



Six Sigma DMAIC Improvement Story

Black Belt Project Objective:
**To Reduce Number and Cost
of Fire Rescue Heavy Fleet Repairs**

Last Updated: 3-3-14

Team: ***Emergency Responders***

Mayra Morales (Team Leader)

Bill Busutil Chief Vince Lombardi Chief Millard Jenkins II Jim Moore Chris Koop



Ray Scher (Sponsor)

Chief Fernando Fernandez (Sponsor)



Select Problem

Management reviewed many problems using a selection Matrix.

Situation Appraisal Matrix

Concerns (Specific separated concerns)	Type Concern (Methodology to Address Concern)	Customer/ Stakeholder	Selection Criteria			Disposition
			A Impact on Customer (Accuracy/ Cost /Timeliness)	B Need to Improve (Performance Gap)	C=A*B Overall	
1 Select Best Method To Maintain PWWM Heavy Fleet	Decision Analysis	PWWM Mgmt/ Taxpayers	5	4	20	OMB Project
2 PWWM Heavy Fleet Repair Costs Are Too High	DMAIC	PWWM Mgmt/ Taxpayers	5	4	20	Assigned After # 1 Above Completed
3 Fire Rescue Heavy Fleet Repair Costs Are Too High	DMAIC	Fire Rescue Mgmt/ Taxpayers	4	4	16	Black Belt Certification Project
4 Select Best Method To Maintain Miami-Dade Light Fleet	Decision Analysis		4	3	12	Deferred
			Rating Scores: 5= Extreme 3= Moderate 4= High 2= Low 1=None			

“Fire Rescue Heavy Fleet Repair Costs Are Too High” was selected and assigned to this team by management.



Identify Project Charter

The team developed a team Project Charter.

Project Charter		
Business Case	Project Name:	To Reduce Number and Cost of Fire Rescue Heavy Fleet Repairs 2✓
	Problem/Impact:	Fire Rescue services are essential to public health, safety and well being. Breakdowns in the Fire Rescue Heavy Fleet increase costs and may cause delays in response time, when fewer vehicles are ready to respond to emergencies. 1✓
	Expected Benefits:	Improvements will result in reduced repair costs and improved emergency response time.
Objectives	Outcome Indicator(s)	Q2- Fiscal Year -to-Date Cost of Fire Rescue Heavy Fleet Repairs
	Proposed Target(s)	Target= 10% reduction from previous fiscal year
	Time Frame:	August 2013 through December 2013
	Strategic Alignment:	Supports the County's Business Plan
Scope	In Scope:	Fire Rescue Heavy Fleet
	Out-of-Scope:	Fire Rescue Light Fleet
	Authorized by:	Chief Fernando Fernandez and Chief Vince Lombardi
Team	Sponsor:	Ray Scher and Chief Fernando Fernandez
	Team Leader:	Mayra Morales
	Team Members:	Chief Vince Lombardi, Chief Millard Jenkins II, Bill Busutil, Jim Moore, Chris Koop
	Process Owner(s):	Chief Vince Lombardi
	Mgmt Review Team:	Ray Scher and Chief Fernando Fernandez
Schedule	Completion Date:	31-Dec-13
	Review Dates:	Monthly and Final Review in December 2013
	Key Milestone Dates:	See Action Plan





Define Measure Analyze Improve Control

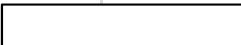

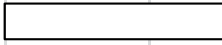





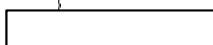

Develop Project Timeline Plan

The team developed a timeline plan to complete the Project.

4. 

Legend:	
	= Actual
	= Proposed

WHAT: Complete DMAIC Story Project by December 31, 2013

DMAIC Story Process Step	WHEN						
	2013					2014	
	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1. Define	 Completed 9/30/13 						
2. Measure		 Completed 9/30/13 					
3. Analyze			 Completed 10/31/13 				
4. Improve				 Completed 12/6/13 			
5. 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. 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. ✓
		• Team identified an indicator; developed a Flowchart and a Spreadsheet
	Step 2 Measure	Objective: Investigate the features of the indicator, stratify the problem and set a target for improvement. 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. ✓
		• Paretos; Histograms; Bar Charts
	Step 3 Analyze	Objective: Analyze the stratified data to identify and verify the root causes. 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. ✓
		• Single Case Bore; Fishbone ; RC Verification Matrix; Boxplots
	Step 4 Improve	Objective: Develop and implement countermeasures to eliminate the verified root causes of the problem. 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. ✓
		• Countermeasures Matrix; Failure Mode and Effects Analysis; Barriers and Aids; Action Plan
	Step 5 Control	Objective: Confirm that the countermeasures taken impacted the root causes and the problem; and that the target has been met. 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. ✓
		• Line Graph
DO	Step 4 Improve	Objective: Prevent the problem and its root causes from recurring. Maintain and share the gains. 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. ✓
		• Process Flowchart; Process Control Chart
		Objective: Evaluate the team's effectiveness and plan future activities. 24. Any remaining problems (or gaps) were addressed. ✓ 25. Lessons learned, P-D-C-A of the Story process, & team growth were assessed & documented. ✓
		• Lessons Learned

