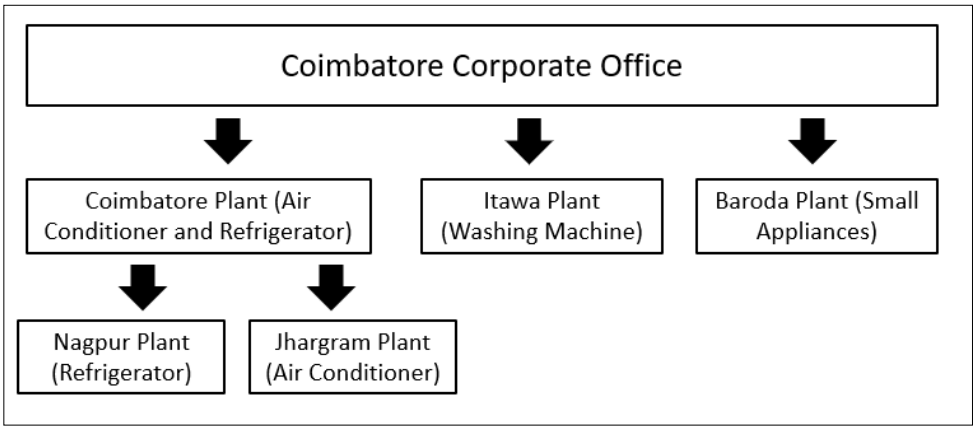


Exhibit II: The Reporting Structure of Nagpur Plant R&D

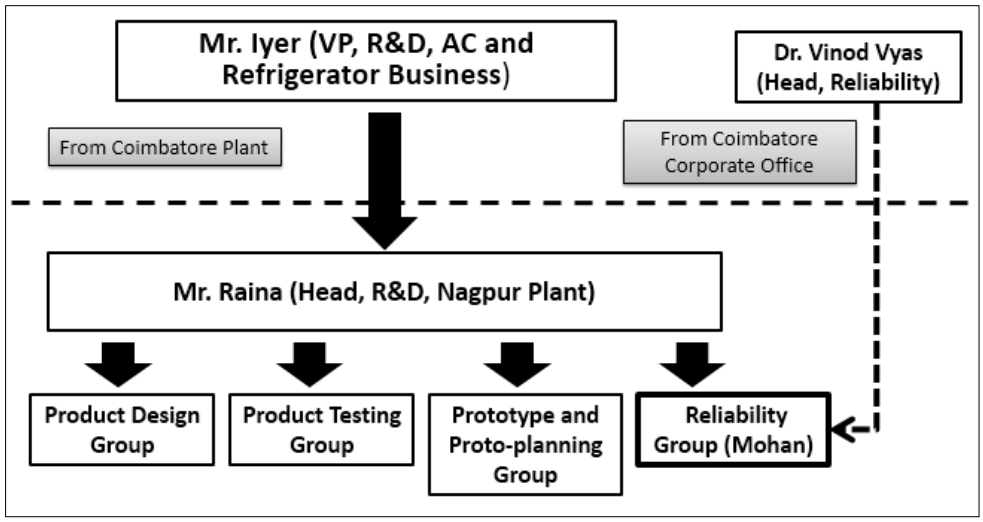


Exhibit III: Different Types of Projects at 5 Stars

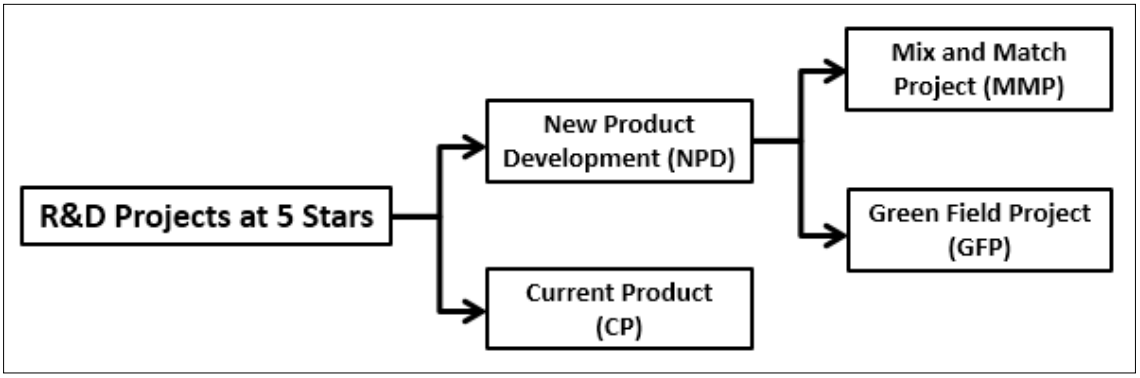


Exhibit IV: The existing Reliability Process for New Product Development at 5 Stars

