PROCESS IMPROVEMENT FOR REPAIR DEPARTMENT

Lean Six Sigma Project

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Acknowledgements

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At Inficon, we have had nothing but absolute support from the get-go and for that we are immensely grateful! First and foremost, we would like to extend a big thank-you to Lorn Christal, our project champion, who has been an amazing support to us throughout the course of our project. He provided us with the right connections and right insight, and has been an invaluable mentor. We would also like to express our gratitude to Scott Dean, Technical services manager, without whose guidance and inputs, this project would not have been possible.

We would also like to sincerely express our gratitude to Krishna Shivaram, who helped us with all our SAP related requests and has been a great source of support throughout the project. Thanks to Glenda, for her prompt response to all our requests and Phillip Fiorentino, always present to provide us with necessary guidance for our project. A sincere thank you to Catherine Pllana for taking the time out from her busy schedule and guide us through the entire warranty process.

Last but not the least, we would like to thank each member of Repair Service center who provided us with all the required inputs for the successful completion of our Project.

Executive Summary

Executive Summary

Business Case

What is the importance of doing this project?

Warranty rate had increased by 25.81% from the year 2016 to the year 2017. Thus the cost incurred by the company has increased by 246,309$. We needed to find the root cause of increasing warranty expense to Inficon, because this is loss to the company profits as well as decreased customer satisfaction.

Pilot Test

Which solutions were implemented?

The recommendation that was pilot tested was : A Customer Returns Portal. The portal lets customers search their orders in a returns portal. The customers can select items they want to return, enter return reasons, and grab and print the return label.

Root Cause Analysis

What are the critical findings/root causes that were discovered?

Fusion, Hapsite and Transpector MPS/MPH were the 3 products that had the most warranty costs. Over both the years, Fusion products contributed to approx. 38%, Hapsite - 10% and Transpector - 5% of total warranty expense. Fusion products were being replaced and not repaired, driving up warranty costs.

Customers often filled wrong information in the service request form which increased the work of the service coordinator

Customers did not have visibility into the warranty return process and spent a lot of time to fill out the repair request.

There is a lack of a standardization in the repair process.

There was a discrepancy in the way warranty data was reported by accounting and by the repair department. Different account indicators were in use to report warranty repairs.

Project Results

What are the measurable process improvements/wins?

The proposed communication plan will ensure that knowledge garnered by individual departments is shared across the organization.

Customer returns portal ensures data validation as well as data integrity of customer information. It reduces possible spam requests and verifies the identity of the customer.

The time taken to report a return reduced by 67%.

There is a checklist provided to each service personnel to ensure that none of the important fields are being left blank in SAP.

Accounting and service departments now use the same measures to report return information.

Recommendations Provided

List key solutions that were implemented to address root causes

Formal Training of different platforms used across the organization should be provided for different repair functions.

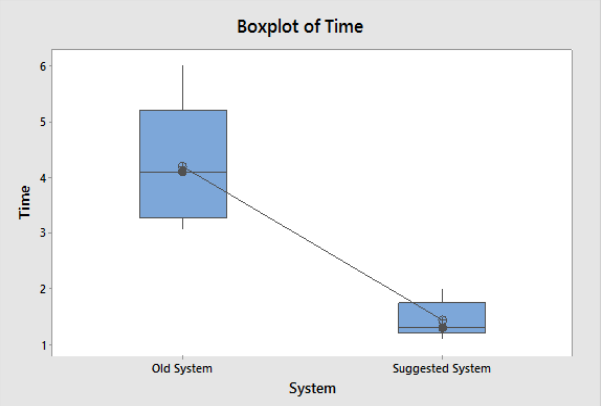
Establish an updated SAP Training Manual for reference

Data Validation : Make relevant fields autopopulated, mandatory and decrease repair codes.
Data Audit should be conducted at regular intervals to archive and update company documentation.

Design a customer returns portal for a hassle free return process.

Barcode Scanner for the Instrument Checkin Process so that reverfication of products doesn't have to be done manually.

Graphical Improvement



Key Terms

RMA - Return Merchandize Authorization Number. A return merchandise authorization (RMA), is a part of the process of returning a product to receive a refund, replacement, or repair during the product's warranty period. It is currently a 9-digit number.

Main Activity Type - The type of return that is being processed by the company. It could be under warranty, onsite repair, goodwill repair, preventive maintenance and so on.

Cost Center - It constitutes the categorization of products by Product family. One product family generally corresponds to one cost center.

Main Work Center - Inficon has a global presence. It has many service centers all around the world. As the data that we have is global, main work center is used to highlight which center we are referring to. Example of the center is Inficon- Syracuse, Inficon - Liechtenstein.

Sales order - This is one of the system functions in SAP which is created when a shipping order needs to be generated so that the product can be shipped back to the Customer. It contains detail on the shipping information and is associated with an RMA.

Repair Order - This is one of the system functions in SAP which is created when a repair order needs to be generated so that the product can be repaired in the service center. It contains detail on the repair information and is associated with an RMA.

Service Coordinator - Coordinates with customers and repair personnel to ensure smooth transition of the products under repair.

Technician - Engineers who work on evaluating and repairing the products.

Service Engineer - Personnel who guide the technicians on repairing products.

Service Request form - The form that the customers fill out when they wish to get a faulty product repaired.

Part Number - One product is assembled using multiple parts. Each part has a number associated with it which is used to identify unique parts.


D
DEFINE
Define the problem
and the ideal in terms
of the target to achieve.

Define

Introduction/Overview

This report provides details of a project that was undertaken by 3 students of the Lean Six Sigma course at Syracuse University to investigate and address the increased warranty expense that INFICON, Syracuse facility had incurred over the past year. INFICON is a growing, global, leading provider of world-class instruments for gas analysis, measurement, and control in sophisticated industrial processes. They are vital to manufacturers and end-users in the complex fabrication of semiconductors and thin film coatings for optics, flat panel displays, solar cells, and industrial vacuum coating applications.

Once the team procured the data necessary for the rudimentary analysis, it was found that during the year 2016, the warranty expense that the company incurred was $954,084. Over the year 2017, the expense increased to $1,200,393. Therefore, there was an approximate 25.81% increase in the warranty expense. They also found a lot of data issues with the data they accrued from SAP such as data discrepancy, missing data, ambiguous data fields etc. Thus, this project identifies several factors contributing to these pain points and also proposes solutions to reduce the warranty expense and improve the overall repair processes.

The team used the DMAIC methodology to identify key opportunities for improvement. In the initial stages of the project, the team went about defining the problem, creating a project charter, and a communication plan. The team then studied the warranty process to identify inputs, outputs as well as the key suppliers and the customers of this process. The team also garnered the voice of the customer in order to understand their pain points with the warranty repair process and identified critical to quality characteristics (CTQs) of the warranty process.

During the measure phase, the team first drafted a data collection plan to understand what all data they would need to collect with respect to the warranty process. They did this in order to be able to analyze the different sources of repair data and find the root cause of the increased warranty expense. Following the data collection plan, the data was collected from various sources and the CTQs were converted into Key Performance Metrics that were important in understanding and measuring the efficiency of the processes.

Once the data had been collected, the team analyzed the causes for the increased warranty expense using the data that had been provided to them by the company. They identified the main contributors to the warranty expense and it was found that 53.48% of the warranty expense was due to top three products. Upon further investigation, the defects in those products were aggregated into categories and the top contributors to the warranty expense were presented to management. It was found that the company was aware of this information and had already begun working on the resolution of the same. The team analyzed the data from the repair process using pareto charts, boxplot and probability plots, etc. The details are provided in the analyze phase.

The brainstorming started with a focus on reducing the warranty expense as it was our first and most important problem statement. During the discussion we came up with several factors that could have affected the warranty expense as well as improve the overall repair process. The team brainstormed solutions and these solutions were then categorized into long term and short-term implementations. The main criteria in deciding the priority of the implementation were the ease of implementation, cost and number of persons impacted. The team then developed a prototype for one of the major solution that was recommended. It was found that through the use of customer return portal the time taken by different actors in the warranty process was significantly reduced. Using the KPIs that were proposed, the company was better able to measure the effectiveness as well as the time involved during different stages in the repair process. Further explanation can be found in the Improve phase of this report. Finally, the team created a control plan to maintain a few suggested improvements.

Project Charter

The project charter is a document that sets the framework and boundaries for the project.

PROJECT CHARTER

Project Name:	Business/Location:
Process Improvement for Repair Department	INFICON Inc 2 Technology Place East Syracuse, NY 13057-9714
Team Leader:	**Champion:**
Akshata Naronakar Raghav Raheja Shambhavi Godbole	Lorn Christal

Project Description/Mission:

Quantification and analysis of field return data to propose recommendations to reduce the warranty expense . We wish to identify the root cause of this problem through analysis of the entire warranty repair process and propose measures to reduce expenses and workload within the process. We also want to standardize the way warranty data is reported across the organization, so that this analysis could be standardized in the future. In addition, we wish to reduce the efforts taken by customer to request repair.

Problem Statement:

1. The warranty expense of INFICON's products have increased by 25.81% from 2016 to 2017
2. Discrepancy in the way warranty data is reported by accounting and by the service department
3. Excessive workload on a customer while requesting a repair

Business Case:

INFICON is expanding rapidly and guarantees warranties on products to emphasize product quality and retain Customers. However, the warranty rate on INFICON products has increased to over 25% in the past year and there is limited analysis into the data. Any mishaps with the products can have high impact in dollars as well as safety of the customers. In addition to this, replacing/repairing of products in warranties causes financial burdens to the company and can affect customer acquisition. If the root cause is identified and rectified accordingly, this could result in enhanced business profits and customer satisfaction. In addition, the indicator used by the service department and accounting department is different and there is discrepancies in what falls under warranty according to each department. Currently, the customer has to fill a service request form which takes in a lot of effort as it contains some fields that he/she might not be knowing.

Deliverables:	Goals:
Root-cause analysis report of increased warranty expense. Ways to remove discrepencies in the data. Reduce work expected from the customer. Recommandations to improve warranty repair process.	Reduce warranty expense Remove data discrepencies Improve customer experience **Metrics** WarrantyRate,Total Repair Turnaround time, Part Delay Time, Returns per Product, Total Repair time

Process & Owner:

Warranty Repair Process - Scott Dean, Catherine Pllana

Project Scope Is:

Identify root cause of high warranty rate and propose a solution which can be used to reduce the same
Analyze data inconsistancy and propose solutions to improve the data collection process
Improve customer experience by reducing their workload

Project Scope Is Not:

Analysis of onsite repairs
Sentiment analysis of the reasons that the products have been returned
Implementation a Dashboard to track warranty trends

Key Customers:	Customer Expectations:
Thin film deposition industry, Semiconductor chip makers, Military Services	Visibility in the return process, Hassle free return process, Faster service , Fixed successfully

Milestones:	
Project Start:	
1/29/2018	Introductory Meeting
5/4/2018	Pilot Test
Project Completion:	
5/7/2018	First week of May

Completion Dates:	
Define	2/13/2018
Measure	3/23/2018
Analyse	4/13/2018
Improve	5/4/2018
Control	5/5/2018

Expected Business Benefits:		Est. Savings		Brief Explanation	
		1-Time	Annual		
	Hard Cost			Soft cost	Money saved through increased efficiency of coordinators and technicians.
*	Soft Cost			Speed	Increased speed of Data entry process in SAP
	Revenue				Enhanced speed of Product Check-in process
*	Speed			Intangible	Increased Customer satisfaction
	Compliance				Increased Service Coordinator Efficiency
*	Intangible				Decreased data discrepancy

Team Members:	
Akshata Naronakar	SU Student
Raghav Raheja	SU Student
Shambhavi Godbole	SU Student
Lorn Christal	Project Champion

Expected Resource Needs:
JIRA Access, SAP Transaction Reports, Minitab

Risk Assessment:

Prepared By:
Shambhavi Godbole
Raghav Raheja
Akshata Naronakar

Date (Last Revision):
5/4/2018

Gemba Visit is a Japanese term that means “the place where the truth can be found.” A Gemba Walk is a method of obtaining the root cause of problem by simply walking on the problem site, understanding the current process and issues, asking queries to learn more about the problem. To understand the problem stated by Inficon ISS, the team performed a Gemba Walk for 4 hours over a period of two weeks.

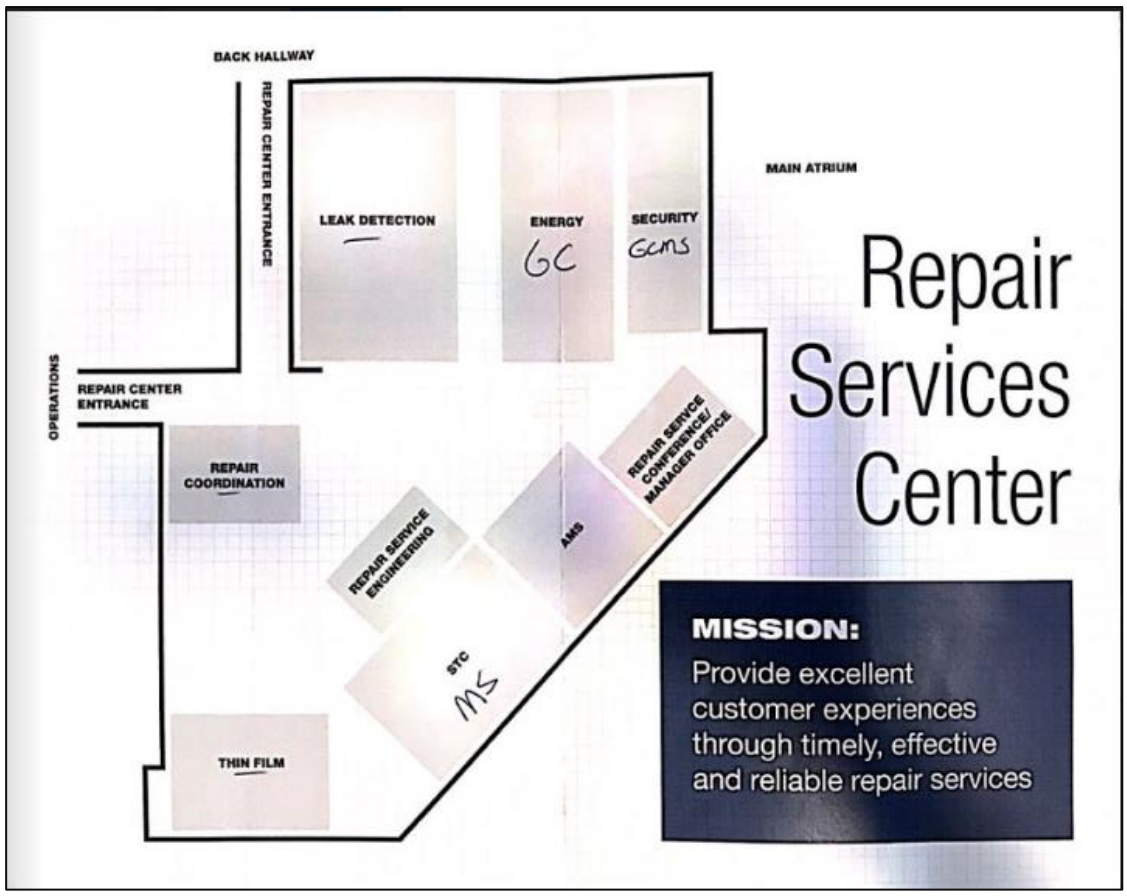
This walk helped the team understand that there was a bigger problem than the stated problem of data collection and customer communication in repair process. The observations led us to the conclusion that the productivity of Service Department Coordinators and Technicians is getting affected because of the repair request creation process on website. Also, the service request creation process affects lead time for repair. This led us to modify our problem statement to incorporate the website design as one of the reasons to data inconsistency.

Organizational Chart

The organizational chart for the service repair department at the Inficon, Syracuse facility is given below. It is organized under Michael Scott Dean who is the Technical Services Manager and is responsible for managing the department. The department is organized with Service Repair Coordinators, Repair Supervisors and Service Engineers. The repair supervisors are responsible for the smooth coordination of repair activities across the repair technicians in the department. The service repair coordinators are responsible for smooth coordination of repair activities between customers and the company. The service engineers are responsible for guiding technicians across different repair functions.

Floor Plan

This is the floor plan of the Repair Services center where we see where products belonging to different product families are sent to for repair. The products go from repair coordination work area to the specific cost center (Product family) where they are worked on by repair technicians/ or service engineers. Once, the product is repaired it is returned to the repair coordination work are, where it is prepped to be shipped.



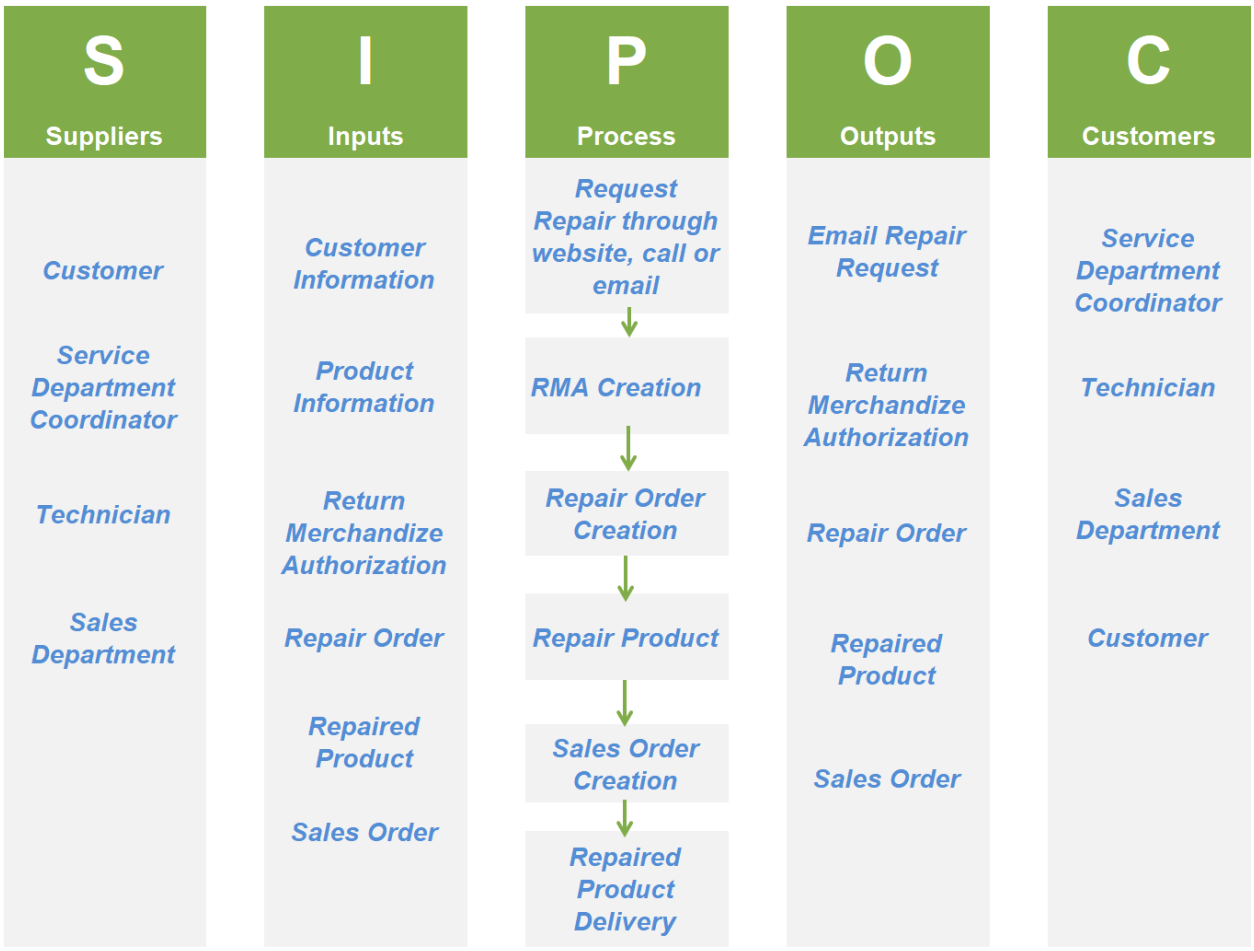
Communication Plan

A communication plan is the approach of providing different stakeholders with information regarding the project. The plan formally defines who should be given specific information, when that information should be delivered and what communication channels will be used to deliver the information. The team identified the main stakeholders in our project and listed out the methods and reason of communication to the stakeholders. One team member was chosen as the single point of contact to interact with the stakeholders.

Communication Plan					
Stakeholder Name	**Method of Communication**	**Purpose of Communication**	**Team member responsible**	**Frequency of Communication**	**Notes**
Lorn Christal	E-mail update Send slides Invite to tollgates Schduled meetings Jira comments	Project Champion	Email : Raghav Jira : Raghav, Akshata, Shambhavi	Weekly, Jira Comments, at tollgate	Senior Compliance/Reliability Engineer
Philip Fiorentino	E-mail update Send slides Invite to tollgates Schduled meetings Jira comments	Information	Email : Raghav Jira : Raghav, Akshata, Shambhavi	As needed	Quality Manager
Scott Dean	E-mail update Send slides Invite to tollgates Schduled meetings Jira comments	Process Owner	Raghav	As needed	Worldwide Technical Services Manager
Krishna Shivaram	E-mail update Send slides Invite to tollgates Schduled meetings Jira comments	Information	Email : Raghav Jira : Raghav, Akshata, Shambhavi	As needed	Supply Chain Strategy Analyst
Catherine Pllana	Invite to tollgates Schduled meetings Jira comments	Information	Email : Raghav Jira : Raghav, Akshata, Shambhavi	As needed	Service Repair Coordinator
Glenda Abbate	Schduled meetings Jira comments	Information	Raghav	As needed	Accounting Manager

SIPOC DIAGRAM

SIPOC stands for Suppliers, Inputs, Process, Output and Customers. It provides a high-level process view and is used to identify key process metrics. The team first identified the high-level process, following which the inputs and the outputs of this process were investigated. Once those were established, the suppliers and the customers of the process were mapped to specific inputs and outputs and the SIPOC was created.



Voice of Customer

Voice of the customer (VOC) is a term used in business and Information Technology to describe the in-depth process of capturing customer's expectations, preferences and aversions. It involves talking to or becoming the customer to understand their needs.

The methods that we used in order to identify the Voice of Customer were:

1. **Market Research:** The team spoke to coordinators and repair supervisors who interacted with the customers on a daily basis. They were able to communicate the customer needs while coordinating business priorities. This proved to be a helpful way to understand the problems that the customers undergo with the service repair process.
2. **Becoming the Customer:** The team also put themselves in the customer's shoes and requested a repair for a product based on a hypothetical scenario. This helped them identify different pain points associated with the requesting a repair from the company.

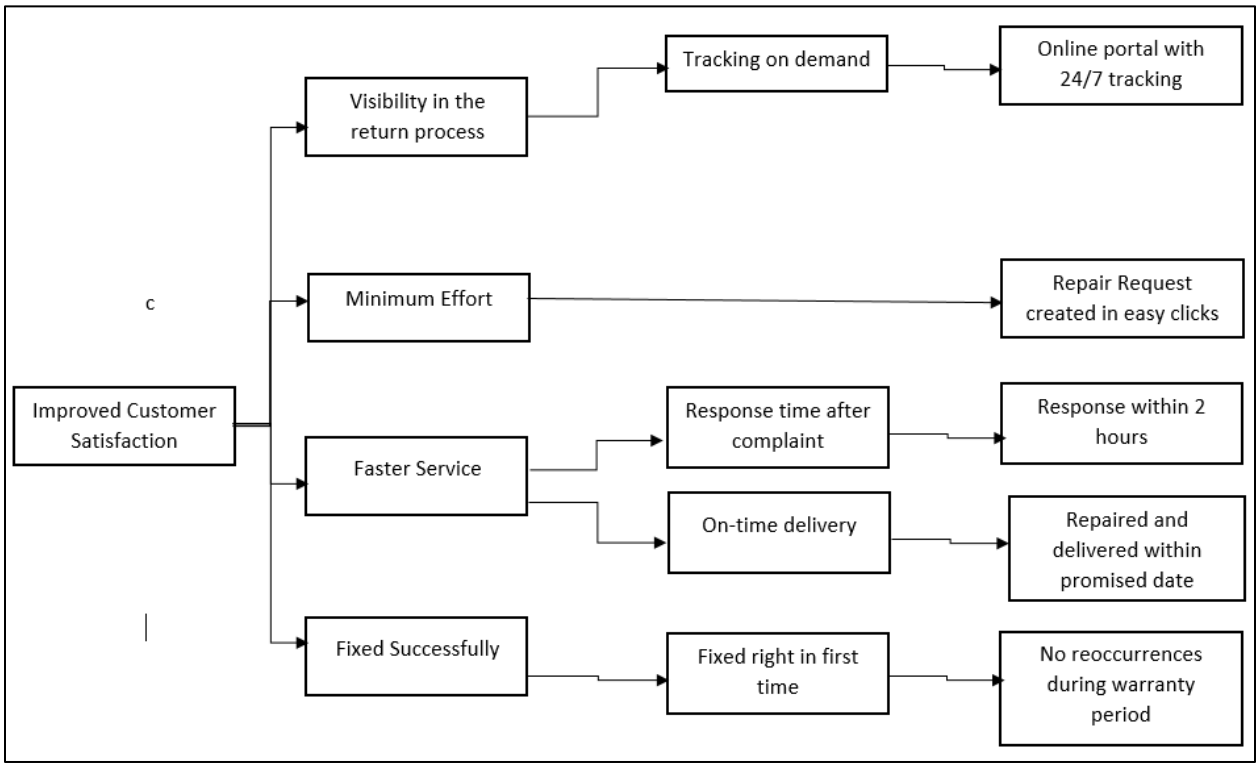
Categorization of VOC as Customer and Inficon

As our project is concerned with increasing the overall efficiency of the warranty repair process, we have defined two types of critical to quality characteristics based on the broad requirements of considering Inficon as a customer of a process as well the actual end users of Inficon products as customers for the Warranty process.

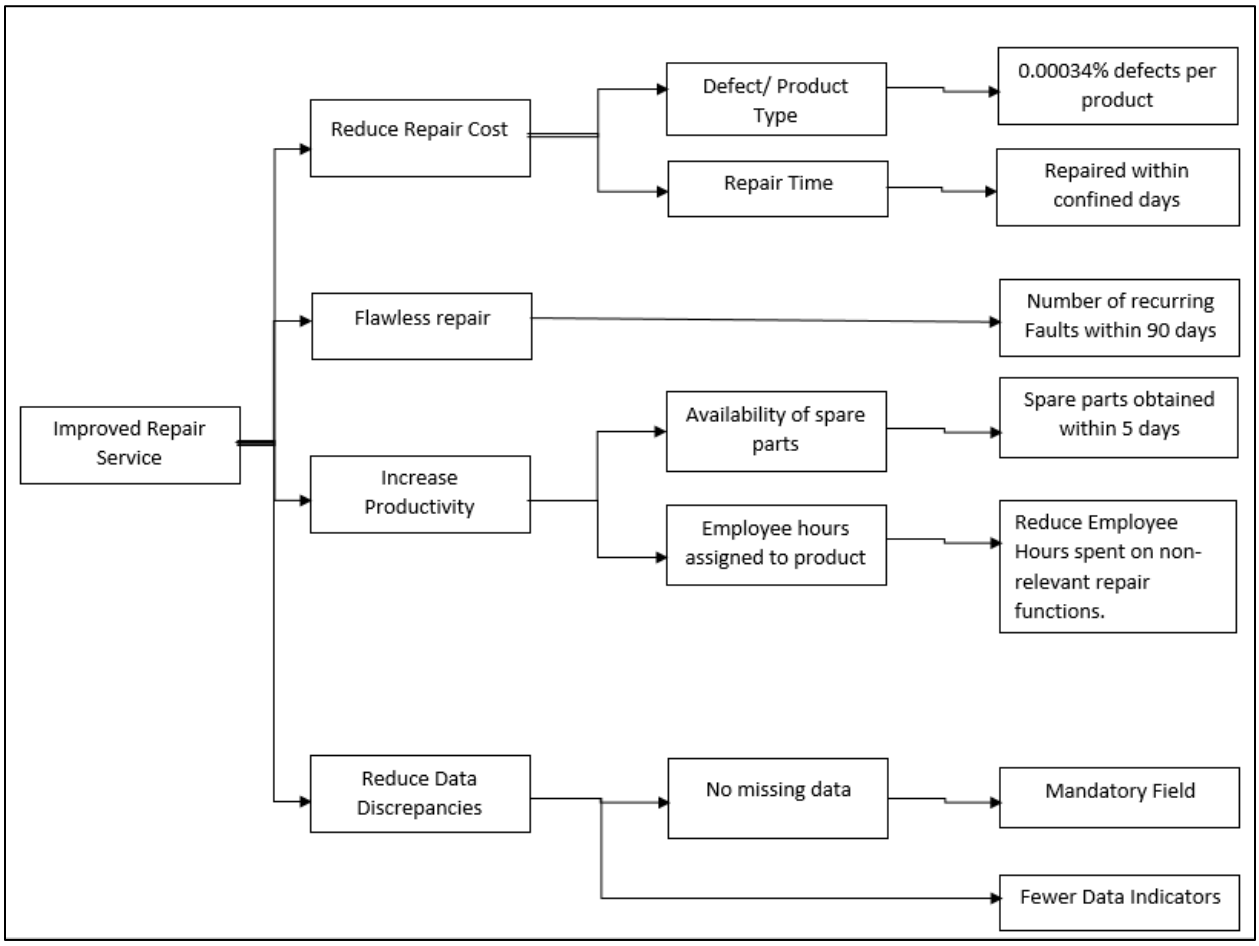
Critical to Quality Trees

CTQ trees (critical-to-quality Tress) are the key measurable characteristics of a product or process whose performance standards or specification limits must be met to satisfy the customer. They align improvement or design efforts with customer requirements.