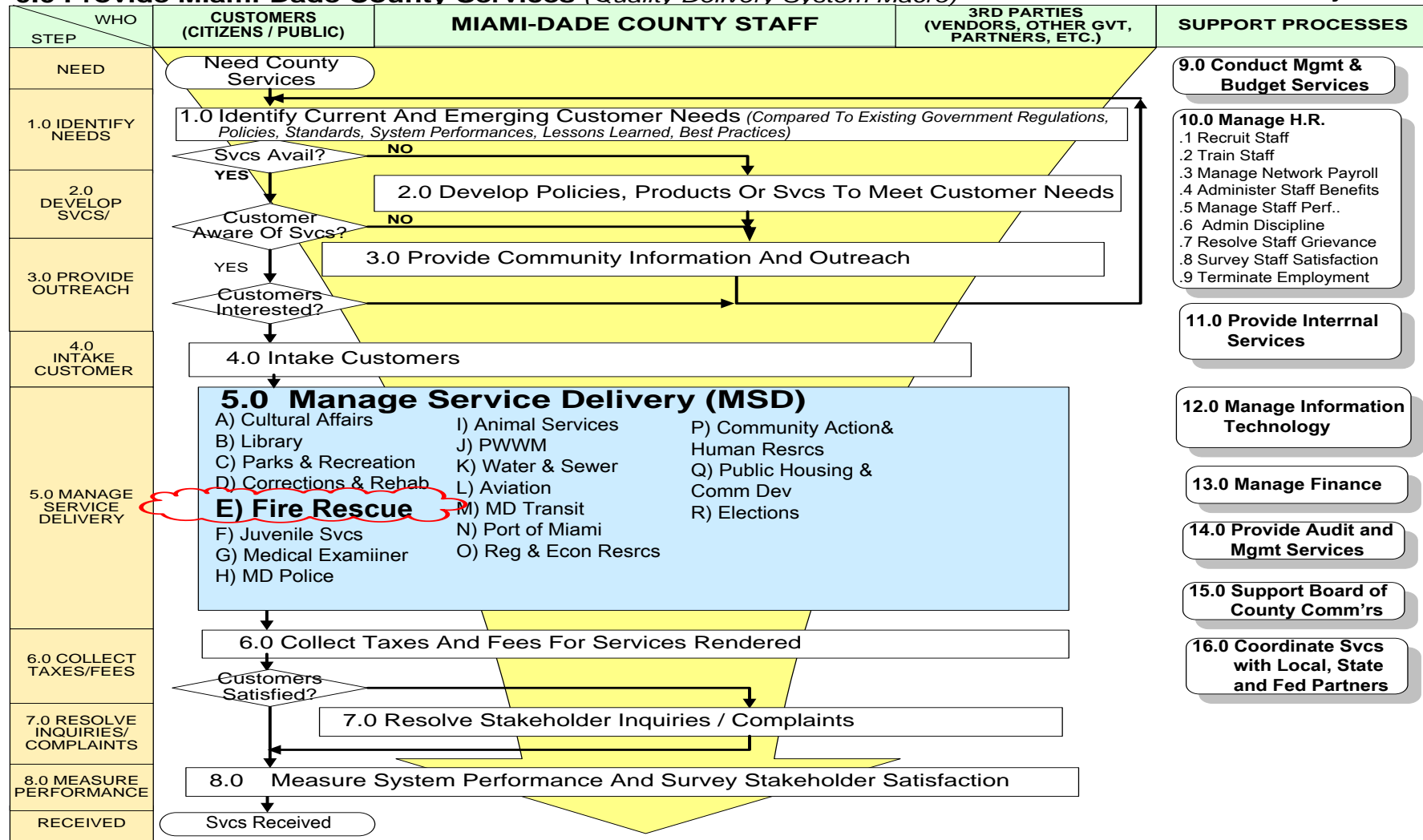


Review Quality Delivery System

The team reviewed the Miami-Dade Quality Delivery System.

0.0 Provide Miami-Dade County Services (Quality Delivery System Macro)

Process Owner: Mayor



The team will focus on a "core" delivery process in the MSD area.



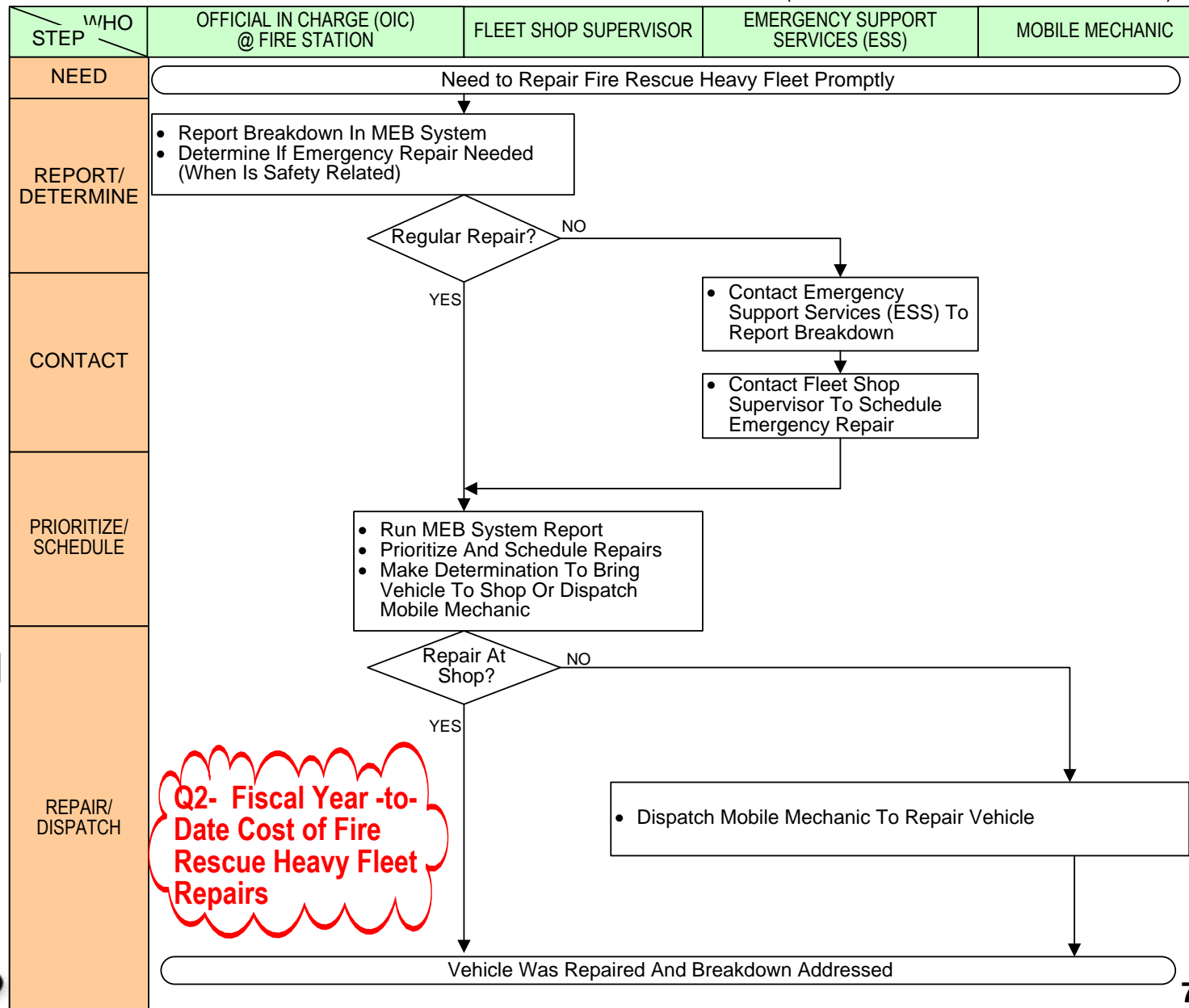
Review Process Flow Chart

The team constructed a Process flow chart describing the Process.

The team next looked closer how to capture indicator data.

Fire Rescue Heavy Fleet Repairs

(Process Owner: Chief Vince Lombardi)



Identify Data Collection Needs

The team developed a data collection spreadsheet...each row is a **Repair Work Order**.
Miami Dade Fire Rescue Heavy Fleet Repairs Summary

BCB							D E M O G R A P H I C S									
Line #	WHAT						WHERE									
	B	C					D				E				F	
	WO#	WO Description					WO Type				Vehicle Serial #				Vehicle Description	
Q1																
1	107259	REPAIR TRANSMISSION					REPAIR REACTIVE				HVMRG-0021-0314				PUMPER	
2	097896	HYDRAULIC LEAK					REPAIR REACTIVE				HVMRG-0021-0438				60 FT RK AERIAL	
3	096897	BRAKES W/TOW					REPAIR REACTIVE				HVMRG-0021-0403				PUMPER	
							MILESTONE DATES								DURATION	
		WHO					FIX								Days Down	
G	H	I	J	K	L	M	N	O	P	Q	R	S	AA	AB	AD= AA-Q	
Vehicle Miles	Vehicle Hours	Total Labor Hours	Total Labor \$	Total Vendor \$	Total Parts \$	Total \$	1- Breakdown Reported				2- Labor Start		3- Labor End		Labor Start TO Labor End	
							Date	Time	Day	Hour	Date/Ti	Day	Date/Ti	Day		
			Avg	Avg	Avg	Avg				%Mo	Avg		%Mo		%Mo	Avg # of Days
			734	490	1,456	2,680				0.0			19.1		14.5	11.1
(Parts Cost) - P1 Q2- (Repairs Cost)																
26,386	14,891	144.5	\$4,791	\$134	\$9,946	\$14,871					3/12/13	Tu	4/13/13	Sa	Q1 32	
100,614	10,750	191.3	\$6,514	\$3,187	\$17,058	\$26,758					12/3/12	Mo	3/27/13	We	114	
42,067	13,180	178.0	\$4,925	\$1,466	\$12,995	\$19,387					11/18/12	Su	5/24/13	Fr	187	

