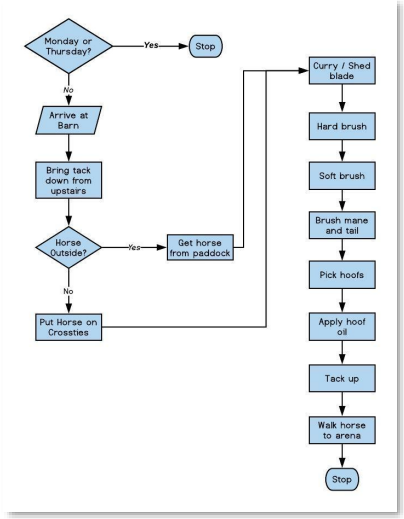
Horse Ride Preparation Process Improvement

Joyce LJ Woznica

Key Dates --->	Launch 10/4/2018	Define 10/4/2018	Measure 10/7/2018	Analyze 11/6/2018	Improve 11/7/2018	Control 11/30/2018

DEFINE

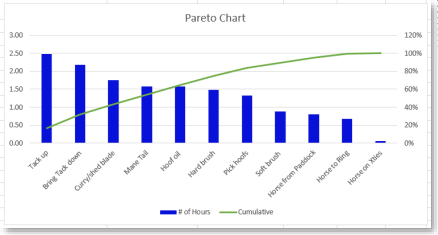
Problem: It takes too long to prepare my horse for riding and I run out of time to actually ride when the arena is not busy.



Impact: If I cannot ride multiple times each week for at least 25 minutes each ride (target is 4 rides per week), the result is additional vet expenses. If this cannot be achieved, injections, medications and vet visits equate to additional expenses that can **average $2,500** per year to handle his sacroiliac (SI) joint.

MEASURE

Data Collection: Collect 14 variables: 3 discrete, 11 continuous associated with ride preparation process.



SQL Before: 1.6

Significant time being spent on a few tasks including bringing tack down and applying hoof oil.

Descriptive Statistics		Statistics in Time Format
Mean	52.20588235	0:52:12
Standard Error	1.369586746	0:01:22
Median	49.9	0:49:54
Mode	48.81666667	
Standard Deviation	5.646950816	0:05:39
Sample Variance	31.88805351	
Kurtosis	1.875052266	
Skewness	1.264866661	
Range	22.93333333	
Minimum	44.26666667	0:44:16
Maximum	67.2	1:07:12
Sum	887.5	
Count	17	

Averaging about 52 minutes with deviations of 5 ½ minutes. Almost 23 minute range between minimum and maximum times.

ANALYZE

Hypothesis Testing:

$H_0: \mu_1 \leq \mu_2$, $H_a: \mu_1 > \mu_2$

P = 0.00000000384

So, since $p < \alpha = 0.05$, then we reject H_0 and conclude that there was process improvement.

Multiple Linear Regression Analysis: In executing several iterations, it was clear that 3 or 4 input variables had direct correlation to my total time for preparation.

- *x4* – Bring tack down
- *x5* – Get horse from paddock
- *x12* – Apply hoof oil

Regression Statistics	
Multiple R	0.978927758
R Square	0.958299555
Adjusted R Square	0.933279288
Standard Error	1.458627309
Observations	17

ANOVA

	df	SS	MS	F	Significance F
Regression	6	488.93292	81.48881999	38.30093257	0.0000025
Residual	10	21.27593626	2.127593626		
Total	16	510.2088562			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	16.48668924	3.616394644	4.558874476	0.00104395	8.428859827
x4 Bring Tack down	0.965258607	0.383649738	2.515989226	0.030596942	0.11043372
x5 Horse from Paddock	0.718747666	0.228349207	3.147581176	0.010375543	0.209953926
x7 Curry/shed blade	0.692540096	0.321005984	2.157405566	0.056355803	-0.022705808
x8 Hard brush	0.742990387	0.415873864	1.786576296	0.104306222	-0.183634326
x11 Pick hoofs	2.774819473	0.675506347	4.107762254	0.002118116	1.269697537
x12 Hoof oil	0.932611059	0.230200264	4.051303167	0.002318718	0.419692907

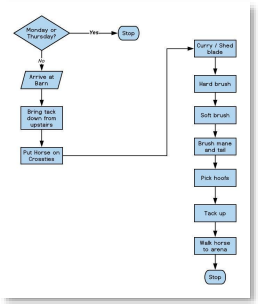
Chi-Squared Test (for $\alpha = 0.05$, ***p* = 0.149072804)** did not prove relationship between horse being outside (in paddock) and total preparation time.

IMPROVE

Improvements Made:

Three improvements were made in my process:

- Put ½ of my tack in my car
- Had someone bring horse inside
- Applied hoof oil after I rode, so removed from the process



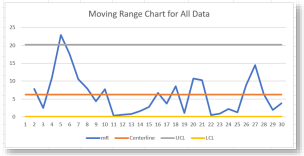
Mean	41.90769231
Standard Error	1.141478111

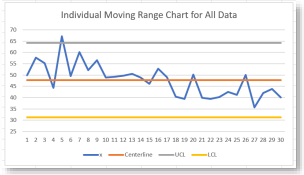
SQL After: 2.5

CONTROL

My xMR and iMR charts showed that my process is under control; however on day 5 of my pre-improved process, there was an issue with control.

Reviewing day 5 (10/14/2018), I found that I took much longer than normal to bring my tack down, get the horse from his paddock and to tack up.