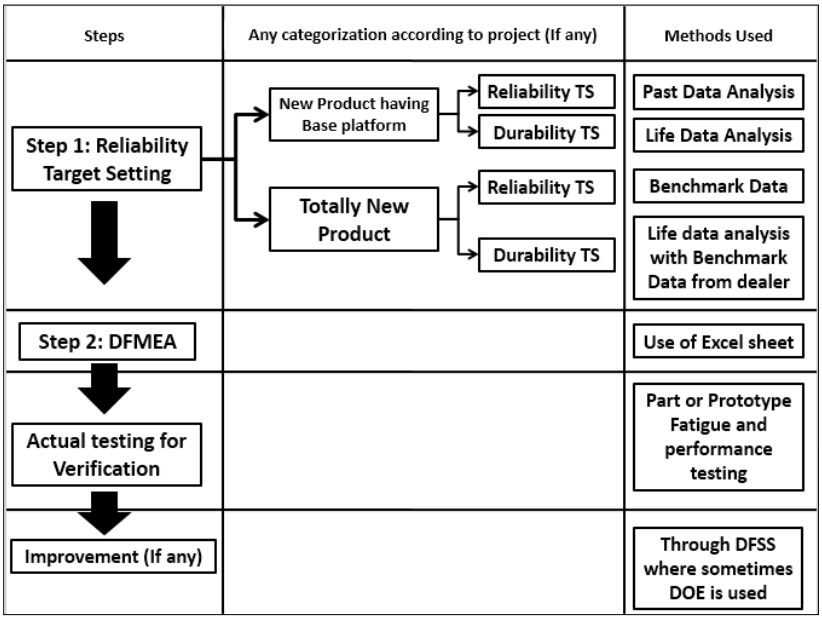


Exhibit V: Example of B10 Life Calculation of a Refrigerator (Overall 20 parts)

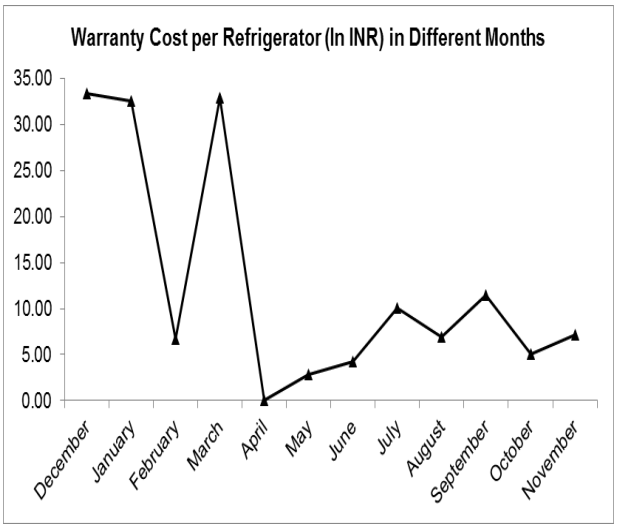
Part Description	Failure time (in hrs.)
Part 1	250
Part 2 (10% of all parts)	**325 (B10 life)**
Part 3	435
Part 4	568
Part 5	609
Part 6	678
Part 7	681
Part 8	795
Part 9	807
Part 10	909
Part 11	1002
Part 12	1101
Part 13	1108
Part 14	1240
Part 15	1589
Part 16	1877
Part 17	1916
Part 18	2078
Part 19	2897
Part 20	2983