Define

Measure

Analyze

Improve

Control

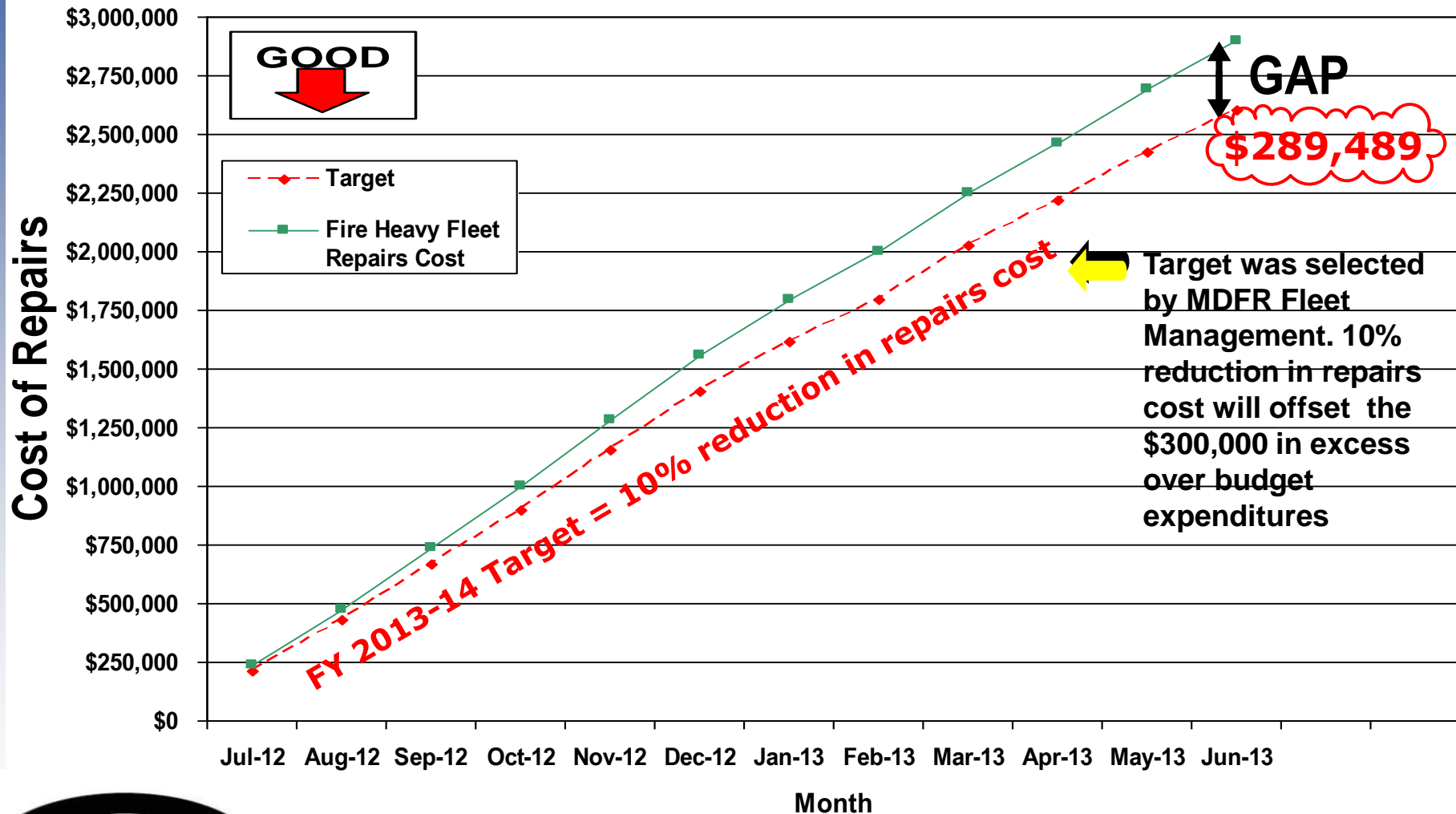


Review Selected Indicator

3.

The team collected Q2 indicator data from July 2012 to June 2013 and reviewed performance trends:

Q2 - Fiscal Year – to- Date Cost of Fire Rescue Heavy Fleet Repairs

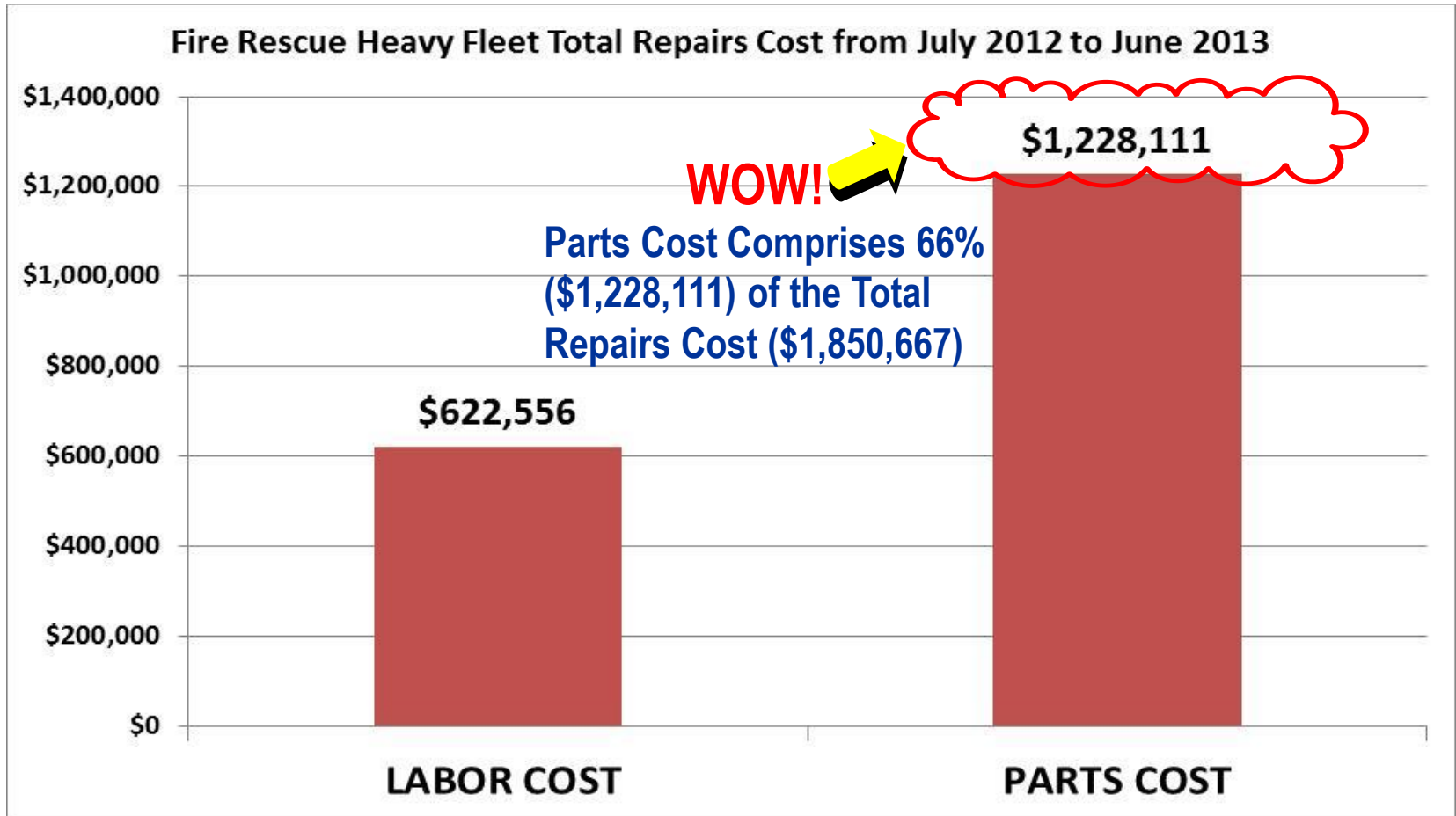


The team looked closer at the Total Repairs Cost from July 2012 to June 2013.



