Six Sigma DMAIC Improvement Story

Project Objective:

To Reduce Number and Cost of PWWM Heavy Fleet Repairs

Last Updated: 10-6-14

Team:

Bill Busutil Danny Diaz Juan Erbella Amy Horton-Tavera Ronald Howard
Nestor Suarez Mayra Morales Larry Wilson Ana Gutierrez Olga Diaz

Ray Scher (Sponsor) Jennifer Moon (Executive Sponsor)

Identify Project Charter

The team developed a team Project Charter.

Project Charter	
Project Name:	To Reduce Cost of maintaining PWWM Heavy Fleet vehicles
Problem/Impact:	Breakdowns in the PWWM Heavy Fleet increase costs and, potentially, may cause service delays.
Expected Benefits:	Improvements will result in reduced repair costs and improved vehicle availability.
Outcome Indicator(s)	Cost of PWWM Heavy Fleet Work Orders (3 month rolling avg.)
Proposed Target(s)	TBD
Time Frame:	May 2014 through September 2014
Strategic Alignment:	Supports the County's Business Plan
In Scope:	PWWM heavy fleet
Out-of-Scope:	PWWM Light Fleet; other County departments' heavy fleet
Authorized by:	Heavy Fleet Decision Analysis Team
Sponsor:	Ray Scher and Jennifer Moon
Team Members:	Amy Horton-Tavera, Mayra Morales, Bill Busutil, Danny Diaz, Nestor Suarez, Juan Erbella, Ronald Howard, Larry Wilson, Ana Gutierrez, Olga Diaz
Process Owner(s):	Lester Sola, Alina Hudak
Mgmt Review Team:	Ray Scher, Jennifer Moon
Completion Date:	9 / 31 / 2014
Review Dates:	Periodic and Final Review in October 2014
Key Milestone Dates:	See Action Plan

Develop Project Timeline Plan

The team developed a timeline plan to complete the Project.

Legend:	
	= Actual
	= Proposed

WHAT: Complete DMAIC Story Project

DMAIC Story Process Step	WHO	WHEN					
		2014					
		May	June	July	Aug	Sept	Oct
1. Define	Team						
2. Measure	Team						
3. Analyze	Team						
4. Improve	Team / PWWM / ISD						
5. Control	Team / PWWM / ISD						

Define → Measure → Analyze → Improve → Control

Monitor Team Progress

The Team and Management used a Checklist to monitor team progress.

DMAIC Story Checkpoints			
PLAN	Step 1 Define	**Objective: Demonstrate the importance of improvement needs in measurable terms.**	▪Team identified an indicator; developed a Flowchart and a Spreadsheet
		1. The stakeholders' need(s) were identified.	
		2. The problem can be described as an "object" with a "defect" with unknown cause(s) that need to be identified.	
		3. A line graph outcome indicator was constructed that appropriately measures the problem (or gap).	
		4. A schedule for completing the five DMAIC Story steps was developed.	
	Step 2 Measure	**Objective: Investigate the features of the indicator, stratify the problem and set a target for improvement.**	▪Paretos; Histograms; Bar Charts
		5. Data contained or directly linked to the indicator were stratified from various viewpoints (i.e., what, where, when and who) and a significant dataset was chosen.	
		6. A target for improvement was established based on the stakeholders' need.	
		7. The impact of the target on the indicator was determined.	
		8. A problem statement that describes the "remaining dataset" was developed.	
	Step 3 Analyze	**Objective: Analyze the stratified data to identify and verify the root causes.**	▪Single Case Bore; Fishbone ; RC Verification Matrix; Boxplots
		9. Cause and effect analysis was taken to the root level.	
		10. Potential causes most likely to have the greatest impact on the problem were selected.	
		11. A relationship between the root causes and the problem was verified with data.	
		12. The impact of each root cause on the gap was determined.	
DO	Step 4 Improve	**Objective: Develop and implement countermeasures to eliminate the verified root causes of the problem.**	▪Countermeasures Matrix; Failure Mode and Effects Analysis; Barriers and Aids; Action Plan
		13. Countermeasures were selected to address verified root causes.	
		14. The method for selecting the appropriate countermeasures was clear and considered effectiveness and feasibility.	
		15. Barriers and aids were determined for countermeasures worth implementing.	
		16. The action plan reflected accountability and schedule.	
CHECK		**Objective: Confirm that the countermeasures taken impacted the root causes and the problem; and that the target has been met.**	▪Line Graph
		17. The effect of countermeasures on the root causes was demonstrated.	
		18. The effect of countermeasures on the problem (or indicator) was demonstrated.	
		19. The improvement target was achieved and causes of significant variation were addressed.	
		20. The effect of countermeasures on the indicator representing the stakeholders' need was demonstrated.	
ACT	Step 5 Control	**Objective: Prevent the problem and its root causes from recurring. Maintain and share the gains.**	▪Process Flowchart; Process Control Chart
		21. A method was established to document, permanently change, and communicate the revised process or standard.	
		22. Responsibility was assigned and periodic checks scheduled to ensure compliance with the revised process or standard.	
		23. Specific areas for replication were identified.	
		Objective: Evaluate the team's effectiveness and plan future activities.	▪Lessons Learned
		24. Any remaining problems (or gaps) were addressed.	
		25. Lessons learned, P-D-C-A of the Story process, & team growth were assessed & documented.	

Define → Measure → Analyze → Improve → Control

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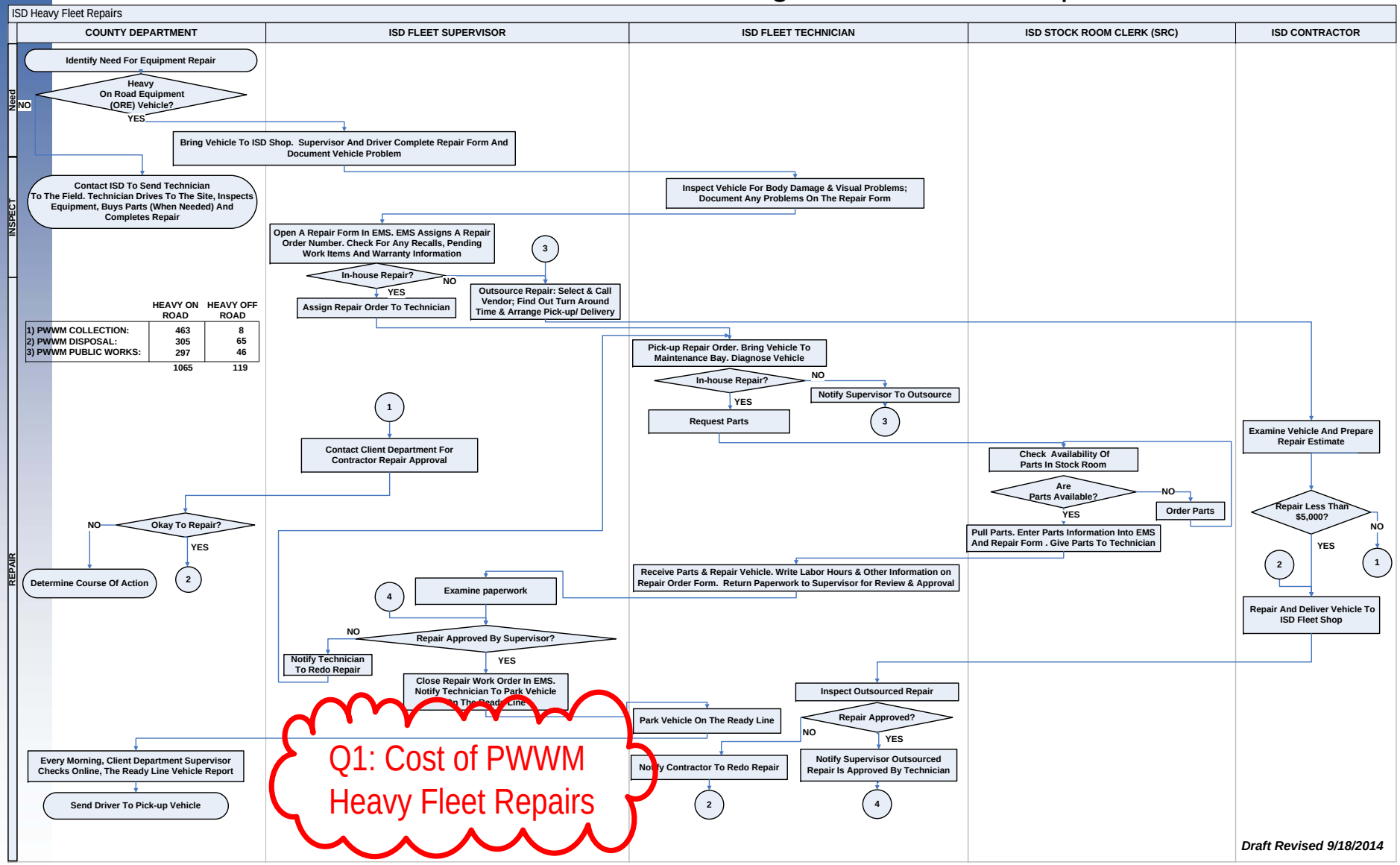
Review Process Flow Chart

The team constructed a flow chart describing the Work Order process.



