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Statapult Catapult DMAIC Project

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Abstract

Using the Statapult Catapult, DMAIC methodology was applied to improve the distance the ball was launched from 11ft to 12.5 ft. The Define phase identified the main challenges in launching the ball and being able to hit the target distance. In contrast, the Measure phase focused on collecting and analyzing performance data to establish our baseline. The analysis phase revealed that the causes of inefficiency were that there was not enough tension provided by the two rubber bands on the machine. Therefore, the Improve phase consisted of implementing solutions such as adding an extra rubber band. Finally, the Control phase established monitoring systems to ensure improvements are maintained over time. The project has resulted in an average distance launched of 14.28 feet. It is expected to have a significant impact on Statapult's operations by reaching our goal of above 12.5 feet and making our Statapult the farthest launcher on the market.

Keywords

Goals, Performance, Defects, Improvements, and Maintenance

1. Introduction

The Statapult is a hands-on learning tool. This device is often used in academic settings to teach statistical principles that can be applied to real-world issues. The Statapult consists of a base with a protractor, an arm with a ball cup, a rubber band hook, and three metal pins. These 3 pins are placed in different areas to control specific variables. There is a tension pin, a stop angle pin, and a pivot point pin. The ball cup position and rubber band hook setting are also adjustable. Once the desired adjustments are set up, the Statapult arm can be pulled back to the preferred angle. All of these factors will affect the distance that the ball is launched. The purpose of this project is to test the Statapult capacity and determine the best settings to maximize the performance of the machine. We will also be looking at Statapult Co. decreasing company sales.

1.1 Objectives

Last quarter a rival store opened up online called Statapult2.0.com and started selling a catapult marketed with a launching distance of 11 feet. Unfortunately, within the last three months, Statapult Co. has seen the average feedback score fall from 4.5/5 stars to 2.5/5 stars. This decline has greatly impacted company sales by 15%. Customers have voiced their dissatisfaction with Statapult Co's machine and the distance the ball is launched on social media and online shopping sites compared to the rival company. The common concern is that the Statapult is showing inconsistency and high variation in distance when launched. It consistently falls short of the advertised launch distance by 30%. We need a way to increase the current average launching range from 2 feet to the promised distance of 12.5 feet. Our intent is to limit fluctuation of the promised average launching range. The voice of customers is essential to the success of Statapult Co., and their feedback is highly valued and respected. By addressing their concerns , the company aims to gain back positive reviews and increase sales annually.

2. Literature Review

Six Sigma refers to achieving fewer than 3.4 defects per million opportunities, which corresponds to a 99.9997% success rate (Pande et al. 2000). Sigma represents the variation around the process average (Büyükozkan and Oztürkcan 2010; Wang et al. 2014). The Six Sigma methodology is widely used in the industry as a business improvement tool for minimizing defects in products, services, and processes (Kumar et al. 2011). In 1987, Motorola had invested $170 million in Six Sigma training. This resulted in $2.2 billion in savings along with enhanced quality (Anthony 2006).

The DMAIC model is used to improve existing products or services. A case study conducted at an automotive parts manufacturing company applied the DMAIC methodology to address process capability issues. This improved the first-pass yield from 94.86% to 99.48% (Gijo and Scaria 2014; Gijo et al. 2014). In another study, a furnace manufacturing company also employed the DMAIC phases (Srinivasan et al. 2016) and was able to reduce muffler production rejection rates from 8.21% to 4.81%. While Six Sigma offers advantages over traditional quality management methods, it also introduces challenges for researchers and is integrated into TQM practices (LLorens-Montes and Molina 2006; Salah and Rahim 2019; Zu et al. 2010). The two key reasons for difficulties in implementing Six Sigma are inadequate understanding of its phases and the significant amount of time required (Ruben et al. 2017). However, thousands of Six Sigma projects are implemented annually. They require considerable investment and careful analysis to ensure beneficial and meaningful returns (Kabir et al. 2013; Singh et al. 2019). Six Sigma projects utilize various tools and techniques to achieve process improvements (Antony et al. 2022). Some examples would include SIPOC, Process Capability analysis, Fishbone analysis, ANOVA, FMEA, Control charts, etc.This paper provides a comprehensive overview of these Six Sigma tools through the DMAIC methodology to systematically improve the launch distance of the statapult catapult.

3. DMAIC Methodology

Group Three's methodology when approaching the DMAIC project was well broken out by following the Six Sigma steps behind a DMAIC project. This means that once a topic was chosen, the group went through the Define, Measure, Analyze, and Improve phases. The group was exempt from the Control phase for this project due to the time crunch circumstances. Group three originally wanted to do a project that was based on CSUN's Library Laptop loaner program, but the program shut down for the semester just before the define phase was due. Instead, the group settled on the provided Statapult project. A goal distance was determined, and once the Measure Phase hit the group devised a plan to lay tinfoil out to more accurately determine where the ball was landed to create a baseline. More information on that layout is provided in Section 4.2.2 - Measure Phase Data Collection Plan. Then, the group thought of three different ways to improve the distance after reviewing the baseline during the Analyze Phase. After the improvements were tested in the Improve phase, a consensus of the addition of another rubber band added to the machine to increase tension was determined the best improvement.