Stratify the Problem

The team stratified Total Repairs Cost for Fire Heavy Fleet from July 2012 to July 2013 and found...



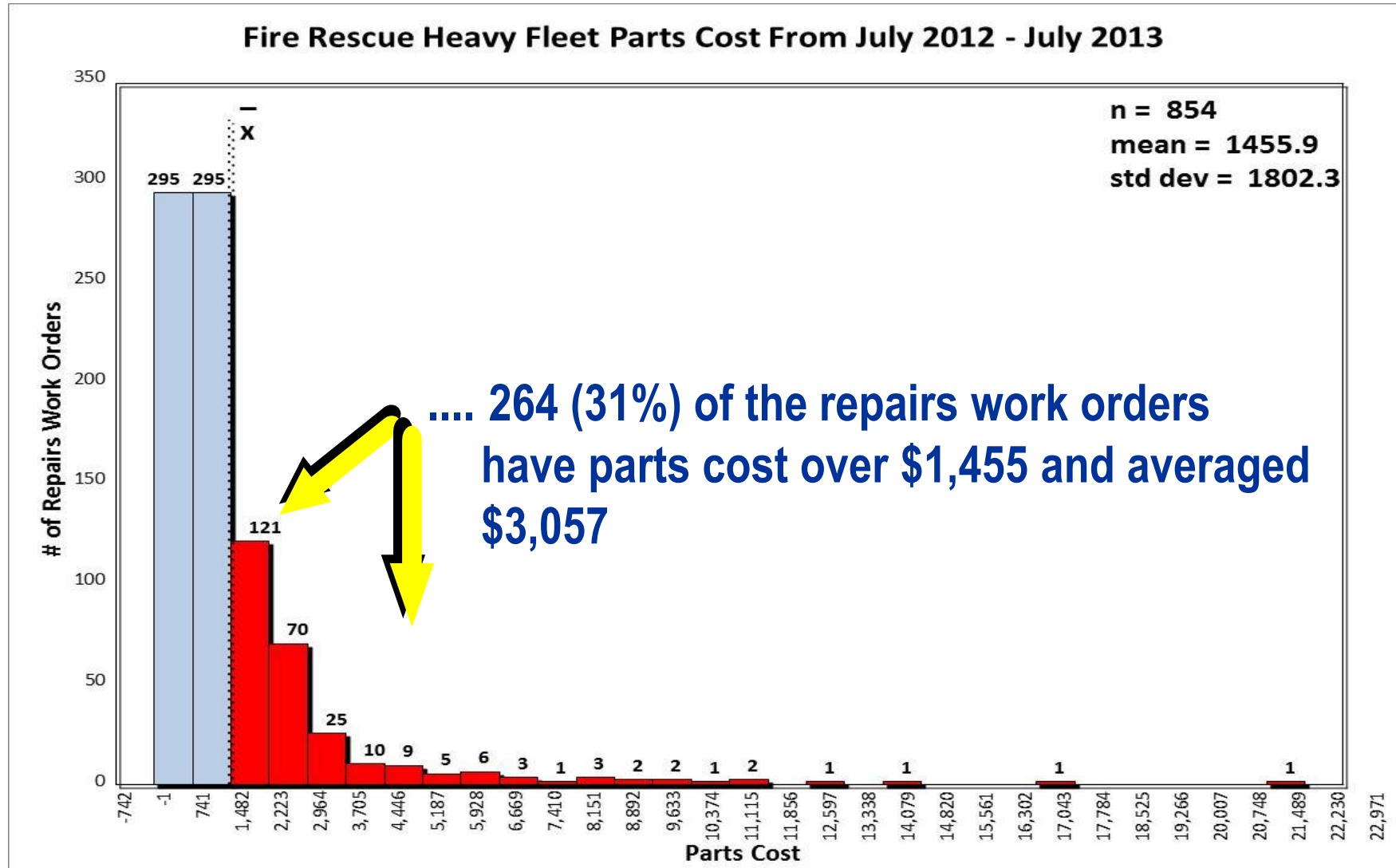
The team looked closer at the \$1,228,111 in Parts Cost.



Stratify the Problem

5. ✓

The team stratified the Fire Rescue Heavy Fleet parts cost data using a histogram and found...



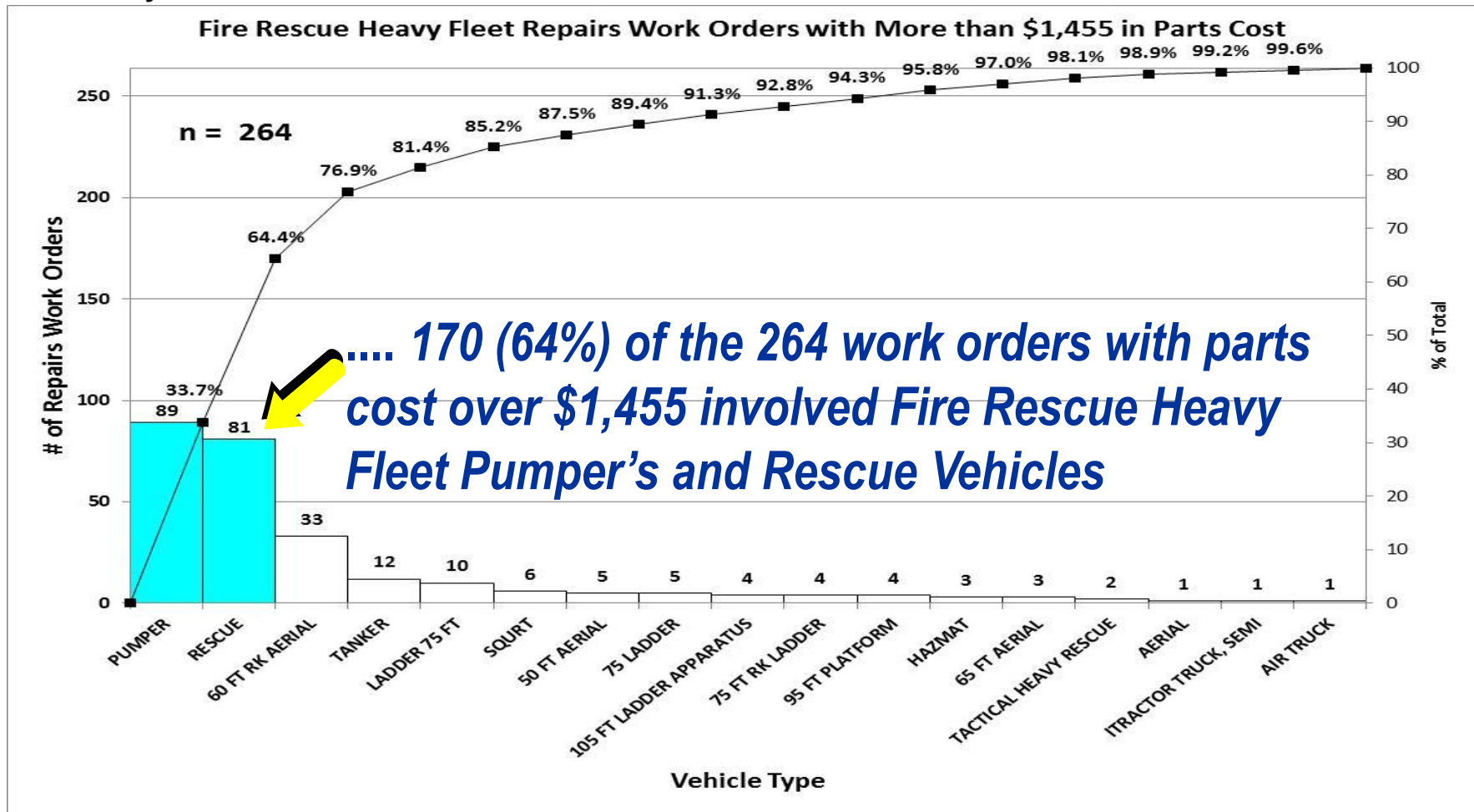
The team looked closer at identifying the work orders with the highest parts cost.