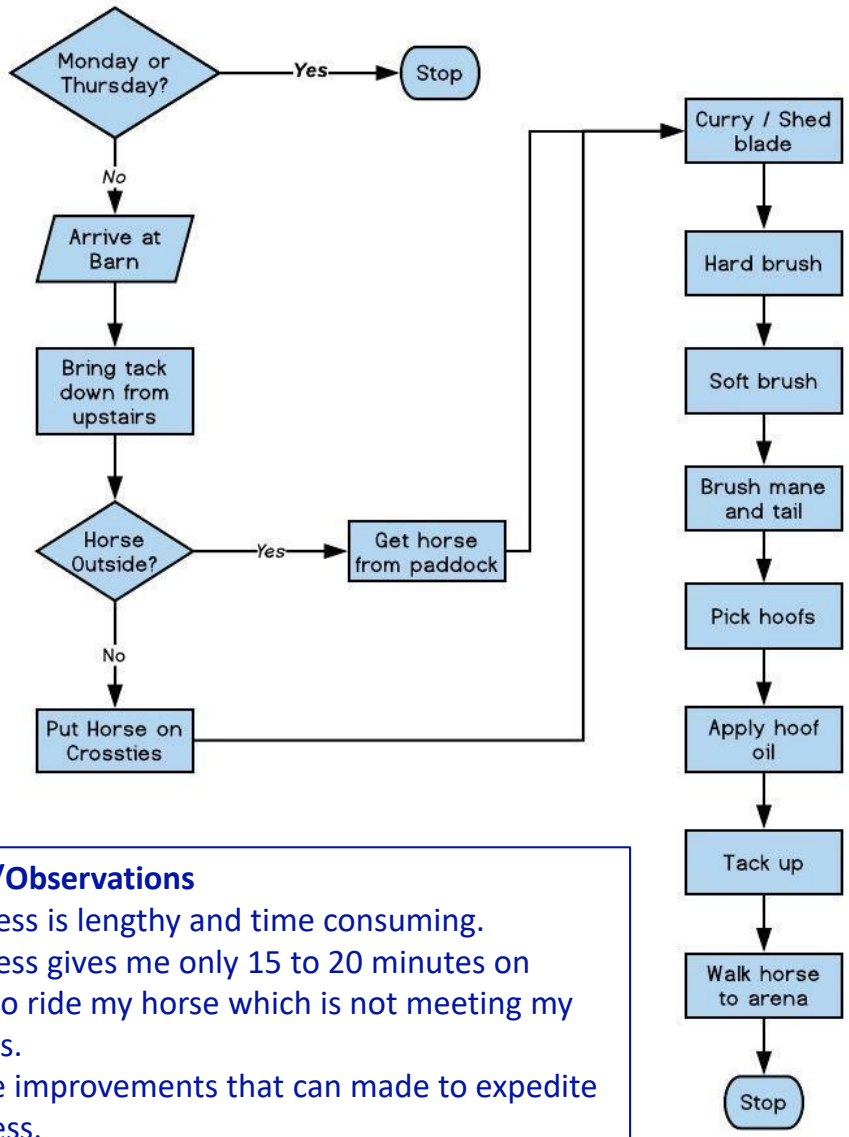


Continue to monitor process for control.

Process Map for Pre-Improvement Process

Process Map Explanation and Business Problem

- The arena/ring at our barn is booked for nightly lessons after 7:00 PM each evening.
  - It is difficult, if not impossible to ride during lessons.
- I do not get out of work until approximately 5:15 PM and have to change and leave for the barn.
- My travel time to the barn is usually 30 minutes.
- I work on Monday nights and have class on Thursday nights, so I cannot ride those days.
- My trainer rides my horse one day per week – usually on Fridays.



Comments/Observations

- The process is lengthy and time consuming.
- The process gives me only 15 to 20 minutes on average to ride my horse which is not meeting my objectives.
- There are improvements that can made to expedite the process.

Process Details

The process started from the moment I stepped out of my car at the barn.

Tack is stored upstairs in the hayloft and requires two trips for me to bring everything down which wastes time:

- Helmet
- Saddle, saddle pads, girth
- Brushes
- Bridle

If my horse is not already in his stall, then I have to walk to his paddock and bring him inside to put on the crossties. If he is inside, I just take him from his stall to the crossties. The former was included in the "Get horse from paddock" task in the process map.

The remaining steps are accomplished in the same order each time I prepare to ride.

Data Measurement Plan

Performance Measure	Data Source / Location	How Collected	Data Collector	When Collected	Target Sample Size
Weekend or Weekday	Excel Spreadsheet	Recorded a 1 for Saturday or Sunday. Recorded a 0 for Monday through Friday.	Self	10/7 – 12/2	40
Ridden Day before – if the horse was ridden the day before by me or someone else.	Excel Spreadsheet	Recorded a 1 for Yes. Recorded a 0 for No.	Self	10/7 – 12/2	40
Horse In or Out	Excel Spreadsheet	Recorded a 1 for In. Recorded a 0 for Out.	Self	10/7 – 12/2	40
Minutes Spent *bringing tack down from upstairs*	ATracker	Start task when leave stall, end task when all tack is by stall	Self	10/7 – 12/2	40
Minutes Spent *bringing horse inside from paddock*	ATracker	Start task immediately after previous task ends, end task when horse is on crossties.	Self	10/7 – 12/2	40
Minutes Spent *bringing horse to crossties*	ATracker	Start task immediate after previous task ends, end task when horse is on crossties. This is 0 if horse is outside in paddock.	Self	10/7 – 12/2	40
Minutes Spent *currying (curry brush) and/or using a shed blade* on horse to clean dirt, remove hair, etc.	ATracker	Start task immediately after previous task ends, end task when next brush is selected.	Self	10/7 – 12/2	40
Minutes Spent *hard brushing* to remove dirt brought to surface from curry	ATracker	Start task immediately after previous task ends, end task when next brush is selected.	Self	10/7 – 12/2	40
Minutes Spent *soft brushing* to smooth hair on face and body	ATracker	Start task immediately after previous task ends, end task when next brush and product are selected.	Self	10/7 – 12/2	40
Minutes Spent *detangling and brushing mane and tail, and applying product*	ATracker	Start task immediately after previous task ends, end task when hoof pick is selected.	Self	10/7 – 12/2	40
Minutes Spent *lifting and picking all dirt, rocks, debris* out of each hoof and scratching off dirt on hoof	ATracker	Start task immediately after previous task ends, end task when hoof oil and brush are selected.	Self	10/7 – 12/2	40
Minutes Spent *applying hoof oil* to each hoof after brushing off any dust from hoof	ATracker	Start task immediately after previous task ends, end task when saddle pad is selected.	Self	10/7 – 12/2	40
Minutes Spent *tacking horse* including: saddle pad, saddle, girth, bridle, grabbing crop	ATracker	Start task immediately after previous task ends, end task when all tack is on horse.	Self	10/7 – 12/2	40
Minutes Spent *walking horse to arena* for riding	ATracker	Start task immediately after previous task ends, end task horse enters ring for riding.	Self	10/7 – 12/2	40