Inficon Customer as Customer



Inficon as Customer




M
MEASURE
Collect relevant data
about the process
and the problem.

Measure

Data Collection Plan

The first step in understanding the problem, was to consider the data that is already being maintained. Inficon has a lot of products, but we wanted to work with the products that were driving the warranty expense, so we decided to break our data collection plan as “For Pareto” and “Post-Pareto”.

Purpose	Performance Measure	Data Source/Location	How Was Data Coll	Who Collected Data	When was it Collected?	Sample Size	Data Collected?	Explaination
Used for Pareto	All repair orders under warranty	SAP System	SAP Query	Krishna Shivaram	Week of Feb28	1/1/2016 – 2/1/2018	Yes	To analyze warranty expense
	Cost of parts associated with the repair						No	To analyze warranty expense
	Identified Issues						Yes	To pareto products based on warranty expense
	Solution of the Issue						No	To understand if resolution of defects was recorded
	Total cost associated with the repair						Yes	To analyze warranty expense
Post-Pareto Analysis	Warranty Period			Krishna Shivaram	Week of Feb28	NA	Yes	To quantify number of products returned under warranty
	Number of products returned for repair within warranty period	SAP System	SAP Query				Yes	To categorize number of products returned under warranty based of product family
	Total warranty expense for each product	Sales Department	Product Manual				Yes	To analyze warranty expense
	Names of employees worked on the product	Service Department	Employee Data	Project Champion	Week of Mar14		Yes	To understand service engineer/planner group responsible for repair
	Timestamps for every stage in the entire repair process	SAP System	NA	NA	NA	NA	No	Not Available
	Time required to request repair by Customer	Subject Cases	Manual	SU Students	Week of Apr 20	10	Yes	To understand the Customer's pain points
	Time spent in RMA creation by Service Coordinator	Subject Cases	Manual	SU Students	Week of Apr 20	3	Yes	To understand non-value added time

Inficon uses SAP across all its locations for data functions. We did not have access to the SAP system due to license considerations, so for the collection of data, we looked at SAP transaction codes and spoke to our clients for the reports that they used to summarize and analyze data. We thus concluded to use IW72, a report used to display service orders and all the information related to them. At a high level, it contained all the required data required to analyze warranty repairs. SAP transaction IW72 has 17432 repair orders, and 126 attributes which describes the repair order. List of all Products along with product families, Codes, Cost, Sales numbers from 2016 till date was provided by Inficon.

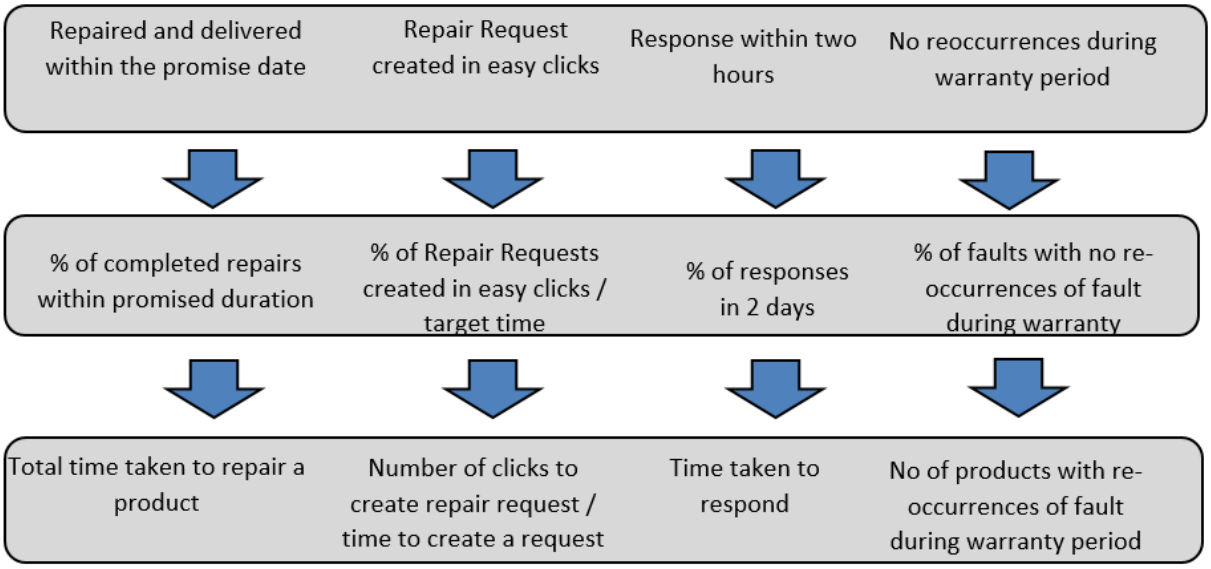
The data also needs to be filtered based on the repair completion date, or Repair Order close date. The date column used for categorization is 'Basic fin. Date'. Service Department and Finance Department used different indicators to decide the products which fall under warranty. This created data discrepancy which will be talked about in the analyze phase. After consulting with the department heads, we concluded that for our analysis, we are going to consider 'MainActivType' (used by the service department) as filter to study the warranty repair data.

Data for Analysis: Data World

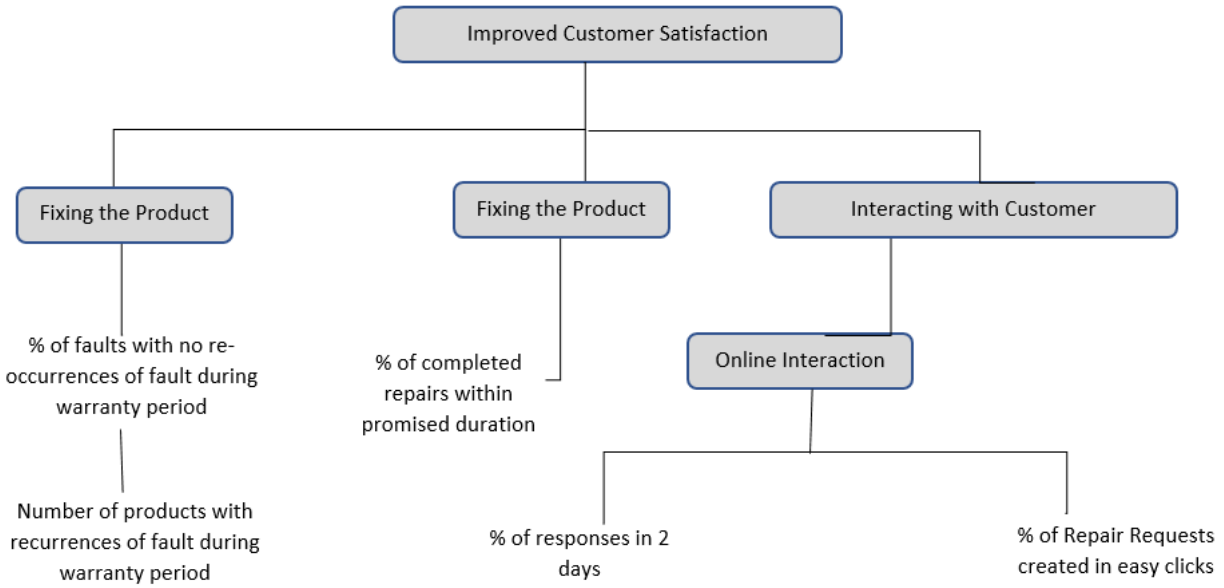
Column Name	Type	Description	Example
MaintActivType	Classification	Maintenance Activity Type (KGW and RGW represent warranty)	KGW, RGW
Acctg Indicator	Classification	The code represents how the repair gets logged by the Accounting department. 2 indicates warranty repairs	2,8
Company Code	Classification	Code to represent different Inficon establishments across the world. C425 represents Inficon, Syracuse.	D427
Main WorkCtr	Classification	Code to represent the work center of the product to be repaired. The service department is divided into work centers. Each work center has specific products that are repaired under it.	SERV-03
Material	Classification	Product Type/ SKU	550-000
Planner group	Classification	Code to represent the personnel who repaired the product	F01
Resp. cost cntr	Classification	Cost Centre code, where specific products fall in the category	51040
Serial Number	Count	Number which is used to track the history of the equipment.	90001114074
Notification	Count	Notification number generated for every RMA	400030082
Order	Count	Repair Order Number	856830
Total act.costs	Continuous	Total Expense borne by Inficon for the repair. Includes Labor cost as well as equipment costs	4,000.00

Inficon Customer as Customer

Generation of KPI



KPI Tree



Operational Definitions

KPI Name: Return Repair Frequency (New)
What does the KPI mean: Number of recurring repairs on the same product that has been purchased by the customer from Inficon.
How will it be calculated: Take the number of repairs on a product with the same serial number during a specific period. We take warranty period for this operational definition.
Detailed definition
Process Start: The time that a product is repaired and repair order is closed.
Process Stop: The time that a product is re-repaired and repair order is closed.
Target Value: Less than or equal to 2

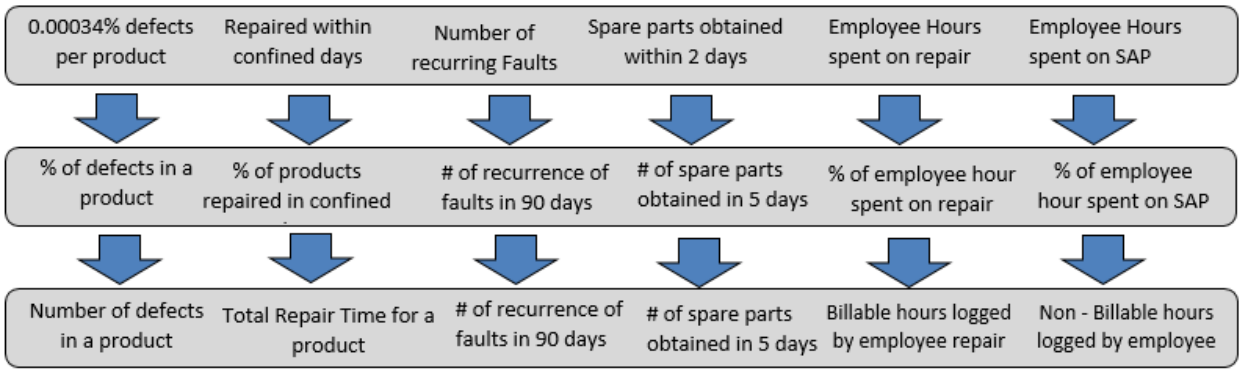
KPI Name: RMA Response Time (New)
What does the KPI mean: Time taken for a customer to obtain a Return merchandize authorization number on a product from Inficon.
How will it be calculated: It will be calculated by capturing the timestamp of when the person submits the repair request and capturing the timestamp when the generated RMA is updated in the customer portal. This will be done for those RMAs that are not created manually.
Currently, this can be calculated using the email timestamps on the service.inficon email account. The RMA response time will be the difference in the timestamp between when the email labeled "INFICON Service Request: #" will be received in the mail vs the timestamp of an email labeled "RMA for INFICON Service Request: #" from the outbox of the service.inficon account.
This is done so that the variation between auto-generation of RMA and manual creation of RMAs can be measured.
Detailed definition
Process Start: The time that the customer submits a repair request.
Process Stop: The time that the customer receives an RMA.
Target Value: 2 days

KPI Name: Repair Turnaround time
What does the KPI mean: Number of days to complete the total repair process at Inficon.
How will it be calculated: The time that the instrument is received by the repair center is recorded when the details are entered into SAP task IW31. The time that the RMA is closed is the time when the repair is completed and is shipped. Time difference on the date-time creation date of the IW52 (Instrument Checking) and the closure of the IW71 (service Notification) will tell us how long did it take for the product to be repaired. This metric will help us measure the check-in to repair order generation time.
Detailed definition
Process Start: The time that the instrument check-in is performed in SAP.
Process Stop: The time that the RMA is closed
Target Value: Depends on product.

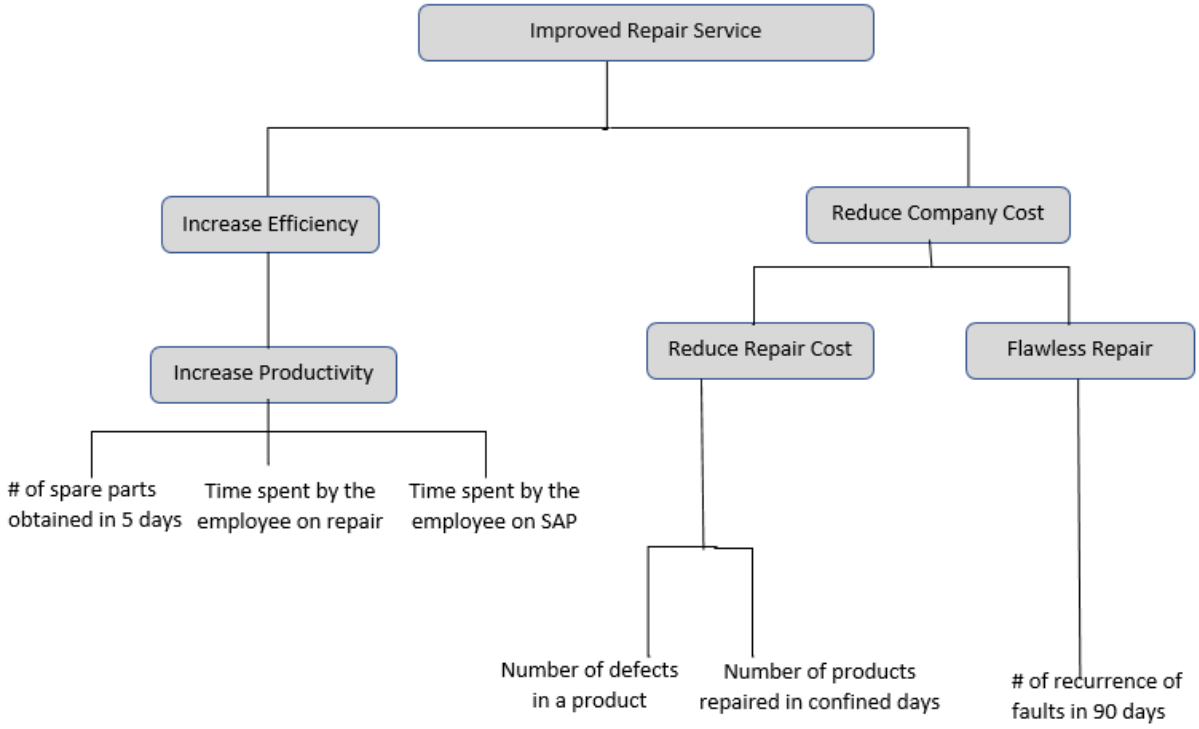
KPI Name: Repair Request Clicks (New)
What does the KPI mean: The number of clicks done by the customer to submit the request repair forms.
How will it be calculated: An Inficon customer who wants to return the product will submit a repair request form using to the return form (old)/portal (new). The number of clicks for each user to submit the request can be measured.
Detailed definition
Process Start: The time that the customer logs in to the portal / hits the service request url (https://service.inficon.com/)
Process Stop: The time that the customer submits the form.
Target Value: Less than 10. (Calculated on ideal scenario using Customer portal)

Inficon as Customer

Generation of KPI



KPI Tree



Operational Definitions

KPI Name: Parts Delay Time
What does the KPI mean: Delay in the time between when the part was ordered from Suppliers vs when it was received.
How will it be calculated: The difference in the time taken to create purchase order for the products and the time taken for the purchase order to be closed.
Detailed definition
Process Start: The time when a purchase order is created.
Process Stop: The time when a purchase order is closed.
Target Value: 5 Days

KPI Name: Employee Hours spent in SAP
What does the KPI mean: The average number of hours spent repairing a product. This value along with the calculation of total repair time will give us an idea about the time spent on the Employee for SAP and other factors.
How will it be calculated: The number of non-billable hours logged for a product divided by the number of total hours logged for a product
Detailed definition
Process Start: The repair order is created.
Process Stop: The repair order is closed.

KPI Name: Employee Hours spent in Repair
What does the KPI mean: The average number of hours spent doing the actual repair work on a product. This value along with the calculation of total repair time will give us an idea about the time spent on the actual product.
How will it be calculated: The number of billable hours logged for a product divided by the number of total hours logged for a product
Detailed definition
Process Start: The repair order is created.
Process Stop: The repair order is closed.

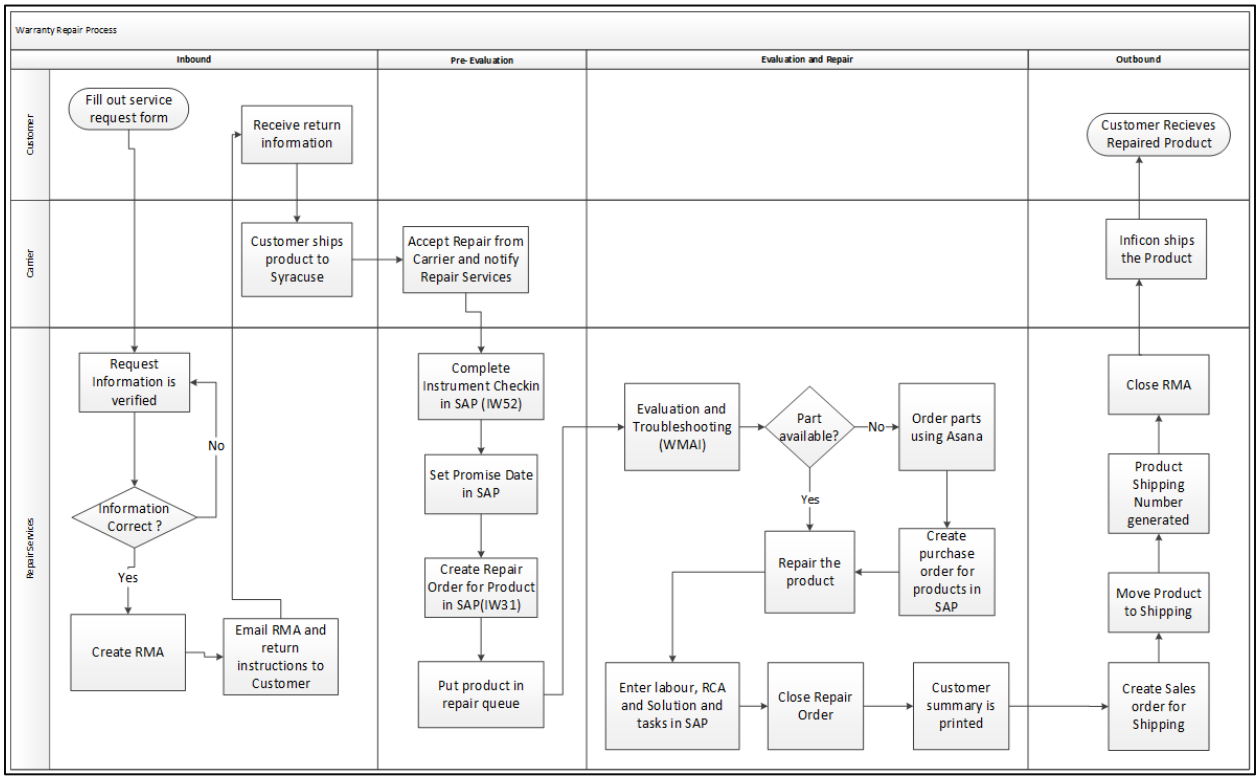
KPI Name: Total Repair turnaround Time
What does the KPI mean : Similar to Repair Turnaround time as mentioned above.

KPI Name: Number of Defects per product
What does the KPI mean : Number of repairs calculated for a particular product type per month
How will it be calculated : The number of products that come back for repair grouped by the service product category.
Detailed definition
Process Start: The product is sold.
Process Stop: The product comes back for repair.
Target Value: Less than 0.0034 percent

KPI Name: Return Repair Frequency (New)
What does the KPI mean: Details similar to End-Customer RRF operational definition

Process Flowchart

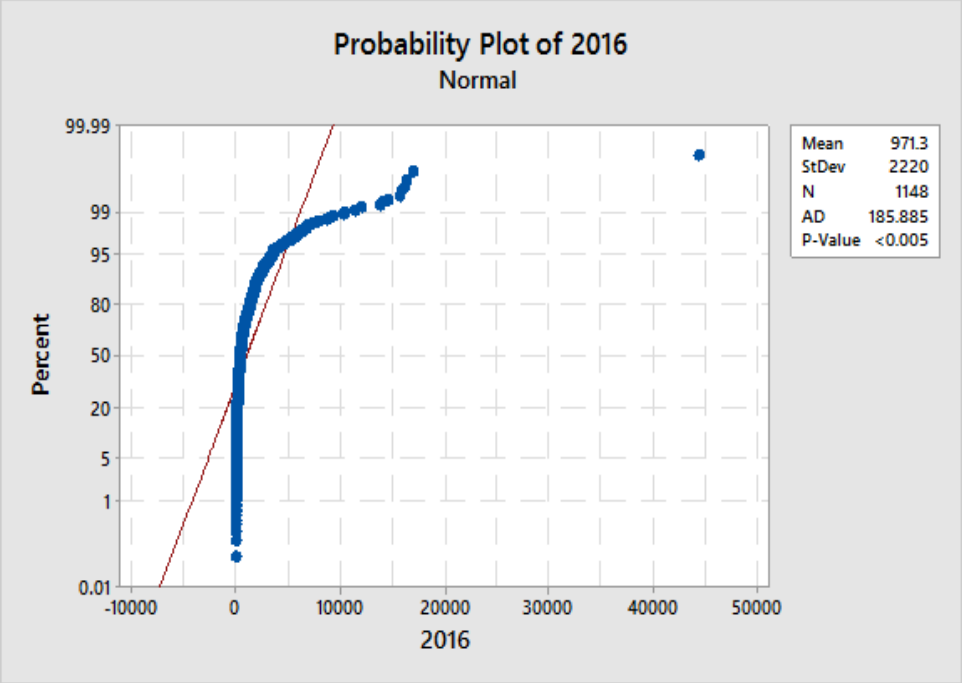
The process starts from a customer requesting a repair. Later, Service coordinators of Inficon collect the required data and create a Return Merchandize Authorization (RMA) record in SAP. The creation of this record is considered as 'Input' to the repair process. Later, customer ships the product to Inficon. On product receiving end, Service Coordinator creates a Repair Order to track the repair of product. This is considered as 'Pre-Evaluation' stage. For warranty repairs, technicians start to evaluate the issues and repair the product. The Repair order is closed once product is repaired or replaced. This is end of 'Evaluation and Repair' stage. Later, service coordinator creates a Sales Order to start the process of shipping the product back to customer. Here, the coordinator also creates an Invoice which is charged to Inficon for warranty cases. Once, the product is moved to shipping doc, RMA is closed. This marks the end of stage of 'Outbound' and end of Warranty Repair process of Service Department at Inficon. Below is the flowchart of end-to-end process of repairs under warranty.

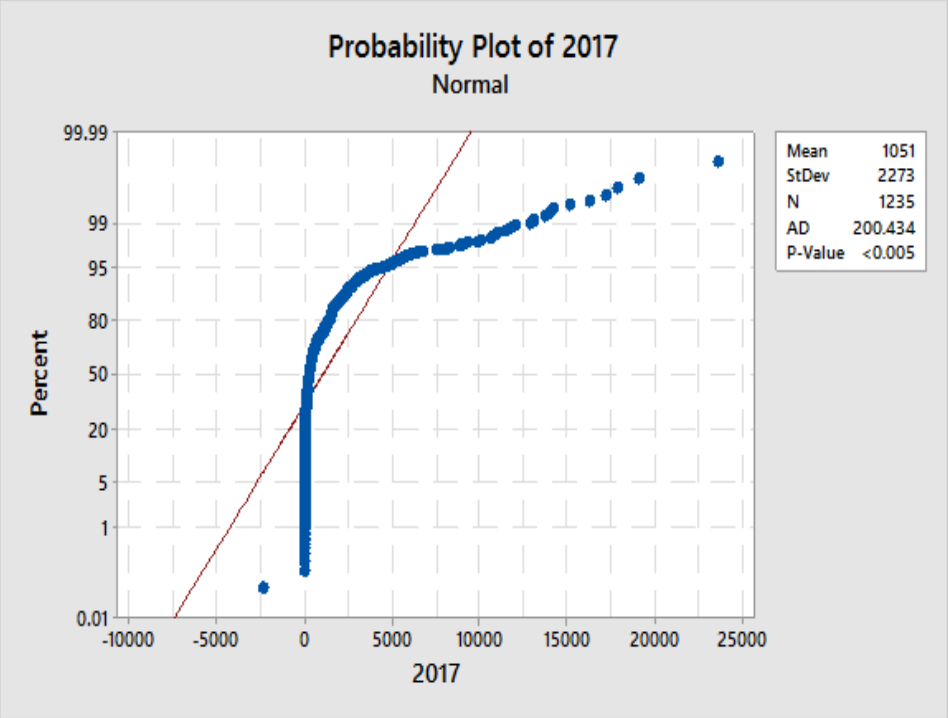


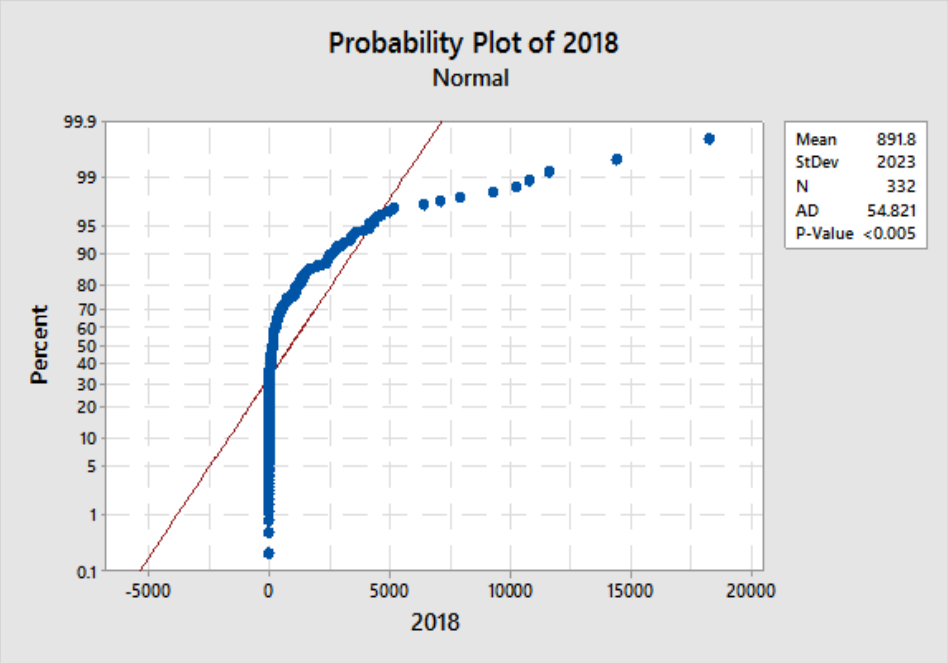
Data Distribution

Warranty Expense for Year 2015, 2016, 2017

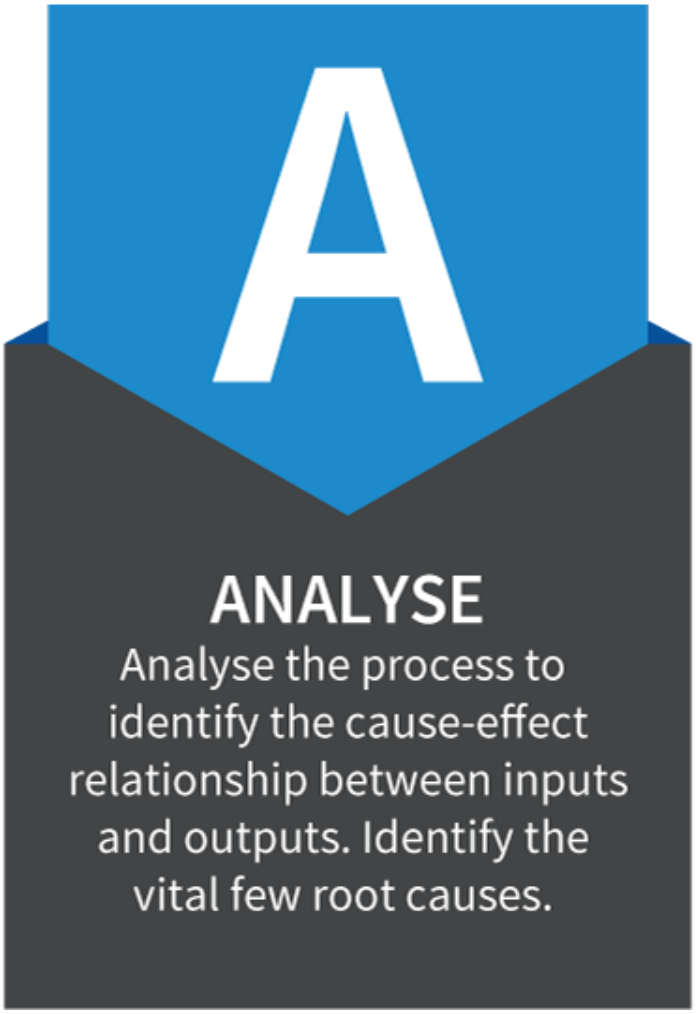
In this section, we trying to see if our data is normally distributed. We have considered the expense from 2016, 2017, 2018 for all the products.