4. Case Study

For this project, this group has outlined the descriptive statistics collected in the Measure Phase under Section 4.2.3 - Descriptive Statistics, and the descriptive statistics for the Improve Phase are listed under Section 4.5.1 - Descriptive Statistics.

4.1 Define

4.1.1 Project Charter

Table 1above is a fundamental part of the project scope, we have the Project Charter to identify, analyze and outline the objectives to be achieved. The project Charter makes it easy to develop the key elements of the project, allowing it to be aligned with the team as a whole, the stakeholders and the organizational objectives. Some of the information outlined in our Project Charter has been changed since the original submission, such as the problem and goal statement and business case and benefits.

Table 1. Project Charter.

Project Charter

Problem Statement	Business Case & Benefits
Last quarter a rival store opened up online called Statapult2.0.com and started selling a catapult marketed with a launching distance of 12.5 feet. Company sales have decreased within the past year due to a low average feedback score of 2.5 stars out of 5. Customers have expressed their concerns with the current launch distance (11 ft on average per 10 launches) on social media. We need a way to increase the distance of the current average range per launch.	Customer ratings are expected to rise by enhancing the launching distance and promising a range of 12.5 feet or more. With more positive reviews and greater customer satisfaction ratings, the Statapult company expects to recieve increased annual sales.

Goal Statement
The goal is to increase the average launching distance by 25% from 11 feet to 12.5 feet or further by the end of the quarter.

Timeline

Phase	Planned Completion Date	Actual
Define:	October 2nd	October 2nd
Measure:	October 23rd	November 6th
Analyze:	November 6th	November 6th
Improve:	November 20th	December 4th
Control:	November 20th	December 4th

Indicator
Average distance (feet) per 10 launches

Team Members

Position	Person	Title	% of Time
Team Lead	Miranda Chavez		25%
Team Member	Brenna Wechsler		25%
Team Member	Jessica Frankel		25%
Team Member	Alexia Ferreira		25%

4.1.2 SIPOC Analysis - Flow Chart

Figure 1 shows the SIPOC for the Statapult project that is a tool used for mapping the process from the beginning to the end. The S stands for Suppliers, I to inputs, P to Process, O to outputs, and C to customers.

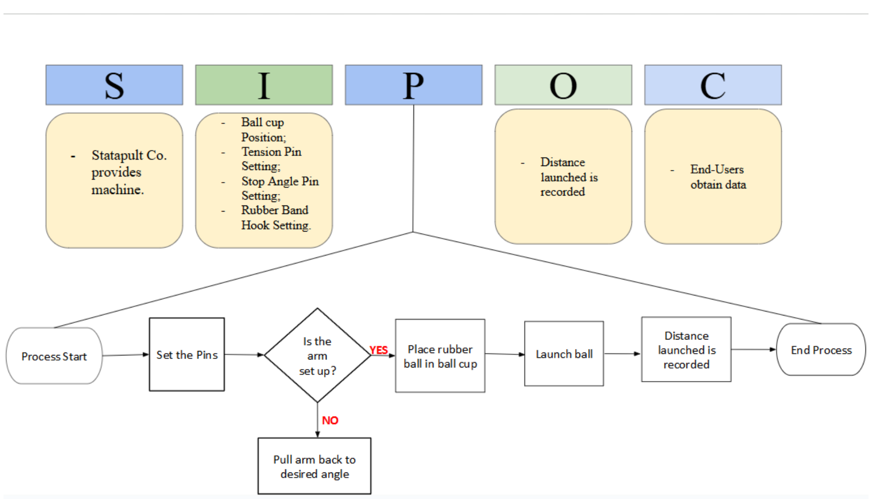

Figure 1. SIPOC Diagram.

4.2 Measure
4.2.1 Introduction
We aim to establish a baseline for the Statapult's current launch distance to make improvements to reach our desired target distance of 12.5 feet. By attempting to perform controlled launches, we can identify sources of variation within the system and confirm if the upgrades made yielded a higher distance. This allows us to refine our approach to achieve consistent and reliable results that are closer to our target.

4.2.2 Data Collection Plan
Our goal was to measure the distance the statapult launched the ball to establish a baseline for future adjustments and improvements. We had two operators launch at similar angles (110° & 120°) and the same amount of times (10 launches). This will help identify variations within the system. We also used two rubber bands instead of only one. Although this adjustment got us closer to our outlined goal of 12.5, there is still room for improvement to fully reach our goal.To enhance measurement accuracy, we layed out tinfoil and placed the measurement tape alongside it. When the ball was launched it created an indent on the tinfoil upon impact. We then marked this indent and measured it against the tape using the following nomenclature - 'Launch Number - Angle'. We made sure that Operator One was marked in blue, and Operator Two launches were marked in black.