Data Collection Method

Data Collection Explanation

General Information

- A tool called "ATracker" (http://www.wonderapps.se/atracker/) was used to in capturing each task in the process map. This tool had both a iPhone application along with an ability to download the data in a spreadsheet for later usage.
    - Manipulation of the spreadsheet was needed to change columns from vertical to horizontal and to add discrete data collected.
- Each task was ended/started when I put down the brush and picked up the next tool in the process. This was determined because of the minimal seconds to put one brush away and grab the next. The app allowed just one touch to end one task and another touch (like a double touch) to start next task to minimize collection errors.
- I collected data each day of the week that I was able to ride – which was not as often as I would have liked due to weather and other commitments beyond my control (so they were not captured in the data collection).

Days of Collection

Pre-Improvement State – Data collection started on October 7, 2018 and there were 17 days collected between that date and November 6, 2018.

Improvement State – Data collection started on November 7, 2018 and there were 13 days collected between that date and December 2, 2018.

Data Collected

- A total of 14 variables was collected.
- Both continuous and discrete data were collected.
- All continuous data was recorded in minutes and seconds.

Discrete Data

- Discrete data captured for 2 additional inputs:
    - *x1* – Weekend (1) or Weekday (0)
    - *x2* – Ridden Day Before (1) or Not (0)
    - *x3* – Horse In (1) or Out (0)
- The output (or *y*) variable of my data was the ***Total Minutes*** that it took me each day to complete all the tasks it takes to prepare to ride.

Continuous Data

Continuous data was time for each task in the map for eleven (11) inputs as follows:

- *x4* – Bring tack down
- *x5* – Get horse from paddock
- *x6* – Put horse on crossties
- *x7* – Curry / shed blade
- *X8* – Hard brush
- *x9* – Soft brush
- *x10* – Brush mane and tail
- *x11* – Pick Hoofs
- *x12* – Apply hoof oil
- *x13* – Tack up horse
- *x14* – Walk horse to ring to mount and ride

Goals and Measurements for Success

Goal

My goal is to increase my riding time to at least 25 minutes each ride which would mean decreasing the time required to prepare for riding by 20% giving me another 10 minutes to ride.

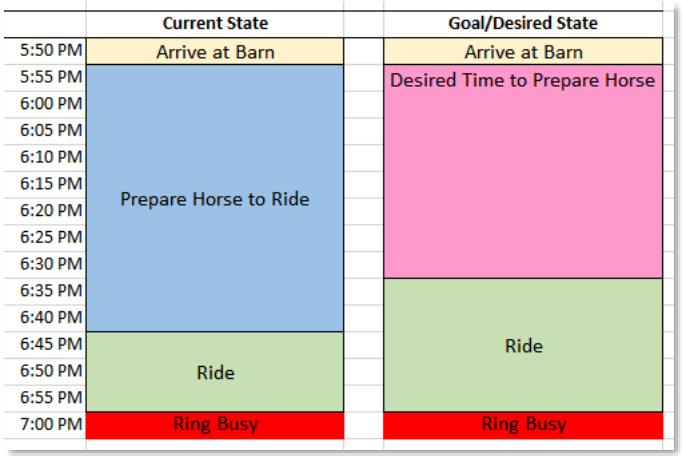
How Derived

The arena/ring is free from busy lessons until 7 PM and I get the barn between 5:45 PM and 6:00 PM – usually by 5:55 PM. With a mean current preparation time of **52 minutes and 12 seconds (my baseline)**, that would mean that I am in the ring to ride usually around 6:45 PM – only giving me a total of 15 minutes to ride before the ring is busy.

To get in the ring by 6:35 PM (allowing me 25 minutes to ride), I would merely need to shave off about 10 minutes off my preparation time. I decided to try to reduce my preparation time by 20% which would give me just over an additional 10 minutes based on my current data.

Goal => **52.2059 minutes** * 20% = **10.44118 minutes**

This was all determined by looking at the descriptive statistics of my "pre-improvement" or "current state" data as shown in the adjacent chart.



Descriptive Statistics		Statistics in Time Format
Mean	52.20588235	0:52:12
Standard Error	1.369586746	0:01:22
Median	49.9	0:49:54
Mode	48.81666667	
Standard Deviation	5.646950816	0:05:39
Sample Variance	31.88805351	
Kurtosis	1.875052266	
Skewness	1.264866661	
Range	22.93333333	
Minimum	44.26666667	0:44:16
Maximum	62.7	1:07:12
Sum	887.5	
Count	17	

Pre-Improvement Pareto Chart

Use of the Pareto Chart
I selected to do a Pareto Chart to better understand where I was spending the most time in preparation to ride. Using this method, I was able to determine what tasks in my process were taking the most time so I could focus my improvements, where appropriate, in those areas.

Chart Creation
I charted the overall time spent on each task (in hours) during my initial 17 days of data collection each continuous data task (*x* variables) in my process.