Stratify the Problem

5,.8. ✓

The team stratified the 264 work orders for Fire Rescue Heavy Fleet with over \$1,455 in parts cost from July 2012 to July 2013 and found...



Problem Statement: "170 (64%) of the 264 work orders with parts cost over \$1,455 involved Fire Rescue Heavy Fleet Pumper's and Rescue Vehicles from July 2012 to July 2013".



Identify Potential Root Causes

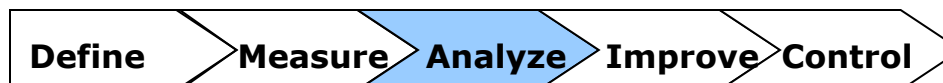
9.

The team reviewed Work Order detail records before completing Single Case Bore Analysis.

Problem Statement: "170 (64%) of the 264 work orders with parts cost over \$1,455 involved Fire Rescue Heavy Fleet Pumper's and Rescue Vehicles from July 2012 to July 2013"

Reasons or Factors (That possibly contributed to the high parts cost in the Fire Rescue Heavy Fleet)	Sampled 20 of the 170 (12%) Work Orders																TOTAL	PERCENTAGE				
	115723	96897	94773	91357	110486	100483	99795	107805	98866	86746	86683	91665	85702	87804	99090	114717			89307	116013	91265	106618
1) Brakes Failed (Rotors/PADS/Calipers) B		x	x									x	x							x	5	25%
2) Alternator Failed C	x				x		x							x	x						5	25%
3) AC Compressor Failed				x																	1	5%
4) Tire Replacement A		x						x	x	x	x	x							x		7	35%
5) Touch Screen Not Working (Control Panel)																x	x				2	10%
6) Suspension Not Working													x								1	5%
7) Fuel Injection Failed																			x		1	5%
8) Portable Refrigerator Not Working																x					1	5%
9) Inverter Not Working																		x			1	5%
10) AC Not Working (Manufacturing Defect)						x															1	5%

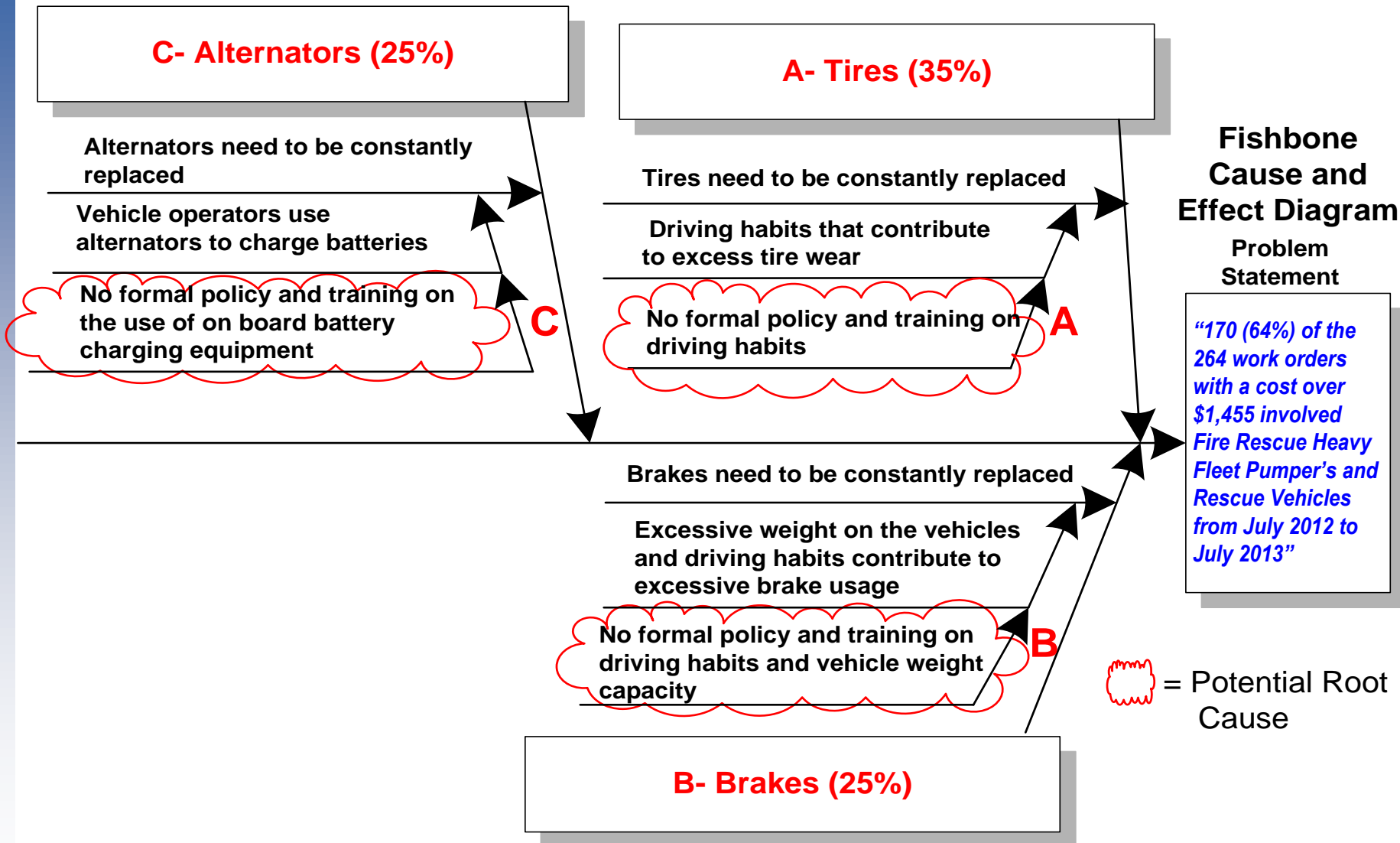
The team next looked closer at these three factors.



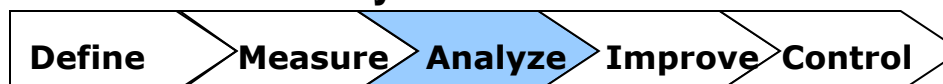
Identify Potential Root Causes

9.,10. 

The team completed Cause and Effect Analysis and found...