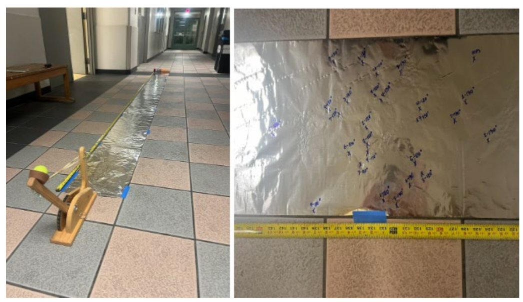

Figure 2. Measuring System with Instruments Adapted by the Group.

Figure 2 shows our measurement process, which uses aluminum foil to leave a mark that would be easier to identify where the ball falls. Blue tape was used to secure the foil and tape measure.

4.2.3 Descriptive Statistics
Figure 3 Both the Average Chart and the Range Chart showed that there was a dip in the distance of the ball after it was launched for the 120-degree value for Operator M. This dip is further analyzed in the next sections of the Measure phase

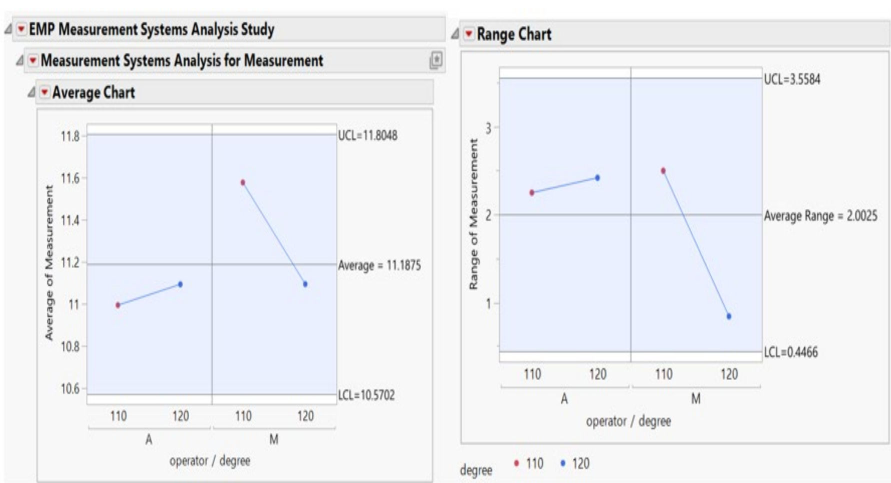

Figure 3. EMP Average and Range Chart.

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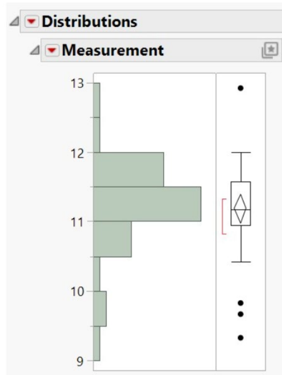


Quantiles

100.0%	maximum	12.92
99.5%		12.92
97.5%		12.897
90.0%		11.83
75.0%	quartile	11.58
50.0%	median	11.17
25.0%	quartile	10.94
10.0%		10.445
2.5%		9.3385
0.5%		9.33
0.0%	minimum	9.33

Summary Statistics

Mean	11.1875
Std Dev	0.6414717
Std Err Mean	0.1014256
Upper 95% Mean	11.392653
Lower 95% Mean	10.982347
N	40
N Missing	0

Figure 4. Descriptive Statistics

The mean, standard deviation, and charts associated with the descriptive statistics are shown in Figure 4. The box plot shown above is skewed to the left, meaning it is closer to the 12.5 ft goal value which is promising. We also see that our standard deviation is showing 0.64, which is equivalent to 7 and 11/16 inches.

4.2.4 Process Capability Analysis (Cp, Cpk)

Figure 6 shows the data generated together with Figure 5. As shown above, the Cp for our data is 1.244. Our Cp suggests that the process has a relatively good potential to meet the specification limits. Cpk takes centeredness into account. Our data set displays a Cpk value of 0.385. When the Cpk value is less than 1 the process does not consistently produce within the specification limit and there is a high risk for defects. Therefore, when it comes to Cpk the process would not have good potential for meeting the specification limits.

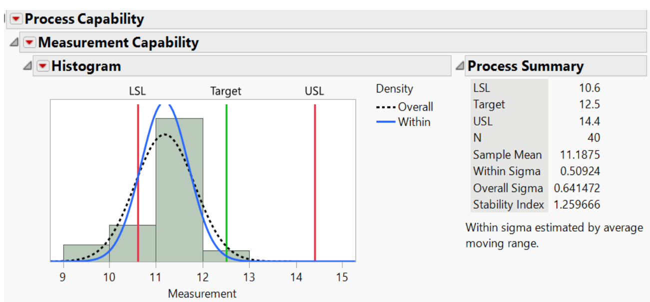


Figure 5. Process Capability (histogra in m).

Figure 5 shows the histogram of process distribution expecting a normal distribution.