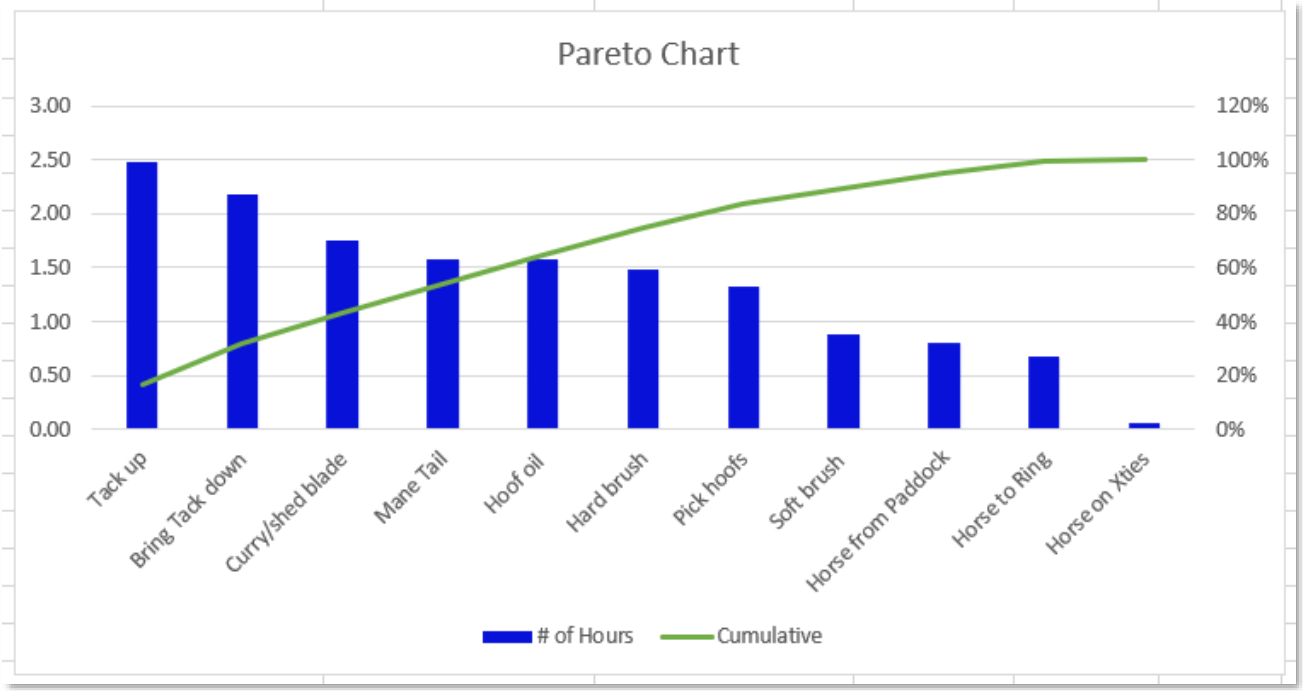


Chart Interpretation
As shown in the chart, there are several tasks where I am spending extensive time before riding preparing my horse. These include:

- Tacking Up
- Bringing my Tack Downstairs
- Currying / Shed Blade
- Brushing Mane and Tail
- Applying Hoof Oil

Unfortunately, tacking up is not an area where much improvement can be applied. You have to put the saddle pad on, the saddle, the girth, the bridle, etc. This doesn't change. This process is also compounded by a fidgety horse which is beyond my control.

However, I do have some control over my tack location and how long that takes me to bring to the aisle, the horse's location and other tasks that appear time consuming on this chart.

This provided great insight into a good place to start to improve this process.

Sigma Quality Level (SQL)

Goal Restatement

My goal is to decreasing required preparation time for riding by 20%.

Operational Definition

As stated on slide #4, the total minutes required to prepare to ride my horse is our *y* for this project. The data was captured in minutes and seconds and then converted to decimals for calculations. Also detailed on slide #4, 11 continuous variables and 3 discrete variables were tracked in minutes and seconds for each time I prepared my horse for riding.

Sigma Quality Level Information

This is the overall data for my SQL calculated:

- A defect for my project was taking longer than ***50 minutes*** in preparing my horse for riding.
- I collected 17 samples pre-improvement.
- Of the 17 samples, there is only 1 chance (each day) to be more than 50 minutes, so 1 possible defect per day.
- In my data, there were ***8*** times that the total preparation time was more than ***50 minutes***.

Total Minutes	Convert to decimal	> 50
0:49:54	49.9000	
0:57:44	57.7333	1
0:55:13	55.2167	2
0:44:16	44.2667	
1:07:12	67.2000	3
0:49:36	49.6000	
1:00:06	60.1000	4
0:52:12	52.2000	5
0:56:30	56.5000	6
0:48:49	48.8167	
0:49:09	49.1500	
0:49:42	49.7000	
0:50:28	50.4667	7
0:48:49	48.8167	
0:46:03	46.0500	
0:52:45	52.7500	8
0:49:02	49.0333	
0:40:29	40.4833	
0:39:25	39.4167	
0:50:09	50.1500	1
0:39:52	39.8667	
0:39:23	39.3833	
0:40:16	40.2667	
0:42:29	42.4833	
0:41:15	41.2500	
0:50:03	50.0500	2
0:35:37	35.6167	
0:41:58	41.9667	
0:43:50	43.8333	
0:40:02	40.0333	

Sigma Quality Level based on Defective Parts per Million Opportunities (DPMO)

Pre-Improvement Data

Description	Variable/Formula	Value
Defect Opportunities per Unit	D	1
Units Produced per Day	U	17
Total Possible Defects per Day	D * U	17
Total Actual Defects	A	8
Defects per Opportunity Rate	A / DU = DPO * 100	47%
Defects per Million Opportunities (DPMO)	DPO * 1,000,000	470,588.24
SQL Value from SQL Table	*approximately*	**1.6**
	^Note - used 460,000 from table	

Post-Improvement Data

Description	Variable/Formula	Value
Defect Opportunities per Unit	D	1
Units Produced per Day	U	13
Total Possible Defects per Day	D * U	13
Total Actual Defects	A	2
Defects per Opportunity Rate	A / DU = DPO * 100	15%
Defects per Million Opportunities (DPMO)	DPO * 1,000,000	153,846.15
SQL Value from SQL Table	*approximately*	**2.5**
	^Note - used 158,000 from table	

Interpretation

There is significant improvement in the process with the SQL improving from **1.7** to **2.5**.