Next, the team considered how to capture indicator data.

Identify Data Collection Needs

The team developed a data collection spreadsheet…each row is a *Vehicle*.

WHAT			WHERE	
Equipment Number	Equipment Description	Average Mileage (or Hours in Operation) at Work Order Intake	Equipment Division Description	Q1: Total Work Order Cost FY 2012-13
060840	AUTOMATED GARBAGE TRUCK	68,547	PWWM COLLECTION	$ 90,301
060917	AUTOMATED GARBAGE TRUCK	72,179	PWWM COLLECTION	$ 65,089
170111	VACTOR TRUCK	39,725	PWWM PUBLIC WORKS	$ 41,245
132124	STEP VAN	78,436	PWWM DISPOSAL	$ 8,506

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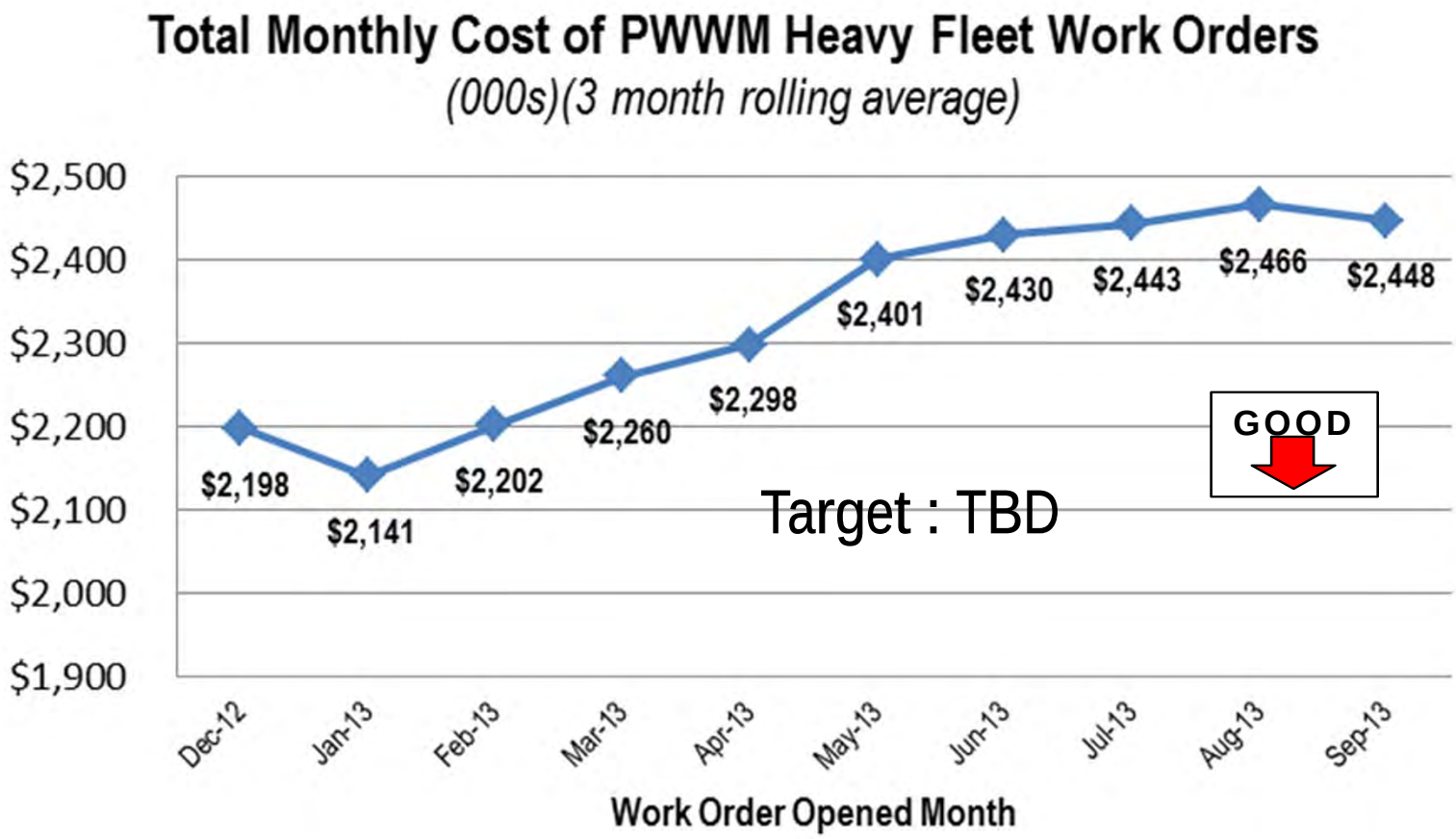
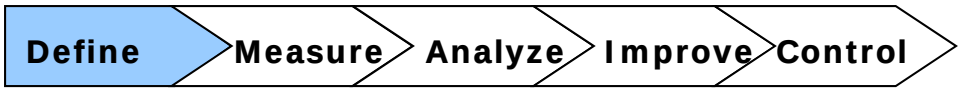
Review Selected Indicator

The team collected outcome indicator data from December 2012 to September 2013 and reviewed performance trends:

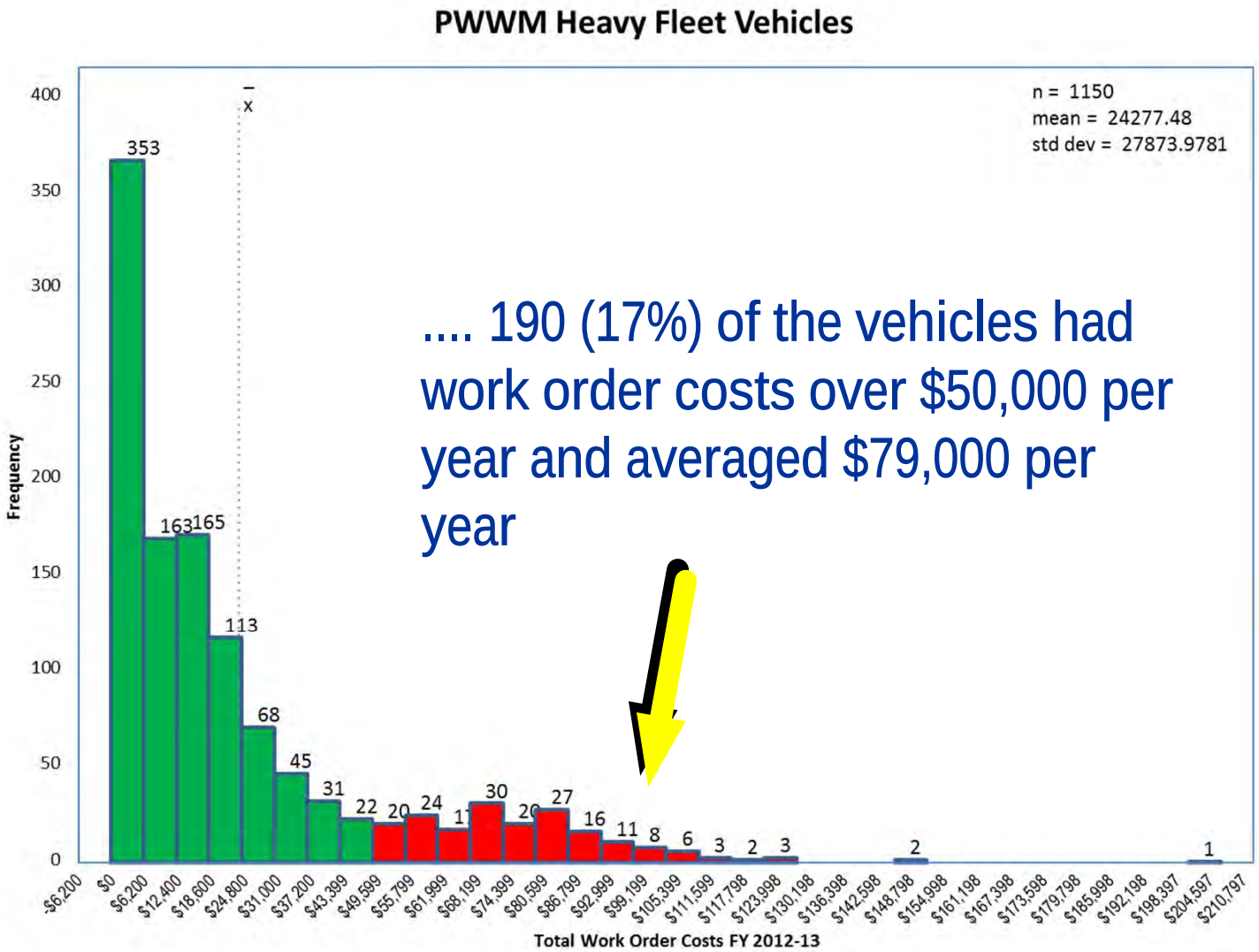


The team looked closer at PWWM heavy fleet vehicles and their work order costs from October 2012 to September 2013.