Within Sigma Capability

Index	Estimate	Lower 95%	Upper 95%
Cpk	0.385	0.235	0.534
Cpl	0.385	0.233	0.532
Cpu	2.103	1.504	2.699
Cp	1.244	0.895	1.591
Cpm	0.450	0.401	0.499

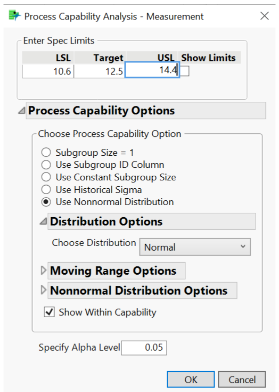
Overall Sigma Capability

Index	Estimate	Lower 95%	Upper 95%
Ppk	0.305	0.182	0.429
Ppl	0.305	0.180	0.427
Ppu	1.669	1.285	2.051
Pp	0.987	0.769	1.205
Cpm	0.434	0.378	0.491

Nonconformance

Portion	Observed %	Expected Within %	Expected Overall %
Below LSL	10.0000	12.4316	17.9869
Above USL	0.0000	0.0000	0.0000
Total Outside	10.0000	12.4316	17.9870

Figure 6. Results from process capability.



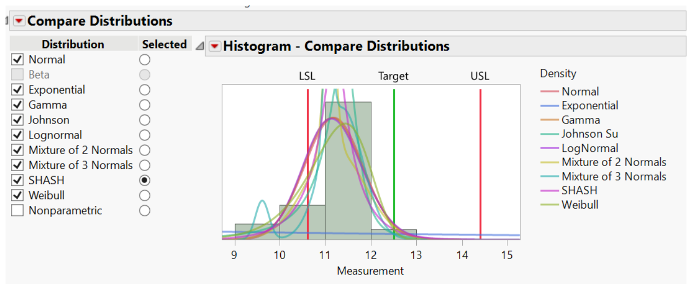


Figure 7 (left). Process capability Analysis - Measurement. Figure 8 (right). A descriptive histogram comparing distribution.

Figure 7 shows the LSL, Target, and USL that were used by this group. The Target value can be taken from the Project Charter. The USL and LSL were determined by taking three times the standard deviation provided on either side of our average, in order to get the Six Sigma goal.

Figure 8 shows the Distribution chart of the baseline data points. It is determined that our process was not capable due to there being a left-skewed distribution. Group three's goal is to make that distribution centered in the Improve Phase. Figure 8 also shows that the SHASH distribution is the one that most fits the data that was collected.

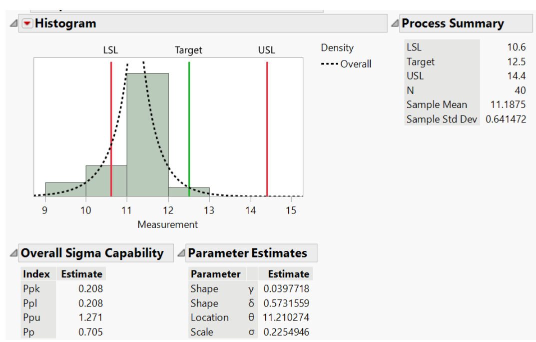


Figure 9. Histogram with the non-normal condition.

Figure 9 shows the histogram with the non-normal distribution. We originally did the normal distribution, which displayed a low Cpk, and a high Cp. When we ran a distribution that is to be the best fit for our process we found that the SHASH is the best fit for our distribution. Using this result, our process is capable due to both values being below one.

4.2.5 Key Insights and Challenges

We are able to view some key insights from the data obtained from our Measure Phase using JMP. The Gauge R&R accounts for 94.8% of the total variation. Any value greater than 30% is considered unacceptable and will require improvement. This high amount of variation due to the measurement system means that both the gauge and operator are introducing a large amount of error. We see that equipment variation/repeatability accounts 91.9% of the total tolerance. This percentage is also very high and indicates that equipment variation is the leading cause for the process variation being so high. A potential reason as to why the Gauge R&R has a relatively high variation of repeatability could be wear and tear of the equipment. Improper maintenance can cause the gauge to produce inaccurate measurements.

Variance Components

Component	Variance Component	% of Total	20 40 60 80	Std Dev
operator	0.01224575	2.9		0.11066
degree	0.00000000	0.0		0.00000
operator*degree	0.02193956	5.2		0.14812
Within	0.38832944	91.9		0.62316
Total	0.42251475	100.0		0.65001

EMP Gauge R&R Results

Component	Std Dev	Variance Component	% of Total	20 40 60 80
Gauge R&R	0.63291010	0.40057519	94.8	
Repeatability	0.62316085	0.38832944	91.9	
Reproducibility	0.11066052	0.01224575	2.9	
Product Variation	0.00000000	0.00000000	0.0	
Interaction Variation	0.14812007	0.02193956	5.2	
Total Variation	0.65001135	0.42251475	100.0	

Figure 10. Gauge R&R Results.