We see from the charts above that the data is not normally distributed, going forward if we must use the warranty expense, we will have to either convert the non-normal data into normal using box cox or will have to use median to do statistical analysis.

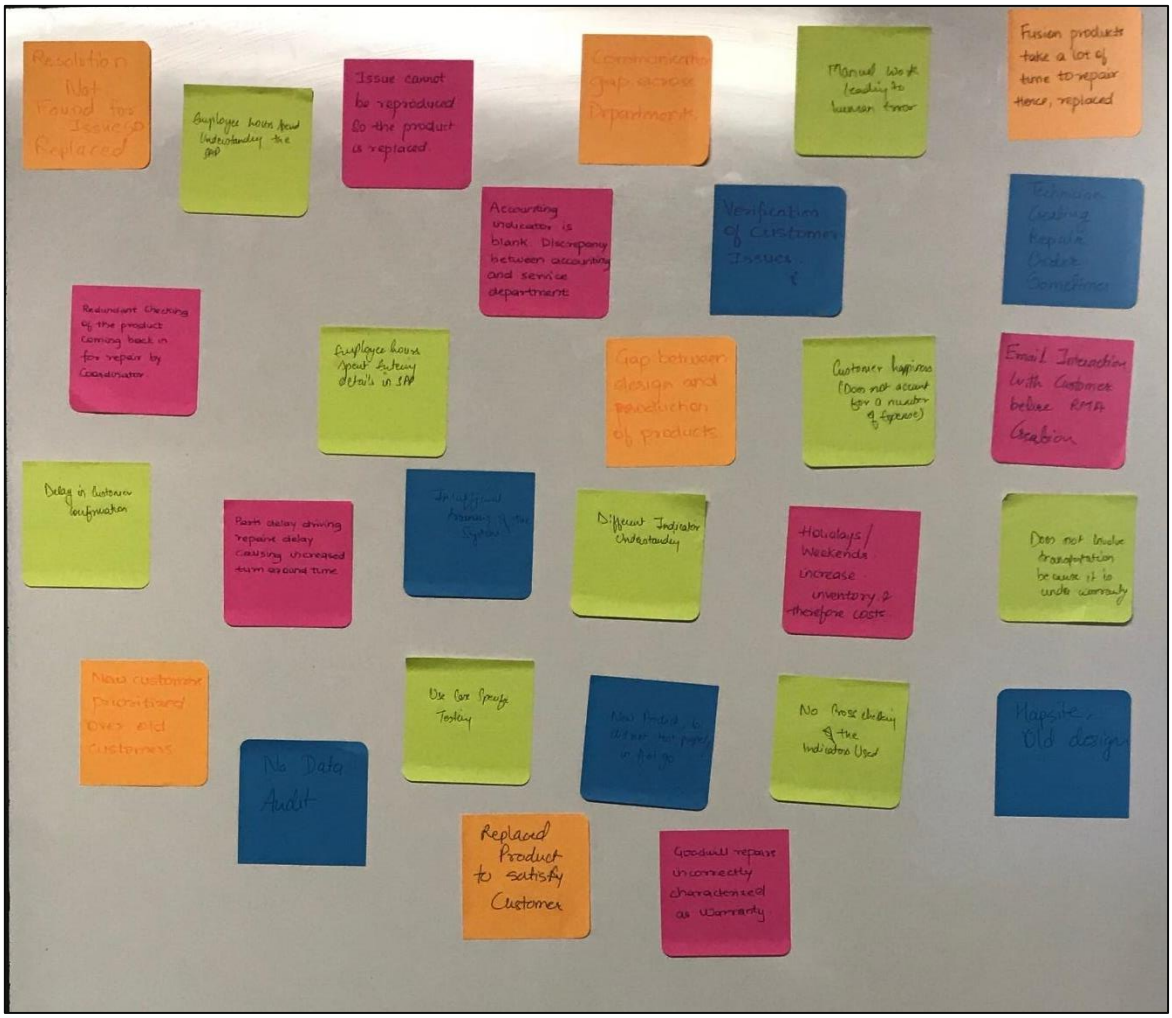

A
ANALYSE
Analyse the process to identify the cause-effect relationship between inputs and outputs. Identify the vital few root causes.

Analyze

Brainstorming for Issues

Our brainstorming started with a focus on reducing the warranty expense as it was our first and most important problem statement. During the discussion we came up with a few ideas and reason that could have affected the warranty expense. These factors are as mentioned below:

1. Customer satisfaction
2. Old design
3. Customer Confirmation
4. Technician hours spent understanding SAP
5. No data audit
6. Time crunch
7. Gap b/w design and production
8. Parts delay
9. Technician hours spent entering data in SAP
10. Different Indicator understanding
11. Issue cannot be reproduced
12. Use case specific testing
13. New customer over old customer
14. Technician creating repair order sometimes
15. No cross checking of the indicators used
16. Solution not found
17. New product
18. Long holidays
19. Redundant checking of data after product comes in
20. Insufficient training
21. Email Interaction with customer before RMA creation
22. Goodwill accounted in warranty
23. Manual work
24. Communication gap
25. Shipping cost not included
26. Blank fields



After noting down all the possible factors, we tried to put them in specific buckets based on the relevance of the fields. We had a couple of different opinions when figuring out the specific buckets in terms of whether the post-it should go in an altogether a new category or it can be allocated in an existing category. After discussing it and considering all the use cases, we finally came up with 5 broad categories:

1. Replacement instead of repair
2. Design defects
3. Delay
4. Non-Value-added processes
5. Data Interpretation

After sorting out the categories, we arranged the sub parameters in relevant buckets, we came up with an affinity diagram

Affinity Diagram

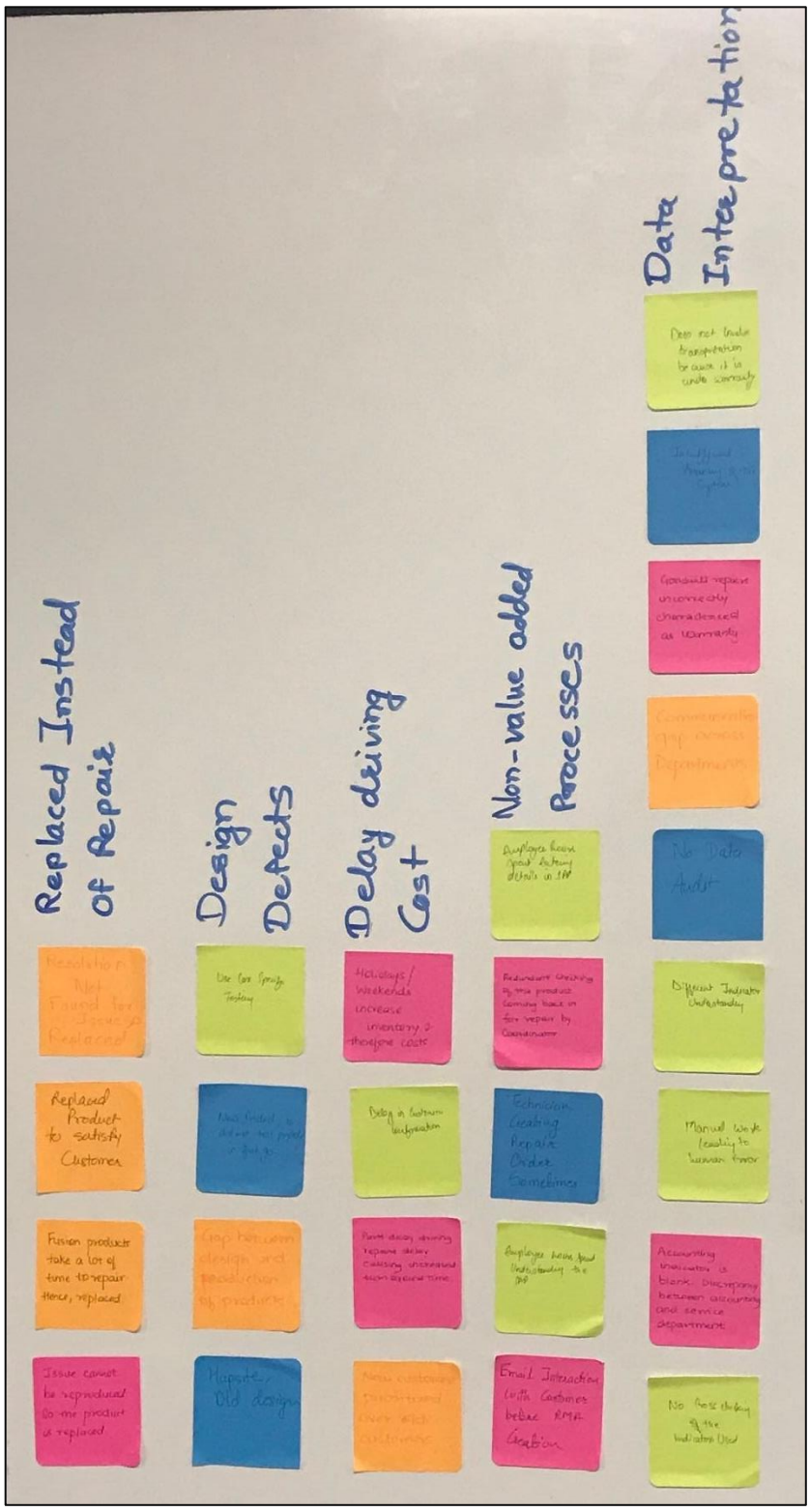
The Affinity diagram gave us the key categories with the specific reasons, which helped us to drill down the major causes of the issue. We found that majority of the points that we could list were under data interpretation, by data interpretation we mean anything that it is not accounted for or noted, it can also include the discrepancies in the data or any form of manual mistakes. We gave it broad term to account for factors that are related to capturing and maintaining information.

During our discussions with Inficon, we came to know how much emphasis is put on customer happiness. Inficon bears a lot of extra expense just to keep their customers happy, one of the categories that tell this story is “replace instead of repair”. This category captures all the reasons, why Inficon took a major bump in their expense in this category.

The “Delay” category covers the probable reasons for why the delay happens. One of the factors that was surprising to the team was prioritizing the new customers over old customers, if both needs common services.

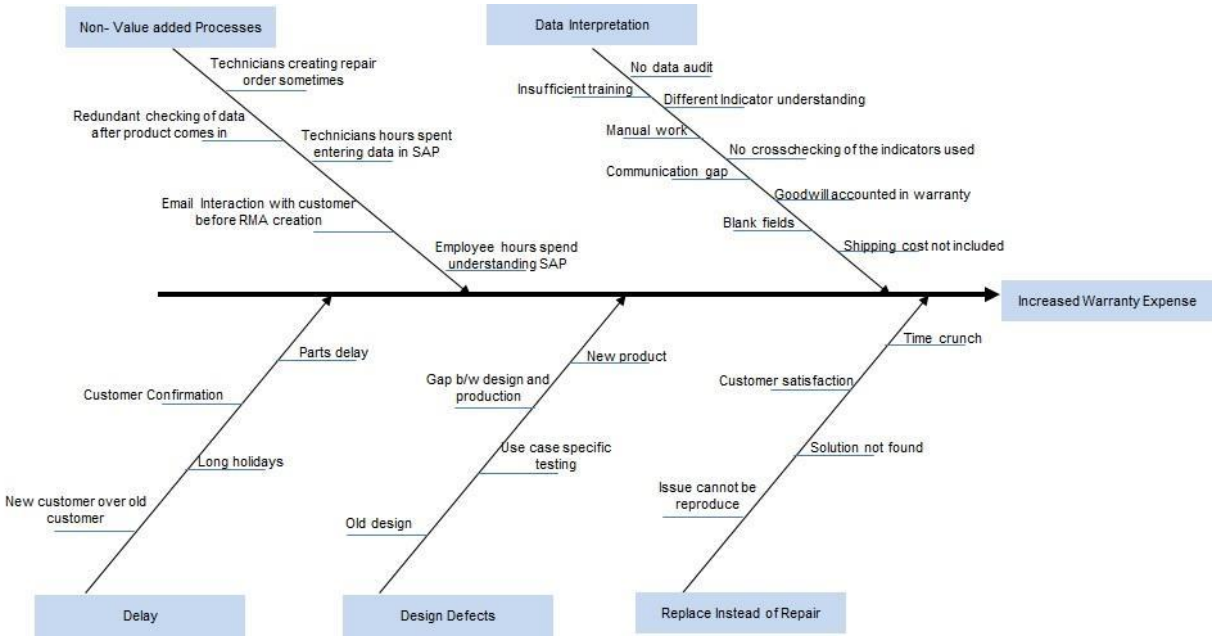
Another category that we have considered is “Non- Value-added processes". A number of processes are termed not useful by the team during the course of the study, some of them being redundant like verifying the details customer provide while filling in the service request form when the product comes on campus. We have listed down different processes that the team considers to be Non-Value added.

The final category that we created was “design defects”. In this category, we have listed down all the possible factors on why the design defects happened. We came to know during our project that one of the products had a design issue which costed Inficon a lot of money as the product failed during the warranty period. Our team calculated that this product contributed the most to the warranty expense.


Replaced Instead of Repair
Design Defects
Delay driving Cost
Non-value added Processes
Data Interpretation
Replaced Product to satisfy Customer
Fusion product take a lot of time to repair hence, replaced
Issue cannot be reproduced so the product is replaced
Mapute, Old design
Holidays / Weekends increase inventory & therefore costs
Technician Creating Repair Order Sometimes
Email Interaction with Customer before RMA Creation
Different Indicator Understanding
Manual Work Possibility to human error
Accounting Indicators is blank. Discrepancy between accounting and service department
No Data Audit
Does not include transportation because it is under warranty

Fishbone Diagram

A **fishbone diagram**, also called a cause and effect **diagram** or Ishikawa **diagram**, is a visualization tool for categorizing the potential causes of a problem to identify its root causes. Using the affinity diagram, the categories and the reason why these categories exists, we created a fishbone diagram to understand the root causes of the problem. The diagram helped the team to visualize the ideas and sought it on the basis of the fields.



Analyze the Data

In this step we focused on all of our problem statements and tried to analyze them and focused on the data points we captured in the measure phase. We will be starting with understanding and finding out which all products fall under which cost centre. The next point we wanted to understand was which cost centre contributed the most towards the warranty expense. After that we looked into the specific product in that category to focus on that product. We tried to do these steps for top 3 products.

The next problem statement was the data discrepancy in the collected data. After discussion with Inficon, we realized that they continuously evolving and in doing so, changes are implemented quicker than they are communicated, which led to different understanding of data among different users. We will be addressing this issue and will look into the impact of the same.

The other concern is the amount of work or responsibility that the company puts on the customers when there is a need for repair. After thorough understanding of the process, we found out that the customer have to go through a laborious process of filling in the service request form where he/she might not be knowing all the details he/she needs to fill. This process leads to double work as the coordinators have to verify the details customers have put once the product reaches Inficon. We will be analysing the impact of that in this section.

Warranty Expense

There are different cost centres under which different products fall in Inficon. Some of the useful cost centres for our study are:

2016	2017
51049 - Products: STC, AMS, Thin Film	51049 - AMS
51043 - Leak Detection	51043 - Leak Detection, STC, Thin Film
51040 - Energy and Security	51040 - Energy and Security

As we can see from the table above, some of the products were shuffled in different cost centres during 2016 and 2017. We look into the major contributor towards warranty expense among these different cost centres.

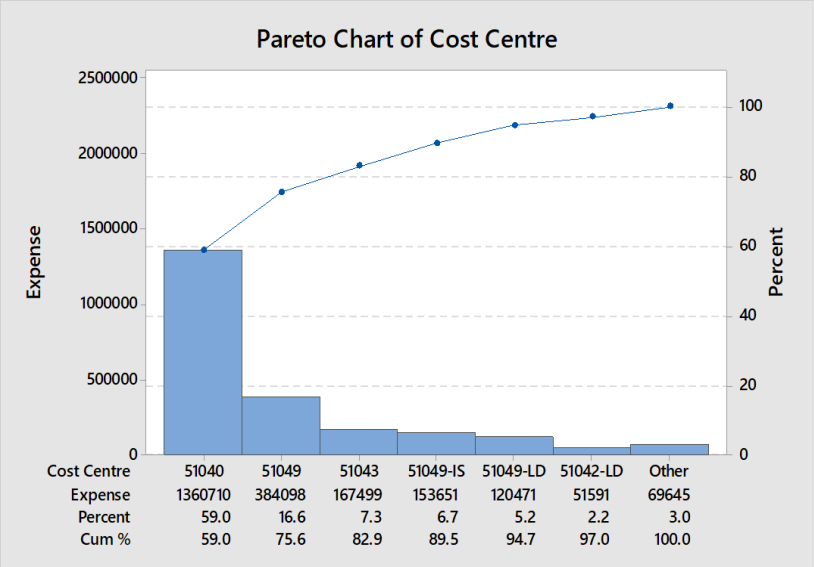
PARETO ANALYSIS for Warranty Expense

The Pareto chart is one of the basic tools of quality control. Pareto charts are extremely useful for analyzing what problems need attention first because the taller bars on the chart, which represent frequency, clearly illustrate which variables have the greatest cumulative effect on a given system. The Pareto chart provides a graphic depiction of the Pareto principle, a theory maintaining that 80% of the output in a given situation or system is produced by 20% of the input. A Pareto chart, also called a Pareto distribution diagram, is a vertical bar graph in which values are plotted in decreasing order of relative frequency from left to right. Pareto charts are extremely useful for analyzing what problems need attention first because the taller bars on the chart, which represent frequency, clearly illustrate which variables have the greatest cumulative effect on a given system.

The independent variables on the chart are shown on the horizontal axis and the dependent variables are portrayed as the heights of bars. A point-to-point graph, which shows the cumulative relative frequency, may be superimposed on the bar graph. Because the values of the statistical variables are placed in order of relative frequency, the graph clearly reveals which factors have the greatest impact and where attention is likely to yield the greatest benefit.

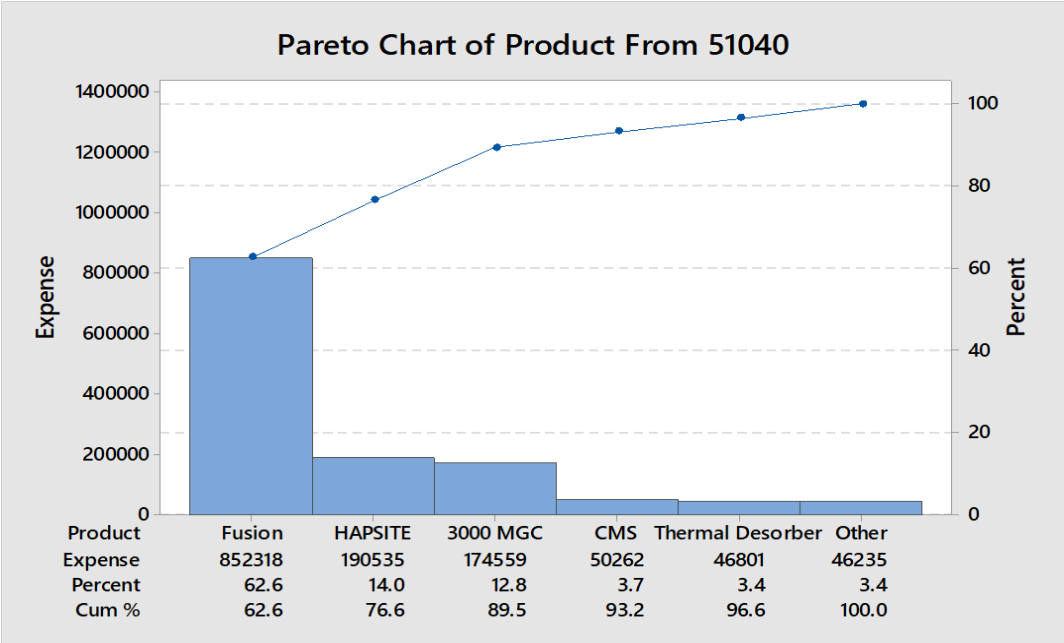
Considering pareto over different cost centre in terms of expense, we can see that 51040 is the major contributor with almost 60% weightage. The second highest is 51049 with almost 17% weightage. Since there was a huge difference in the first highest and the second. It was the obvious choice to go with 51040.

Cost center description, Pareto based on cost center:



Pareto for Products Under 51040

51040 majorly has 4 products, namely: Fusion, Hapsite, 3000 MGC and Thermal Desorber. After creating a pareto chart for the products under 51040, we found that Fusion was the product that was driving the warranty expense the most with almost 63% weightage, the second product was Hapsite with 14% weightage.



We decided to go into detail and study Fusion to figure out the exact reason for so many products coming back within warranty period. We found that, there is some specific part that was coming in a number of discussions, this was “Micro GC Fusion 2 Mod System”. After discussion with the product manager, we were told that the product manager was already aware of Fusion being the expense driver. Fusion had a design issue which was diagnosed in 2016, due to which a lot of customers started sending the products back. In order to keep the customers happy, Inficon replaced the product instead of repairing the product, which shot up their expense. Some of the old products are still in the market and they keep coming in periodically within the warranty period. All the products did not come in at the same time, the products sold till 2016 still come in under warranty period since the warranty period is of 2 years. We were told that the reason for fusion coming in the most was known, but we still went ahead and tried to see if the expense on this product is decreasing or has been the same since 2016.

Fusion

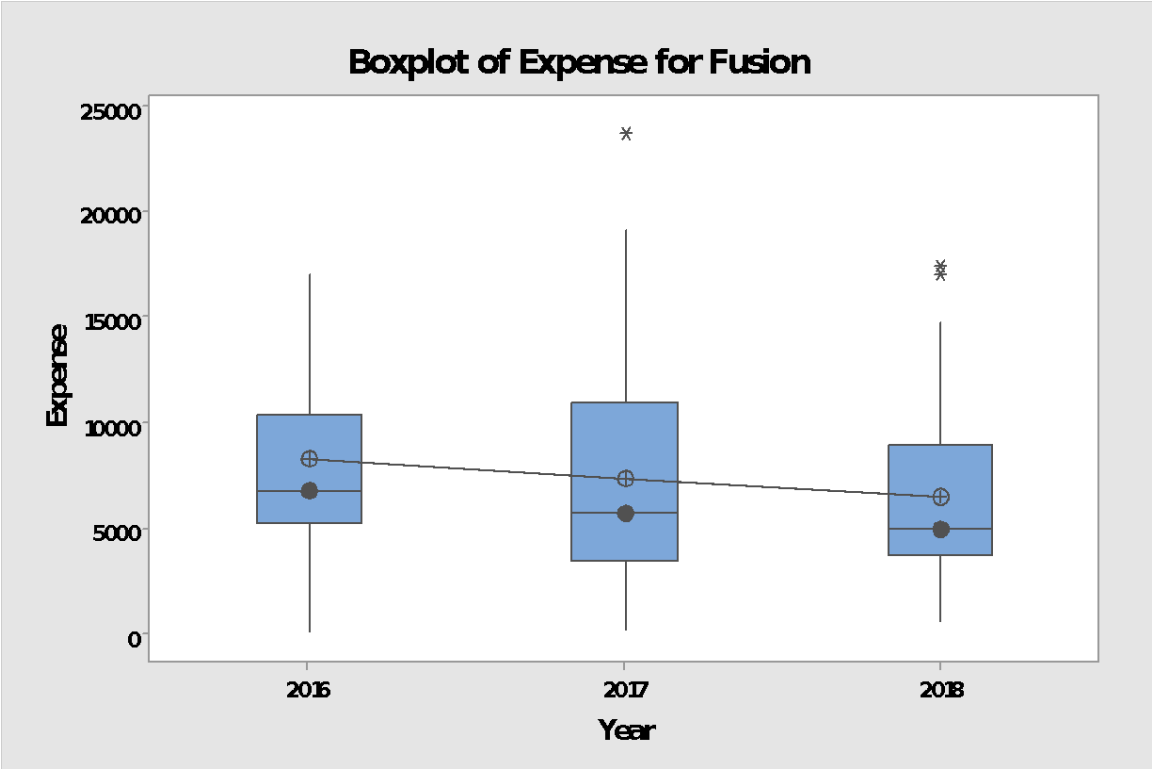
Fusion is a relatively new product. It was introduced in 2013. But in 2016 there were certain design changes which caused a lot of fusion products to malfunction. There was no callback for fusion. But when it did come back, it was replaced instead of being repaired to avoid long lead times for service. The cost to replace a fusion product is on an average 4000$, but the cost to repair it is on an average 1500$. The warranty period for fusion is 2 years.

Fusion 2016			
BF 1.0uL , TCD2, M5A 10m/Q-BOND 3m, LL	1	10338.07	4.04%
HEATER ON ISC FAILED	1	0	0.00%
Micro GC Fusion 2 Mod System	20	129667.78	50.67%
MicroGC Fusion 2 Mod System	12	115885.84	45.29%
Grand Total	**34**	**255891.69**	
Fusion 2017			
BF 1.0uL , TCD2, M5A 10m/Q-BOND 3m, LL	5	8555.77	1.51%
LV, TCD, RTx-1, 10m	1	1854.88	0.33%
LV, TCD, Rxi-1ms 20m, LL	1	4756.71	0.84%
LV, TCD2, Rt-Q-BOND 12m x2, LL	2	18598.65	3.29%
Micro GC Fusion 2 Mod System	64	506789.16	89.73%
Micro GC Fusion 3 Mod System	1	1661.04	0.29%
Micro GC Fusion 4 Mod System	2	5820.35	1.03%
Valve SF, 10 Way, 21 Port, 1/16 Tube, SS	2	1340.5	0.24%
VV, TCD2, Rt-Q-BOND 12m x2, LL	2	8827.09	1.56%
VV, TCD2, Rxi-1ms 20m, LL	1	5051.26	0.89%
VV, TCD2, Stabilwax 10m, LL	1	1527.79	0.27%
Grand Total	**82**	**564783.2**	

For the manufacturing process of fusion, they take 2 days for assembly and 2 weeks for testing. They give extended warranty to specific customers. There are long lead times in service. In 2016, they sold about 50 products, in 2017 they sold 170 and in 2018 they have sold 300 products. Design is still ongoing, they are still discovering issues in fusion. They started repairing their products in 2018. They redesigned the circuit boards, display etc.. Fusion testing process has changed, someone got in to build a module for testing the fusion products.