Stratify the Problem

The team stratified the Work Order total cost data using a histogram and found…

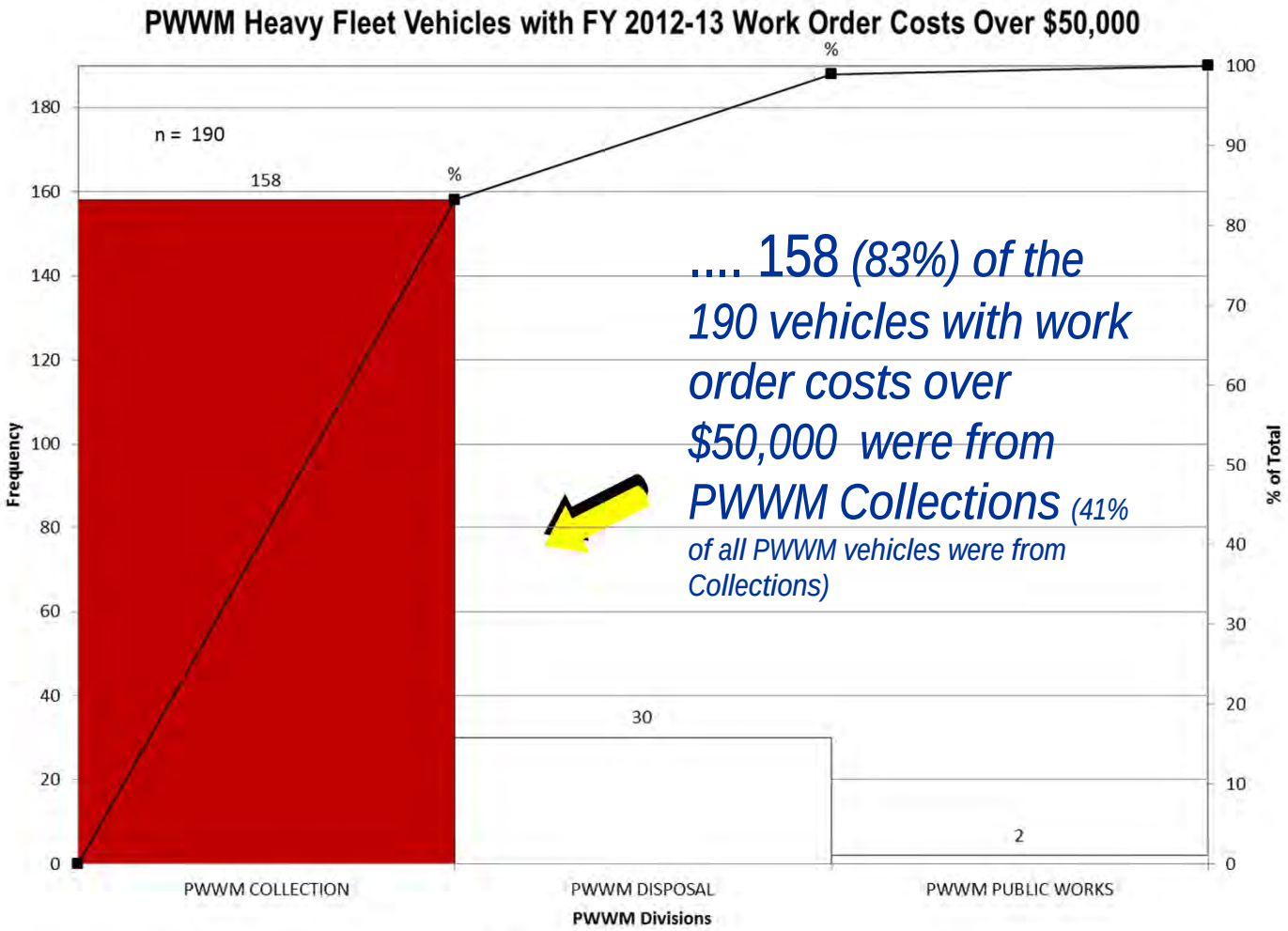


The team looked closer at the vehicles with the highest total cost.

Define | Measure | Analyze | Improve | Control

Stratify the Problem

The team stratified the 190 PWWM Heavy Fleet vehicles with annual work order costs over $50,000 and found…

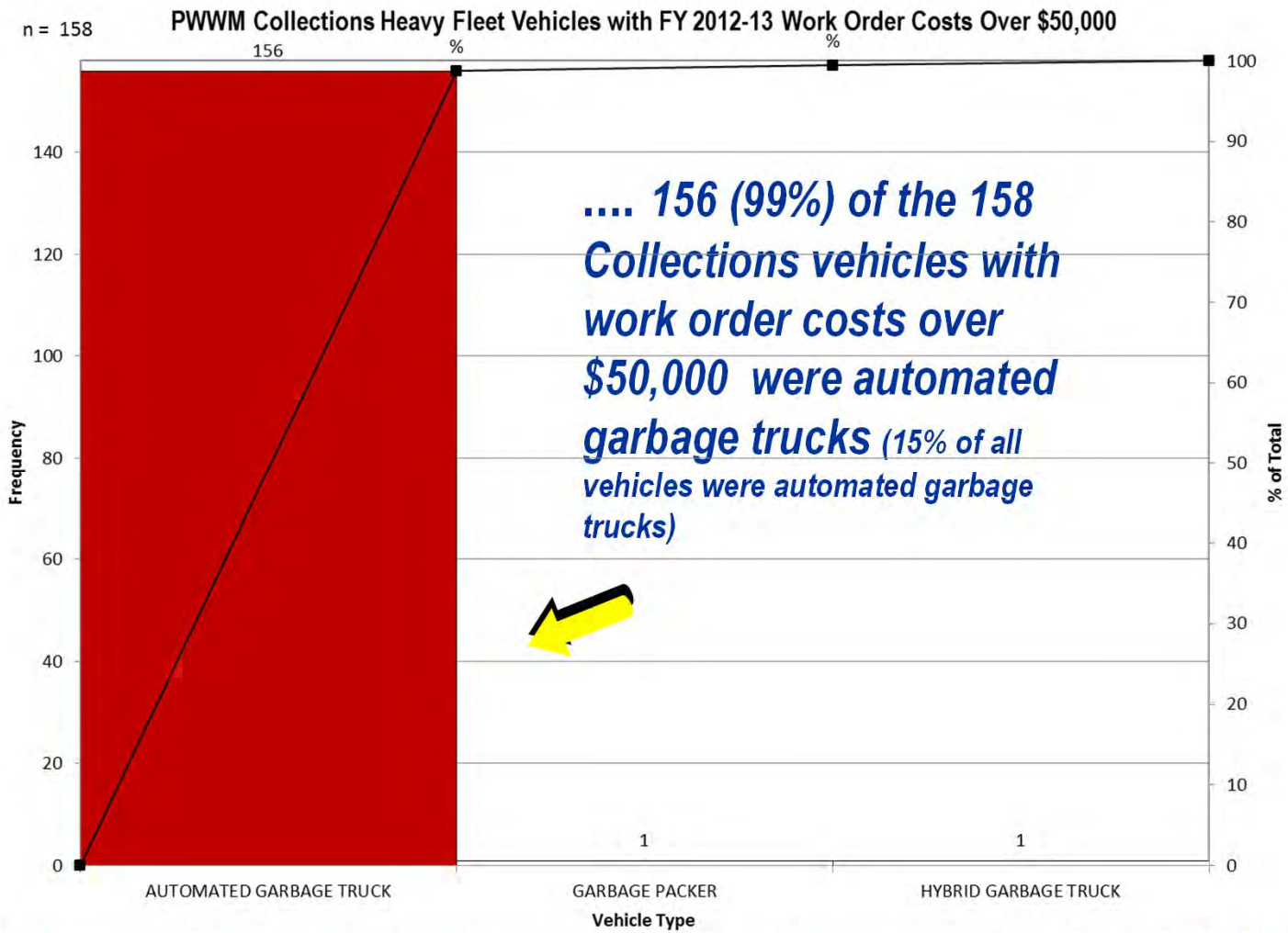


The Team looked closer at these vehicles…

Define | Measure | Analyze | Improve | Control

Stratify the Problem

The team stratified the 158 PWWM Collections Heavy Fleet vehicles with annual work order costs over $50,000 and found…



Problem Statement: "156 automated garbage trucks had work order costs over $50,000 in FY 2012-13."

Define | Measure | Analyze | Improve | Control

Identify Potential Root Causes

The team reviewed additional data regarding these vehicles.