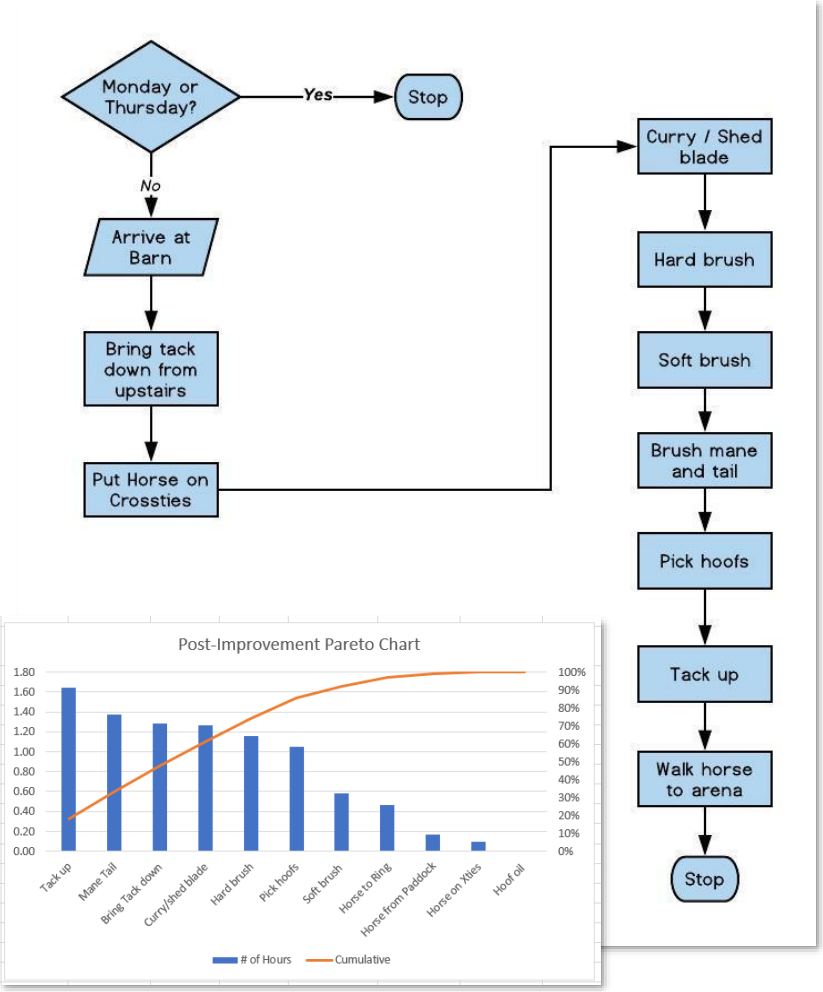
Improved Process Map

Process Map Modifications

As I looked at the original process, I found a few things that could be done right away. Some involved enlisting the help of others and some involved just changing my routine.

As per my original Pareto Chart (slide #6), there were some activities that were contributing most significantly to my total preparation time including: Tacking Up, Bringing my Tack Downstairs, Currying / Shed Blade, Brushing Mane and Tail, Applying Hoof Oil. However, some of these are difficult to change specifically and are uncontrollable. For example, if the horse rolled in the mud, currying takes longer as that is the step to remove dirt. I cannot control that behavior. The same goes for his mane and tail being extra dirty and requiring more time to brush. In viewing my chart, I did see some things that might help dramatically and were easy to change.

1. For example, putting hoof oil on and then riding the ring is actually nonsensical. I have done it for years, but it makes more sense to move this routine to **after** I have ridden as it is not necessary to do this before for the same benefits. So, I removed this from my preparation process.
2. I also found that I had to take 2 trips upstairs to bring down all my items (tack): saddle, saddle pad, quarter pad, girth, brushes, helmet, bridle, etc. So, I moved my helmet and brushes to my car, so that I could just take one trip upstairs for the remaining items.
3. Although not taking substantial time, I also found that I could ask the feeders to bring my horse inside I did not denote this in my process, because the feeders just brought him in first everyday for me. This saved some time, but added some to putting the horse on the cross ties.



As shown on slide #7, this new process had an improved Sigma Quality Level of 2.5 (significantly better than the 1.6 of the pre-improved process).

Hypothesis Testing

Hypotheses to be tested

Testing to see if there really is a difference between the two populations (before improvement and after improvement). We want to confirm that my preparation time was reduced in the second population.

Definitions

μ_1 = Mean of Pre-Improvement Data
μ_2 = Mean of Post-Improvement Data
$\alpha = 0.05$, $n \geq 30$ (because $n = n_1 + n_2 = 17 + 13 = 30$)

Hypothesis

H_0: $\mu_1 \leq \mu_2$ (post-improvement mean is less than or equal to pre-improvement mean – so no improvement shown)
H_a: $\mu_1 > \mu_2$ (post-improvement mean is greater than pre-improvement mean – so there was improvement)

We want to reject H_0 as we would like to see that improvement was realized with the changes implemented.

Data Values for the test

$\bar{x}_1 = 52.2059$, $s_1 = 5.6480$, $n_1 = 17$
$\bar{x}_2 = 41.9077$, $s_2 = 4.1157$, $n_2 = 13$

$$z = \frac{52.2059 - 41.9077}{\sqrt{\left(\frac{5.6480^2}{17}\right) + \left(\frac{4.1157^2}{13}\right)}} = 5.7754$$

$$Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Which means a p-value of = 1 - 0.99999999616 = 0.00000000384

So, since $p < \alpha = 0.05$, then we reject H_0 and conclude that there was process improvement.

Which Test?

To determine which test and formulas to use, we have to look at our data:

- Our data is time, so continuous.
- We have two samples (pre and post improvement) testing the hypothesis shown to the left, so we have a one-tail, upper/right tail test.
- Our $n = n_1 + n_2 = 17 + 13 = 30$. So we are on the cusp of the large sample size ($n \geq 30$), so this means or our sample size is large.