We considered the expense of 2016, 2017 and 2018 for Fusion to see if the expense is actually decreasing. We used Boxplot to see if the mathematical mean is actually going down.

Boxplot

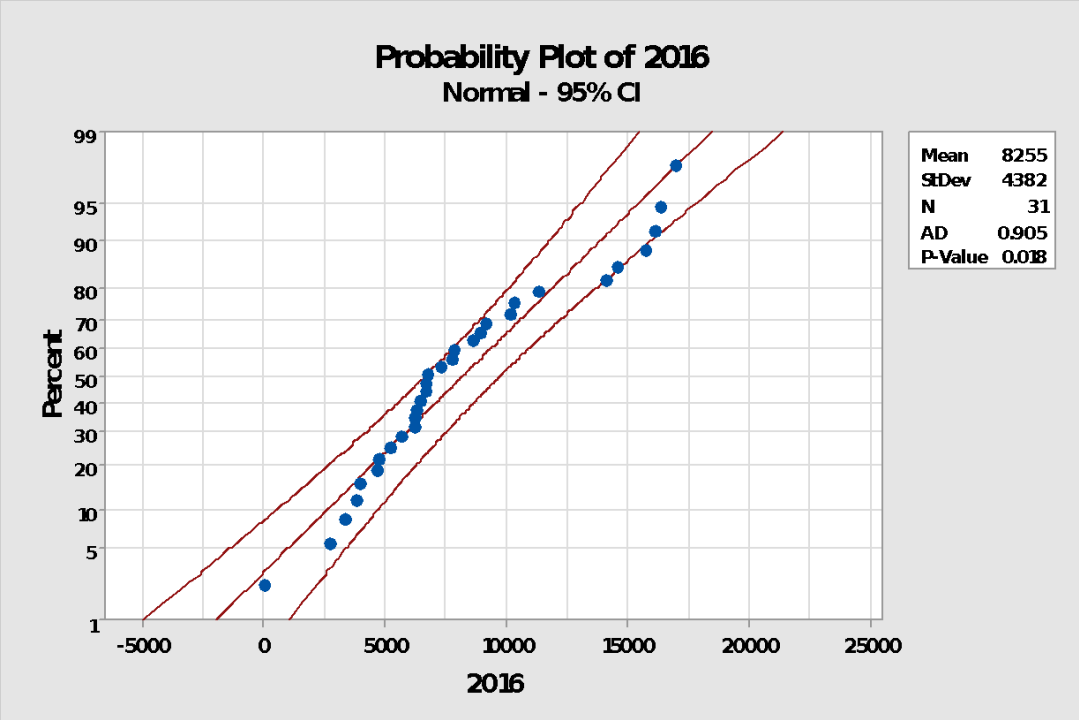


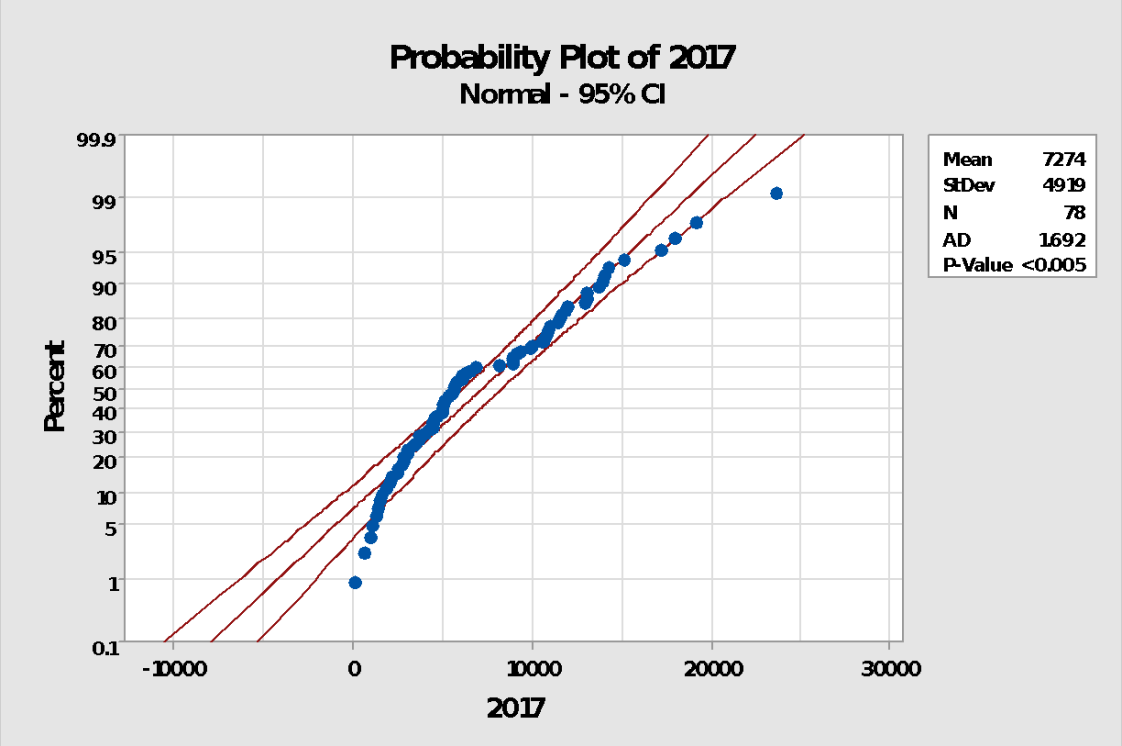
Looking at the boxplot, we saw that the mathematical mean is actually going down since 2016, but we were not convinced since it was not much and also there were a number of outliers for 2017 and 2018.

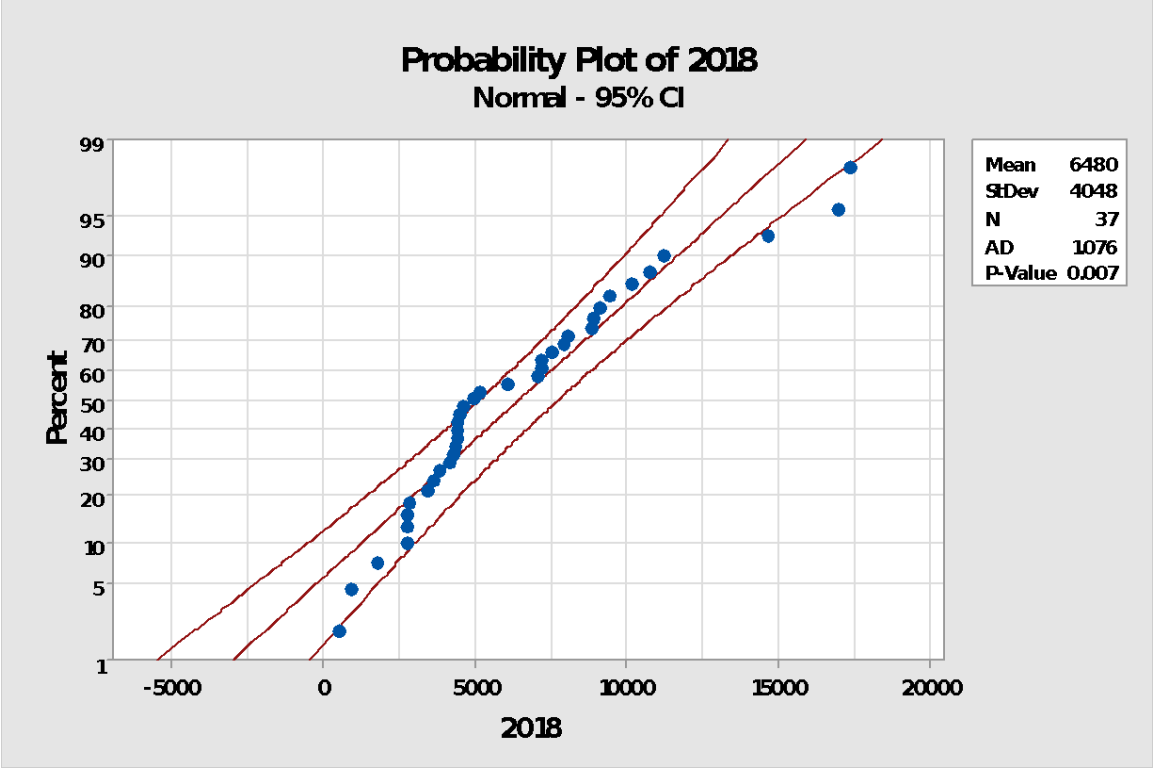
We decided to confirm it using hypothesis testing to see if the statistical mean and median is also going down. We first wanted to check if our data is normally distributed or not, to see that we used probability plot and used P-value to confirm our findings.

After creating the probability plot, we saw that the data for 2016, 2017, and 2018 was not normally distributed since the P-value for all three was less than 0.05. We had two options now, we could consider mean by converting our data into normal form by using box cox method or we can work with the median. We saw that our data does not have the same sample size and also the data for 2017 and 2018 had a couple of outliers, using median would be a good choice, but we wanted to be extra sure, so we considered both the approaches, we converted our data into normal form using Box Cox and used ANOVA to see if the mean for 2016, 2017 and 2018 are statistically similar. After that, we considered Mood's Median to confirm our result. We used Mood's Median because our data had outliers.

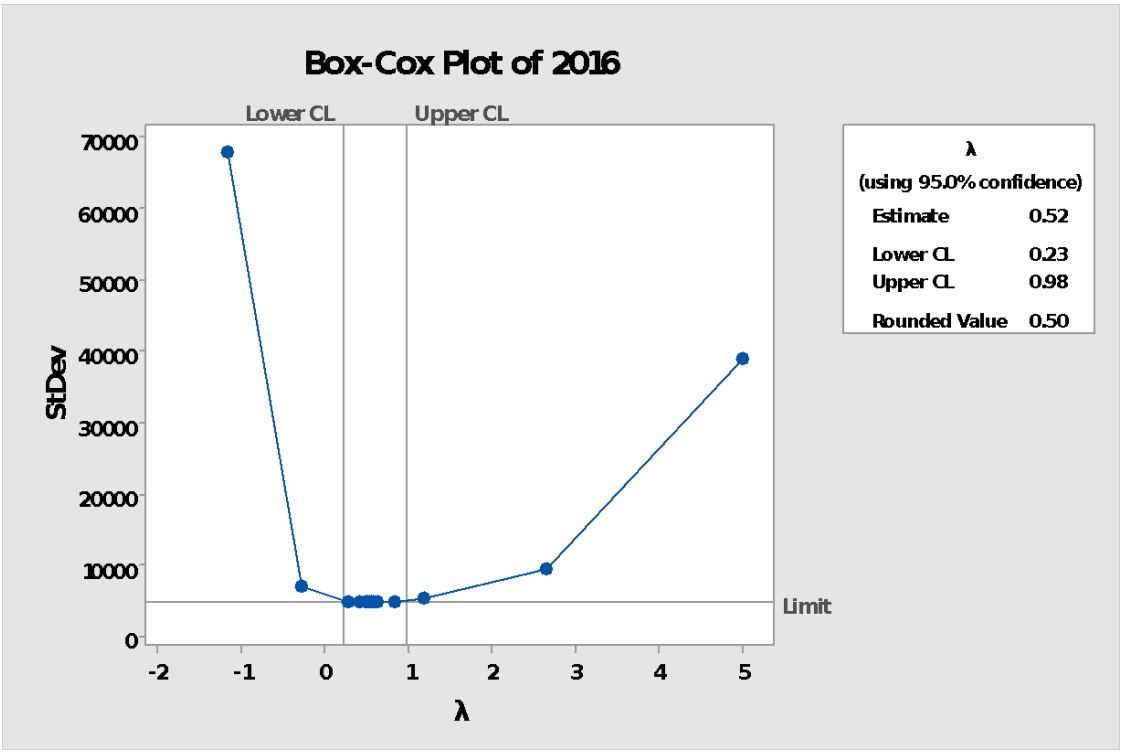
Probability Plots

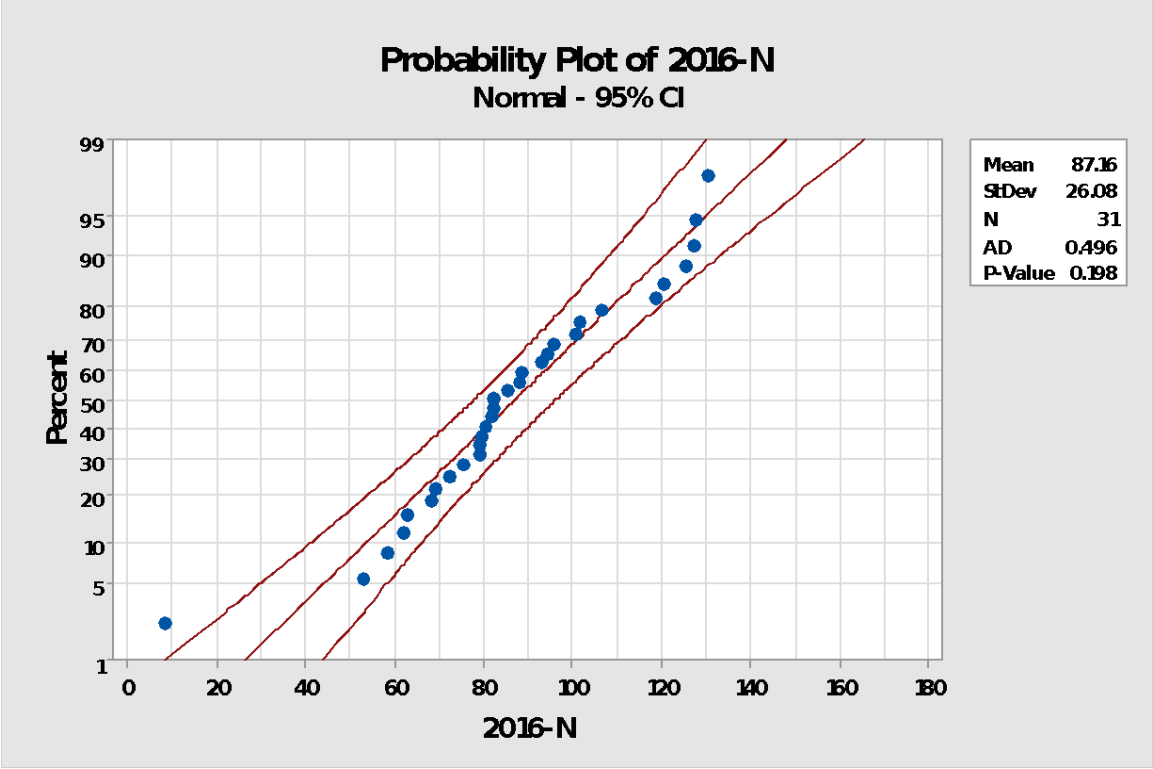


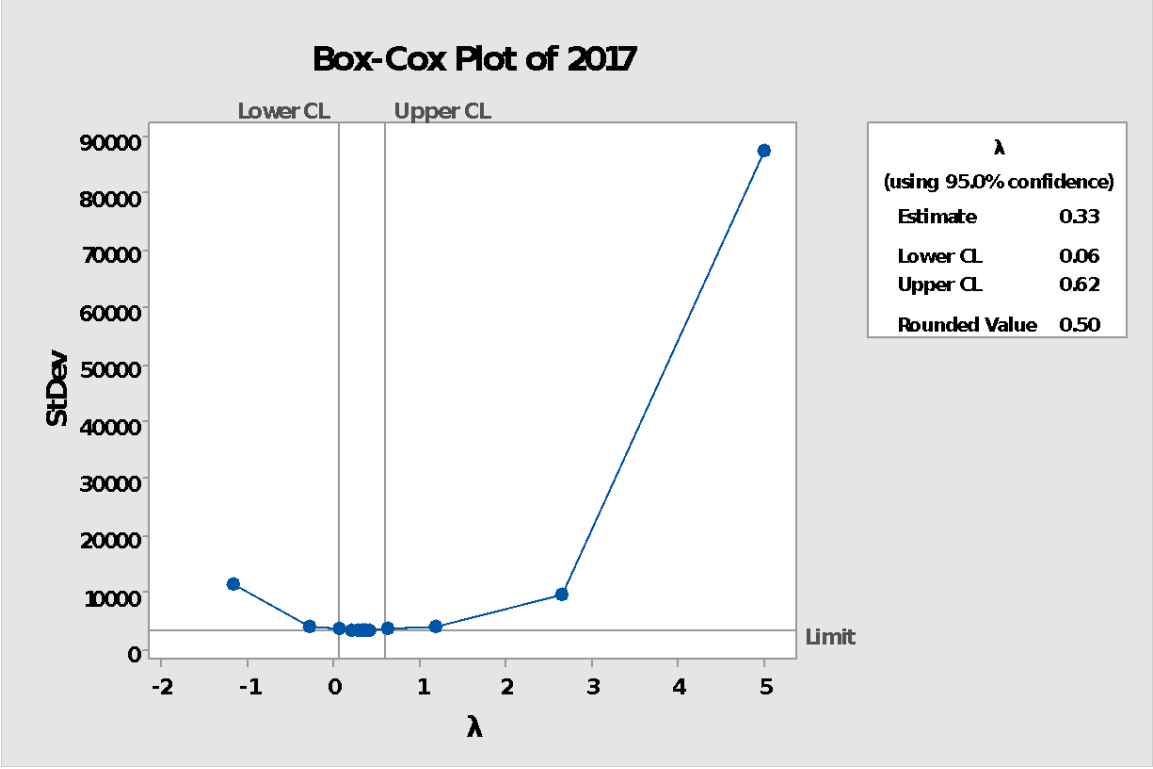


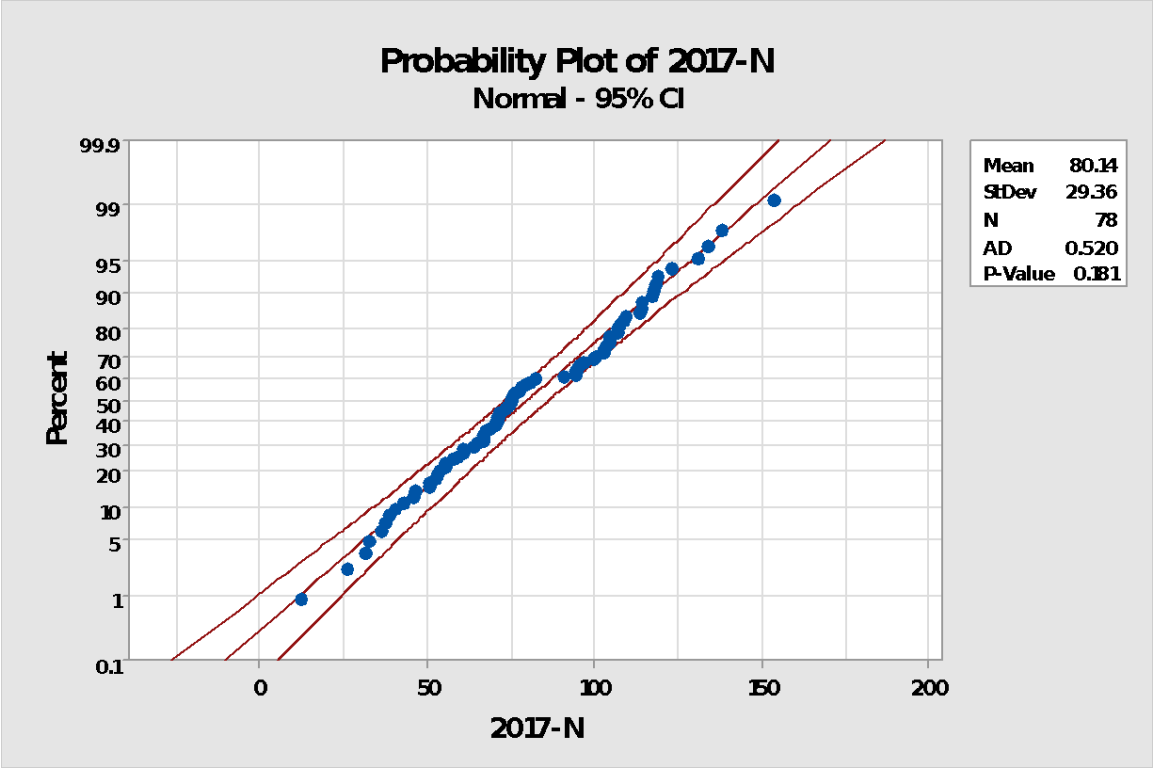

Probability Plot of 2018
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
-5000
0
5000
10000
15000
20000
2018
Mean 6480
StDev 4048
N 37
AD 1076
P-Value 0.007

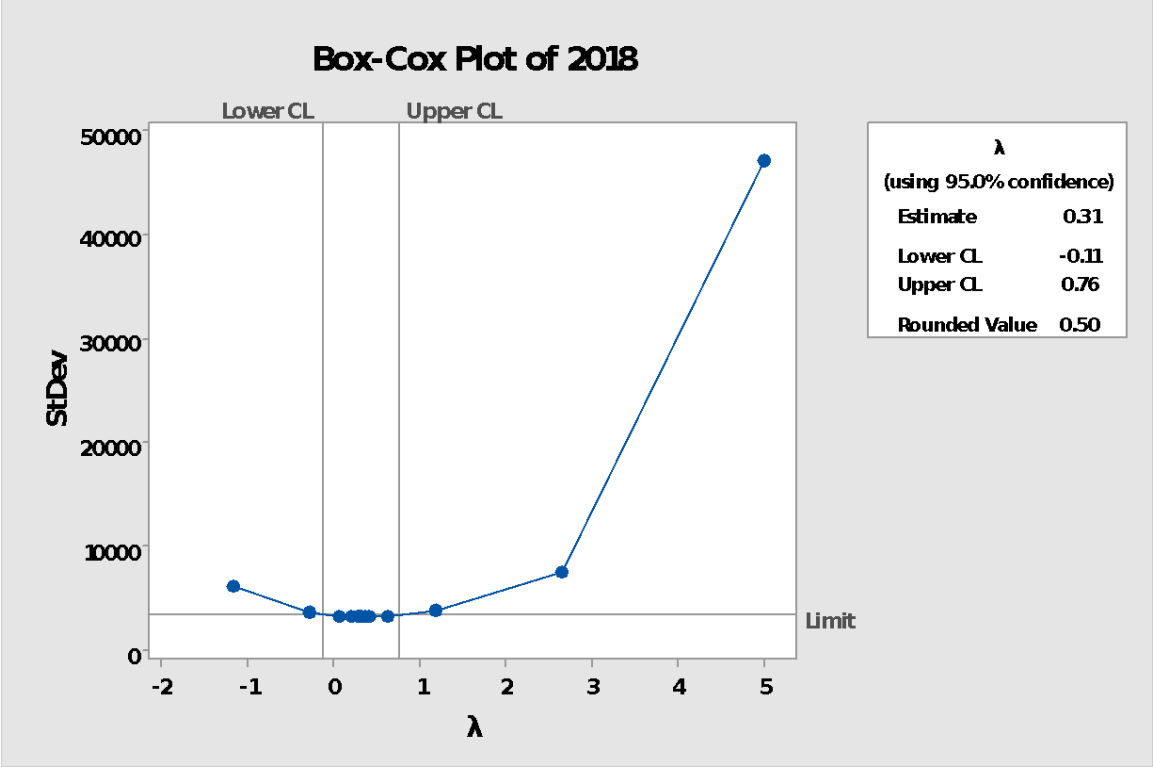
Box-Cox Plot

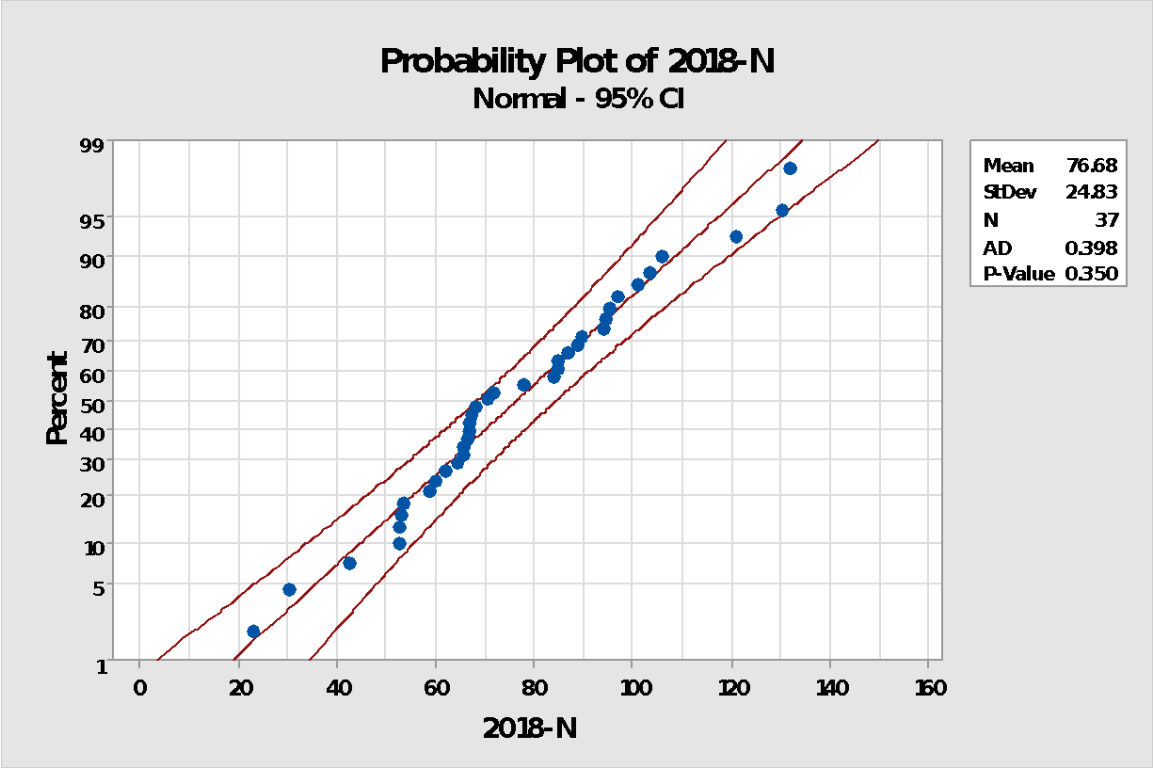

Box-Cox Plot of 2016
Lower CL
Upper CL
StDev
70000
60000
50000
40000
30000
20000
10000
0
-2
-1
0
1
2
3
4
5
λ
Limit
λ
(using 95.0% confidence)
Estimate 0.52
Lower CL 0.23
Upper CL 0.98
Rounded Value 0.50