Costliest Work Order Types

(All automated garbage trucks in FY 2012-13)

Primary Repair Description	Number of Repair Orders FY 2012-13	Sum of Total Cost	Sum of PARTCOST	Sum of LABORCOST	Sum of Commercial Cost	Average Labor Hours per Repair Order	Average Parts Cost per Repair Order	Avg. Annual Repair Orders per Truck	Avg. Repair Orders per Truck, per Month
TIRES	5,694	$ 2,484,662	$ 2,171,997	$ 312,382	$ 283	0.8	$ 381	31.6	2.6
AUTOMATED PACKER	2,287	$ 1,442,314	$ 661,990	$ 240,776	$ 539,549	1.4	$ 289	12.7	1.1
AUTOMATED ARM	3,903	$ 1,279,924	$ 851,733	$ 421,414	$ 6,777	1.5	$ 218	21.7	1.8
BRAKES	2,588	$ 1,153,274	$ 638,069	$ 303,746	$ 211,460	1.6	$ 247	14.4	1.2
WELDING WORK	[illegible]	$ 1,018,525	$ 340,667	$ 188,4[illegible]	$ 489,379	2.7	$ 363	5.2	0.4
DIAGNOSIS	11,347	[illegible]	[illegible]	$ 737,986	$ 535	0.9	[illegible]	63.0	5.3
HYDRAULICS	2,983	$ 568,324	$ 326,508	$ 239,623	$ 2,194	1.1	$ 109	16.6	1.4
ENGINE	2,947	$ 444,282	$ 84,532	$ 133,641	$ 226,109	0.6	$ 29	16.4	1.4
REBUILT UNIT	2,846	$ 400,009	$ 64	$ [illegible]45	$ -	1.9	$ 0	15.8	1.3
COOLING SYSTEM	2,065	$ 343,003	$ 171,847	$ 16[illegible]53	$ 6,103	1.1	$ 83	11.5	1.0
Other	22,964	$ 3,163,522	$ 1,302,080	$ 1,542[illegible]8	$ 318,974	63	$ 57	128	11
Grand Total	60,563	$ 13,038,146	$ 6,551,272	$ 4,685,[illegible]	$ 1,801,362	1.1	$ 108	336.5	28.0

Tires, automated arm, automated packer and brakes repairs comprised 49% of total work order costs

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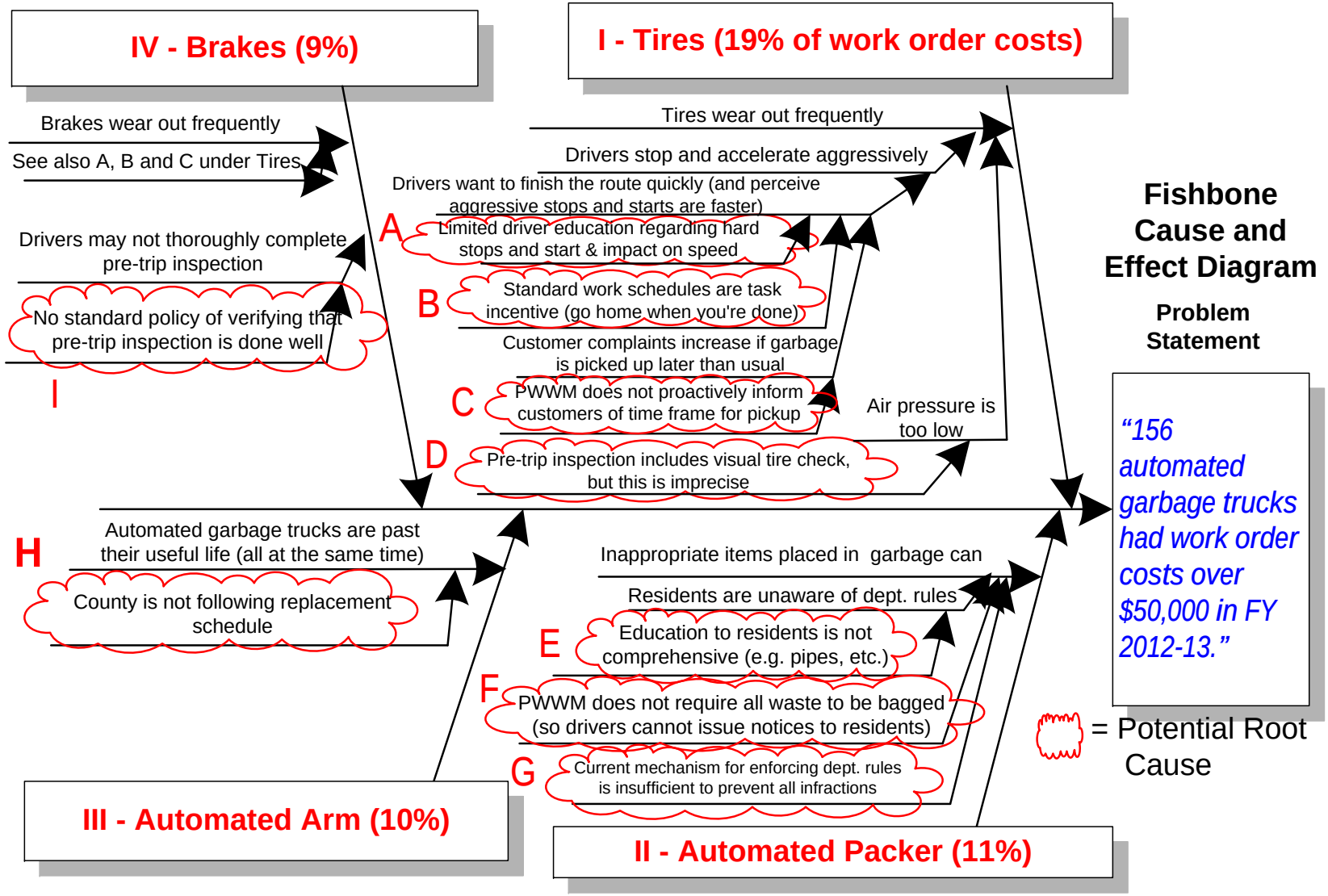
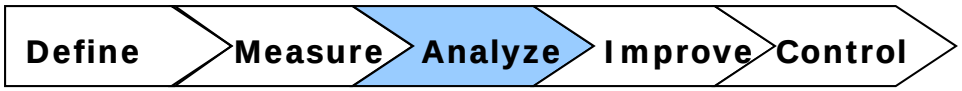
Identify Potential Root Causes

The team completed Cause and Effect Analysis and found…



The team next looked to verify these Potential Root Causes.

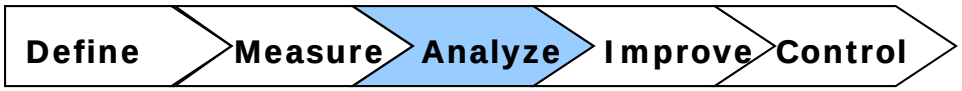


Verify Root Causes

The team collected data to verify the root causes and found….

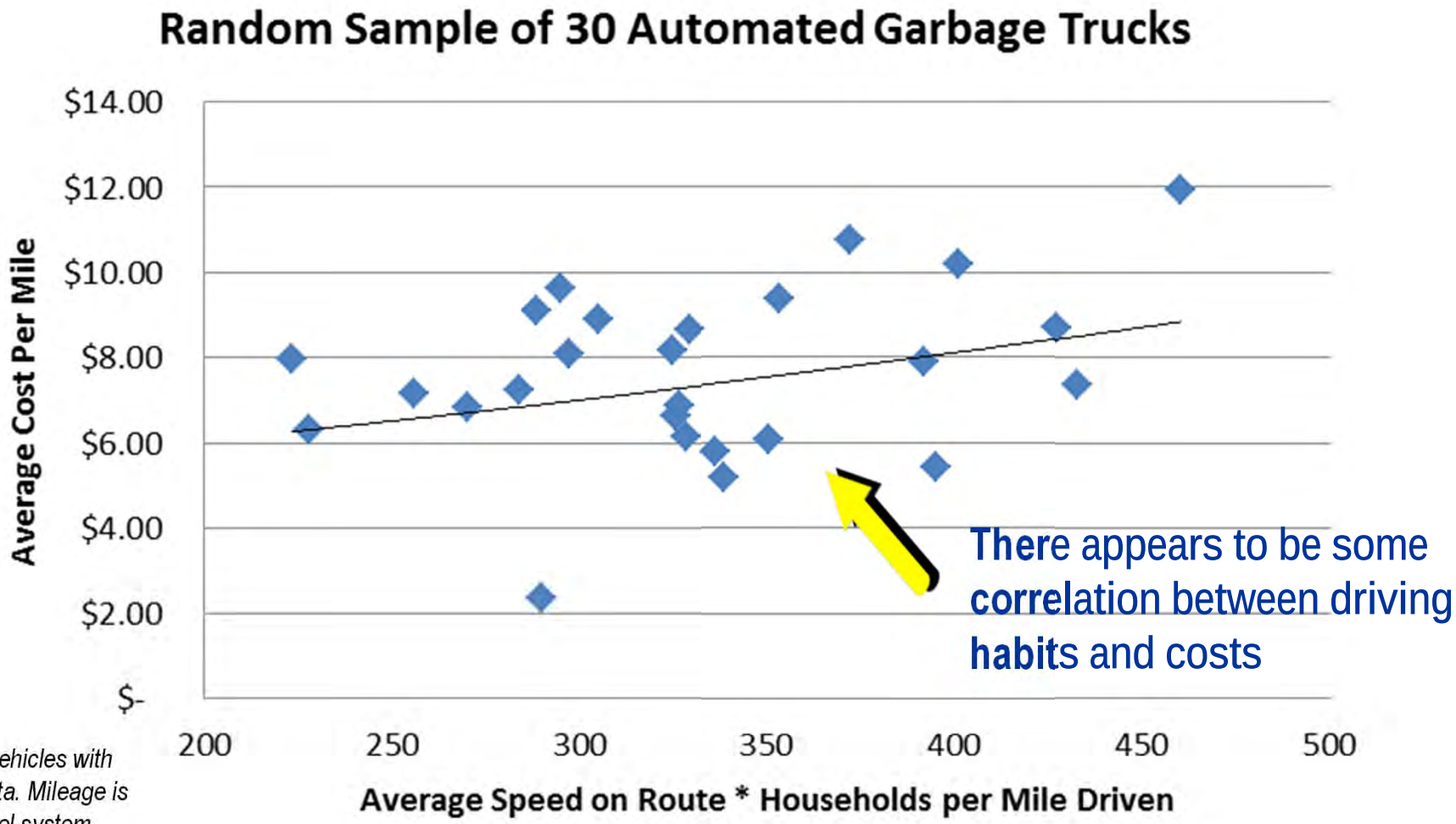
	Potential Root Cause	How Verified?	Root Cause or Symptom
A	Limited driver education regarding hard stops and start & impact on speed	Team verified that there is limited driver education on hard stops and starts for non-hybrid trucks. Team used a scatter diagram to compare driver speed relative to route density with overall vehicle maintenance	Root Cause
B	Standard work schedules are task incentive (go home when you're done)	Team verified current work schedules. Team used a scatter diagram to compare driver speed relative to route density with overall vehicle maintenance costs	Root Cause
C	PWWM does not proactively inform customers of time frame for pickup	Team verified current customer education efforts.	Root Cause
D	Pre-trip inspection includes visual tire check, but this is imprecise	Team verified current pre-trip inspection policies	Root Cause
E	Education to residents is not comprehensive (e.g. pipes, etc.)	Team determined that an annual Waste Guide is provided to residents but this may not include all problematic items or explain consequences of placing these items in the can	Root Cause
F	PWWM does not require all waste to be bagged (so drivers cannot issue notices to residents)	Team verified current policies	Root Cause
G	Current method for enforcing department rules is insufficient to prevent all infractions	Team verified current policies *(Note: Garbage trucks do have camera in hopper and driver issues violation form to resident if inappropriate items are seen. These are referred to code enforcement.)*	Root Cause
H	County is not following replacement schedule	Team verified current policies	Root Cause
I	No standard policy of verifying that pre-trip inspection is done well	Team verified current policies	Root Cause