4.2.6 Changes to the Equipment

We originally tried to launch the Statapult without any adjustments made to the equipment. When this happened, our launches only yielded around 2 feet of distance. This meant we would certainly not meet our outlined Project Goal from our previously displayed Project Charter. After this disappointing result, we were advised to add another rubber band to the Statapult launcher. After implementing this change to the equipment, it was determined that this was a much better launch, yielding around 11.18 feet per launch. We used this method of two rubber bands for the machine to create our baseline values for the measurement phase.

4.3 Analyze

4.3.1 Detailed Process Map

Figure 11 shows the detailed process map, which describes the process in detail from start to finish. This tool helps you get your bearings and is useful for understanding complexities, identifying inefficiencies and documenting processes. Our team's detailed process map could be seen above. It is a step by step figure that outlines the Data Collection Plan explained in Section 4.2.2.

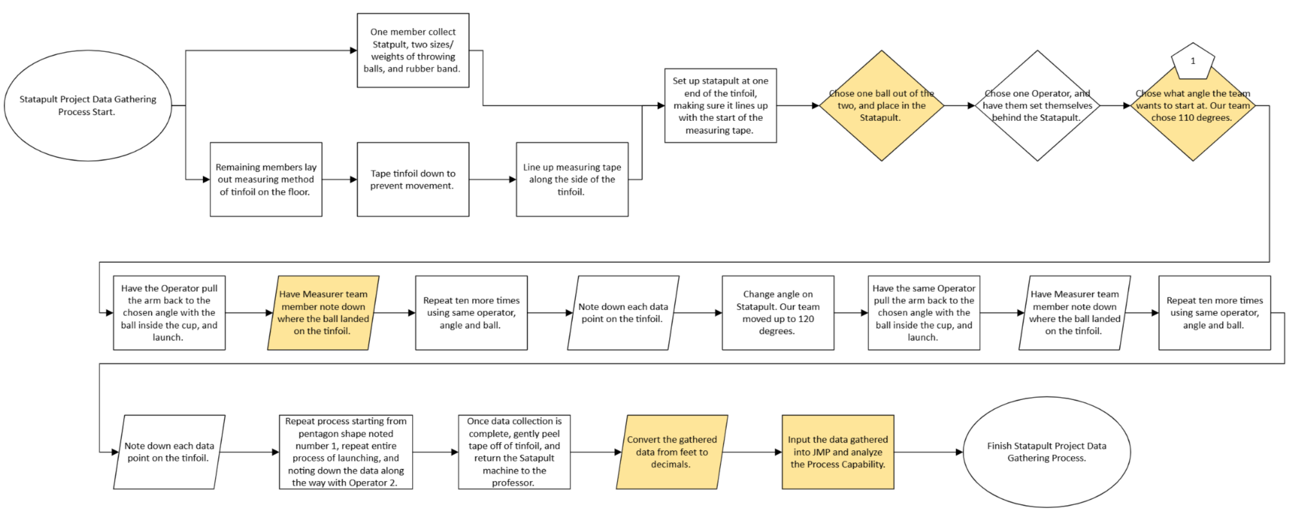


Figure 11. Detailed Process Map.

4.3.2 Fishbone Diagram

Figure 12 shows the fishbone diagram. Fishbone diagrams are used to help brainstorm and identify the root causes of a problem and help to track the process over time.

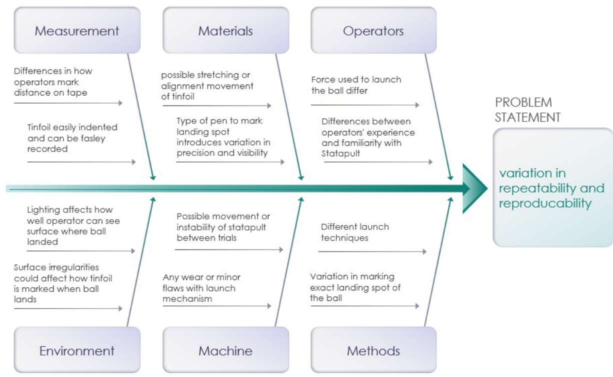


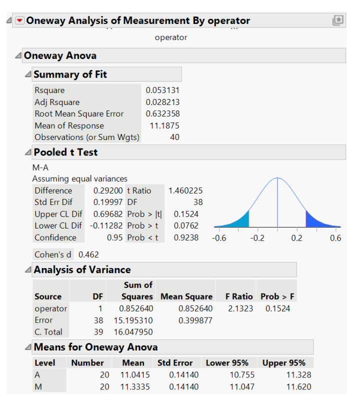
Figure 12. Fishbone Diagram.

4.3.3 Brainstorming Results

After review of the fishbone diagram shown in Analyze Section 2, we believe that the machine could be one of the main errors of our machine not meeting the required 12.5 feet of distance. We also believe that if we swap the rubber bands in between operators, it will eliminate any variation between launches due to wear on the rubber bands.

4.3.4 ANOVA

According to our one-way ANOVA that is described in figure 13, we see that our p-value is 0.1524, indicating that operator differences are not significant. The mean comparisons between operators A and M show minimal differences. Therefore, ANOVA demonstrates that operator variability is low.