Two-Sample Hypothesis Tests for Continuous Data (Green)

Select:	Two-tail test	One-tail test	
	Two-tail	Lower/left-tail	Upper/right-tail
	$H_0: \mu_1 = \mu_2$	$H_0: \mu_1 \geq \mu_2$	$H_0: \mu_1 \leq \mu_2$
	$H_a: \mu_1 \neq \mu_2$	$H_a: \mu_1 < \mu_2$	$H_a: \mu_1 > \mu_2$
Choose:	**Sample size**		
	Large	Small	
	$n_1 + n_2 \geq 30$ (or σ known)	$n_1 + n_2 < 30$ (or σ unknown)	
Calculate:	**Test statistic**		
	$Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$	$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$ $df = n_1 + n_2 - 2$	
Identify:	***p*-value**		
	Two-tail	Lower/left-tail	Upper/right-tail
	$p = 2 \times$ area past Z or t	$p =$ area left of Z or t	$p =$ area right of Z or t

Confidence Interval and Sample Size

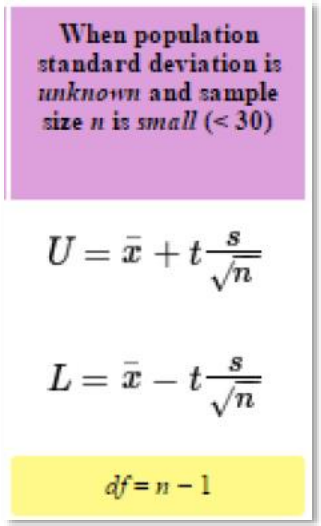
Confidence Interval for the μ

Unfortunately, we can not always be assured that we can obtain the correct sample size for our analysis – especially with the constraints of a semester window and, in my case, the death of a parent which had me out of town much of the semester reducing my ability to collect samples.

To determine the proper sample size for my analysis, I used this information:

- $n = 17$
- $\bar{x} = 52.2059$
- $s = 5.6480$
- $\alpha = 0.05$, 95% confidence ($p = 0.95$)

This information would then imply that my degrees of freedom (*df*) is 16 (or $n - 1$). Using Table D (page T-11), my *t* statistic = 2.120.



That means that my Upper Limit and Lower Limits are as follows:

$$U = \bar{x} + t\frac{s}{\sqrt{n}} \qquad L = \bar{x} - t\frac{s}{\sqrt{n}}$$

$$E = 2.120\frac{5.6480}{\sqrt{17}} = 2.904063$$

verified with Excel
CONFIDENCE.T(0.05,5.648,17) = 2.903934

$$L = 52.2059 - 2.120\frac{5.6480}{\sqrt{17}} = 49.04063$$

$$U = 52.2059 + 2.120\frac{5.6480}{\sqrt{17}} = 55.10996$$

What does this mean?

This means that I am 95% confident that my mean is between 49.04063 and 55.10996 or $49.04063 \leq \mu \leq 55.10996$. That implies that my mean total time to prepare to ride would be between 49.04 and 55.11 minutes.

The Right Sample Size

Unfortunately, we can not always be assured that we can obtain the correct sample size for our analysis – especially with the constraints of a semester window and, in my case, the death of a parent which had me out of town much of the semester reducing my ability to collect samples.

To determine the proper sample size for my analysis – I used this information:

- 95% confidence means $z^* = 1.96$
- $E = 2$ minutes
- $\hat{\sigma}$ = estimated to be 5 minutes

$$n = \left(\frac{z^* \hat{\sigma}}{E}\right)^2$$

$$n = \left(\frac{1.96*5}{2}\right)^2 = 23.76563 \text{ or } 24$$

However, if I am okay with a margin of error of 3 minutes, my sample size only needs to be 11 days (10.5625). I also could have used a confidence interval of 90%, my sample size is just large enough (16.91266 or 17 days). So with this smaller sample of 17, I am taking a risk. This small of a sample increases the likelihood of a Type II error (failing to reject the null hypothesis when I should have).

Multiple Linear Regression Analysis

Regression Analysis of my Pre-Improved Model

In looking at my data, it seems practical to me (based on my Pareto Chart) and just reviewing the data – that there were certain variables that were influencing my total preparation time. Some of these were not under my control, others could be improved, changed, or removed.

Multiple Linear Regression Process

I did several multiple linear regression analyses with my data removing variables as they no longer seems significant.

The first model I ran was with the following x-variables:

- *x4* – Bring tack down
- *x5* – Horse from paddock
- *x6* – Put horse on crossties
- *x7* – Curry / shed blade
- *X8* – Hard brush
- *x9* – Soft brush
- *x10* – Brush mane and tail
- *x11* – Pick Hoofs
- *x12* – Apply hoof oil

1st Iteration

Regression Statistics	
Multiple R	0.983846552
R Square	0.967954039
Adjusted R Square	0.926752089
Standard Error	1.528310608
Observations	17

becomes 1 when I add more variables

ANOVA

	df	SS	MS	F	Significance F
Regression	9	493.858723	54.87319144	23.49291809	0.000200931
Residual	7	16.3501332	2.335733315		
Total	16	510.2088562			

		Coefficients	Standard Error	t Stat	P-value	Lower 95%
	Intercept	8.693138775	7.32428245	1.186892892	0.273983031	-8.626037131
x4	Bring Tack down	1.239780705	0.449014104	2.761117513	0.028050768	0.178031066
x5	Horse from Paddock	1.263125184	0.564910335	2.23597464	0.060435742	-0.072675495
x6	Horse on Xties	2.460657086	3.04674686	0.80763424	0.445873423	-4.743754428
x7	Curry/shed blade	0.926801188	0.424590735	2.182810674	0.065368898	-0.07719636
x8	Hard brush	1.027440354	0.484259843	2.121671597	0.071544682	-0.117652214
x9	Soft brush	0.555839059	0.639234435	0.869538667	0.41337234	-0.955710189
x10	Mane Tail	0.792858588	0.551335788	1.438068423	0.193578449	-0.510843388
x11	Pick hoofs	1.876265765	0.961783498	1.950819253	0.092056391	-0.397990819
x12	Hoof oil	0.710911838	0.292878518	2.427326671	0.045599103	0.018364192

***Note**: I selected these input variables because I have little control over tacking my horse (x13). Over the last 40 years I have found every shortcut possible. Horses are animals and can be distracted or uncooperative. This is not something I can control. In addition, walking my horse to the ring (x14) is dependent on things I cannot control - how many others are also tacking horses on the aisle, how quickly they move, how long I have to wait to enter the ring due to activity in the ring – also beyond my control.*

1st Iteration Analysis

As shown, I did have a low significance F (.0002), so I knew that at least one of my coefficients was doing a good job predicting my total time. Adjusted R^2 was also strong with .9268, so I ran my regression again using only *x4*, *x5*, *x7*, *x8*, *x11* and *x12*.