…**all** were validated as root causes.



Verify Root Causes

The team reviewed additional data regarding a random sample of these vehicles.



Excludes vehicles with missing data. Mileage is from the fuel system. Speed data compares mileage to the time on the road between 7:00 a.m. and the last dump of the day per the scale house system.

Identify and Select Countermeasures

The team brainstormed many countermeasures and narrowed them down to these for evaluation:

Problem Statement	Verified Root Causes		Countermeasures	Ratings (Legend: 5=Extremely, 4=Very, 3=Moderately, 2=Somewhat, 1=Little or)			
				Effectiveness	Feasibility	Overall	Take Action? Yes/No
"156 automated garbage trucks had work order costs over $50,000 in FY 2012-13."	A	Limited driver education regarding hard stops and starts & impact on speed	Develop and implement driving improvement training program	2-3	4-5	8-15	Y
			Explore the use of technology to monitor driving habits	4	3	12	Y
	B	Standard work schedules are task incentive (go home when you're done)	Utilize data from new Route Smart software to identify drivers who complete routes faster than predicted and address any issues	3	4	12	Y
			Establish a working group (to include union participation) to evaluate refinements to current task incentive policy	4	3	12	Y
	C	PWWM does not proactively inform customers of time frame for pickup	Work with PIO / 311 to develop strategy for informing / reminding customers that pick up may occur later in the day	1-2	4-5	4-10	Y (but don't spend a lot)
	D	Pre-trip inspection includes visual tire check, but this is imprecise	Conduct cost-benefit analysis of installing tire pressure monitoring technology on existing and/or new trucks	4	3	12	Y

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Identify and Select Countermeasures

The team brainstormed many countermeasures and narrowed them down to these for evaluation:

Problem Statement	Verified Root Causes		Countermeasures	Ratings: Effectiveness	Feasibility	Overall	Take Action? Yes/No
				Legend: 5=Extremely 4=Very 3=Moderately 2=Somewhat 1=Little or			
"156 automated garbage trucks had work order costs over $50,000 in FY 2012-13."	E	Education to residents is not comprehensive (e.g. pipes, etc.)	Explore placing stickers on garbage can with list of prohibited items (or printing the information on new cans)	3-4	3	9-12	Y
			Include information on prohibited items in school outreach	3	4-5	12-15	Y
			Review / refine Waste Guide and other educational materials & media to address inappropriate items	2	5	10-15	Y
	F	PWWM does not require all waste to be bagged (so drivers cannot issue notices to residents)	Require residents to bag all waste	2	2	4	N
	G	Current enforcement mechanism is insufficient to prevent all infractions	Implement spot checks of garbage cans	2	2	4	N
			Incorporate spot checks into existing code enforcement and supervisor duties as appropriate / feasible	2	5	10	Y
	H	County is not following replacement schedule	Implement replacement schedule	5	2	10	?
	I	Standard procedure for verifying that pre-trip inspection is done well may be ineffective	Review and update inspection policies & procedures (including verification and follow-up), including pre- and post- trip	2-3	4-5	8-15	Y

The team selected 12 countermeasures for implementation.

Define → Measure → Analyze → Improve → Control

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Identify Barriers and Aids

The team performed Barriers and Aids analysis on the selected Countermeasures.

Countermeasure(s): Implement 12 Countermeasues to Reduce Cost of PWWM Heavy Fleet Maintenance

Barriers		Aids	
Impact (H, M, L)	**Forces against Implementation**		**Forces For Implementation**	
L	1) Implementation of training may impact operations *(Supported by Aid: A, B, E)*	A)	PWWM already has good programs for driver training and public education with broad support
M	2) Costs may be high *(Supported by Aid: B, E)*	B)	Everyone wants to achieve cost savings
H	3) Possible resistance to change from employees *(Supported by Aid: C, D)*	C)	Willingness / desire of labor and management to work collaboratively
H	4) Move to CNG may impact replacement schedule (Supported by Aid: B)	D)	Possible opportunities to incentivize savings
		E)	Management is supportive of the project

The team next sought to incorporate this analysis into the team's Action Plan.

Develop and Implement Action Plan

Legend:
■ = Actual
□ = Proposed

The team implemented an Action Plan for the team's Countermeasures.

WHAT: Implement Countermeasures to Reduce Cost of Heavy Fleet Repairs

HOW	WHO	WHEN 2014 Oct	Nov	Dec	2015 Jan	Feb
1. Secure Management Approval of Countermeasures (share benefits and cost savings)	Team					
2. Develop & Implement Countermeasures:						
A1- Develop and implement driving improvement training program	PWWM Garbage Division & Training Specialists					
A2- Explore the use of technology to monitor driving habits	Danny & ISD Fleet					
B1- Utilize data from new Route Smart software to identify drivers who complete routes faster than predicted and address any issues	PWWM Garbage Division (route coordinators)					
B2- Establish a working group (to include union participation) to evaluate refinements to current task incentive policy	PWWM & OMB & Local 3292					
C1- Work with PIO / 311 to develop strategy for informing / reminding customers that pick up may occur later in the day	PIO / 311					
D1- Conduct cost-benefit analysis of installing tire pressure monitoring technology on existing and/or new trucks	Danny & ISD Fleet					
E1- Explore placing stickers on garbage can with list of prohibited items (or printing the information on new cans)	PWWM Garbage Division, PIO					
E2- Include information on prohibited items in school outreach	PWWM PIO					
E3- Review / refine Waste Guide and other educational materials & media to address inappropriate items	PWWM PIO					
G1- Incorporate spot checks into existing code enforcement and supervisor duties as appropriate / feasible	PWWM Garbage & Enforcement					
H1- Implement replacement schedule	County				*ongoing*	
I1- Review and update inspection policies & procedures (including verification and follow-up), including pre- and post- trip	PPWM Garbage, PWWM Fleet, ISD Fleet, Local 3292					
3. Establish On-going responsibilities, standardize countermeasures into operations, and continuously evaluate results	Process Owner				*ongoing*	

Define → Measure → Analyze → **Improve** → Control

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Savings Due to the Implementation of Countermeasures

The team estimated annual automated garbage truck work order cost savings by implementing all selected countermeasures as follows…

	FY 2012-13 Work Order Cost	Estimated Potential Savings (%)	Estimated Potential Savings ($)
Tires, Brakes & Automated Arm	$ 4,917,860	10%	$ 491,786
Automated Packer	$ 1,442,314	15%	$ 216,347
All Other Components and Repair Activities	$ 6,677,972	15%	$ 1,001,696
Total	$ 13,038,146	13%	$ 1,709,829

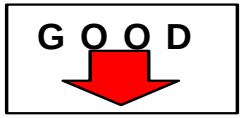
Savings on tires and brakes associated with improvements in driving habits and tire pressure monitoring. Savings on other components associated with adhering to fleet replacement plan (replacement every 6 years), improved pre-trip inspections and improved public education and enforcement. Automated arm savings are lower than other components because accidents may require costly repairs irrespective of vehicle age or other improvements.

This is equivalent to a 6.1% reduction of department-wide heavy fleet work order costs.