Oneway Analysis of Measurement By operator

operator

Oneway Anova

Summary of Fit

Rsquare	0.053131
Adj Rsquare	0.028213
Root Mean Square Error	0.632358
Mean of Response	11.1875
Observations (or Sum Wgts)	40

Pooled t Test

M-A

Assuming equal variances

Difference	0.29200	t Ratio	1.460225
Std Err Dif	0.19997	DF	38
Upper CL Dif	0.69682	Prob > |t|	0.1524
Lower CL Dif	-0.11282	Prob > t	0.0762
Confidence	0.95	Prob < t	0.9238

Cohen's d 0.462

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
operator	1	0.852640	0.852640	2.1323	0.1524
Error	38	15.195310	0.399877		
C. Total	39	16.047950			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
A	20	11.0415	0.14140	10.755	11.328
M	20	11.3335	0.14140	11.047	11.620

Std Error uses a pooled estimate of error variance

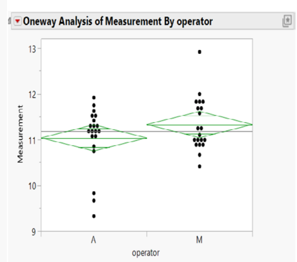


Figure 13. Anova one way analysis.

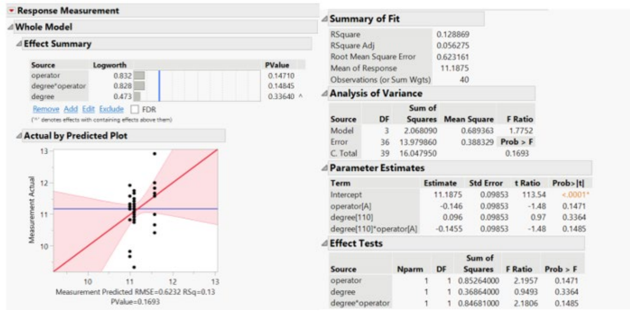


Figure 14. Two-way analysis.

According to our two-way ANOVA that is described in figure 14, we can see a p-value of 0.1471 for operator, 0.3364 for degree, and the interaction between operator and Degree is 0.1485. This means operator, degree, and the interaction effect of the two do not significantly affect the outcome. Therefore, we can accept the null hypothesis.

4.4 Improve

4.4.1 Possible Solutions

Our team explored several possible solutions to increase the launch distance of the catapult. One solution is to adjust the angle of the catapult by placing textbooks beneath it to tilt the machine. This varying angle is thought to optimize the trajectory for greater distance. Another approach involves adding an extra rubberband to increase the tension. This will be done in hopes to provide more tension and propel the ball further. Lastly, using a ball with a heavier weight could potentially generate greater momentum upon release and improve the distance launched. We chose to use a golf ball as opposed to the previous rubber ball. These ideas will be tested to determine their effectiveness in reaching the target distance.

4.4.2 Decision matrix

Table 2 identifies the decision matrix that characterizes the three solutions determined by the group to increase the launch and achieve our goal. Solution A (Adjust Launch Angle), Solution B (extra rubber band), and Solution C (A golf ball). Therefore, analyzing the data in the table, it is easy to identify that the last two solutions are feasible, but in practice only the addition of an extra rubber band was able to achieve the goal estimated by the group.

Table 2. Decision Matrix

Criteria	Solution A (Adjust Launch angle)	Solution B (Extra Rubber Band)	Solution C (A golf ball)
Effectiveness	-1	+ 1	0
Cost	0	+ 1	+ 1
Ease of Implementation	+ 1	0	+ 1
Sustainability	+ 1	+ 1	+ 1
Total Score	+1	+ 3	+3

4.4.3 FMEA Analysis

As Table 3 above shows, FMEA is a critical tool in the DMAIC project. You can see the failure analysis through to the recommendation for action. As our project describes, we chose three angles: the catapult, the extra elastic and the golf ball.

Table 3. Failure Modes and Effects Analysis (FMEA)