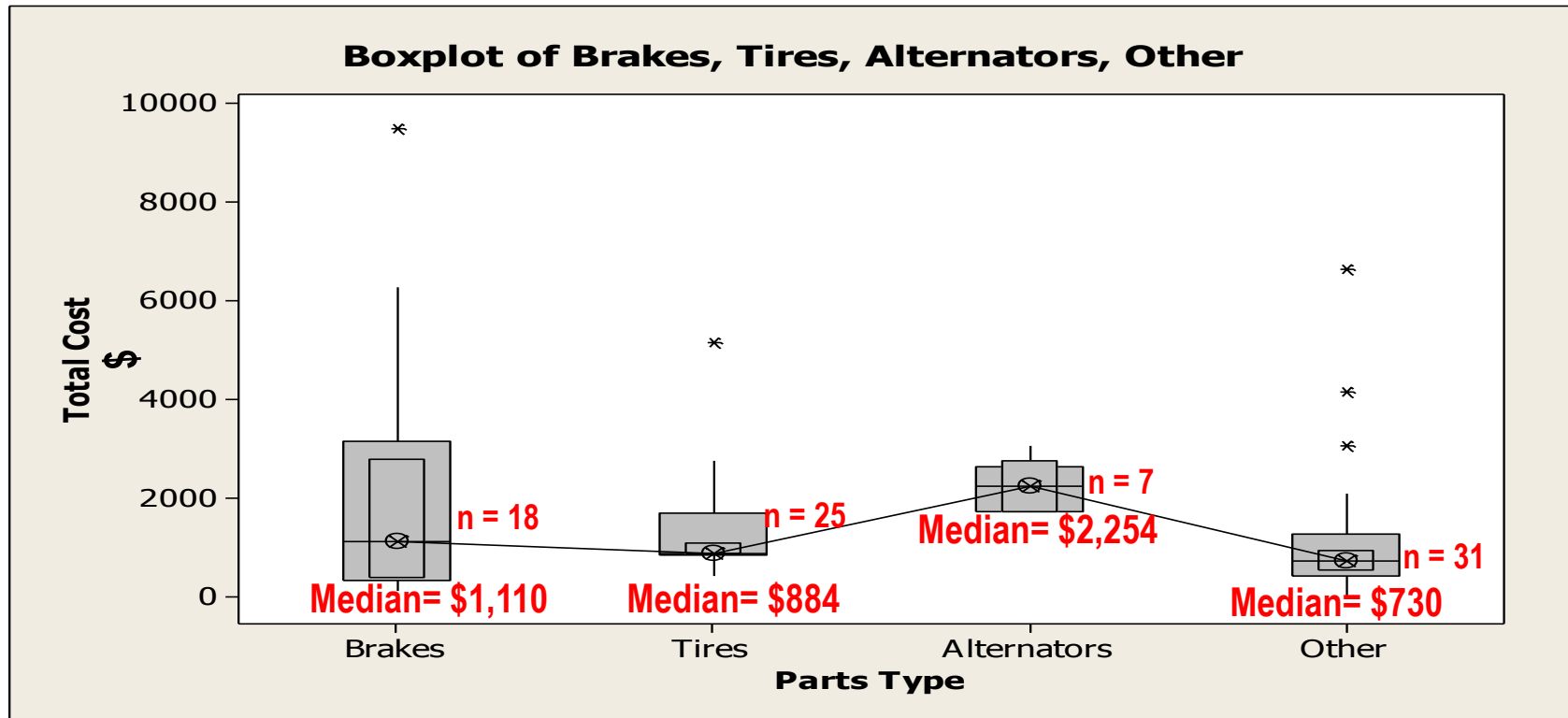
The team next looked to verify these 3 Potential Root Causes.



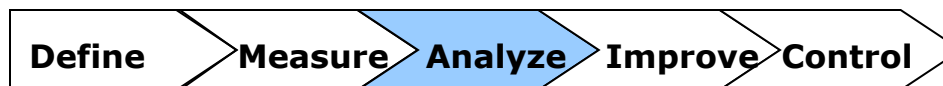
Identify Potential Root Causes

9.,10. ✓

The team selected and analyzed 50 repair work orders by identifying parts cost for Brakes, Tires, Alternators and Other.



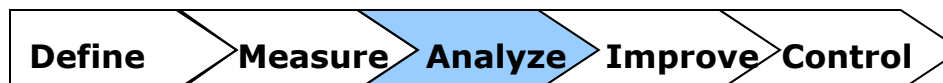
....Median Parts Cost for “Brakes”, “Tires” and “Alternators” are much higher compared to the Median Parts Cost for “Other” and they represent 70% of the total parts cost.



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

Root Cause Verification Matrix			
Potential Root Cause		How Verified?	Root Cause or Symptom
A	No formal policy and training on driving habits	Discussed with MDFR Management and determined that there is no formal guidelines or training provided for drivers to conserve tires, brakes and alternators while operating heavy fleet vehicles	Root Cause
B	No formal policy and training on driving habits and vehicle weight capacity		Root Cause
C	No formal policy and training on the use of on board battery charging equipment		Root Cause

...all were validated as root causes.



Identify and Select Countermeasures

13.,14. 

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

Countermeasures Matrix							
Problem Statement	Verified Root Causes	Countermeasures	Legend:				
			3=Moderately				
			5=Extremely				
			4=Very				
			Ratings				
			Effectiveness	Feasibility	Overall	Take Action? Yes/No	
<p>“170 (64%) of the 264 work orders with a cost over \$1,455 involved Fire Rescue Heavy Fleet Pumper’s and Rescue Vehicles from July 2012 to July 2013”</p>	<p>A - Tires: No formal policy and training on driving habits</p>	<p>A1- Create vehicle maintenance policy and include as part of policy to:</p> <p>A1-1 Check tire pressure and tire condition daily</p> <p>A1-2 Use nitrogen instead of compressed air to fill tires</p> <p>A1-3 Use recap tires when applicable</p>	4	5	20	Y	
		<p>A2- Create online training video and include as part of training:</p> <p>A2-1 Proper driving habits</p>	4	5	20	Y	
	<p>B - Brakes: No formal policy and training on driving habits and vehicle weight capacity</p>	<p>A1- Create vehicle maintenance policy and include as part of policy to:</p> <p>A1-4 Measure weight of vehicle at least once a year fully loaded with crew</p> <p>A1-5 Create and approve inventory equipment list to maintain MDRF vehicle weight specifications</p> <p>A1-6 Use Cryogenic/ Diamond treated brake components</p>	4	5	20	Y	
		<p>A2- Create online training video and include as part of training:</p> <p>A2-1 Proper driving habits</p>	4	5	20	Y	

The team selected 4 countermeasures for implementation.



Identify and Select Countermeasures

13.,14. 

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

Countermeasures Matrix							
Problem Statement	Verified Root Causes	Countermeasures	Legend:				
			5=Extremely		3=Moderately		
			4=Very		2=Somewhat		
			1=Little or None				
			Ratings				
Effectiveness	Feasibility	Overall	Take Action? Yes/No				
“170 (64%) of the 264 work orders with a cost over \$1,455 involved Fire Rescue Heavy Fleet Pumper’s and Rescue Vehicles from July 2012 to July 2013”	C - Alternators: No formal policy and training on the use of on board battery charging equipment	A1- Create vehicle maintenance policy and include as part of policy to: A1-7 Proper vehicle battery charging procedures A1-8 Require to plug in vehicle equipment while at the station	4	5	20	Y	
		A2- Create online training video and include as part of training: A2-2 Proper vehicle equipment usage	4	5	20	Y	
		C1- Add low voltage alarm to new and existing fleet	5	4	20	Y	
		C2- Add solar panel technology to new fleet	5	5	25	Y	

The team selected 4 countermeasures for implementation.