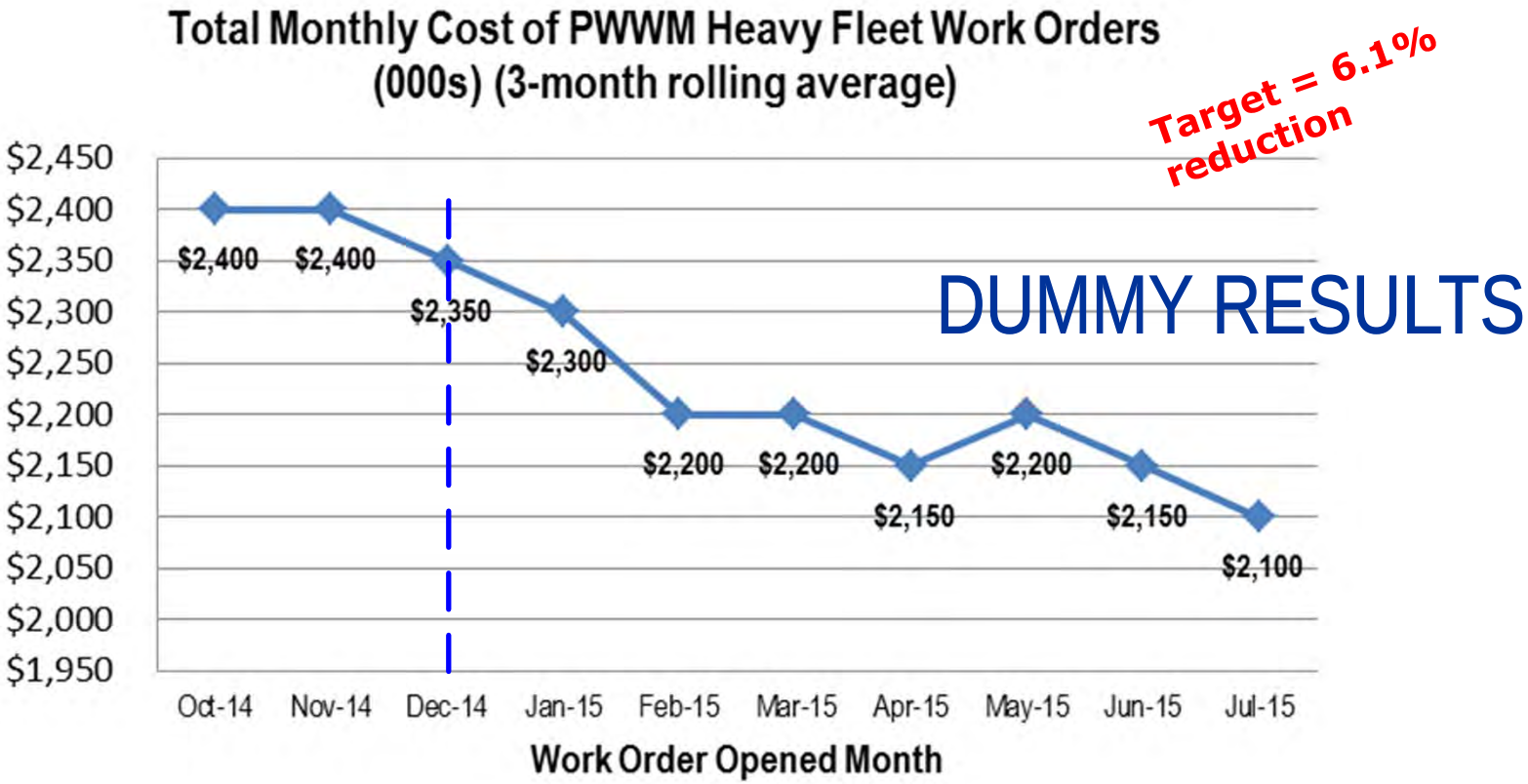
Review Selected Indicator

The team collected indicator data and reviewed results.

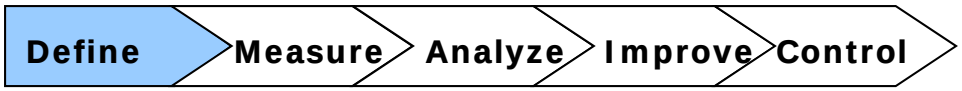
Q1: Total Monthly Cost of PWWM Heavy Fleet Work Orders (3-month rolling avg.)



Countermeasures implemented in December 2014



The team will continue to monitor the countermeasures and results.



Standardize Countermeasures

The team Developed a Process Control System (PCS) to monitor the process on-going.

Process Control System

Process Name: PWWM Heavy Fleet Repairs	**Process Owner:** Alina Hudak, Lester Sola
Process Customer: PWWM, Solid Waste fee payers, County taxpayers	**Critical Customer Requirements:** Heavy Fleet Vehicles Ready and Available to Meet Operational Needs
Process Purpose: Efficiently Maintain PWWM Heavy Fleet	**Current Sigma Level:** TBD
	Outcome Indicators: Q1; others TBD

Process and Quality Indicators			Checking / Indicator Monitoring			Contingency Plans / Misc.
Process Indicators		Control Limits	Data to Collect	Timeframe (Frequency)	Responsibility	• Actions Required for Exceptions • Procedure References
Quality Indicators		Specs/ Targets	What is Checking Item or Indicator Calculation	When to Collect Data?	Who will Check?	
Q1	Monthly Cost of PWWM Heavy Fleet Repairs (3 month rolling average)	6.1% reduction	Monthly Cost of PWWM Heavy Fleet Repairs (3 month rolling average)	Monthly	PWWM Fleet Management	•

Note: Additional process and quality measures will be developed by the Heavy Fleet Working Group as recommended by the PWWM Heavy Fleet Decision Analysis Team.

Approved: _____ Date: _____ Rev #: _____ Rev Date: _____

Define → Measure → Analyze → Improve → **Control**

Other Observations

1) Mileage data in the ISD work order system did not match mileage information from the fuel system and appeared to be inaccurate

2) Automated garbage trucks are in the shop for work every four to five days, on average (see appendix)

3) A random sample of 30 automated garbage trucks yielded an average vehicle age of 7.6 years. One vehicle in the sample was five years old; annual maintenance cost of this vehicle was 54% below the sample average (see appendix)

4) The sample also yielded an average fleet maintenance cost per ton of $34 and an average cost per mile of $9 (see appendix)

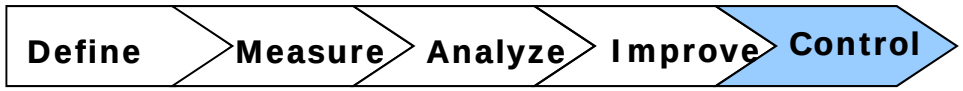
Identify Lessons Learned

Lessons Learned

1) Collaboration between all parties (including operations) was important for project success
2) Experienced employees provide valuable insights
3) Stratification of repair data was very helpful in identifying root causes

Next Steps

1) Continue to monitor the countermeasures and performance results.



Questions?

APPENDIX:

ADDITIONAL INFORMATION REGARDING AUTOMATED GARBAGE TRUCKS

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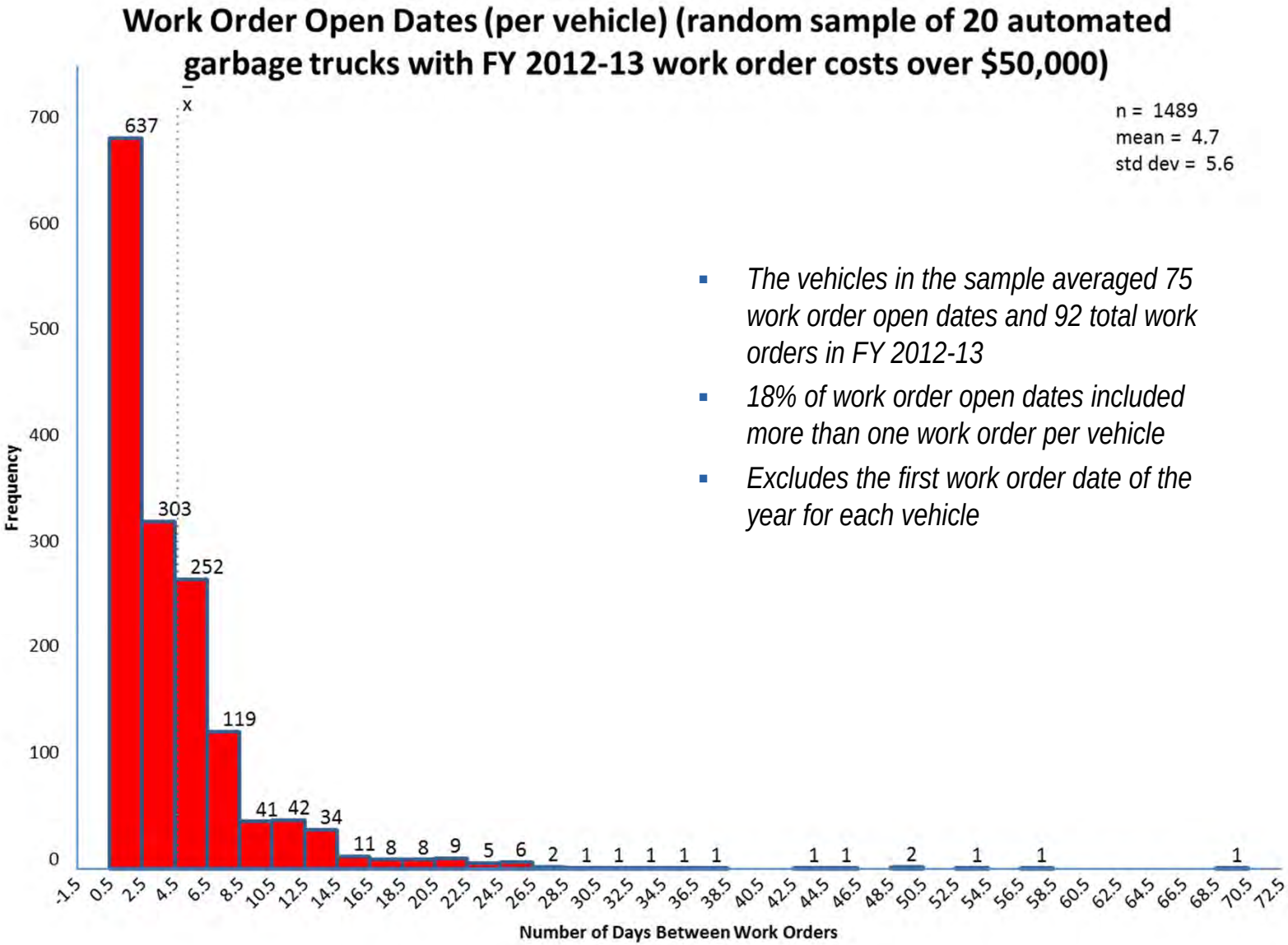
Appendix: Days Between Work Orders