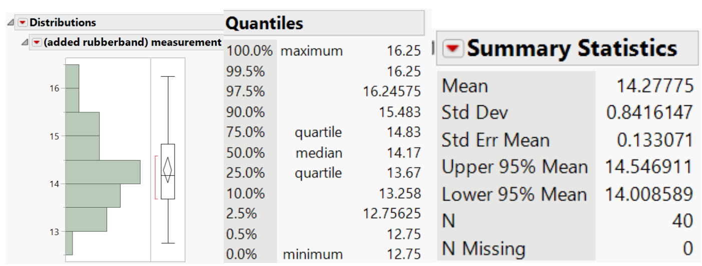
FEMEA

Process Step/Component	Failure Mode	Effect	Severity (S)	Cause	Occurrence (O)	Detection (D)	Risk Priority Number (RPN)	Recommended Action
use a heavier ball (such as a golf ball).	heavier ball does not reach a longer distance compared to the lighter ball	The process will not be capable of reaching our target goal of 12.5 ft. Possible impacts would be dissatisfied customers and company loss due to low sales. Consequently, it loses credibility in the market.	2	the ball used for the improvement is heavier than expected	5	2	20	Our recommendation would be to obtain varoius types of balls to test their weights to ensure we select the ball that matches the required specifications for the target distance
angle/tilt the catapult	angling the machine causes the distance launched to be shorter than baseline	The process will not be capable of reaching our target goal of 12.5 ft. Possible impacts would be dissatisfied customers and company loss due to low sales. Consequently, it loses credibility in the market.	2	it could cause the ball to travel in a more exageratted parabloic shape. Instead of increasing distance it could increase height.	6	3	36	Our recomendation is to develop a standardized procedure for setting the correct angle/tilt of the catapult. This can be done using markers to ensure consistency. We can also have operators perform test trials to check and verify the correct angle before collecting data
add another rubber band	could cause the machine to have too much tension, potentially sling-shotting the ball into the ground and damage tinfoil	A potential effect of the addition of a rubber band for a total of 3 to the machine is that the machine could break. The rubber band hook could be overwhelmed with the quantity of the rubber bands and pull off of the machine.	8	The rubber band could cause a strain on the pin and the arm of the machine would break.	4	1	32	Our recomendation for reducing the risk is to conduct tests to determine the optimal number of rubber bands without exceeding the machine's structural limits

4.5 Control

4.5.1 Descriptive Statistics

In Figure 16, we see that the mean is 14.28 with a standard deviation of 0.84. This average is above our target goal which is ideal. The box plot is skewed to the right, displaying most of its range of 12.5ft



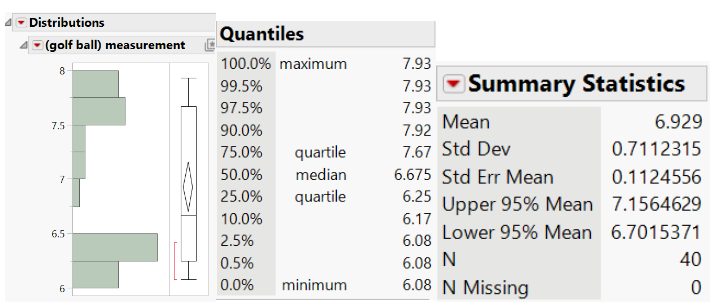
Quantiles

100.0%	maximum	16.25
99.5%		16.25
97.5%		16.24575
90.0%		15.483
75.0%	quartile	14.83
50.0%	median	14.17
25.0%	quartile	13.67
10.0%		13.258
2.5%		12.75625
0.5%		12.75
0.0%	minimum	12.75

Summary Statistics

Mean	14.27775
Std Dev	0.8416147
Std Err Mean	0.133071
Upper 95% Mean	14.546911
Lower 95% Mean	14.008589
N	40
N Missing	0

Figure 16. Descriptive statistics using additional rubberband



Quantiles

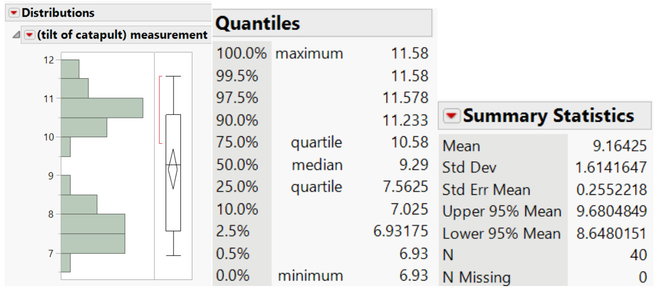
100.0%	maximum	7.93
99.5%		7.93
97.5%		7.93
90.0%		7.92
75.0%	quartile	7.67
50.0%	median	6.675
25.0%	quartile	6.25
10.0%		6.17
2.5%		6.08
0.5%		6.08
0.0%	minimum	6.08

Summary Statistics

Mean	6.929
Std Dev	0.7112315
Std Err Mean	0.1124556
Upper 95% Mean	7.1564629
Lower 95% Mean	6.7015371
N	40
N Missing	0

Figure 17. Descriptive statistics using Golf ball

In Figure 16, we see that the mean is 6.93 with a standard deviation of 0.71. This average is below our target goal and is unsatisfactory. The box plot shows a narrow range from 6ft to 8ft and displays variability.



Quantiles		
100.0%	maximum	11.58
99.5%		11.58
97.5%		11.578
90.0%		11.233
75.0%	quartile	10.58
50.0%	median	9.29
25.0%	quartile	7.5625
10.0%		7.025
2.5%		6.93175
0.5%		6.93
0.0%	minimum	6.93