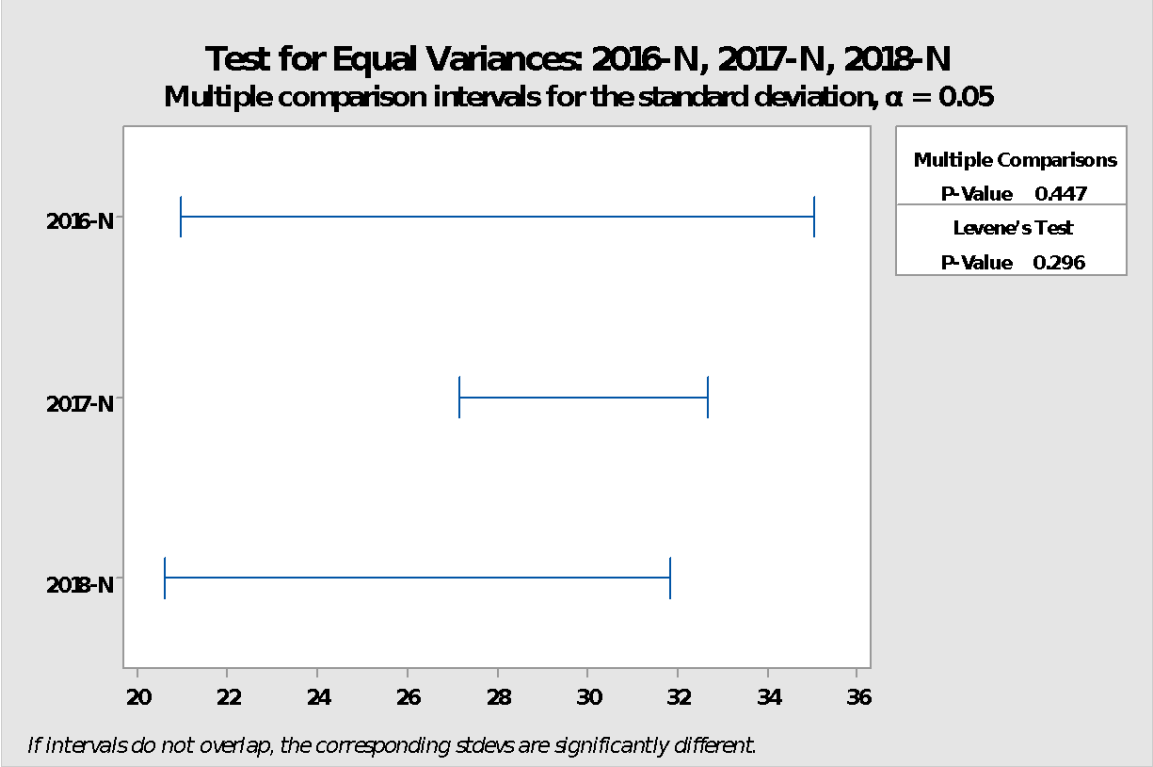

Probability Plot of 2016-N
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0
20
40
60
80
100
120
140
160
180
2016-N
Mean 87.16
StDev 26.08
N 31
AD 0.496
P-Value 0.198

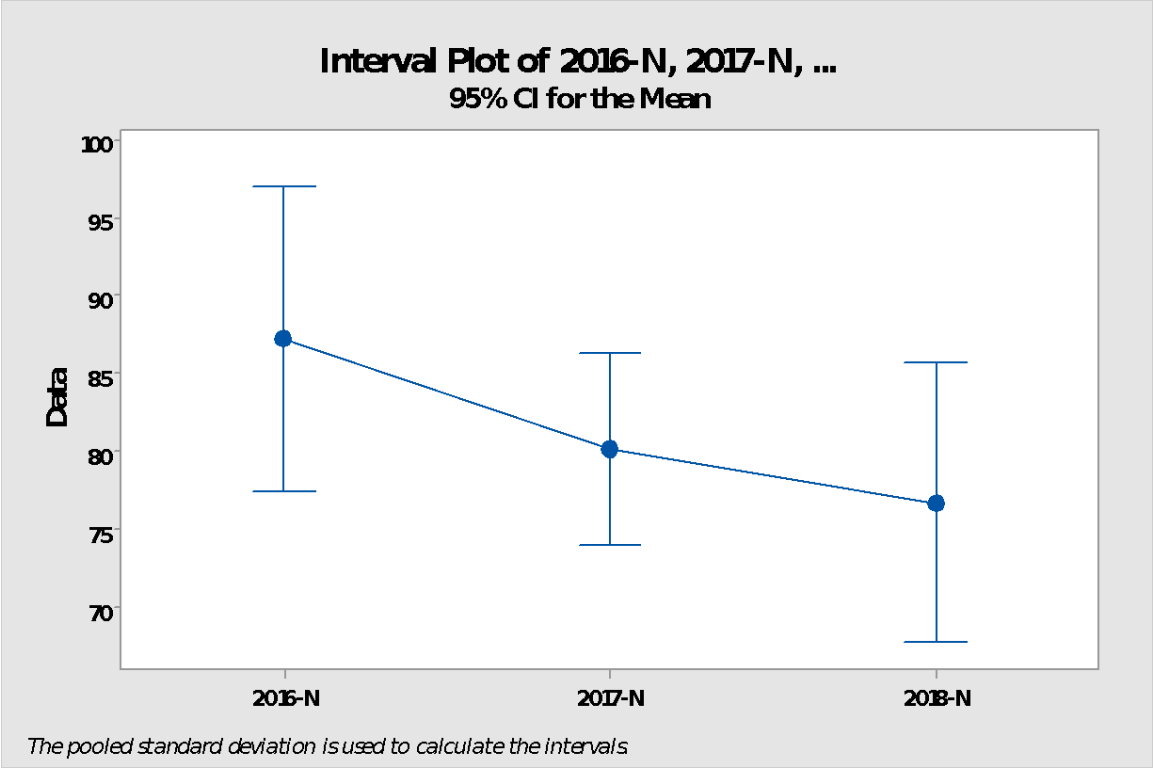

Box-Cox Plot of 2017
Lower CL
Upper CL
StDev
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-2
-1
0
1
2
3
4
5
λ
Limit
λ
(using 95.0% confidence)
Estimate 0.33
Lower CL 0.06
Upper CL 0.62
Rounded Value 0.50


Probability Plot of 2017-N
Normal - 95% CI
Mean 80.14
StDev 29.36
N 78
AD 0.520
P-Value 0.181
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0
50
100
150
200
2017-N


Box-Cox Plot of 2018
Lower CL
Upper CL
λ
(using 95.0% confidence)
Estimate 0.31
Lower CL -0.11
Upper CL 0.76
Rounded Value 0.50
StDev
50000
40000
30000
20000
10000
0
Limit
-2
-1
0
1
2
3
4
5
λ


Probability Plot of 2018-N
Normal - 95% CI
Mean 76.68
StDev 24.83
N 37
AD 0.398
P-Value 0.350
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0
20
40
60
80
100
120
140
160
2018-N


Test for Equal Variances: 2016-N, 2017-N, 2018-N
Multiple comparison intervals for the standard deviation, α = 0.05
Multiple Comparisons
P-Value 0.447
Levene's Test
P-Value 0.296
2016-N
2017-N
2018-N
20
22
24
26
28
30
32
34
36
If intervals do not overlap, the corresponding stdevs are significantly different.


Interval Plot of 2016-N, 2017-N, ...
95% CI for the Mean
Data
100
95
90
85
80
75
70
2016-N
2017-N
2018-N
The pooled standard deviation is used to calculate the intervals.

One-way ANOVA: 2016-N, 2017-N, 2018-N

Method

Null hypothesis All means are equal
Alternative hypothesis At least one mean is different
Significance level α = 0.05
Rows unused 22

Equal variances were assumed for the analysis.

Factor Information

Factor Levels Values
Factor 3 2016-N, 2017-N, 2018-N

Analysis of Variance

Source DF Adj SS Adj MS F-Value P-Value
Factor 2 1914 957.2 1.26 **0.288**
Error 143 108988 762.2
Total 145 110903

Model Summary

S R-sq R-sq(adj) R-sq(pred)
27.6072 1.73% 0.35% 0.00%

Means

Factor N Mean StDev 95% CI
2016-N 31 87.16 26.08 (77.36, 96.96)
2017-N 78 80.14 29.36 (73.96, 86.32)
2018-N 37 76.68 24.83 (67.71, 85.65)

Pooled StDev = 27.6072

From the results above, we saw that even after using Box Cox transformation, the P-values for 2016, 2017 and 2018 was greater than 0.05 but still the data for all the years was not adequately normally distributed. Since, we did not get an adequately normally distributed data, we planned to use Mood Median to be double sure.

Mood Median Test: Expense versus Year

```
Mood median test for Expense
Chi-Square = 6.95    DF = 2    P = 0.031

                    Individual 95.0% CIs
Year  N≤  N>  Median  Q3-Q1   -+---------+---------+---------+-----
2016  9  22   6764   5100            (--*-------------)
2017  43  35   5656   7493       (----*----------------)
2018  21  16   4974   5163   (---*----------------)
                 -+---------+---------+---------+-----
                4500     6000     7500     9000
Overall median = 6093
```

From the result above, we see although the variance of the data overlaps, the p-value is less than 0.05. So, we will have to see which of the year's median is different.

Mood Median Test: Expense versus Year

```
Mood median test for Expense
Chi-Square = 3.89    DF = 1    P = 0.049

                    Individual 95.0% CIs
Year  N≤  N>  Median  Q3-Q1  --------+---------+---------+--------
2016  11  20   6764   5100         (---*------------------)
2017  44  34   5656   7493  (----*---------------------)
                --------+---------+---------+--------
                   6000     7200     8400

Overall median = 6255


A 95.0% CI for median(2016) - median(2017): (128,3808)
```

Mood Median Test: Exp versus Ye

```
Mood median test for Exp
Chi-Square = 0.29    DF = 1    P = 0.593

                    Individual 95.0% CIs
Ye   N≤  N>  Median  Q3-Q1  ----+---------+---------+---------+--
2017  38  40   5656   7493       (----*---------------------)
2018  20  17   4974   5163  (----*---------------------)
                ----+---------+---------+---------+--
                 4800     6000     7200     8400

Overall median = 5573


A 95.0% CI for median(2017) - median(2018): (-2084,1746)
```

Mood Median Test: Expense versus Year

Mood median test for Expense
Chi-Square = 1.48 DF = 1 P = **0.223**

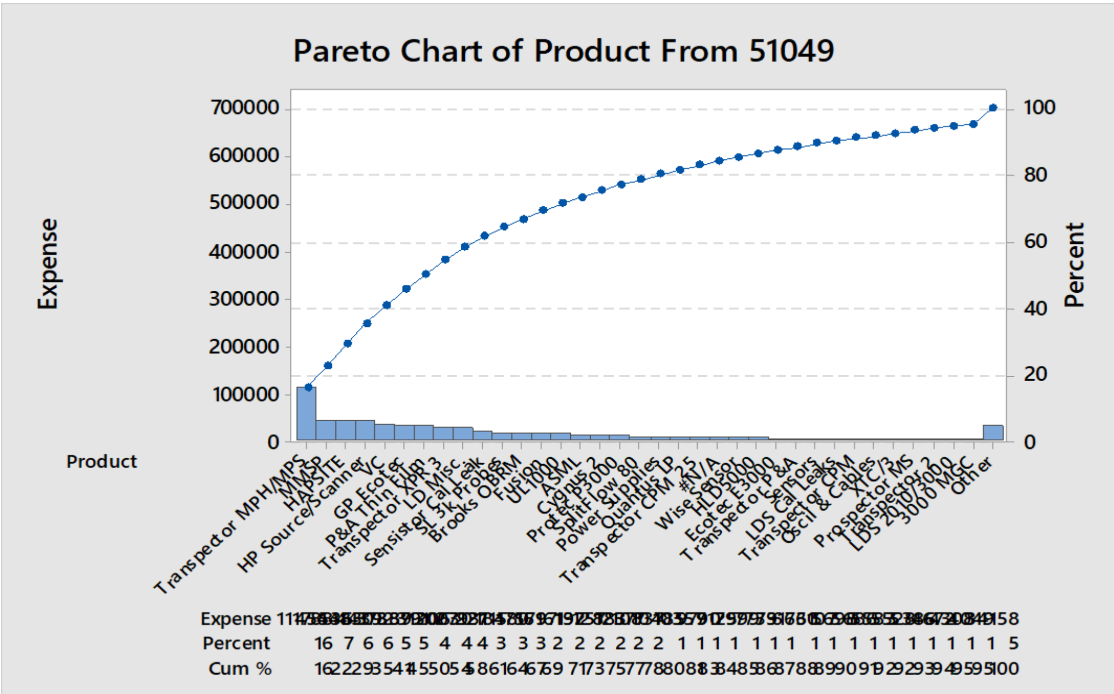
```
                 Individual 95.0% CIs
Year  N≤  N>  Median  Q3-Q1   -+---------+---------+---------+-----
2016  13  18   6764   5100            (--*--------------)
2018  21  16   4974   5163    (---*----------------)
                  -+---------+---------+---------+-----
                 4500     6000     7500     9000
```

Overall median = 6609

A 95.0% CI for median(2016) - median(2018): (-870,4207)

We can see from mood median between 2016 and 2017, the p-value above, which is 0.049 which means that we reject the Null hypothesis and median expense of 2017 and median expense of 2016 is not the same. However, we can not be very sure since p-value is very close to 0.05. Looking at the results between 2017-2018 and 2016-2018, we can say that the median expense from 2016 and median expense from 2018 is statistically the same, so we know that there has been little to no improvement in terms of reduction in expense since 2016.

Pareto Chart for 51049



To select other products we created a pareto chart of the cost centre 51049 and found that Transpector MPH/MPS contributed to almost 16% which is 2% more than Hapsite in 51040, but if we consider the actual expense. The expense on Hapsite is more than the expense on transpector. So, we chose Hapsite as our second product of study.

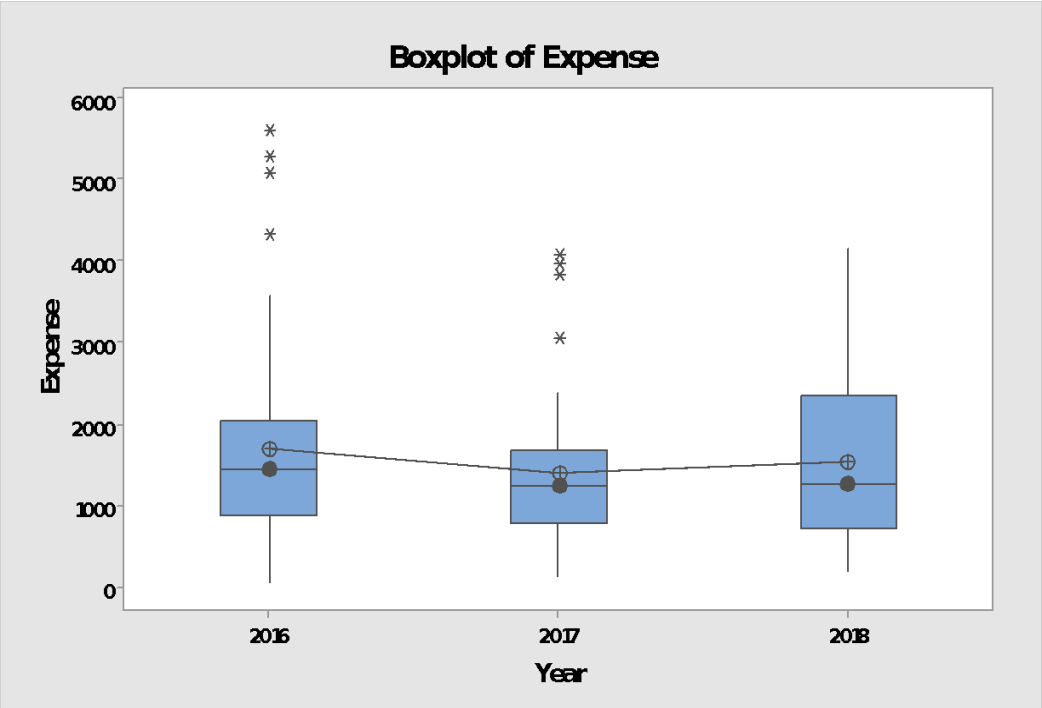
Hapsite

We went into Hapsite to observe the exact issues faced in the product. We used the descriptions written by the technicians to code the below chart.

Hapsite 2016			
Row Labels	**Count of Order**	**Sum of Total act.costs**	
Dynamic Sample Collector	2	984.26	1%
Flash Drive, ER	2	1988.61	2%
GC Controller Board, HAPSITE ER, Tested	2	1546.54	1%
HAPSITE ER WITHOUT NEG	2	9158.88	8%
HAPSITE ER, USB/Wireless, w/NEG	48	85304.78	70%
HAPSITE Smart Plus, w/NEG	1	1620	1%
HAPSITE Smart to Plus Upgrade	1	1080	1%
Hapsite Smart Upgrade	1	1210.61	1%
Headspace Sampling System, ER HAPSITE	1	719.57	1%
Headspace Sampling System, HAPSITE	1	858.5	1%
Load Lock and Motor Assembly	1	1785.81	1%
Spare Non Evaporable Getter (NEG) Pump	1	1768.75	1%
SPME Accessory, HAPSITE ER	1	1219.86	1%
Thermal Desorber Accessory, HAPSITE ER	32	12125.67	10%
Grand Total	**113**	**122091.84**	
Hapsite 2017			
Row Labels	**Count of Order**	**Sum of Total act.costs**	
110V(ac) Power Supply, United States	1	1153.12	1%
230V(ac) Power Supply, Australia / China	1	1153.11	1%
Concentrator, Tri-Bed Kit	1	564.05	1%
ETX Board, Tested	1	1566.23	2%
Hapsite Battery	2	1920.54	2%
HAPSITE ER WITHOUT NEG	1	997.05	1%
HAPSITE ER, Blue, w/NEG	2	3261.61	3%
HAPSITE ER, USB/Wireless, w/NEG	29	49106.67	49%
HAPSITE Smart to Plus Upgrade	2	1757.16	2%
HAPSITE VIPER GREEN w NEG	1	771.45	1%
High Voltage Module PCB,Tested	2	1265.19	1%
Thermal Desorber Accessory, HAPSITE ER	45	34313.09	34%
Grand Total	**97**	**99953.9**	

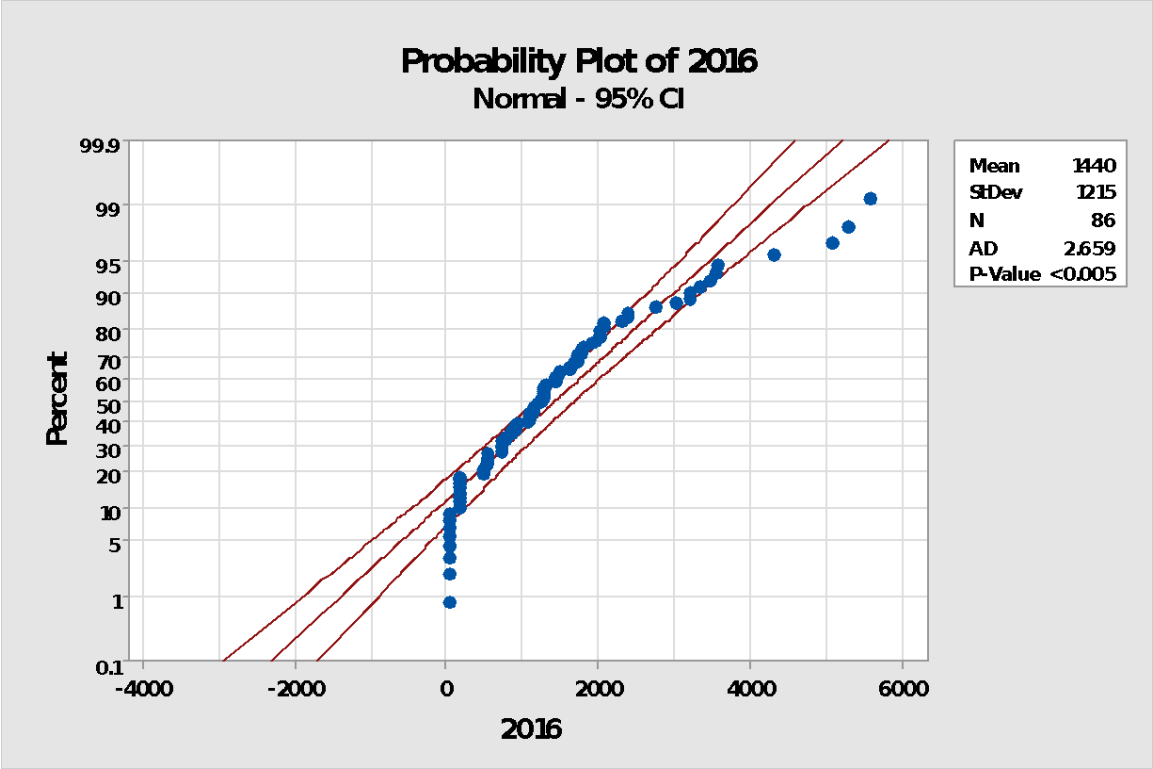
We considered the expense of 2016, 2017 and 2018 for Hapsite to see if the expense is actually decreasing. We used Boxplot to see if the mathematical mean is actually going down.

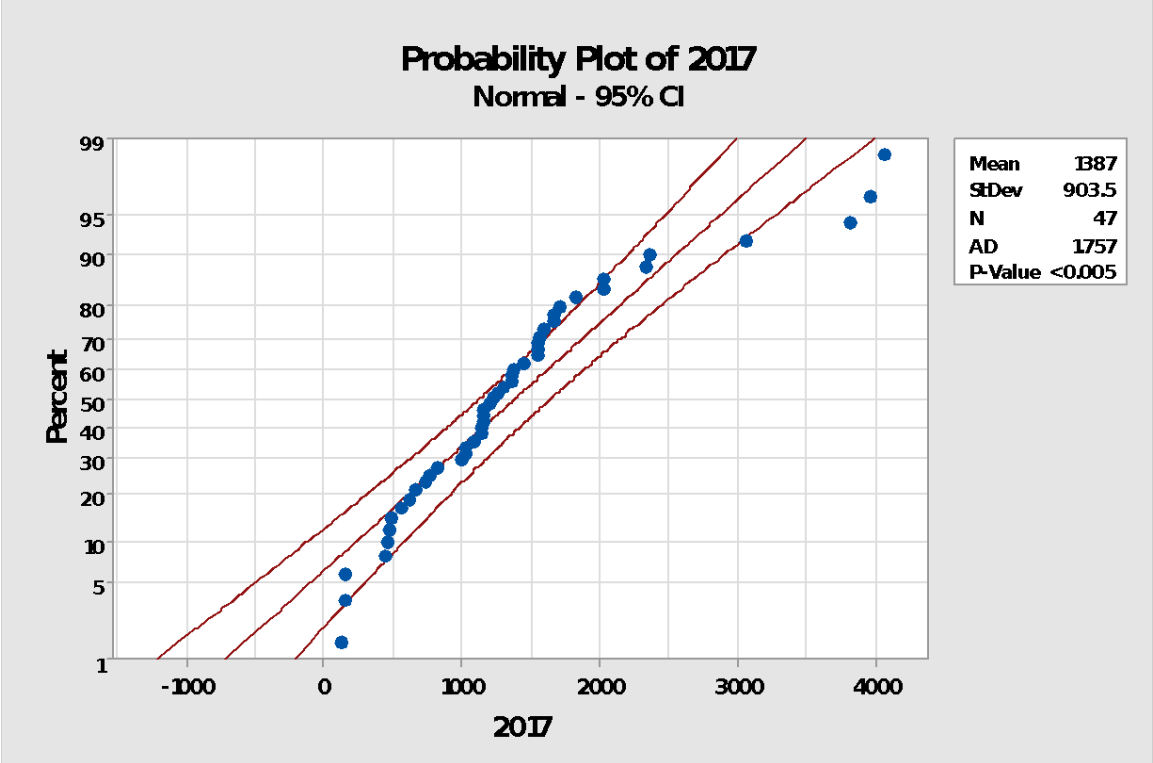
Boxplot

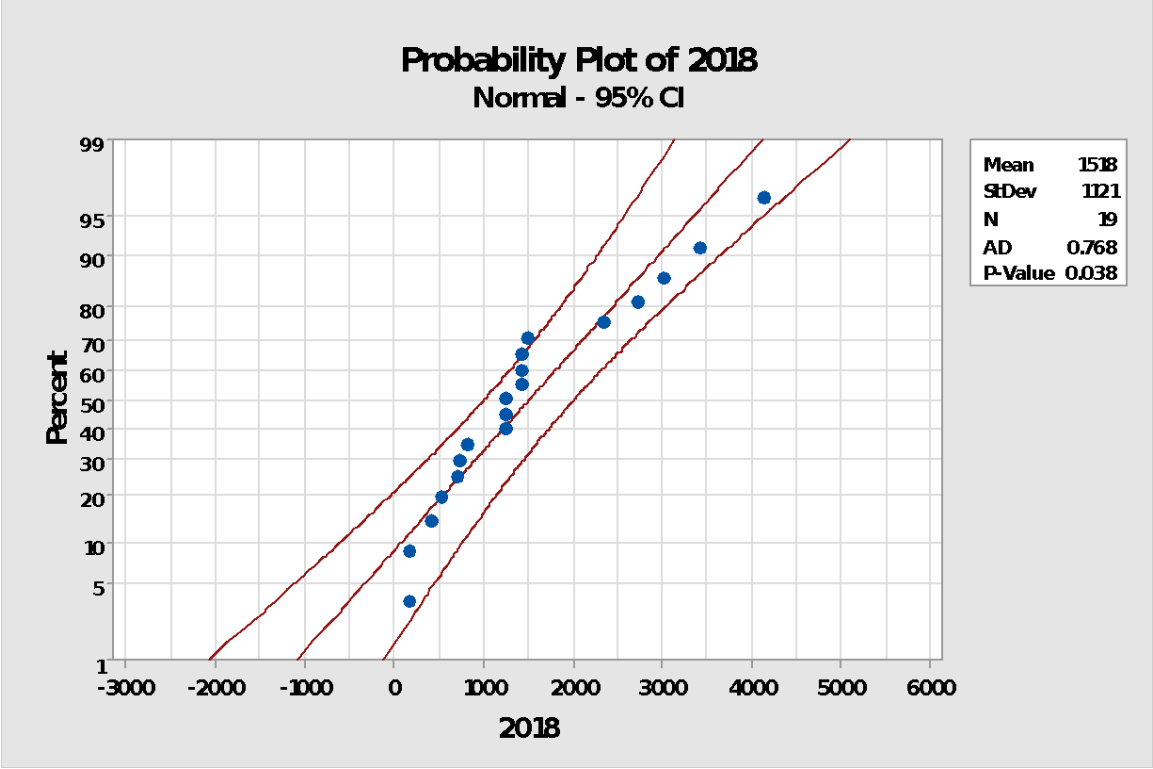


We performed the same steps we performed for fusion to check if the data is normally distributed and then did hypothesis testing and confirmed it using Mood Median as there are a number of outliers.