The team looked at how frequently automated garbage trucks were in the shop.



- *The vehicles in the sample averaged 75 work order open dates and 92 total work orders in FY 2012-13*
- *18% of work order open dates included more than one work order per vehicle*
- *Excludes the first work order date of the year for each vehicle*

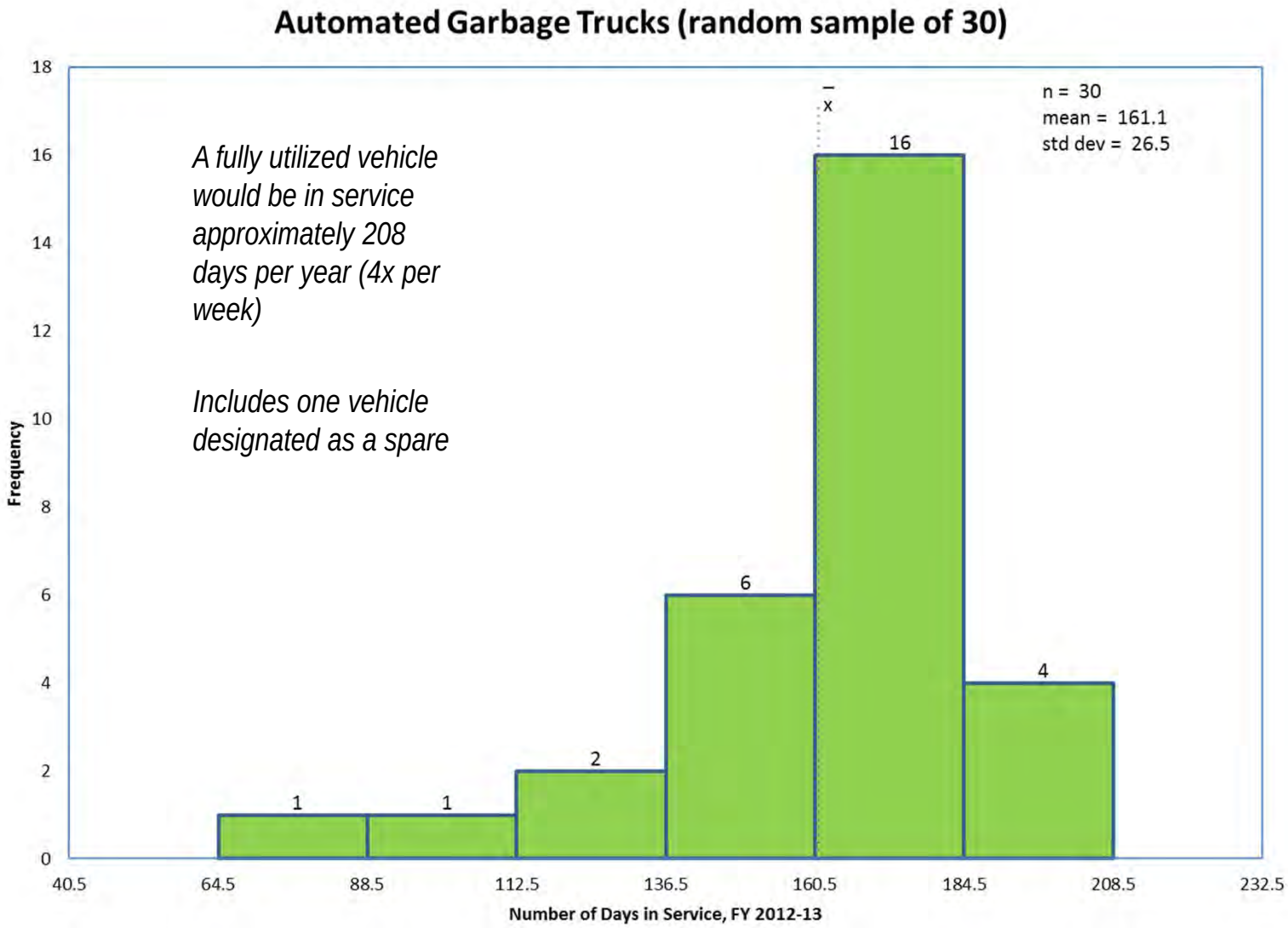
Define → Measure → Analyze → Improve → Control

Appendix: General Information on Automated Garbage Trucks

The team reviewed a random sample of 30 automated garbage trucks and examined additional data regarding these vehicles (for FY 2012-13).

Mfr.	# Vehicles	Avg. Age	Avg. # Trips	Avg. Maint. Cost	Avg. Net Tons	Avg. Maint. Cost per Ton	Avg. Miles Driven	Avg. Maint. Cost per Mile
AMRLAF	13	7	277	$ 85,410	2,471	$ 38	11,058	$ 8.49
PETERBILT	16	8.25	264	$ 72,078	2,334	$ 31	9,633	$ 9.73
AUTOCAR	1	5	209	$ 43,281	2,131	$ 20	7,047	$ 6.14
Grand Total	30	7.6	268	$ 76,895	2,386	$ 34	10,133	$ 9.09