2nd Iteration

Regression Statistics	
Multiple R	0.978927758
R Square	0.958299555
Adjusted R Square	0.933279288
Standard Error	1.458627309
Observations	17

ANOVA

	df	SS	MS	F	Significance F
Regression	6	488.93292	81.48881999	38.30093257	0.0000025
Residual	10	21.27593626	2.127593626		
Total	16	510.2088562			

		Coefficients	Standard Error	t Stat	P-value	Lower 95%
	Intercept	16.48668924	3.616394644	4.558874476	0.00104395	8.428859827
x4	Bring Tack down	0.965258607	0.383649738	2.515989226	0.030596942	0.11043372
x5	Horse from Paddock	0.718747666	0.228349207	3.147581176	0.010375543	0.209953926
x7	Curry/shed blade	0.692540096	0.321005984	2.157405566	0.056355803	-0.022705808
x8	Hard brush	0.742990387	0.415873864	1.786576296	0.104306222	-0.183634326
x11	Pick hoofs	2.774819473	0.675506347	4.107762254	0.002118116	1.269697537
x12	Hoof oil	0.932611059	0.230200264	4.051303167	0.002318718	0.419692907

2nd Iteration Analysis

The significance F was smaller (.0000025) and Adjusted R^2 was larger (.9333), so I ran one more iteration with just *x4*, *x5*, *x11* and *x12*.

3rd Iteration

Regression Statistics	
Multiple R	0.9654852
R Square	0.9321616
Adjusted R Square	0.9095488
Standard Error	1.6983265
Observations	17.0000000

ANOVA

	df	SS	MS	F	Significance F
Regression	4.0000000	475.5971017	118.8992754	41.2227385	0.0000006
Residual	12.0000000	34.6117545	2.8843129		
Total	16.0000000	510.2088562			

		Coefficients	Standard Error	t Stat	P-value	Lower 95%
	Intercept	23.4449356	2.5245399	9.2868152	0.0000008	17.9444356
x4	Bring Tack down	0.8573331	0.4261194	2.0119550	0.0672290	-0.0711014
x5	Horse from Paddock	0.6933288	0.2187507	3.1694925	0.0080772	0.2167119
x11	Pick hoofs	2.9811019	0.5744815	5.1892046	0.0002259	1.7294143
x12	Hoof oil	1.1392263	0.2369741	4.8073868	0.0004281	0.6229040

3rd Iteration Analysis

The significance F was even smaller (.0000006) but Adjusted R^2 was smaller (.9095), but it became clear to me that *x4*, *x5* and *x12* all were impacting predicting the total time for preparation.

Chi-Squared Test for Independence

Determining the Test for Chi-Squared Test for Independence
There were two discrete variables that were captured as part of my data measurement. The Chi-Squared test for independence was to determine if the horse was outside or inside (*x1*) when I arrived to ride had a relationship to the total preparation time (*y*).

Hypothesis

- H_0 = Horse Location and Total Preparation Time are Independent
- H_a = Horse Location and Total Preparation Time are not independent
- $\alpha = 0.05$
- Categories: Total Minutes > 50 (defect)
  and Total Minutes ≤ 50 (desired)

Before Improvement Data (Observed)

	Horse In	Horse Out	Total
TM > 50	1	7	8
TM <= 50	4	5	9
	5	12	17

Before Improvement Data (Expected)

	Horse In	Horse Out	Total
TM > 50	2.352941176	5.647058824	8
TM <= 50	2.647058824	6.352941176	9
	5	12	17

Probability Result
Using the CHISQ.TEST function in Excel, the probability for this data was ***p* = 0.149072804** so approximately 0.15 which is larger than our $\alpha = 0.05$, so we would **Accept** our H_0 and conclude that horse location (inside or out) and the total preparation time are indeed independent.

NOTE: Risks of Sample Size
Unfortunately, my sample size if very small and does not meet the requirements for a Chi-Squared test, but I ran the analysis regardless. In my case, the small sample size probably did affect the conclusions, as I had to accept the null hypothesis that the location of my horse (inside or out) and how long it takes me to prepare for riding are independent.

For More Fun
I did the test again with both before and after improvement data – where I had improved the process by having someone bring my horse inside each day.

All Data (Observed)

	Horse In	Horse Out	Total
TM > 50	2	8	10
TM <= 50	13	7	20
	15	15	30

All Data (Expected)

	Horse In	Horse Out	Total
TM > 50	5	5	10
TM <= 50	10	10	20
	15	15	30

Result of All Data
In this case, our ***p* = 0.02013675** meaning that I would **Reject** the H_0 and conclude that horse location (inside or out) and the total preparation time are not independent and there is some affect on the total time based on horse location.

Is My Process In Control?

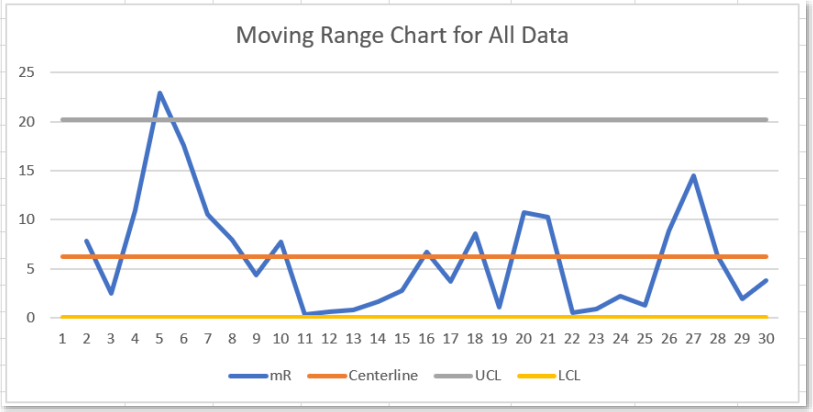
Now I need to confirm that my process is in control. In this case, I looked at all the data. If a data point is out of control, this is a signal that something might need to be investigated. We also want to look to see if there are any patterns. In my data, the first 17 day points represent my pre-improved process and the last 13 points represent my improved process.