Failure Mode and Effects Analysis - FMEA

Product or Process Steps	Failure Mode	Failure Effects	SEV	Causes	OCC
Vehicle breakdown	Harsh driving habits	Delays in responding to emergency call. Additional wear and tear to engine and related components. Also, could contribute to vehicle crash when responding to emergency call	10	No accountability for driving habits	8
Vehicle breakdown	Unnecessary usage of the chassis drive engine	Delays in responding to emergency call. Additional wear and tear to engine and related components	7	Current chassis design lacks engine management system	10
Preventive maintenance	Unable to perform preventive maintenance	Extended service intervals are causing more vehicle breakdowns and compromising life expectancy of major vehicle components	9	Not adhering to preventive maintenance standards	9
Vehicle breakdown	No start/low voltage readings	Delays in responding to emergency call	8	Unable to predict alternator failures or other causes	7
Vehicle design specifications	Vehicles are operating at maximum and/or exceeding weight capacity at all times	Additional wear and tear to engine and related components	7	Modifications and usage exceed intended vehicle capacity	8

The team identified these process failures with FMEA.



Identify and Select Countermeasures - FMEA

13.,14 

Failure Mode and Effects Analysis - FMEA

Controls	D E T	R P N	Action Recommended	Action Taken	After Action Taken			
					S E V	O C C	D E T	R P N
No formal control in place	10	800	Pilot a proactive driver feedback and performance monitoring system (black box)	Yes	5	4	1	20
No formal control in place	10	700	Add Engine Management system to new vehicles that provides full control of both the chassis engine and Auxiliary Power Unit (APU) - (green technology that will enable driver to shut down engine while vehicle is stationary)	Yes	1	1	1	1
No formal control in place	9	729	Increase frequency of preventive maintenance to meet current guidelines	Yes	3	3	3	27
Marginal predictive capability (driver only)	8	448	Implement use of statistical predictive/ preventive maintenance analysis on heavy fleet vehicles	Yes	3	4	2	24
No formal control in place	10	560	Specify future procurements of heavy fleet vehicles so that those vehicles stay within 90% of gross vehicle weight per respective axle and remain laterally neutral within 2 to 3% when fully loaded, including personnel	Yes	4	3	3	36
Total Risk Priority Number=		3237			"After" Risk Priority Number=		108	

The team identified 5 actions/ recommendations to minimize the effect of the failures identified with FMEA

Define > Measure > Analyze > Improve > Control

20



Identify Barriers and Aids

15. ✓

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

Countermeasure(s): Implement 4 Countermeasures to reduce number of breakdowns			
Barriers		Aids	
Impact (H, M, L)	Forces against Implementation	Forces For Implementation	
M	1) Resistance from Employees (Supported by Aid:A,B,C,D)	A)	Cost savings could be significant
M	2) Cost (Supported by Aid:A,B,C,D)	B)	Management very supportive of team's effort in saving costs
M	3) Limited Manpower (Supported by Aid:A,B,C,D)	C)	Extend life of vehicles
L	4) Procurement can be lengthy (Supported by Aid:A,B)	D)	More reliable vehicles during emergency response

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.

16 

WHAT: Implement 9 Countermeasures to reduce the number of Fire Rescue Heavy Fleet Repairs

HOW	WHO	2014											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Develop Countermeasures:													
A1- Create vehicle maintenance policy	Team				3/21/14								
A2- Create online training video	Chief Millard Jenkins II				4/25/14								
C1- Add low voltage alarm to new and existing fleet	Chris Koop												
C2- Add solar panel technology to new fleet	Chris Koop												
D1- Pilot a proactive driver feedback and performance monitoring system	Chief Vince Lombardi												11/28/14
D2- Add Engine Management system to new fleet	Chris Koop												
D3- Increase frequency of preventive maintenance to meet current guidelines	Team												10/31/14
D4- Implement statistical predictive/ preventive maintenance analysis	Jim Moore												
D5- Specify future procurements of heavy fleet vehicles to maintain 90% of gross vehicle weight per respective axle	Chief Vince Lombardi												
2. Secure Management Approval of Countermeasures (share benefits and cost savings)	Team												
3. Communicate/Train MDRF Staff in Countermeasures and related policies/procedures (share benefits and cost savings)	Chris Koop/ Jim Moore												9/29/14
4. Implement Pilot for Countermeasures	Team												10/31/14
5. Review Pilot and determine Benefits and adjust as necessary and present results to management	Team												12/31/14
6. Establish On-going responsibilities and standardize countermeasures into operations	Team												

Define

Measure

Analyze

Improve

Control

22

Savings Due to the Implementation of Countermeasures 20. ✓

The team estimated Annual Repairs Cost Savings by Implementing the Selected Countermeasures as follows...

Estimated Annual Savings = **Total Repairs Cost from June 2012 to July 2013** **X** **% Reduction in Total Repairs Cost (MDFR Management approved target)**
(slide #10) (slide #9)