Appendix: Automated Garbage Trucks Days in Service

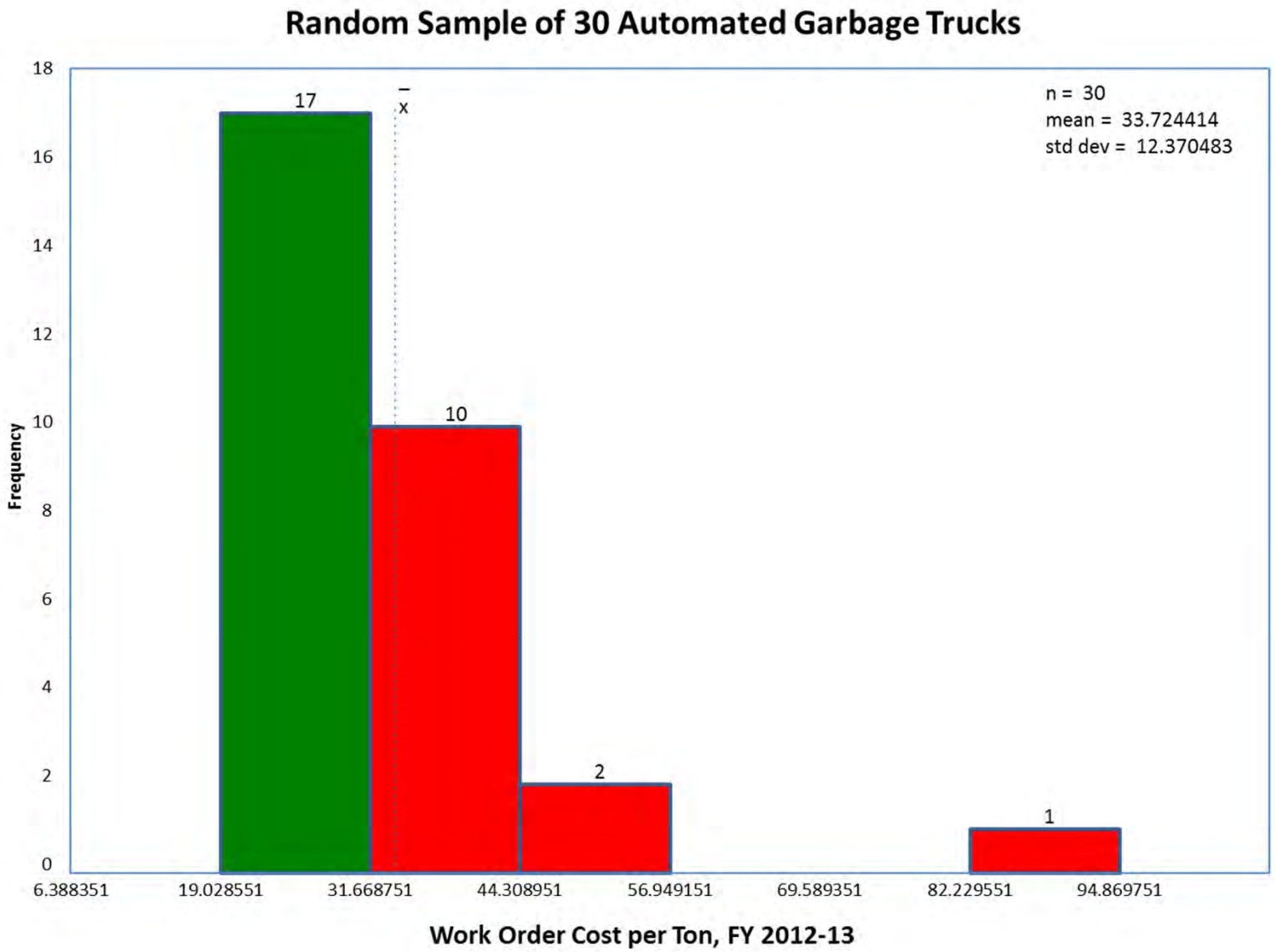


A fully utilized vehicle would be in service approximately 208 days per year (4x per week)

Includes one vehicle designated as a spare

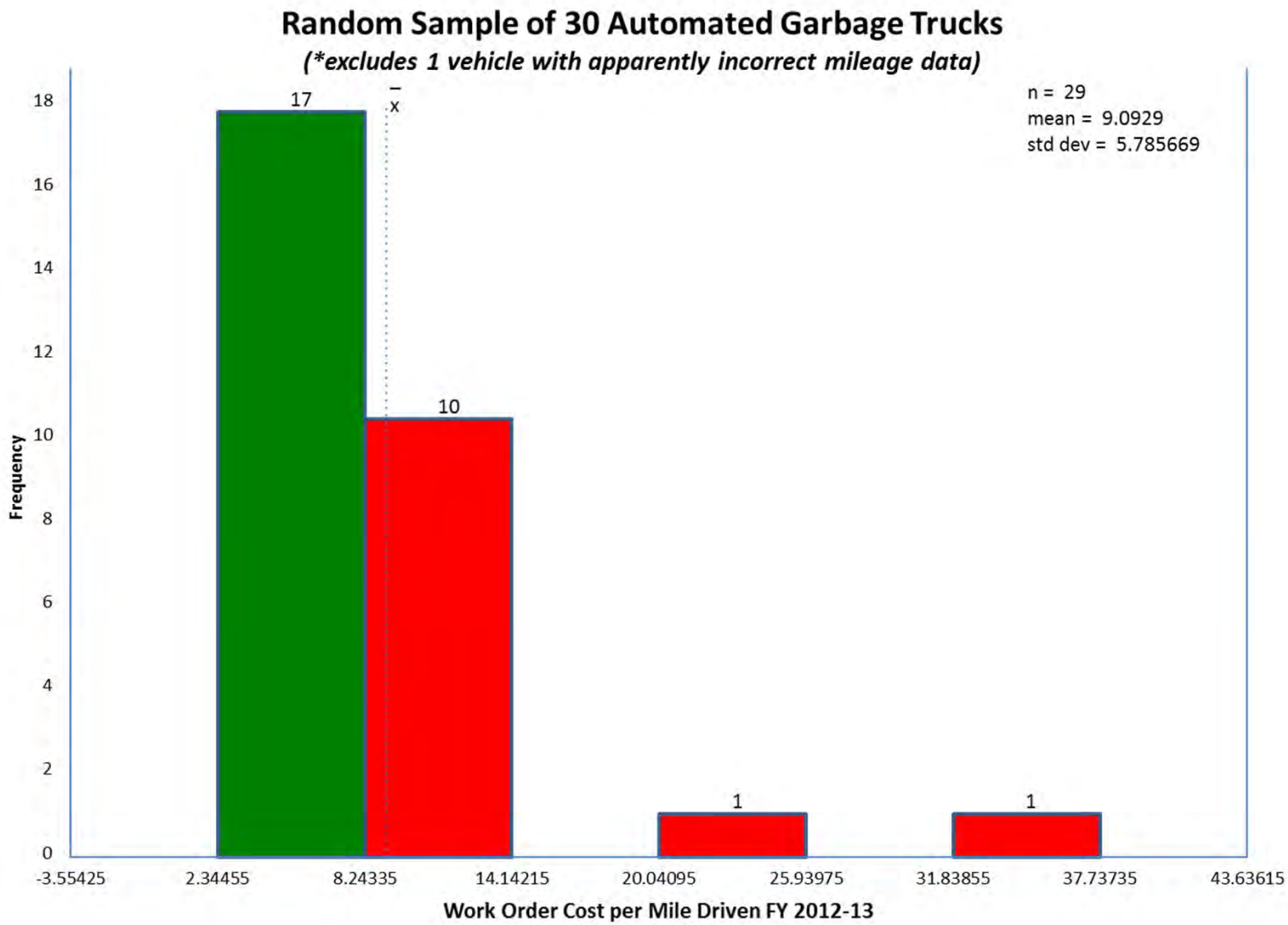
Define > Measure > Analyze > Improve > Control

Appendix: Work Order Cost per Ton



Define | Measure | Analyze | Improve | Control

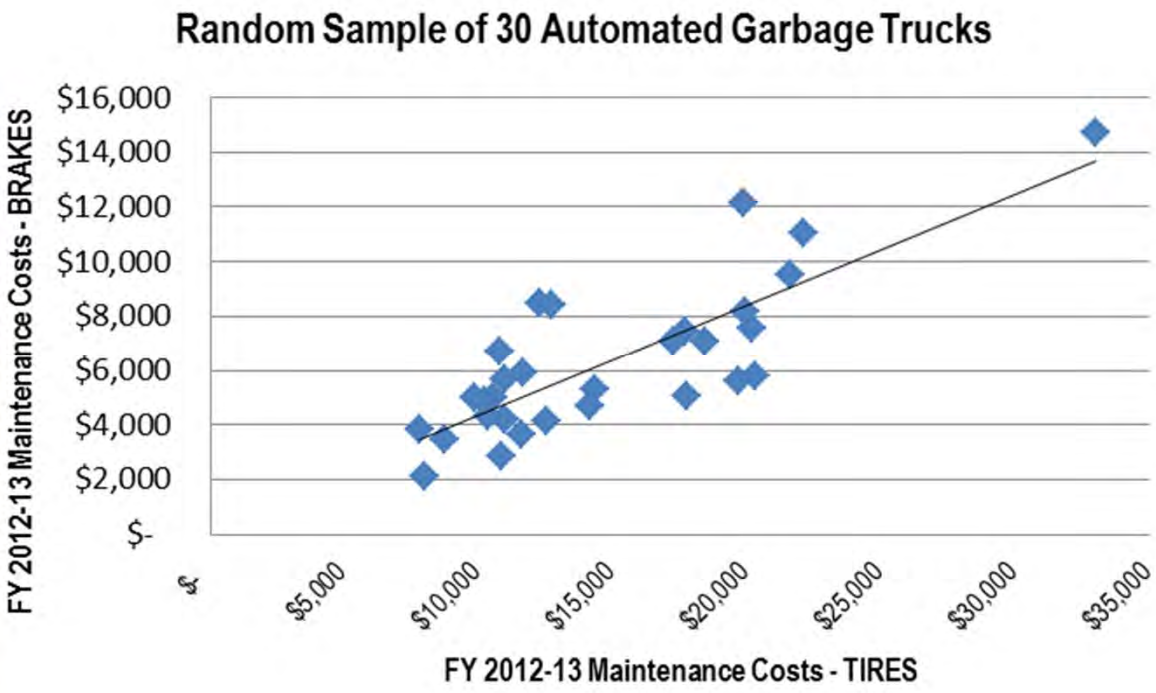
Appendix: Work Order Cost per Mile

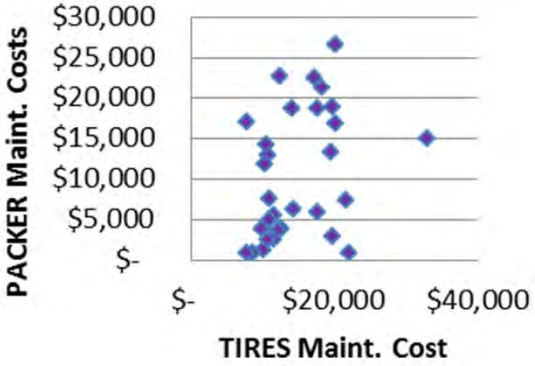


Define > Measure > Analyze > Improve > Control

MIAMI-DADE COUNTY

Appendix: Correlation Between Repair Types





Maintenance costs of tires and brakes are highly correlated.