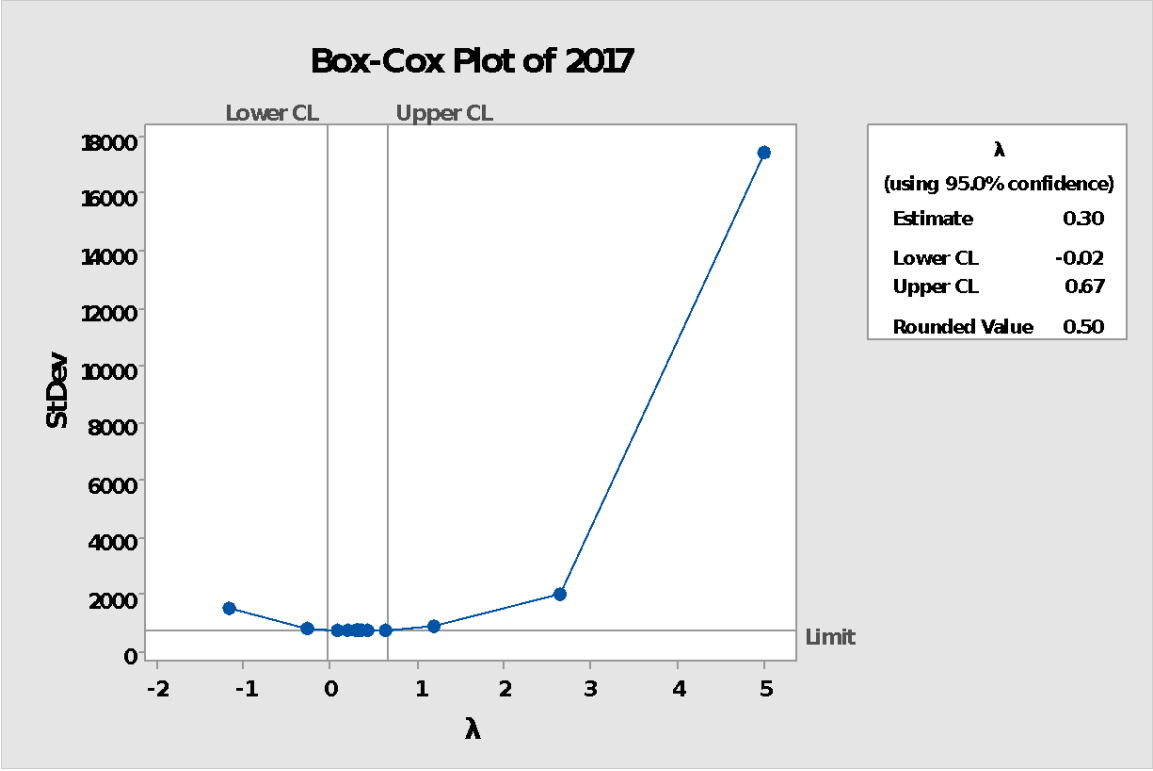
Probability Plot

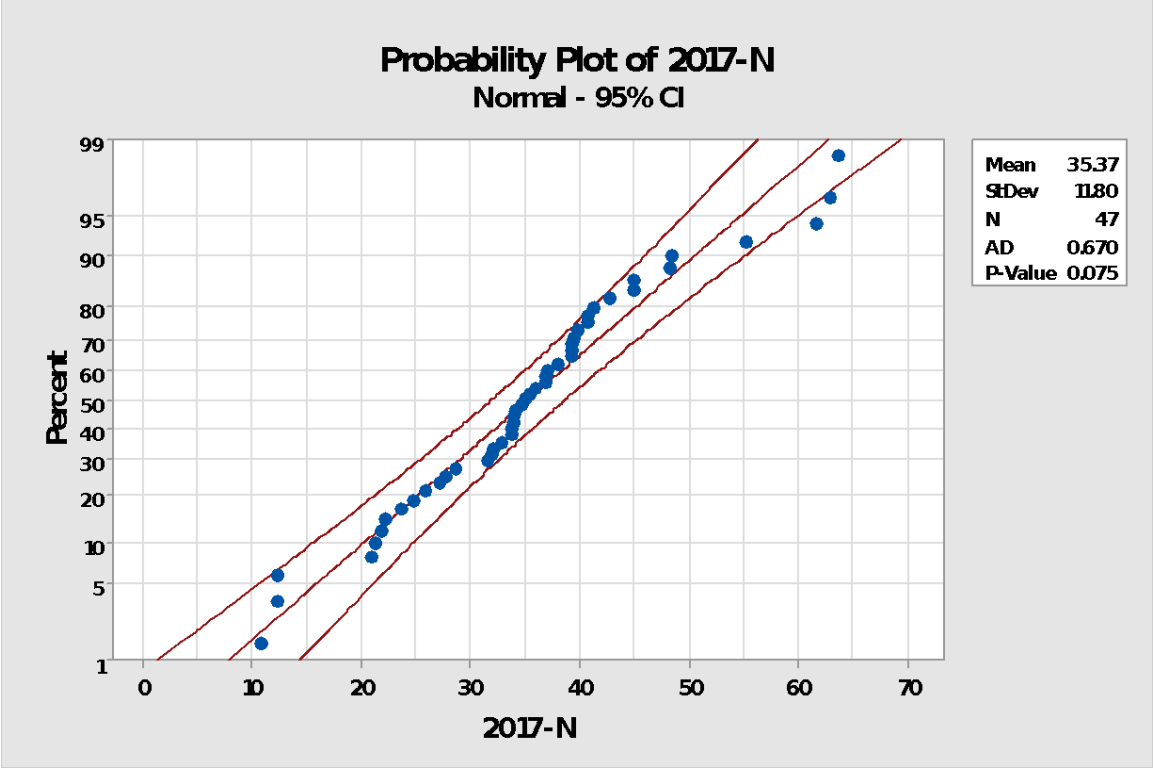


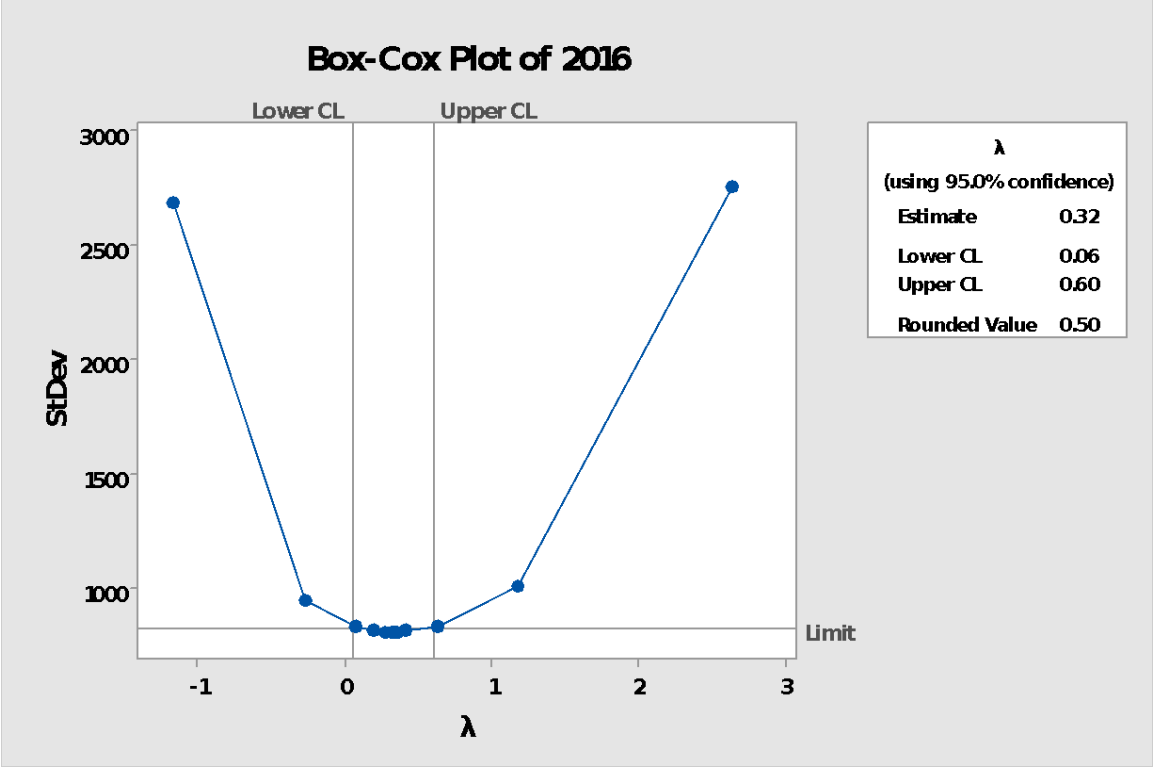


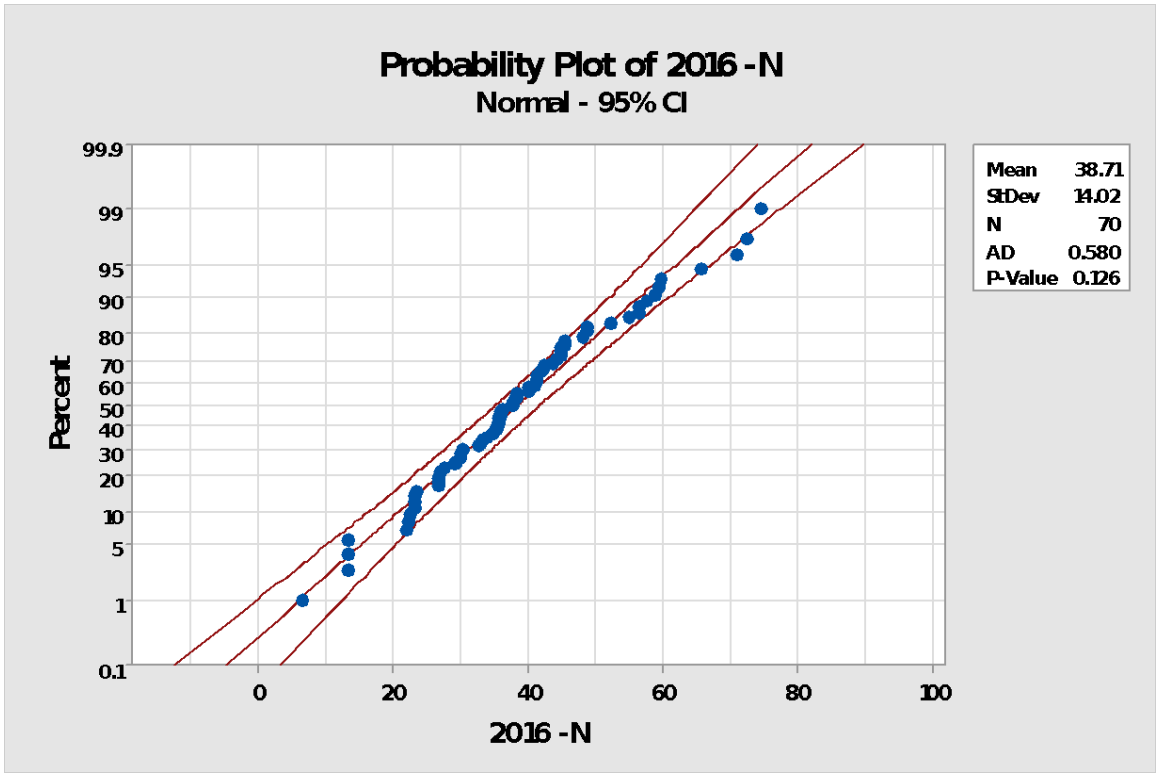

Probability Plot of 2018
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
-3000
-2000
-1000
0
1000
2000
3000
4000
5000
6000
2018
Mean 1518
StDev 1121
N 19
AD 0.768
P-Value 0.038

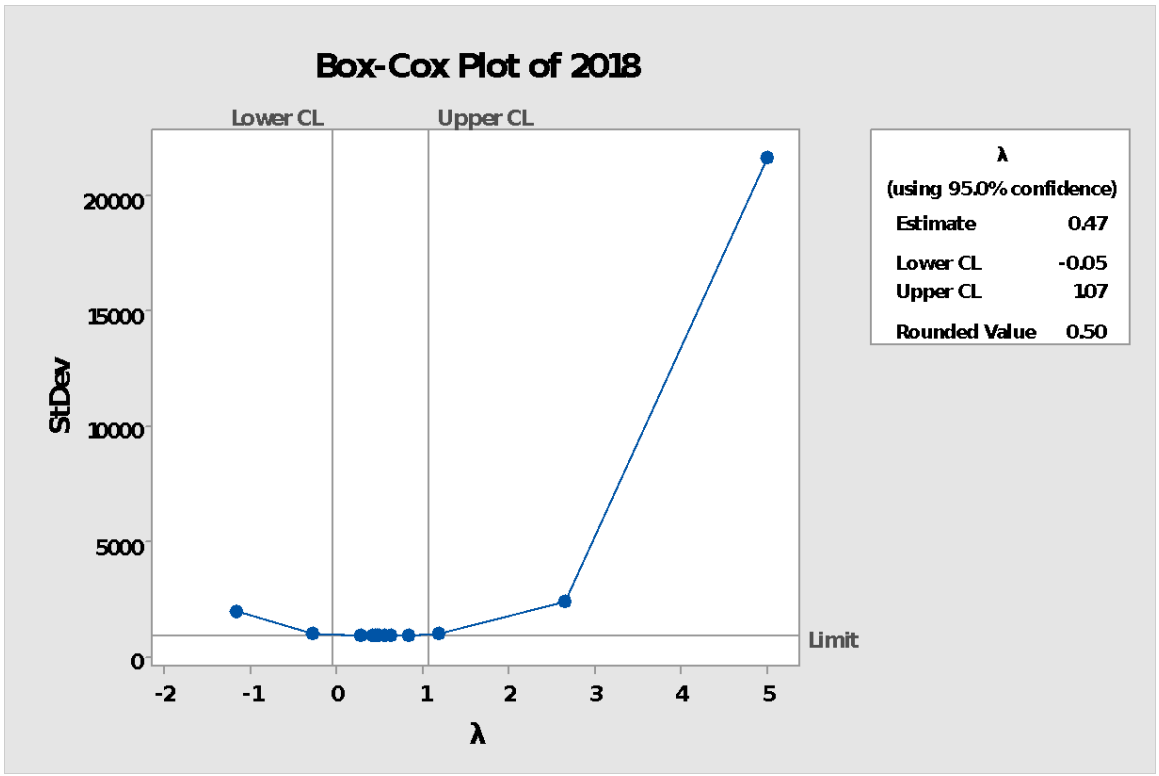
Box-Cox

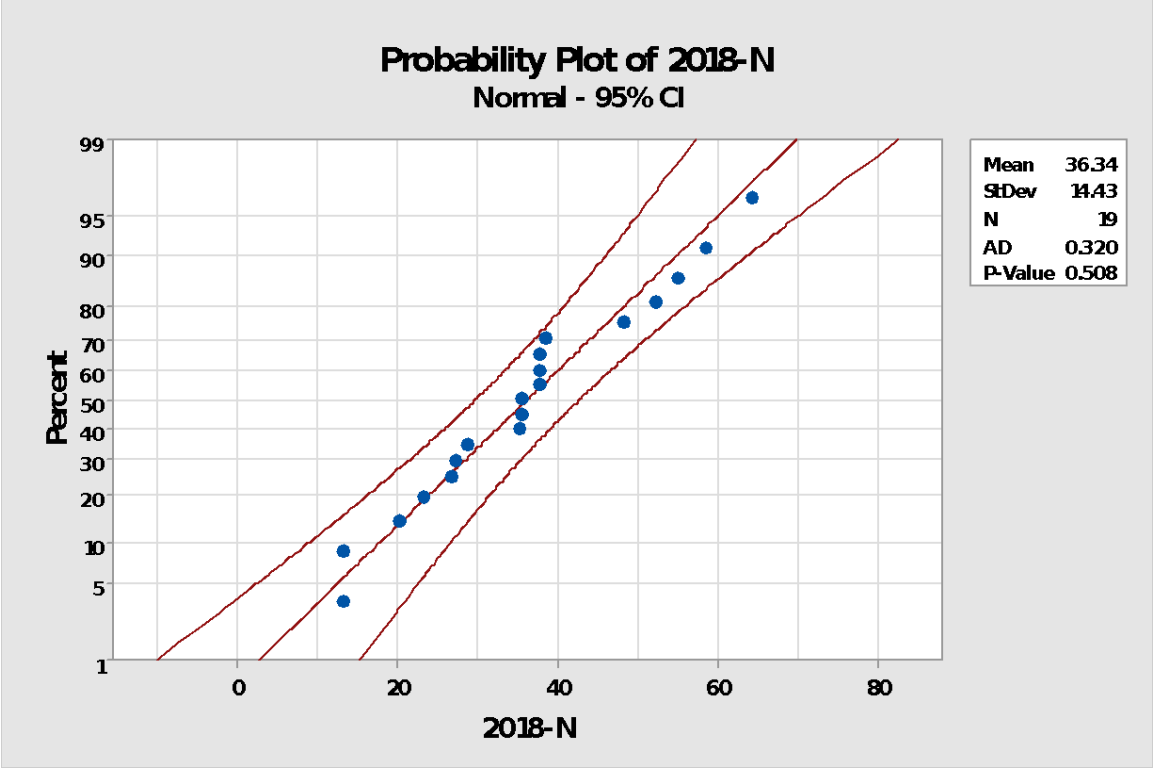

Box-Cox Plot of 2017
Lower CL
Upper CL
StDev
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2
-1
0
1
2
3
4
5
λ
Limit
λ
(using 95.0% confidence)
Estimate 0.30
Lower CL -0.02
Upper CL 0.67
Rounded Value 0.50

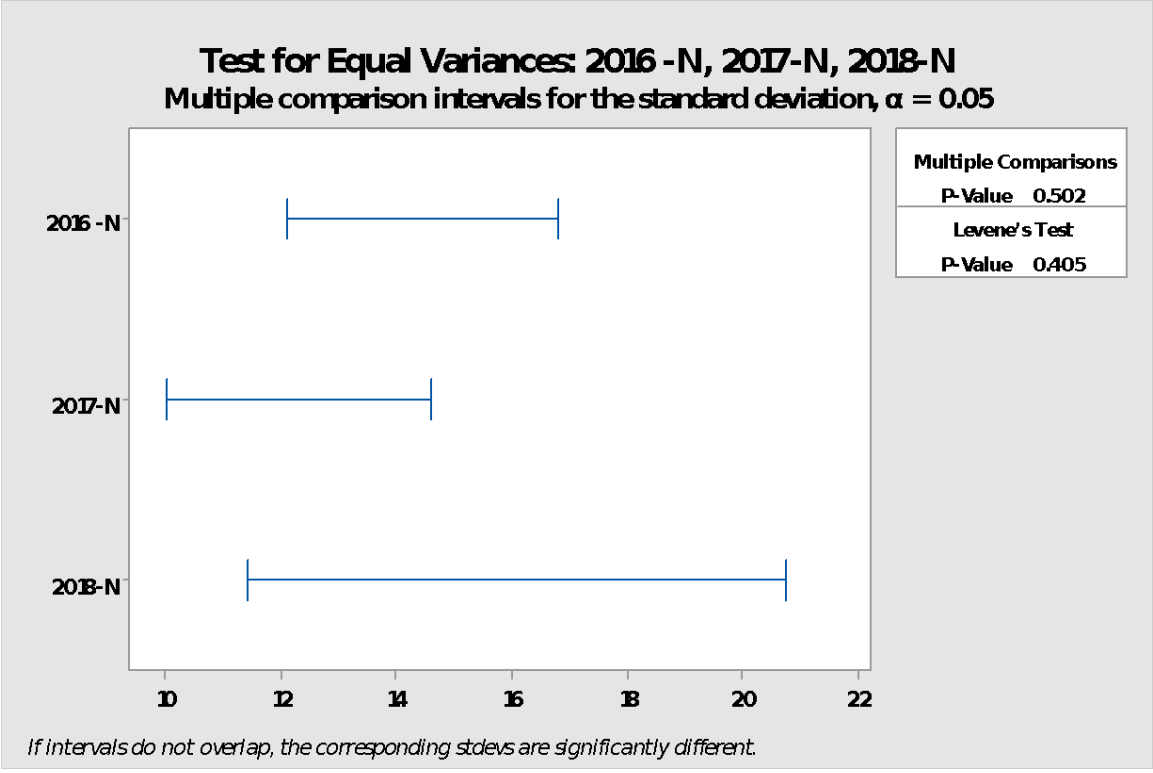

Probability Plot of 2017-N
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0
10
20
30
40
50
60
70
2017-N
Mean 35.37
StDev 11.80
N 47
AD 0.670
P-Value 0.075

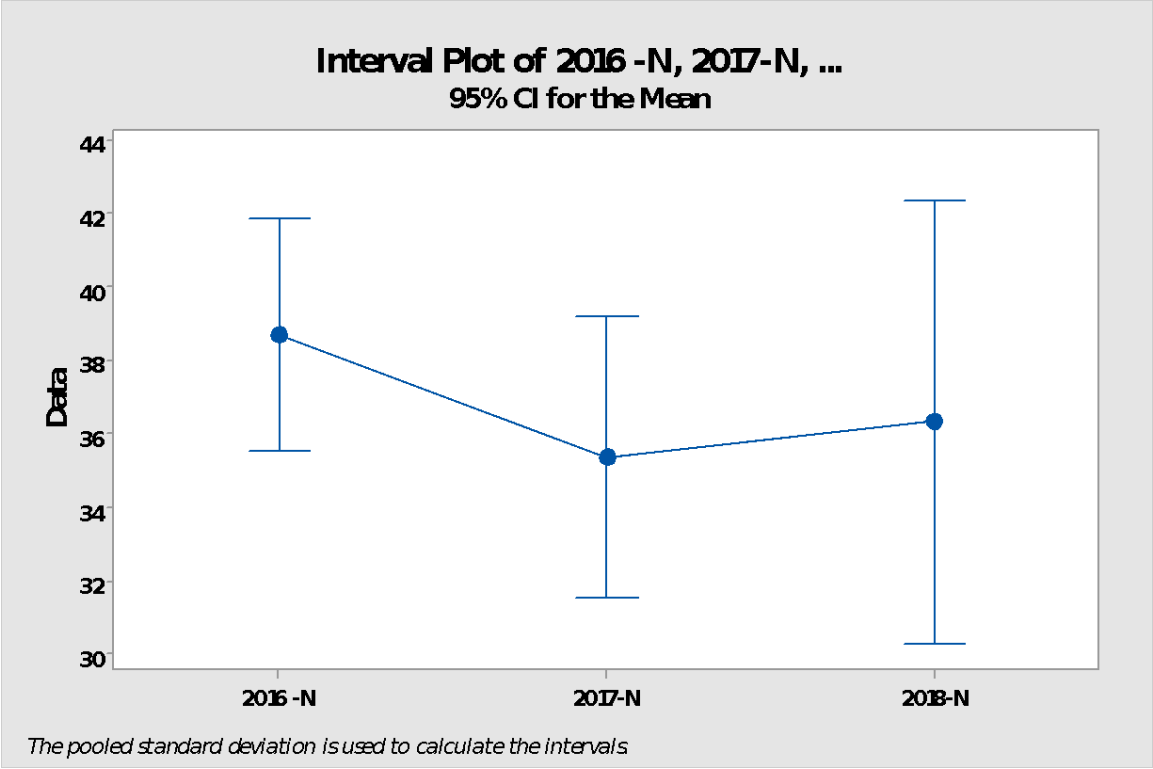

Box-Cox Plot of 2016
Lower CL
Upper CL
StDev
3000
2500
2000
1500
1000
-1
0
1
2
3
λ
Limit
λ
(using 95.0% confidence)
Estimate 0.32
Lower CL 0.06
Upper CL 0.60
Rounded Value 0.50


Probability Plot of 2016 -N
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0
20
40
60
80
100
2016 -N
Mean 38.71
StDev 14.02
N 70
AD 0.580
P-Value 0.126


Box-Cox Plot of 2018
Lower CL
Upper CL
StDev
20000
15000
10000
5000
0
-2
-1
0
1
2
3
4
5
λ
Limit
λ
(using 95.0% confidence)
Estimate 0.47
Lower CL -0.05
Upper CL 1.07
Rounded Value 0.50


Probability Plot of 2018-N
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0
20
40
60
80
2018-N
Mean 36.34
StDev 14.43
N 19
AD 0.320
P-Value 0.508


Test for Equal Variances: 2016 -N, 2017-N, 2018-N
Multiple comparison intervals for the standard deviation, α = 0.05
2016 -N
2017-N
2018-N
10
12
14
16
18
20
22
Multiple Comparisons
P-Value 0.502
Levene's Test
P-Value 0.405
If intervals do not overlap, the corresponding stdevs are significantly different.


Interval Plot of 2016 -N, 2017-N, ...
95% CI for the Mean
Data
44
42
40
38
36
34
32
30
2016 -N
2017-N
2018-N
The pooled standard deviation is used to calculate the intervals.

One-way ANOVA: 2016 -N, 2017-N, 2018-N

Method

Null hypothesis All means are equal
Alternative hypothesis At least one mean is different
Significance level α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor Levels Values
Factor 3 2016 -N, 2017-N, 2018-N

Analysis of Variance

Source DF Adj SS Adj MS F-Value P-Value
Factor 2 329.7 164.9 0.92 0.399
Error 133 23720.7 178.4
Total 135 24050.4

Model Summary

S R-sq R-sq(adj) R-sq(pred)
13.3548 1.37% 0.00% 0.00%

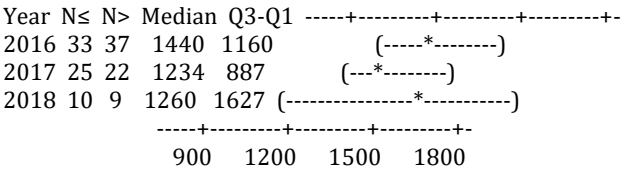
Means

Factor N Mean StDev 95% CI
2016 -N 70 38.71 14.02 (35.55, 41.86)
2017-N 47 35.37 11.80 (31.52, 39.23)
2018-N 19 36.34 14.43 (30.28, 42.40)

Pooled StDev = 13.3548

Mood Median Test: Expense versus Year

Mood median test for Expense
Chi-Square = 0.47 DF = 2 P = 0.790



Overall median = 1296

We can see from the result above that by ANOVA we got a p-value of 0.399 which is greater than 0.05, so we fail to reject the NULL hypothesis and the mean expense of all the three is statistically the same. We are not very comfortable with the result from ANOVA since the sample size is highly varied and also after using box cox we get a very weak normally distributed data. We used Mood Median and found that again the p-value is 0.79 which is a very strong result and hence we can say that the expense for Hapsite is statistically not going down over the years.

We were told that the company is comfortable with the warranty expense of hapsite since the selling price of the product is considerably high and Inficon believes that there are some parts in this product that require continuous maintenance and some of them are actually sold on a subscription basis.

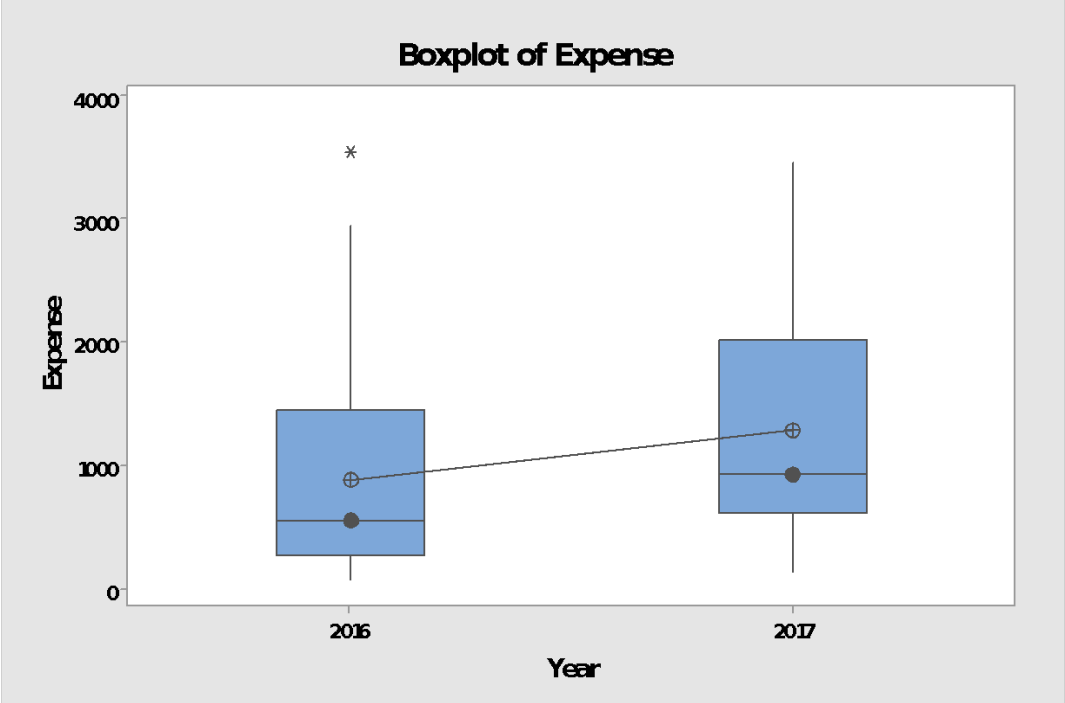
Transpector MPS/MPH

For Transpector we considered only 2016 and 2017 since there were very few products available in 2018.