Since I only have one data point in my continuous data per day (total time per day to prepare to ride) or $n = 1$, then I must do a moving range charts (xMR and iMR).

Control Chart (xMR)

For the xMoving Range Chart, the following information was used:

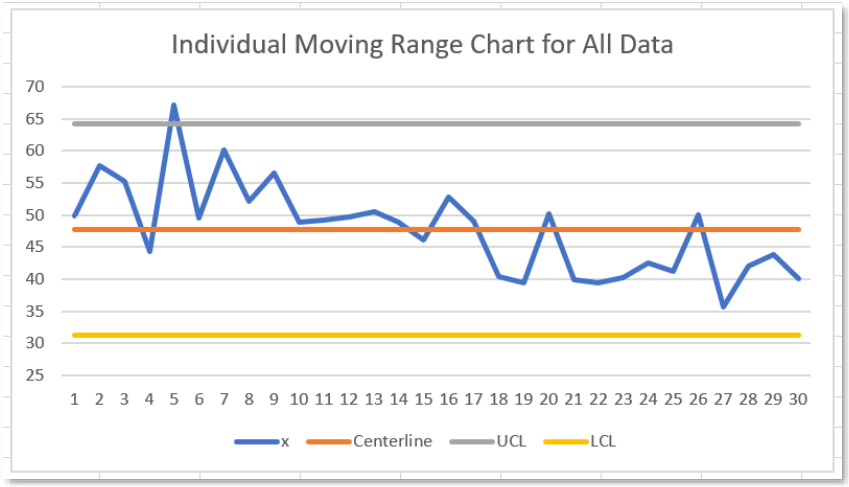
- *mRbar* = 6.186207 = Centerline
- UCL = D4**mRbar* = 16.935875
- LCL = D3**mRbar* = 0.00
- D4 = 3.27 from chart with $n = 2$
- D3 = 0.00 from chart with $n = 2$



Control Chart (iMR)

For the Individual Moving Range Chart, the following information was used:

- $\bar{x}$ = 47.74333
- UCL = $\bar{x}$ +E2**mRbar* = 64.19864
- LCL = $\bar{x}$ -E2**mRbar* = 31.28802
- E2 = 2.66 from chart with $n = 2$



The above charts indicate that the process is under control, with the exception of Day 5 (10/14/2018). On this day, I took more than over 11 minutes to bring my tack downstairs, 5 minutes to bring my horse in (he was likely eating and did not want to come to me) and then 14 minutes to take up. I must have been chatting and distracted that day, or my horse was uncooperative.
In addition, the overall time continues to remain lowers after improvement. Need to monitor to maintain that improvement.

Overall Outcome and Conclusions

Overall Conclusions

I found some overall conclusions based on the tests that I used as well as the data collection that I felt were worthy of sharing.

Biggest Impact: I was able to shave off, in most cases, 10 minutes off my preparation time, so my goals were met!

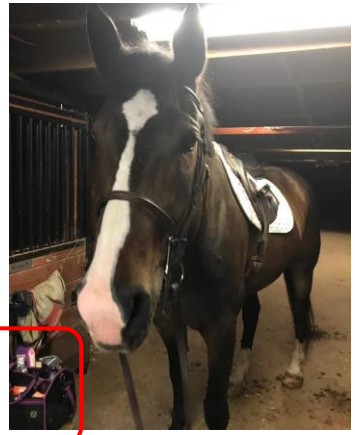
Mean	41.90769231
Standard Error	1.141478111

Conclusions

- *Distraction* - There were times when my process went a bit off target by talking to others and being distracted even though I knew I had a time constraint. I believe I became more aware of this and tried to minimize this in my post-improvement process and that had overall benefits. I am very chatty and did become a hinderance to my process.
- *Uncontrollable Forces* – The process I tried to improve has many things that are completely uncontrollable and I got frustrated sometimes. These include:
    - *Dirty Horse* - Some days, they come in from outside clean and brushing and other tasks are a breeze. Other times, they decide to roll around in the mud. There is nothing that can control this, so it had an effect on my data, but was out of my control.
    - *Cooperation* – These are animals and some times they just do not feel like cooperating. For example, instead of coming to the gate when asked in the paddock, they may decide to play tag with you instead. Or, they may not stand still on the cross ties when you try to put their boots on or try to pick up their feet.
    - *Other People* – At a barn with over 40 horses, there are always others preparing to ride, riding or untacking and putting horses away. How much time it takes to get people's attention so you can pass them on the narrow aisle, or get into the ring while they are riding, etc. is something that it not something I can control.
    - *Traffic* – sometimes my entire process was out of whack because I was stuck in traffic after work and got to the barn much later. I still went through the process on these days, but this is something that I cannot control.
- *Awareness* – this goes back to distraction. Once I started tracking my time, I became more aware. I instinctively started to do things faster. I also found that I was encouraged to improve by just the mere task of keeping track of how much time things actually take. Much of this just happened by default.
- *Analysis* – only work with what you can control, not what you cannot.

Photo Background

Photos for Background
Since my use case for this project can be considered a bit different and hard to visualize, I felt it might help to provide some photos to back up my data.



brushes

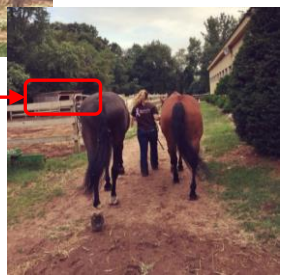
Saddle/tack

Horse Aisle with Stall, Brushes and Tack Available

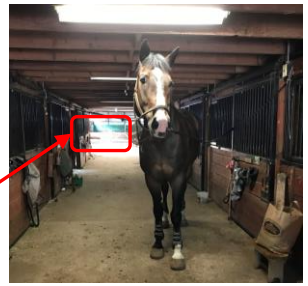
Horse Hoof Before and After Oil

(Typical) Horse Before Preparation

Horse Paddock
(see shed location)



Horse in Paddock in relationship to Barn



Riding ring entrance

View from Horse on Aisle to Ring for riding

Horse Clean, Brushed and Tacked for Riding