= \$1,850,667 **X** 10%

Estimated Annual Savings = \$185,066.70



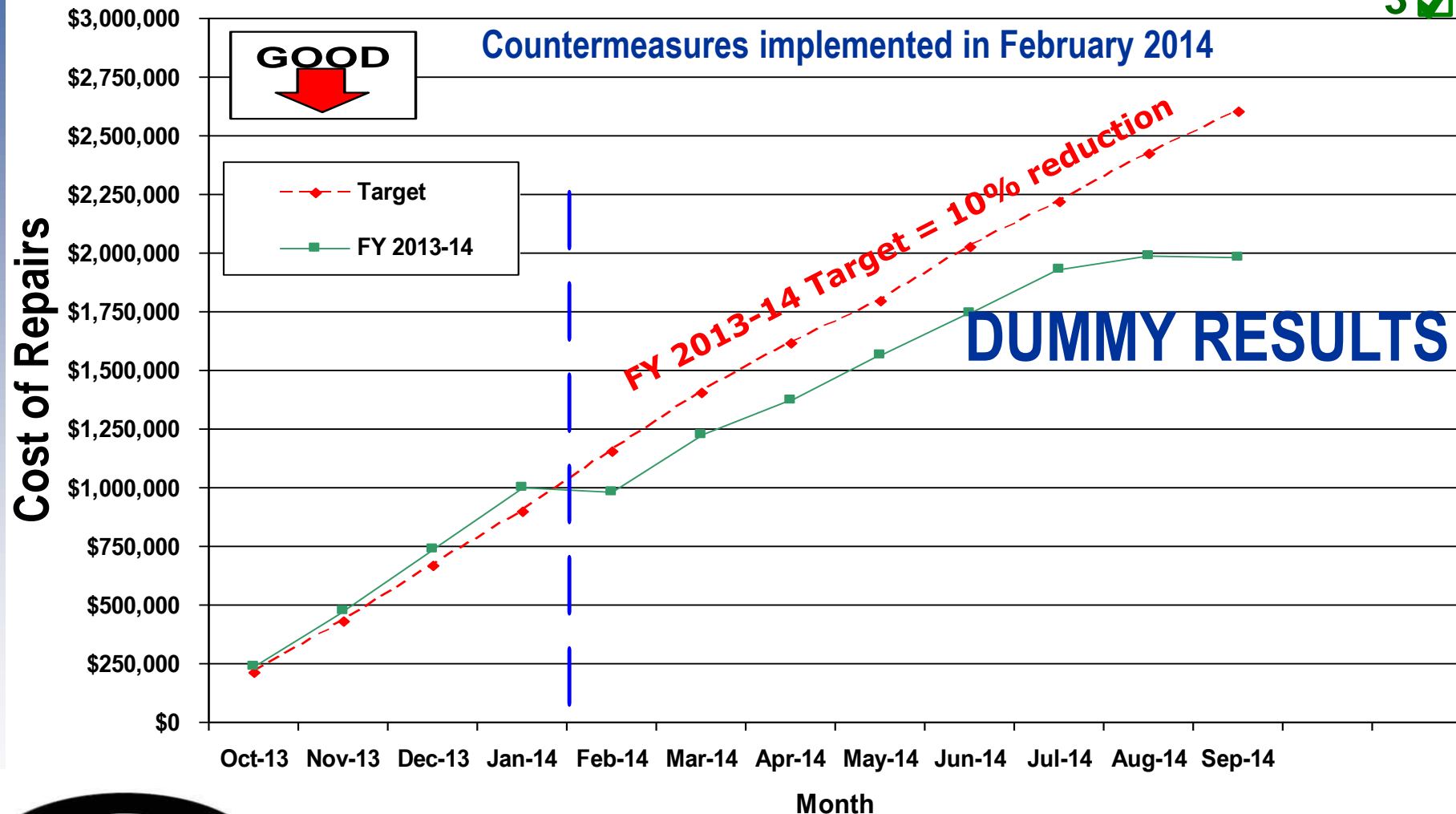
Review Selected Indicator

17.,18.,19.,20 ✓

The team collected indicator data and reviewed results of it's countermeasures.

Q2 - Fiscal Year – to- Date Cost of Fire Rescue Heavy Fleet Repairs

3 ✓



The team will continue to monitor the countermeasures and results.

Define

Measure

Analyze

Improve

Control

24

Standardize Countermeasures

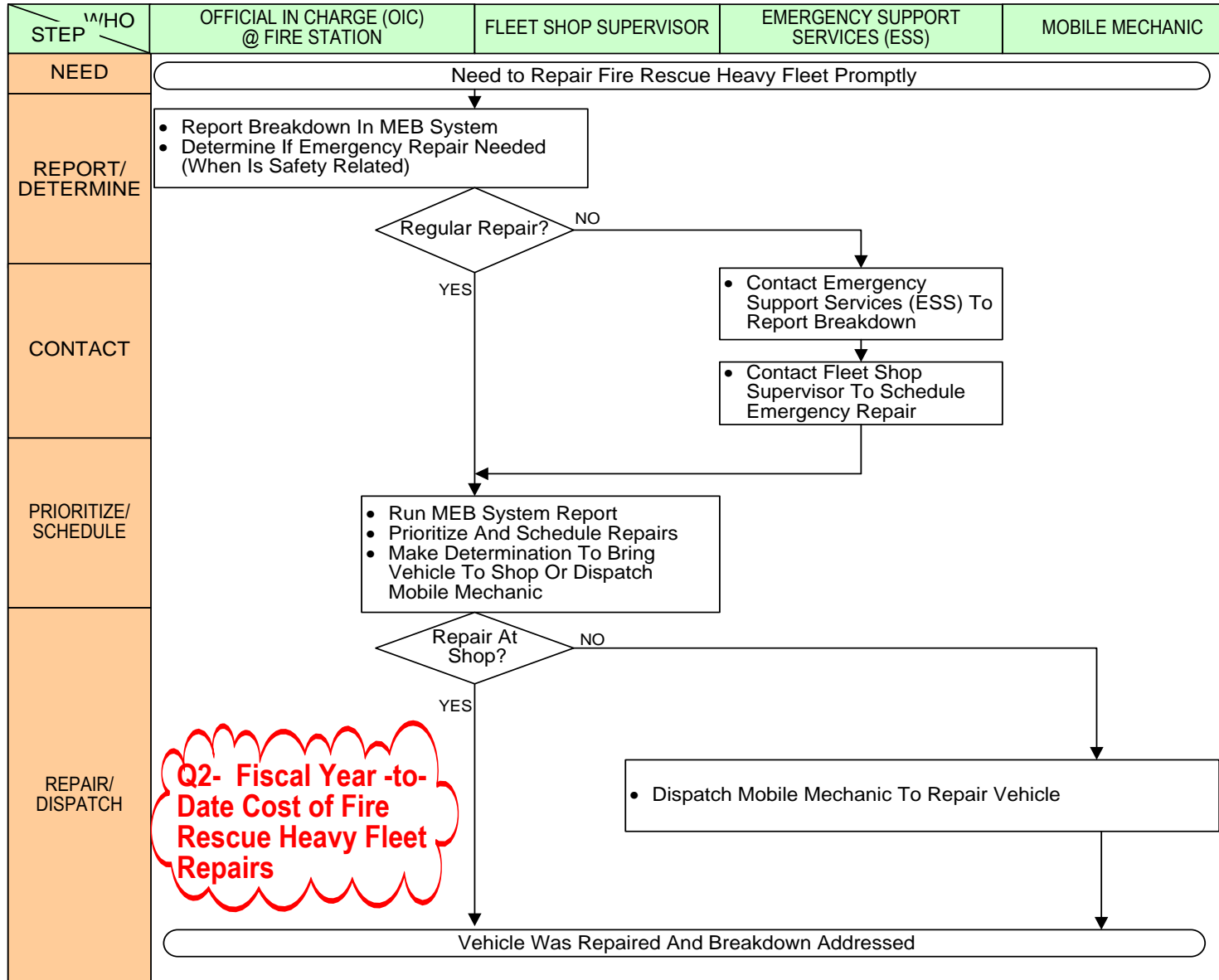
21.,22.,23. ✓

The team revised the flowchart and indicators and developed a Process Control System.

The team looked to standardize the Indicator monitoring

Fire Rescue Heavy Fleet Repairs

(Process Owner: Chief Vince Lombardi)



Define

Measure

Analyze

Improve

Control

25



Standardize Countermeasures

21.,22.,23. ✓

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

Process Control System					
Process Name: MDFR Heavy Fleet Repairs			Process Owner: Chief Vince Lombardi		
Process Customer: County Taxpayer, MDFR Employees			Critical Customer Requirements: Heavy Fleet Vehicles Ready and Available to Respond to Emergency call		
Process Purpose: Reduce Number of Heavy Fleet Repairs			Current Sigma Level: TBD		
			Outcome Indicators: Q2		
Process and Quality Indicators		Checking / Indicator Monitoring			Contingency Plans / Misc. • Actions Required for Exceptions • Procedure References
Process Indicators	Control Limits	Data to Collect	Timeframe (Frequency)	Responsibility	
Quality Indicators	Specs/ Targets	What is Checking Item or Indicator Calculation	When to Collect Data?	Who will Check?	
P1 Total Parts Cost	10% reduction	MDFR Total Parts Cost	Monthly	MDFR-Logistical Services Division	• MDFR Management
Q2 FYTD Cost of Heavy Fleet Repairs	10% reduction	MDFR FYTD Cost of Heavy Fleet Repairs	Monthly	MDFR-Logistical Services Division	• MDFR Management

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



Lessons Learned

- 1) Root Cause Analysis (Single Case Bore, Fishbone, Boxplots and Verification Matrix) helped the team identify, verify and support the relationship between the potential root causes and the problem.
- 2) FMEA was an effective technique used by the team to capture process failures and it enable the team to build additional recommendations that will minimize the risk associated with the failures identified.
- 3) Creative Thinking Techniques was critical in helping the team identify more diverse recommendations and think “outside the box”.

Next Steps

- 1) Continue to monitor the countermeasures and performance results.
- 2) Areas requiring further study:
 - a) Construction of a new service and repair facility
 - b) Additional staff requirements (5 heavy equipment technicians and 1 parts specialist)