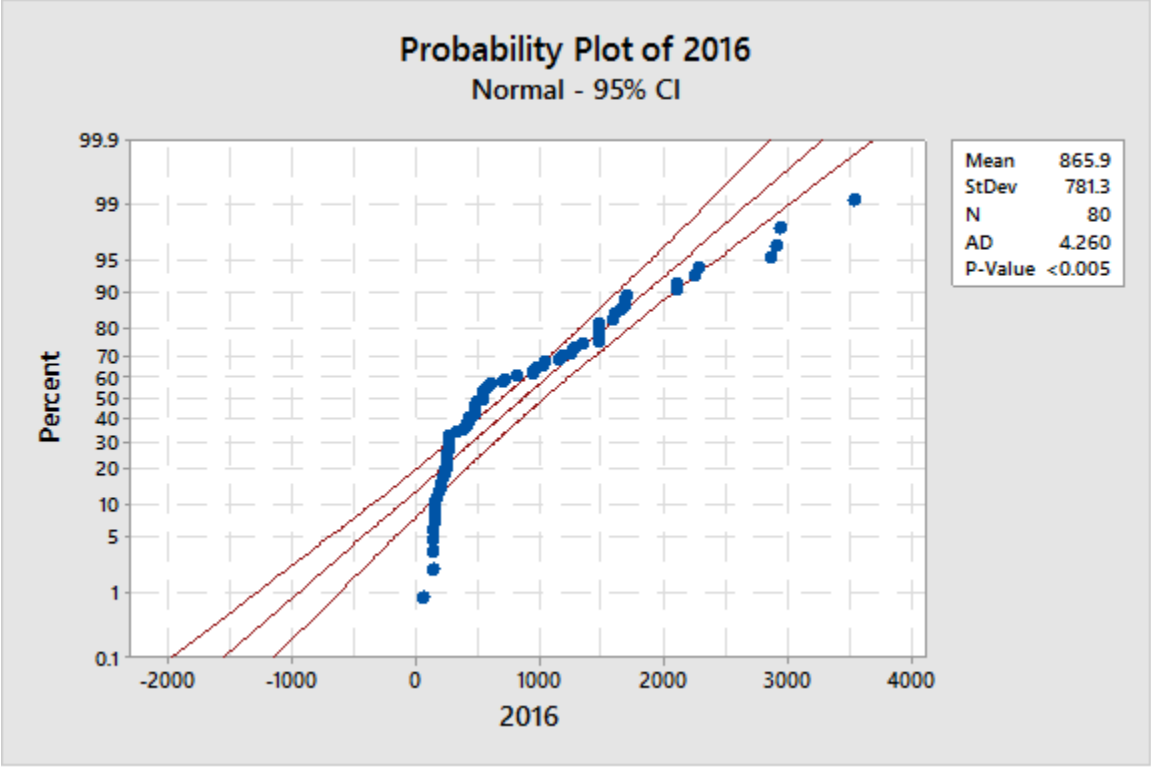
We created a detailed view to find out the exact issue in Transpector by looking into the descriptions put in by the technicians:

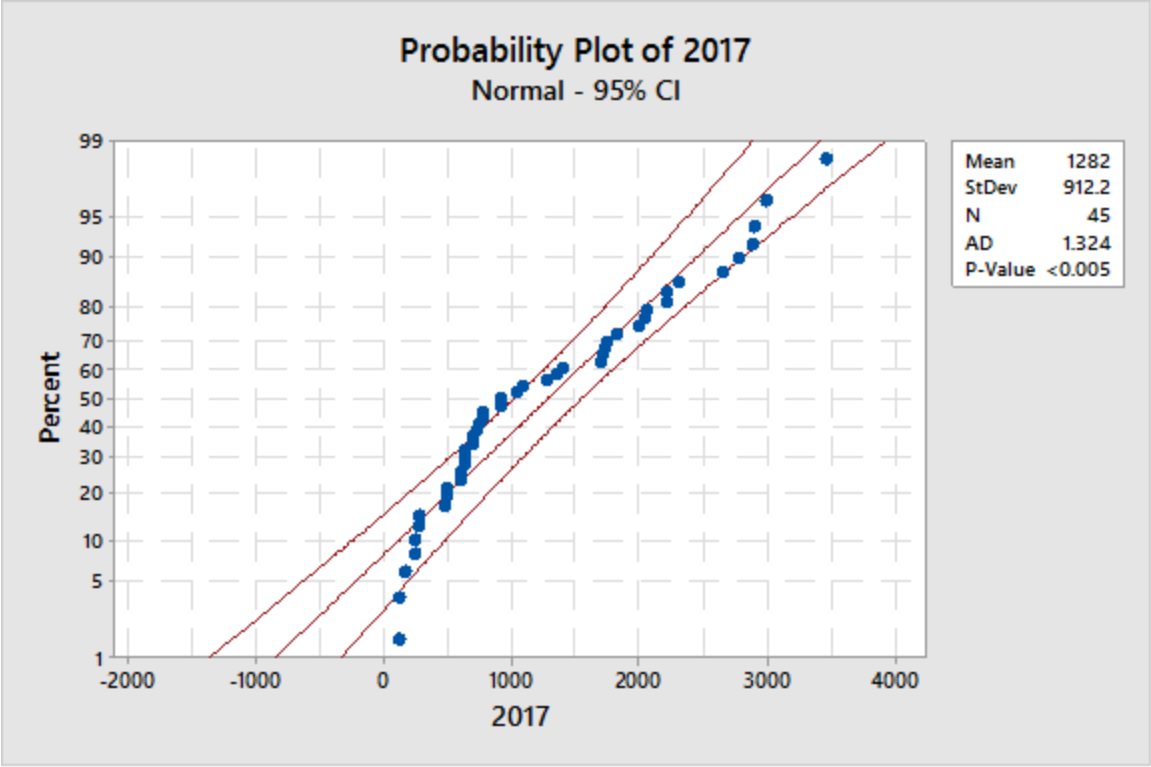
2017			
MPH100 Electronics Box w/ Ethernet Comm	3	3389.28	9%
MPH200 Electronics Box w/ Ethernet Comm	3	823.2	2%
MPH300 Electronics Box w/ Ethernet Comm	2	1248	3%
MPS200 Electronics Box w/ Ethernet Comm	1	504	1%
Transpector MPH100M	4	5654.28	14%
Transpector MPH200M	2	1950	5%
Transpector MPH200P	4	8554.66	21%
Transpector MPH300H	6	14570.45	37%
Transpector MPS100M	2	2224.37	6%
Transpector MPS200M	1	924	2%
Grand Total	**28**	**39842.24**	
2016			
MPH100 Electronics Box w/ Ethernet Comm	46	15468.66	22%
MPH200 Electronics Box w/ Ethernet Comm	2	660	1%
MPS100 Electronics Box w/ Ethernet Comm	1	721.39	1%
Transpector MPH100H	4	4266.94	6%
Transpector MPH100M	7	10046.17	14%
Transpector MPH100P	9	13331.93	19%
Transpector MPH200M	7	12845.41	18%
Transpector MPH200P	4	6211.91	9%
Transpector MPS100F	1	821.16	1%
Transpector MPS100M	4	5855.02	8%
Grand Total	**85**	**70228.59**	

From the boxplot below, we can see that the mathematical expense is actually going up from 2016 and 2017. Since we do not have normally distributed data and we have some outliers, so we will directly use Mood Median to see the result.



Probability Plot





Mood Median Test: Expense versus Year

Mood median test for Expense
Chi-Square = 4.48 DF = 1 P = 0.034

				Individual 95.0% CIs
Year	N≤	N>	Median	Q3-Q1
2016	46	34	541	1198 (--*--------)
2017	17	28	924	1403 (-----*----------)

700 1050 1400

Overall median = 695

A 95.0% CI for median(2016) - median(2017): (-974,-110)

Sign Test for Median: 2016

Sign test of median = 924.0 versus < 924.0

	N	Below	Equal	Above	P	Median
2016	80	49	0	31	0.0287	540.7

We can see from the result above that the data is not normally distributed, so we can use Mood median. The median expense of 2016 and median expense of 2017 is not the same from Mood Median. We perform the sign test to see the exact movement and find that the median expense of 2016 is less than the median expense of 2017. After talking to Inficon, we were told that there is an ongoing research on the filament that they use in the product. So, they are already working on the same.

Conclusion

We found that the cost centre 51040 contributes to almost 59% of the total expense on warranty products, while the second highest (51049) is around 16%. However, Hapsite contributes to 14%, but in terms of expense Hapsite contributes more than Transpector. The analysis done above shows that Fusion contributes to almost 62% of the expense from 51040 cost centre and the second highest contributor is Hapsite (14%). Transpector MPH/MPS contributes the maximum (16%) in the second cost centre (51049).

After discussion with the project champion, it was brought to our knowledge that fusion had a design issue that was found in the second half of 2016, this lead to a major return of the products which included replacing the whole part from the product which costed the company $4500 on each product, this was the reason behind Fusion being the major contributor towards warranty expense. This product went through a change in the design and the new product is in circulation since the end of 2017. The second product Hapsite is also going through a design change, but the company feels confident about the product since its warranty expense is little in comparison to the revenue generated just by one single product. Also, it is sold on subscription basis, so the company can explain the warranty expense. The third product we considered (Transpector) is also going through a lot of research on increasing the life of the filament used in the product. This filament has been a major cause towards driving the warranty expense in 51049.

Confusion Matric for Data Discrepancy

We looked at the data and found that there are two different indicators used by service department and finance department. The most surprising thing was that the service department had lack of communication in terms of what indicators do finance department use to report the numbers under warranty expense. This led to substantial amount of money not accounted for or additional money being accounted for. We see that using this way, there is only 58.77% chances of obtaining the correct data. We have created a confusion matrix below for the count and the expense and calculated the accuracy respectively. The actual accuracy should be 100% to account for all the repair expense.

Number of Repairs:

Confusion Matrix	Finance Indicator 2	Finance Indicator Not 2
KGW and RGW	1219	916
Not KGW and RGW	108	0

Accuracy = 1219+0 / (1219+916+108+0) = **54.34%**

Expense in $:

Confusion Matrix	Finance Indicator 2	Finance Indicator Not 2
KGW and RGW	1679784	1073573
Not KGW and RGW	104764	0

Accuracy = 1679784+0 / (1679784+1073573+104764+0) = **58.77%**

Workload on Customer

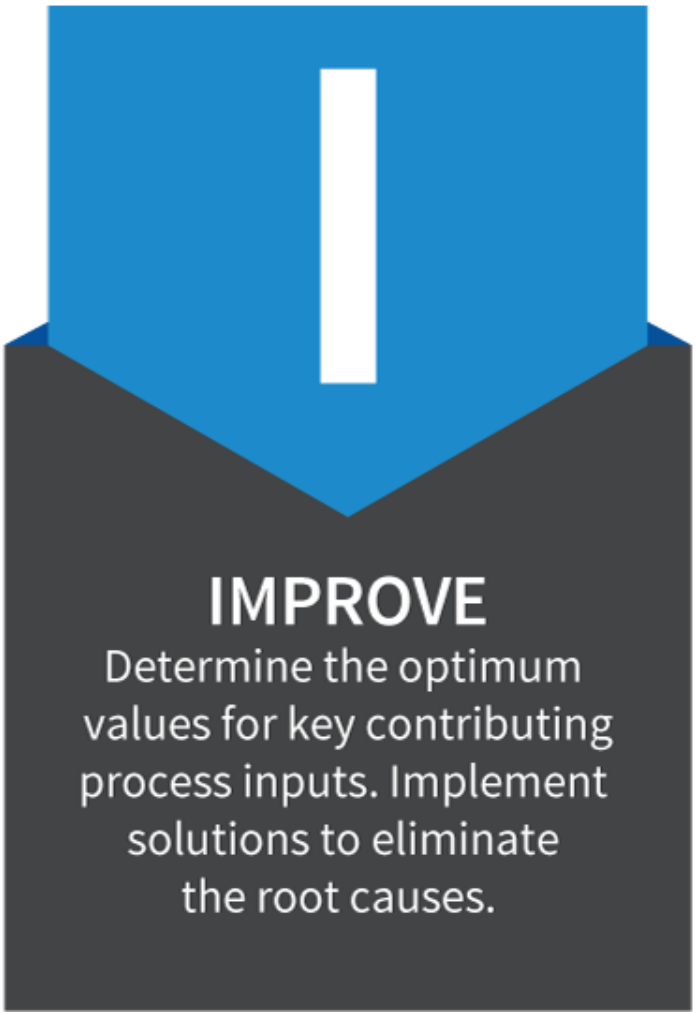
Below are the observations of the service request form required to be filled in by a customer requesting repair:

1. The existing portal does not require a customer to login, and it is accessible globally.
2. The portal is not connected to any database currently. Due to this, Customer has to go through the list of all products and select the one he/she wants to get repaired.
3. The customer (company) information along with billing and shipping addresses needs to be filled manually.
4. For product selection, the customer also needs to type-in the serial number and part-number of the product. If a customer is not aware of these details, he/she can type-in any other information and proceed to request the repair.
5. In addition, all of the fields in repair request form (except Point of contact's email address) do not validate data type of fields. For example, one can input alphabets in a Phone Number or Zip-Code field.
6. The form does not verify if the submitted City, State, Zip-Code and Country values exist and the combination is valid. Since most of the fields are required to fill, a lot of times customer fills garbage data to proceed with the request which needs to be corrected later by Service Coordinator at Inficon.

Below we have observed 10 samples for time taken by customer to fill in the service request form and for the service coordinator to create an RMA.

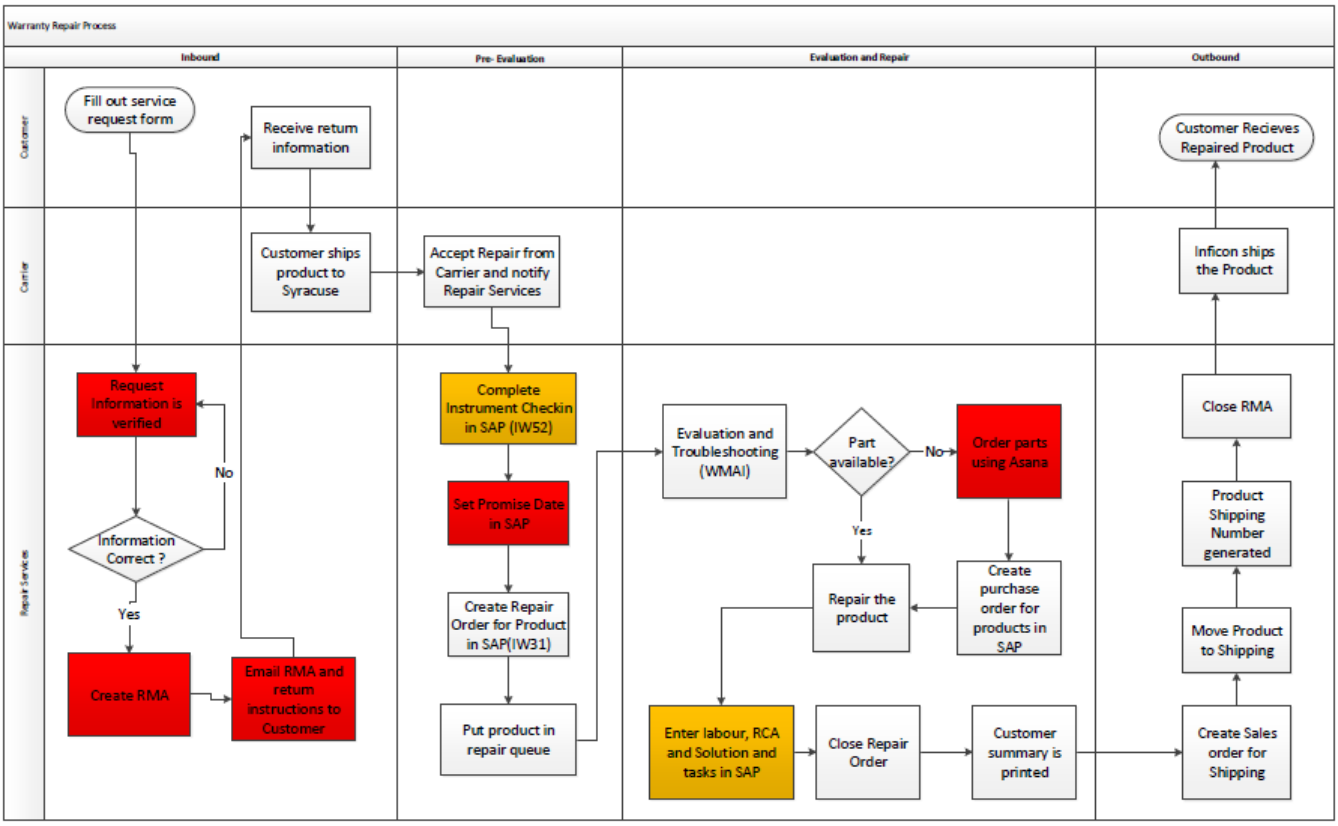
Customer time to fill SRF	Creation of RMA
3.13	3.02
4.42	4.08
5.37	4.32
3.71	4.86
3.16	3.60
5.66	4.49
5.29	3.89
3.63	4.36
3.06	3.98
3.07	3.15

Once the customer submits the form, an Email is received by Service Coordinators at 'service.usa@inficon.com' Account with details of the form. The Service Coordinator validates the Customer, Product and Product Failure information before proceeding to create an RMA in SAP and re-enters the information in SAP. If any of the information is incorrect, Service Coordinator emails customer or checks SAP data to get the correct information required to create RMA. On an average, if the customer has all the information, it takes 5 minutes to fill the information and submit the request, and 4 minutes for Service Coordinator to create a RMA.


I
IMPROVE
Determine the optimum values for key contributing process inputs. Implement solutions to eliminate the root causes.

Improve

Value Added Flow Chart



Red Blocks: Process steps which are identified as non-value-added process. These steps can be eliminated.

Yellow Blocks: Process steps which can be partially eliminated in terms of time consumed in sub-steps.

White Blocks: Process steps which are identified as value-added steps.

Recommendations

After brainstorming, the team came up with below suggestions for Inficon. All of the recommendations can be categorized in short term and long term goals. The short term goals are easy to implement, cost effective, feasible, less complex, easy to follow and have less impact the existing process as compared to long term recommendations.

Short term recommendations for process improvement:

To reduce data discrepancy in SAP:

1. **Technician training on SAP:** The team observed that as technicians did not undergo any SAP related training, everyone has a different approach for SAP interaction. Most of the technicians have their own notes or manuals which they follow for SAP processes. Due to this, there is discrepancy in the generated data. This discrepancy leads to incorrect interpretation of repair process. To avoid this, a new joiner training for SAP related processes can be developed. This training can be designed by creating a cross-functional team which includes people from Service Department, Finance Department and SAP Business Analyst. The cross-functional team creation is to avoid gaps in between different departments at Inficon. The same training can be conducted for existing technicians to standardize the process followed currently.

2. **Updated SAP Training Manual for reference:** The SAP guides used by technicians were last updated in 2007. There have been several changes in indicators as well as the process Inficon follows after the last SAP document was updated. Such changes need to be updated periodically and stored on cloud or shared drive so that it's accessible by all the employees who use SAP. Additionally, the location and information of these SAP documents needs to be communicated to technicians.

3. **Make relevant fields required to complete process:** The historical transaction data suggested that the indicator values used for data interpretation in SAP were kept blank for a few repairs. For example, "Acctg. Indicator" suggests the categorization of the repair expense from the accounting perspective. This field was left blank for a number of repairs. We propose that these fields are made mandatory to maintain data accuracy.

4. **Update SAP attributes list:** The team observed that there are multiple attributes in SAP which hold same value. For this, the need of SAP attributes needs to be analyzed and unwanted fields can be removed from SAP user interface. Also, a lot of attributes have blank values for example ABC indicator, Assembly desc, Functional Loc., Group, Group Counter**,** etc. The necessity of these fields can also be analyzed, and they can be

excluded from reporting and user interface. Since the user interface of SAP transactions is same all over the world, Inficon-Syracuse will have to consult with Inficon Headquarter before making this change.

5. **Data Audit:** The SAP data is inconsistent due to changes in cost center and products in it. Thus, few of the 2016 repairs are miscounted as their cost center is changed in 2017. To avoid such incorrect calculation, a data audit needs to be performed on SAP data. Additionally, the shared drive of inficon has files which has a lot old files that can be archived/updated/removed. The shred drive can be audited, cleaned and utilize to store information, manuals which can be referred by all.

To reduce SAP license cost:

1. **Verify the actual need of SAP access (people who are just using SAP for exports):** One SAP license costs inficon $4000 per year. Since it's a tool which has all the data, it is used by all the Inficon employees which increases the total license cost. Thus, the need of SAP license for every user can be analyzed, and license of people who do not use SAP can be revoked.

2. **Reduce SAP cost per Technician:** The team felt that the technicians can invest more time in repairing the products instead of SAP data entry. Thus, if alternative solutions are found for the tasks technicians perform in SAP, their license cost can be avoided.

Long term recommendations for process improvement:

To increase Customer satisfaction and decrease total Lead time:

Customer portal design Change for easy returns: This recommendation includes below changes:

a. Login portal for Customers
b. Connect database to website so that customers can request repair for products that they have purchased
c. Auto-calculation of whether the repair is under warranty or billable
d. Remove verification process for Customer and product identity. This is to save service coordinator's time.
e. Automate responses (email or validation on website) based on predefined conditions e.g. Contact Service expert/coordinator when a certain chemical is in contact with the product, or it hazardous.
f. Auto-create RMA for straightforward cases and automate the process of sending return instructions for the same
g. Tracking Id/RMA notification Number - visibility to customer on portal for repair as well as shipping. The repair steps performed by technicians can be reflected on the customer portal. This will facilitate immediate visibility.

A pilot test was performed to visualize above recommendations.

To reduce non-value added processes by service personal:

1. **Barcode Scanner for repair process:** Barcode scanners can be used while checking in the repair product in service center. This barcode scanner can also be used when a product is received by technician for repair, and when a Sales Order is created by service coordinator to ship the repaired product. It will reduce the time required for product and customer company verification. It will also avoid human errors.

2. **Auto-populate Promise date based on product type:** Currently Service coordinator types in the Promise date or Expected end date for the repair. Instead this can be auto populated based on the product type. This will reduce human errors.

3. **Remove duplicate usage - ASANA and SAP:** Technicians use ASANA to order parts required for repair. They document the orders again on SAP by creating Purchase Orders. This is duplication of work to achieve the same goal, and this can be removed by choosing any one tool to perform this activity. This will save working hours as well as reduce license cost of either SAP or ASANA.

4. **Move to SAP-Cloud**: SAP-Cloud in a cloud platform similar to SAP. It uses modern design principles and employ existing skills to deliver agile applications such as rewarding employee performance, improving customer experiences and Internet-of-Things-enabled applications. This improvement will be a complete restructuring of existing system, thus it is expensive and time-consuming. This recommendation will have to be communicated to upper management in order to start the org-restructuring. It will take a few months for implementation, but once the new system is in-place, all the existing processes will be streamlined. This will help in the future expansion of Inficon business model.

   Information related to SAP-Cloud can be found here:
   https://cloudplatform.sap.com/index.html

Pilot Testing

A Pilot test is a mini implementation of a selection of recommendations in order to test the feasibility of the new process. It also ensures the necessity and effectiveness of the new process before actual implementation.

The team chose to implement a prototype for a few of the recommendations related to customer portal used for requesting repair. The team then measured the time required to request a repair on both the old and proposed website to compare the design and efficiency of 'request repair under warranty' process. The data was then analyzed and the team concluded that time taken for customer to fill the Service Request Form was reduced by 67% with new design. Also, the repair can be requested with less number of clicks.

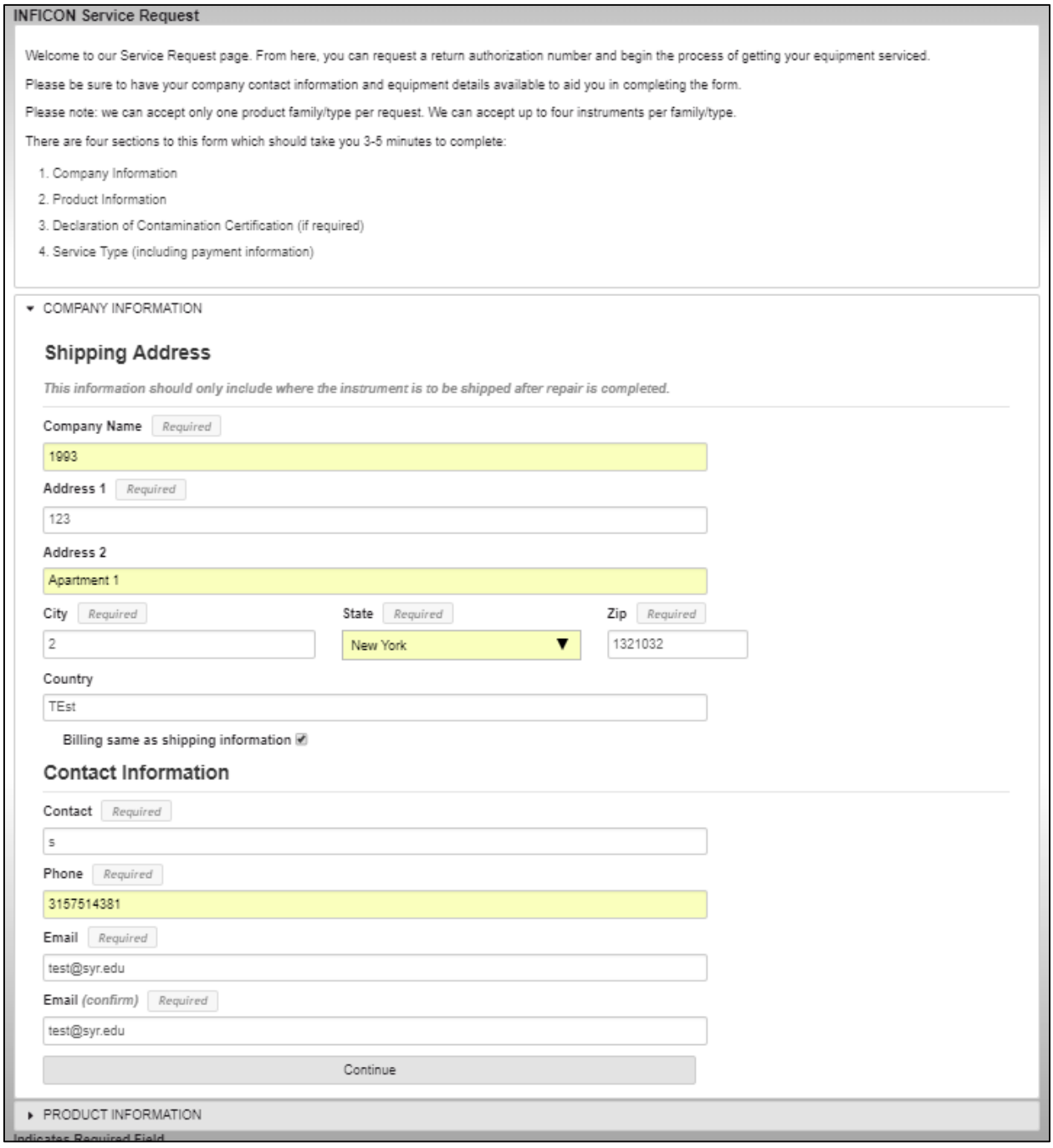
The team felt that the existing process of requesting repair is tedious for customer. An easy-click design would increase the customer satisfaction and happiness. Also, adding validations, automatic processes and database connection for customer portal will facilitate hassle-free RMA creation. It would save minimum 30% of Service-Coordinator's time which can be utilized somewhere else.