Exhibit VI: The Warranty Cost Calculation Sheet

Production Month	Production (in No.)	Failure/Complain Code (CC)	Total Warranty cost (in INR)	Cost/Refrigerator (In INR)	Cumulative Cost / Refrigerator (In INR)
December	300	CC3	10000	33.33	33.33
January	200	CC2	5000	25.00	32.50
		CC4	1500	7.50	
February	300	CC1	2000	6.67	6.67
March	350	CC5	3600	10.29	32.86
		CC2	4500	12.86	
		CC4	3400	9.71	
April	400	CC2	2000	5.00	5.00
May	350	CC3	1000	2.86	2.86
June	500	CC4	2100	4.20	4.20
July	400	CC6	3000	7.50	10.10
		CC7	1040	2.60	
August	450	CC4	3100	6.89	6.89
September	350	CC5	500	1.43	11.43
		CC6	800	2.29	
		CC2	900	2.57	
		CC1	1800	5.14	
October	500	CC8	2500	5.00	5.00
November	420	CC7	3000	7.14	7.14

Month	**Cost (In INR) / Refrigerator**
December	33.33
January	32.50
February	6.67
March	32.86
April	0.00
May	2.86
June	4.20
July	10.10
August	6.89
September	11.43
October	5.00
November	7.14

Exhibit VI a: The Plot of Warranty Cost per Refrigerator in Different Months



Annexure 1: An Example of DFMEA (For Refrigerator Door Handle) conducted by 5 Stars

Process or Product Name:		Refrigerator Door Handle
Process Owner:		Mr. Mohan (Reliability Manager)

Prepared by:	Mr. Harish (Reliability Engineer)	Page: 1 of 1
FMEA Date (Orig):	dd/mm/yyyy	Rev. 1

Function	Items / Sub-Systems	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s)/ Mechanism(s) of Failure	Occurance	Current Process Controls	Detection	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
												Actions Taken	Sev	Occ	Det	RPN
Helps to open the Refrigerator easily	Refrigerator Door Handle	Handle Broken	User's Discomfort	4	Material Grade is not as per specification	3	Part Level testing	5	60	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	4	2	3	24
		Handle grip is not Ok	User's Discomfort	4	The development process is not as per design	3	Part Level testing	5	60	Extra Focus on Process	xx/yy/zzzz	Y	4	2	3	24
			Accident May Occur	9	The development process is not as per design	3	Part Level Testing	5	135	Extra Focus on Process	xx/yy/zzzz	Y	9	2	3	54
		Handle is loose / Handle play is there	Damage may occur while opening Refrigerator	6	The development process is not as per design	3	Part Level testing	5	90	Extra Focus on Process	xx/yy/zzzz	Y	6	2	3	36
					Hole is not as per specification	4	Fitment Trial	5	120	Extra Focus on Process	xx/yy/zzzz	Y		3	3	54
					Material Grade is not as per specification	3	Part Level testing	5	90	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y		2	3	36
			Accident May Occur	9	The development process is not as per design	3	Part Level testing	5	135	Extra Focus on Process	xx/yy/zzzz	Y	9	2	3	54
					Hole is not as per specification	4	Fitment Trial	5	180	Extra Focus on Process	xx/yy/zzzz	Y		3	3	81
					Material Grade is not as per specification	3	Part Level testing	5	135	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y		2	3	54
	Bolts for the Refrigerator Door Handle	Bolt is not of proper size	Damage may occur while opening Refrigerator	6	Material is not as per design	3	Part Level testing	4	72	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	6	2	3	36
			Accident May Occur	9	Material is not as per design	3	Part Level testing	4	108	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	9	2	3	54
		Bolt thread is not proper	Damage may occur while opening Refrigerator	6	Material is not as per design	3	Part Level testing	5	90	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	6	2	3	36
			Accident May Occur	9	Material is not as per design	3	Part Level testing	5	135	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	9	2	3	54
		Bolt is rusted	Damage may occur while opening Refrigerator	6	Material is not as per design	3	Part Level testing	5	90	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	6	2	3	36
			Accident May Occur	9	Material is not as per design	3	Part Level testing	5	135	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	9	2	3	54
		Bolt Length is not proper	Damage may occur while opening Refrigerator	6	Material is not as per design	3	Part Level testing	4	72	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	6	2	3	36
			Accident May Occur	9	Material is not as per design	3	Part Level testing	4	108	More Stringent Supplier Selection / Penalty Imposed	xx/yy/zzzz	Y	9	2	3	54