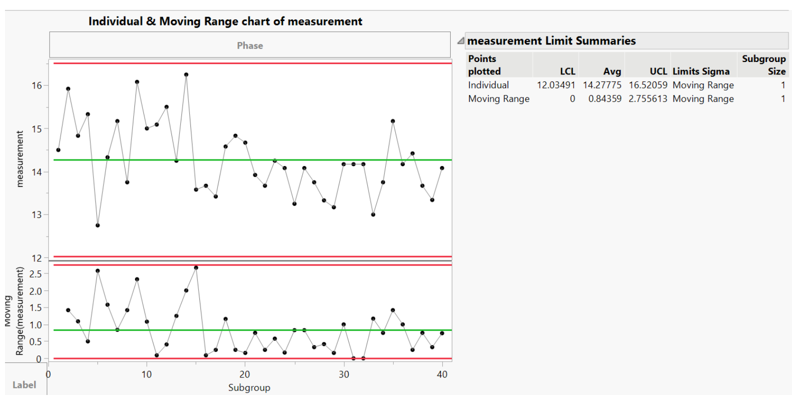
Summary Statistics	
Mean	9.16425
Std Dev	1.6141647
Std Err Mean	0.2552218
Upper 95% Mean	9.6804849
Lower 95% Mean	8.6480151
N	40
N Missing	0

Figure 18. Descriptive statistics using tilt of Catapult

In Figure 18, we see that the mean is 9.16 with a standard deviation of 1.61. This average is below our target goal which is underperforming. The box plot is slightly skewed towards lower values and shows greater variability.

4.5.2 Control chart

As Figure 15 shows, the ratio is more evenly distributed and all the data points are within the limits. The average of 14.28 feet is well above our target distance. Although some data points are further away, they are still within the proposed limits.

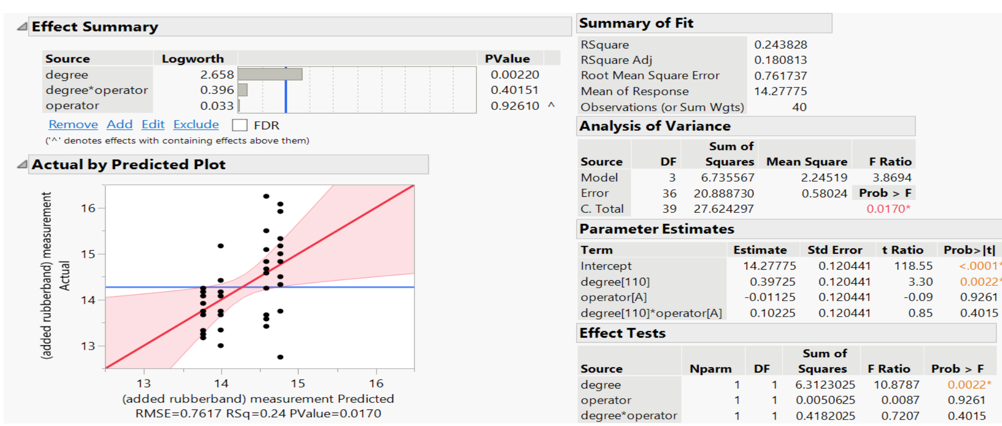


Points plotted	LCL	Avg	UCL	Limits Sigma	Subgroup Size
Individual	12.03491	14.27775	16.52059	Moving Range	1
Moving Range	0	0.84359	2.755613	Moving Range	1

Figure 15. Control Chart utilizing an extra rubber band

4.5.3 ANOVA analyses

As shown in Figure 19, the results of the ANOVA show that the p-value for the degree is less than 0.05 and therefore significantly affects the outcome. Operator is 0.9261 and the cross between the degree and operator is 0.4015, so the interaction between them is nonsignificant for the process. Looking at the actual by predicted plot, it is possible to visualize that the points on scatter are close to the center point which means that the Anova model is working well.



Source	Logworth	PValue
degree	2.658	0.00220
degree*operator	0.396	0.40151
operator	0.033	0.92610 ^

Summary of Fit	
RSquare	0.243828
RSquare Adj	0.180813
Root Mean Square Error	0.761737
Mean of Response	14.27775
Observations (or Sum Wgts)	40

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	6.735567	2.24519	3.8694
Error	36	20.888730	0.58024	Prob > F
C. Total	39	27.624297		0.0170*

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	14.27775	0.120441	118.55	<.0001*
degree[110]	0.39725	0.120441	3.30	0.0022*
operator[A]	-0.01125	0.120441	-0.09	0.9261
degree[110]*operator[A]	0.10225	0.120441	0.85	0.4015

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
degree	1	1	6.3123025	10.8787	0.0022*
operator	1	1	0.0050625	0.0087	0.9261
degree*operator	1	1	0.4182025	0.7207	0.4015

Figure 19. Anova using an extra rubber band

5. Conclusion and Future Work

Upon the completion of the project, Group three has decided that the best method to be able to hit our goal of achieving a launching distance of 12.5 feet is to add an additional rubber band to the Statapult machine. The average of the launch distances for the additional rubber band trial in the Improve phase was 14.28, which is well over the goal. The other two trial runs we went through during the Improve phase were the use of a golf ball instead of the provided ping pong ball and tilting the machine, and those two average distances travelled were 6.93 and 9.16 respectively. If we had to do a Control phase for our experiment, we would use the three rubber band method on multiple different Statapult machines to ensure that the averages are proving consistent throughout the different machines. This would ensure that the extra rubber band method is the best option for ensuring the ball goes farther than 12.5 feet consistently.

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Biographies

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