Existing Service Portal:

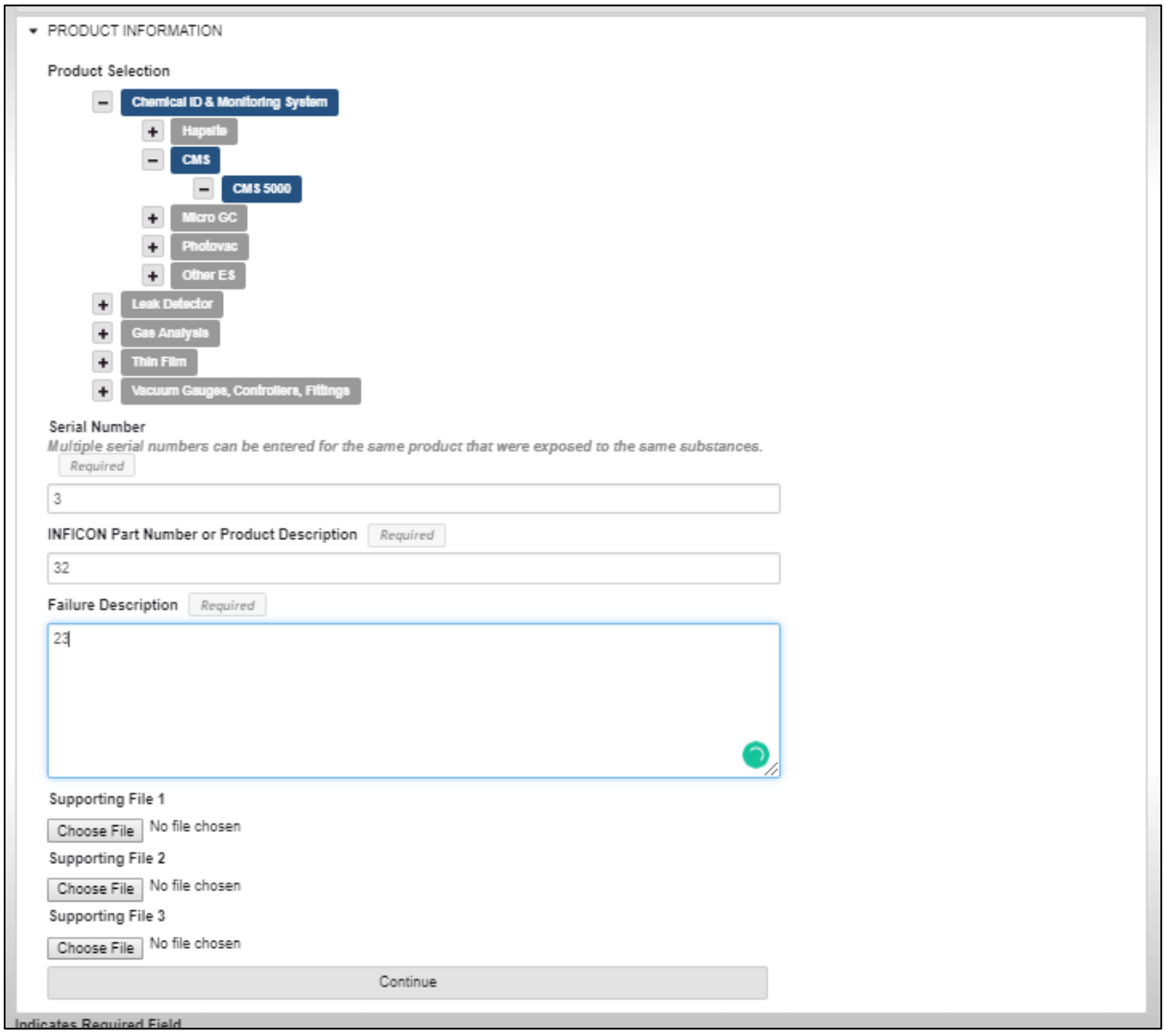
INFICON Service Portal Link: https://service.inficon.com/

Below are the steps taken by customer to fill the service request form:

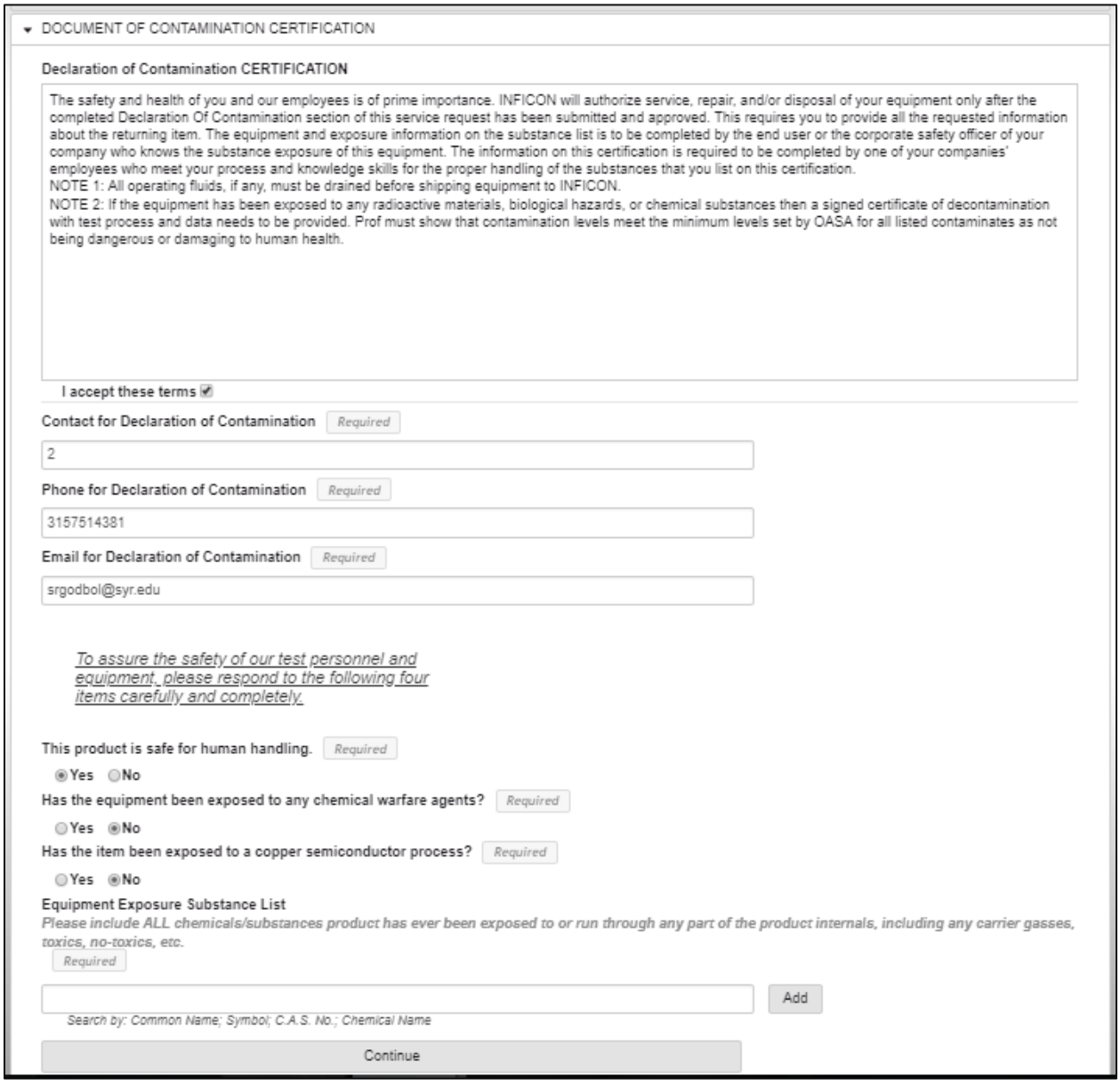
Step 1: Fill customer company information



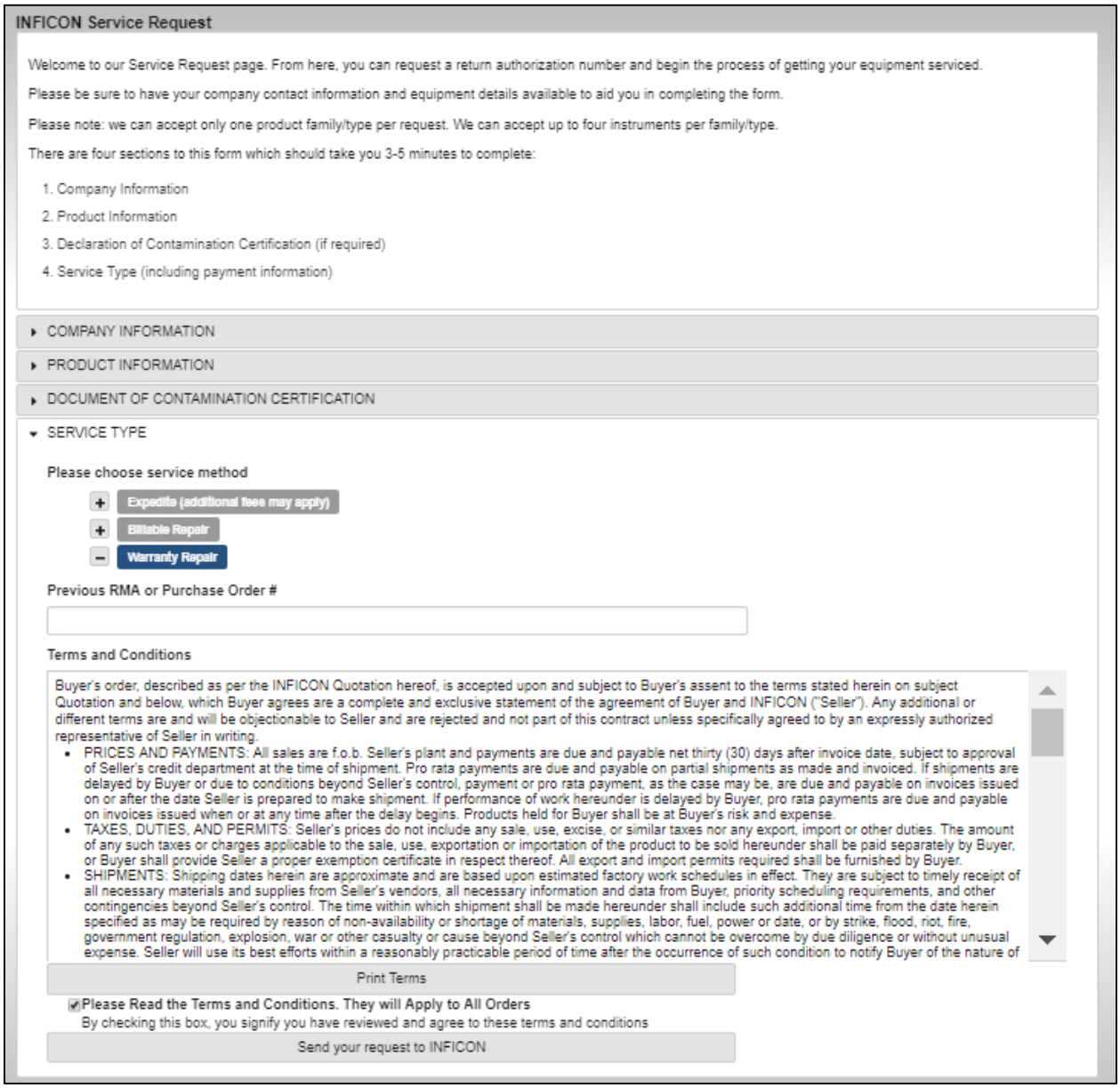
Step 2: Select product to be repaired, Enter relevant information



Step 3: Enter relevant information for declaration of contamination



Step 4: Select service type (Warranty for pilot test), enter relevant information



Below information is received by Service Coordinator, and it is used to create RMA

Your Service Request Has Been Sent

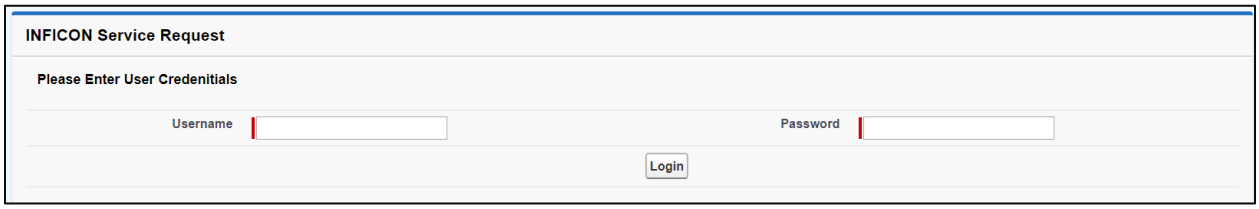
```
---Company Information---

---Shipping Address---
Company Name:   TEST, PLEASE IGNORE
Address 1:      123
Address 2:      Apartment 1
City:   2
State:  New York
Zip:    1321032
Country:        TEst

---Billing Address---
Same as shipping

---Contact Information---
Contact:        s
Phone:  3157514381
Email:  test@syr.edu

---Product Information---
Product Selection:
        Chemical ID & Monitoring System
                CMS
                        CMS 5000

Serial Number:  3
INFICON Part Number or Product Description:     32
Failure Description:    23
Supporting File 1: No file attached
Supporting File 2: No file attached
Supporting File 3: No file attached

---Document of Contamination Certification---

------
Contact for Declaration of Contamination:       s
Phone for Declaration of Contamination: 3157514381
Email for Declaration of Contamination: srgodbol@syr.edu
This product is safe for human handling.
        yes
Has the equipment been exposed to any chemical warfare agents?
        no
Has the item been exposed to a copper semiconductor process?
        no
Equipment Exposure Substance List:      1. 2-Butene, cis; CH3CH:CHCH3 or C4H8; 590-18-1; 2-Butene, (Z)-

---Service Type---
Service method:
        Warranty Repair

Previous RMA or Purchase Order #:       test please ignore
Upload PO: No file attached
```

Proposed Service Portal:

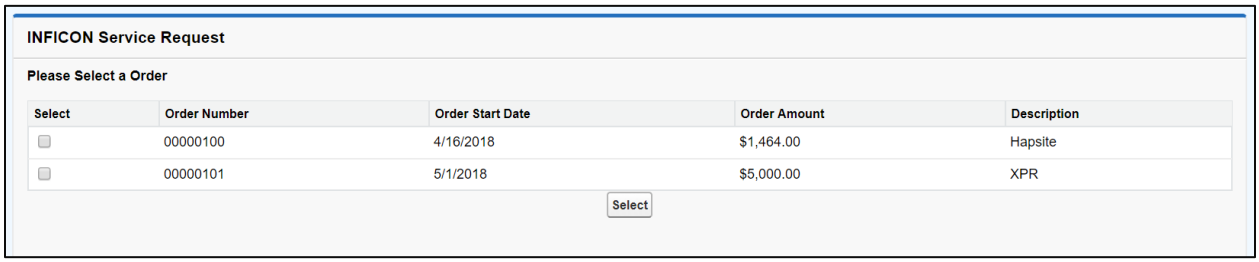
The team used **'Poka Yoke'** method for error-proofing the customer portal. According to the new design which is created in Salesforce, customer will have a login. Thus, the customer will see only those products which have been bought by them. Also, the serial number, part number and Product details of all orders will be linked to customer's login. The proposed system also pre-populates the address fields of customer which reduces the efforts taken to fill the form. In the end, once the customer verifies the details and clicks on 'Repair' button, RMA will be automatically generated. This will result in avoiding human error incurred while typing information in existing service request form as well as RMA generation.

Below are the steps to be taken by customer to fill the service request form on new portal:

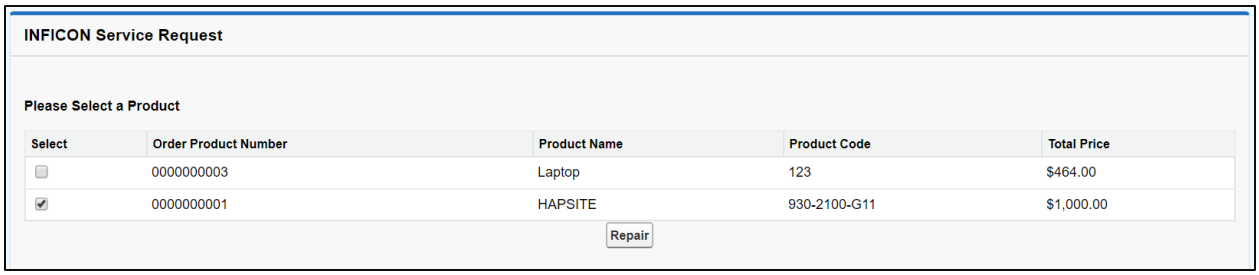
Step 1: Login to customer portal



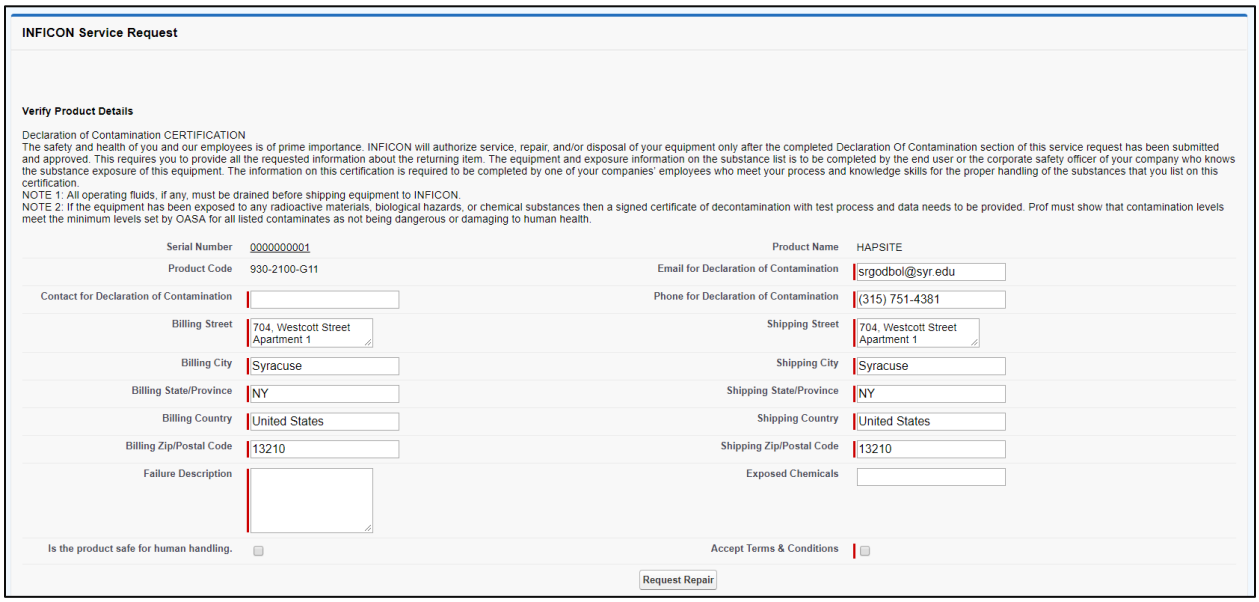
Step 2: Select order containing repair product:

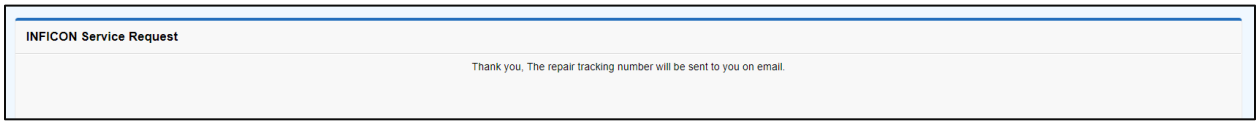


Step 3: Select product which needs repair:

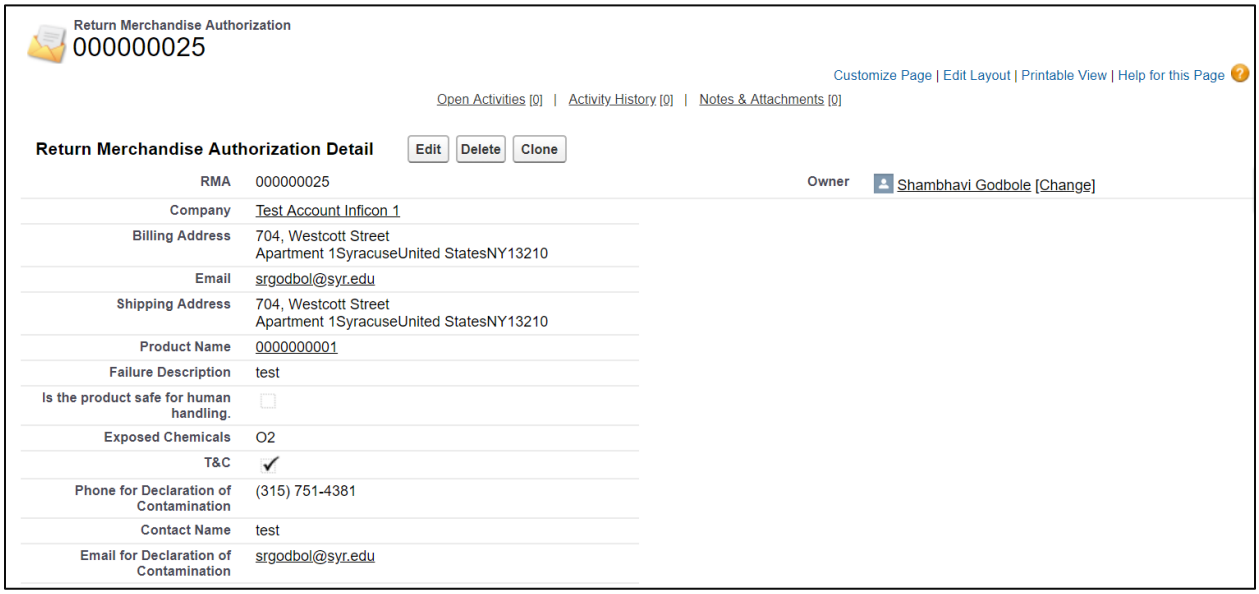


Step 4: Verify pre-populated information and fill Failure description and Point of contact Name





RMA is created automatically using backend workflows for pre-defined product




C
CONTROL
Establish standards and controls to sustain improvements in the long run.

Control

Improvement Quantified

Numbers that we got after working on the old system and new system

Observations	Old System	New System
1	3.07	1.88
2	4.12	1.09
3	4.28	1.70
4	4.06	1.31
5	3.07	1.19
6	5.99	1.42
7	5.42	1.20
8	3.32	1.27
9	3.38	1.24
10	5.12	1.05

We performed the paired T-Test for see if the new system will improve the overall process.

Paired T Test

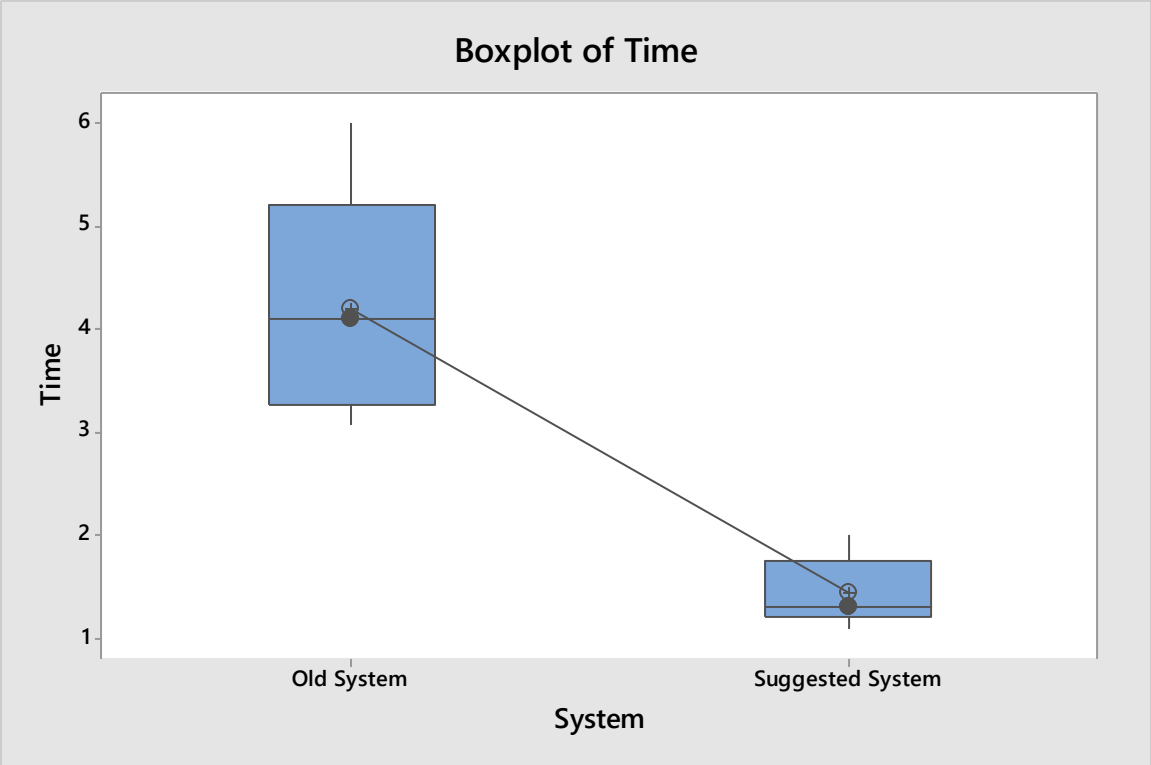
Paired T-Test and CI: Old System, New System

Paired T for Old System - New System

	N	Mean	StDev	SE Mean
Old System	10	4.657	1.004	0.317
New System	10	1.493	0.215	0.068
Difference	10	3.164	0.907	0.287

95% lower bound for mean difference: 2.638
T-Test of mean difference = 0 (vs > 0): T-Value = 11.03 P-Value = 0.000

Boxplot



We calculated the time that the coordinator takes to create an RMA and we compared with the time taken to fill in the data in our proposed solution. The data we used was normally distributed, so we went ahead to check if the time taken in each of the process is statistically same. After doing the paired t test, we reject the null hypothesis and accepted the alternate hypothesis, which say that the difference in both the processes is greater than zero, which shows that using the proposed system will save customer's time as well as the efforts. Not to forget that most of the data is auto populated, so data is pre-validated and there is no need for verification, thereby reducing the data discrepancy and redundant processes.

Observations	Creation of RMA	Creation of Repair Order
1	3.55	5.47
2	3.58	4.54
3	4.52	5.78
4	4.22	2.01
5	4.95	5.17
6	4.66	4.95
7	4.08	2.16
8	4.03	2.03
9	4.59	5.66
10	3.11	3.35
Average Time Taken (min)	4.13	4.11
Average Time Taken (hour)	0.07	0.07
On average 15 RMA are created per day	**1.03**	**1.03**
Considering 240 workdays	**247.76**	**246.68**

We also calculated the time taken by the coordinator to create RMA and create repair order which are similar processes because they require verifying the product details and customer details at different stages of repair. The website will auto generate RMA for the customer, thereby saving the coordinator's time. Also, the coordinator spends almost 2-3 hours every day just interacting with the customers through emails, responding them to where there products are, using the system (customer Portal), customer can track the product itself and thereby saving more coordinator's work. In all, using this process, coordinator can save up to 3 hours a day, in other words saving 720 hours per year.

Communication Plan

During our conversation with the Inficon team during this project, we realized that a lot of things are happening in different departments but not many team members are aware of the same. We wanted to create a planner for the company through which they can track the ongoing in the company and everyone is equally aware of numbers and progress. The company might already have something like this, but the idea of this communication plan is to communicate the pain points among different departments.

Type of Communication	**Audience**	**Purpose of Communication/Tasks (Pain Points)**	**Frequency**	**Facilitator**	**Time**	**Record**
Repair Team Meeting	Technician/Coordinators/Service Engineers/Supervisor	Communicate any changes in the process and report on Work in Progress (WIP)	Once in a week	Technical Services Manager	TBD	Confluence
Department Team	Department Heads	Communicate any changes in the department. Interrelated Field/Indicators discussion. Comparison of numbers from different departments.	Once in 2 weeks	Division Head	TBD	Confluence
Quality Control Meeting	Quality Assurance Team and Product Managers	Product Managers observation in terms of Issues in the product and Number of defects coming in each product.	Once in a month	Quality Assurance Head	TBD	Confluence
Question and Answer Meeting for SAP	Whoever uses SAP and have questions on it	Understand the working of SAP	Once in a month	SAP Expert	TBD	Confluence

Control Plan

The main challenge faced by Inficon is data discrepancy in SAP. As mentioned in Improve phase, training manuals and knowledge transfer sessions and SAP Q&A meetings will be useful to bring everyone's SAP knowledge on the same page. In addition, it is suggested to create a standardized document which is accessible by all SAP users. This is to define the expected data entry in SAP. To ensure if everyone is following the standardized process, we will have to create checklists for different users. For example, if one of the Service Coordinators is on leave, and due to high workload one of the technicians are working as coordinator. In such cases, a process checklist will ensure that all the necessary tasks have been performed by the person. This will avoid future data inconsistency. We suggest that during creation of RMA, "Acctg. Indicator" be input by checking whether the product falls under warranty. Below is a checklist created for Service coordinator for RMA creation process:

Sample Checklist

Role	Service Coordinator	
Process	RMA Creation	
Task Finished		
Task Not Finished		
Checklist	Tips	Is Completed
Opened Transaction IW51		
Notification Type	Z7 for field service, S2 for internal RMAs	
Set Acctg. Indicator	2 for Warranty	
Added Description		
Input Customer Information		
Input Serial Number		
Input Material		
Input Failure Description		
Input Priority	billable or non billable	
Input Main WorkCtr	Product Department	
Input Required End date	Check Estimated turnaround time	
Task IFBT		
Task IFBT Text : DOC	Copy Paste Service Request form	
Task Responsible	Author	
Save		
Partner Name	Author	
Green Check		