Six Sigma DMAIC Improvement Story

Green Belt **Project Objective:**

To Reduce Number of (and Costs)

of Transit Bus Road Reported Incidents

Last Updated: 4-16-13

Team: *Under the Bus*

Derrick Gordon (Co-Team Leader) William Campbell (Co-Team Leader)

Jennifer Moon Ryan Elliott Robert Villar Mariaelena Salazar

Alina Hudak (Sponsor) Jennifer Moon (Sponsor)

Identify Project Charter

The team developed a team Project Charter.

Project Charter		
Business Case	*Project Name:*	To Reduce Number of and Costs of Transit Bus Road Reported Incidents
	Problem/Impact:	Transit Bus Road Reported Incidents and breakdowns cause schedule delays and additional costs.
	Expected Benefits:	Improvement will result in improved schedule adherence and reduced costs
Objectives	*Outcome Indicator(s)*	Q1- Fiscal Year-to-Date # of Transit Bus Road Reported incidents
	Proposed Target(s)	Target=10% reducton from previous Fiscal year
	Time Frame:	Nov 2012 through March 2013
	Strategic Alignment:	Supports the County's Business Plan
Scope	*In Scope:*	Transit Bus Road reported Incidents
	Out-of-Scope:	Bus Pre-Trip and Post Trip Unscheduled maintenance incidents
	Authorized by:	Alina Hudak and Jennifer Moon
Team	*Sponsor:*	Alina Hudak and Jennifer Moon
	Team Leader:	Derrick Gordon and Willian Campbell
	Team Members:	Jennifer Moon, Ryan Elliott, Robert Vilar, Mariaelena Salazar
	Process Owner(s):	Derrick Gordon
	Mgmt Review Team:	Alina Hudak and Ysela Llort
Schedule	*Completion Date:*	31-Mar-13
	Review Dates:	Monthly and Final Review in March 2013
	Key Milestone Dates:	See Action Plan

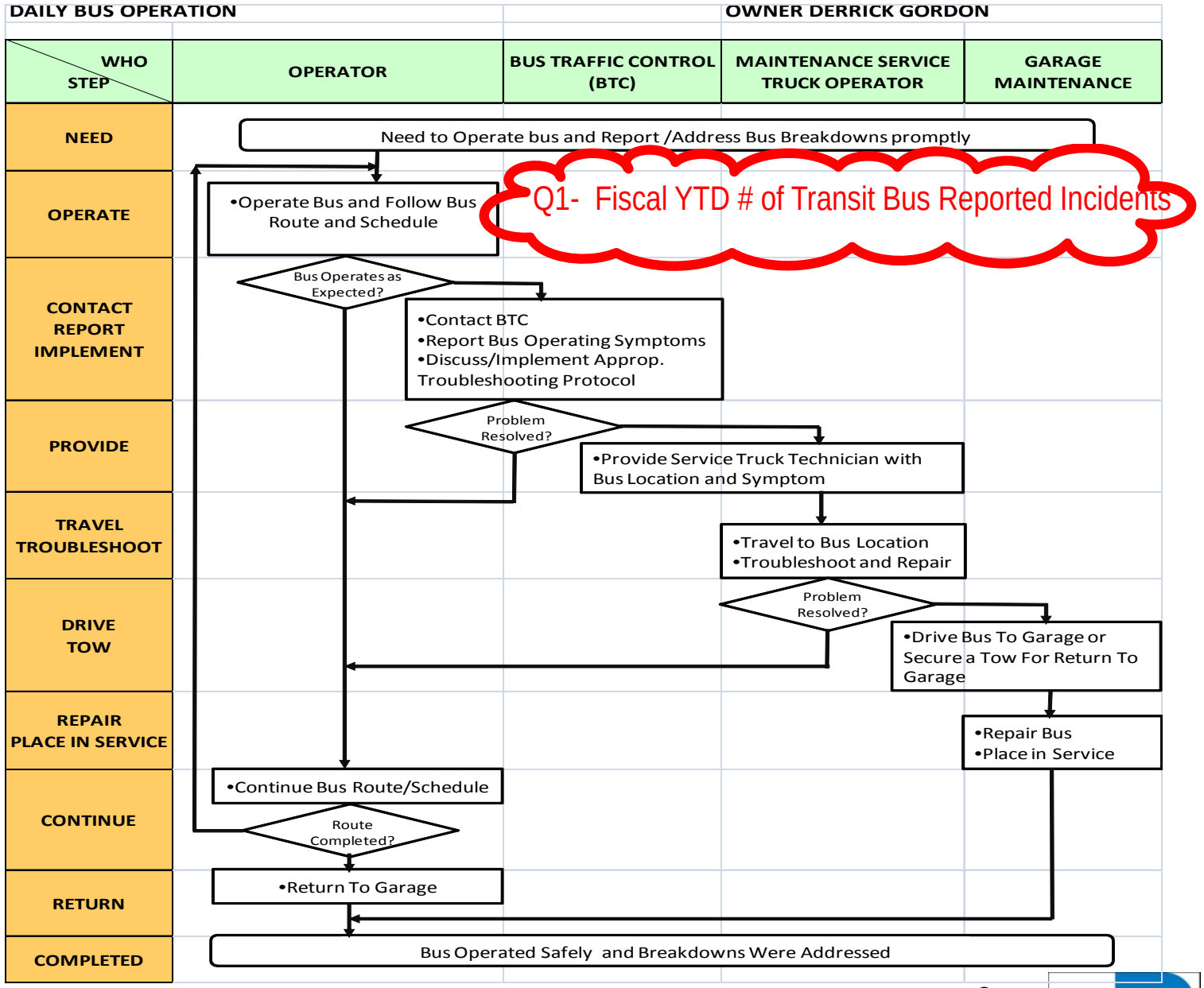
1. ☑

2. ☑

Review Process Flow Chart

The team constructed a Process flow chart describing the Process.

The team next looked closer how to capture indicator data.



Annual Transit Bus Breakdown Costs

5.

The team identified costs associated with Transit Bus Breakdowns

ANNUAL BREAKDOWN COSTS

1)	**MAINTENANCE SERVICE TRUCKS TRIP COSTS**			
	Number of Service Trucks	7		
	Annual Operating Cost of Each Service Truck	$8,944.00		
	Annual Cost of Service Trucks		$62,608.00	
	Number of Service Truck Technicians	17		
	Avg. Annual Tech Salary, Loaded	$80,724.80		
	Annual Cost of Service Truck Technicians		$1,372,321.60	
			TOTAL	**$1,434,929.60**
2)	**STANDBY BUS and OPERATOR COST**			
	Number of Standby Operators		6	
	Avg. Annual Operator Salary, Loaded		$68,182.40	
	Avg. Annual Bus Cost		$59,000.00	
	Annual Cost of Standby Operators		**TOTAL**	**$763,094.40**
3)	**BUS TOWING EXPENSE**			
	Avg. tow cost		$156.72	
	X Number of tows per year		1,472	
	Annual Towing Costs		**TOTAL**	**$230,691.84**
	TOTAL ANNUAL BREAKDOWN COST =			**$2,428,715.84**

Cost per Incident
$142.78
$2,428,715.84 ÷ 17,010 incidents

Note: Other factors include additional workload on other buses, OT, BTC/Mgmt time to adjust resource schedule, rider dissatisfaction, etc.

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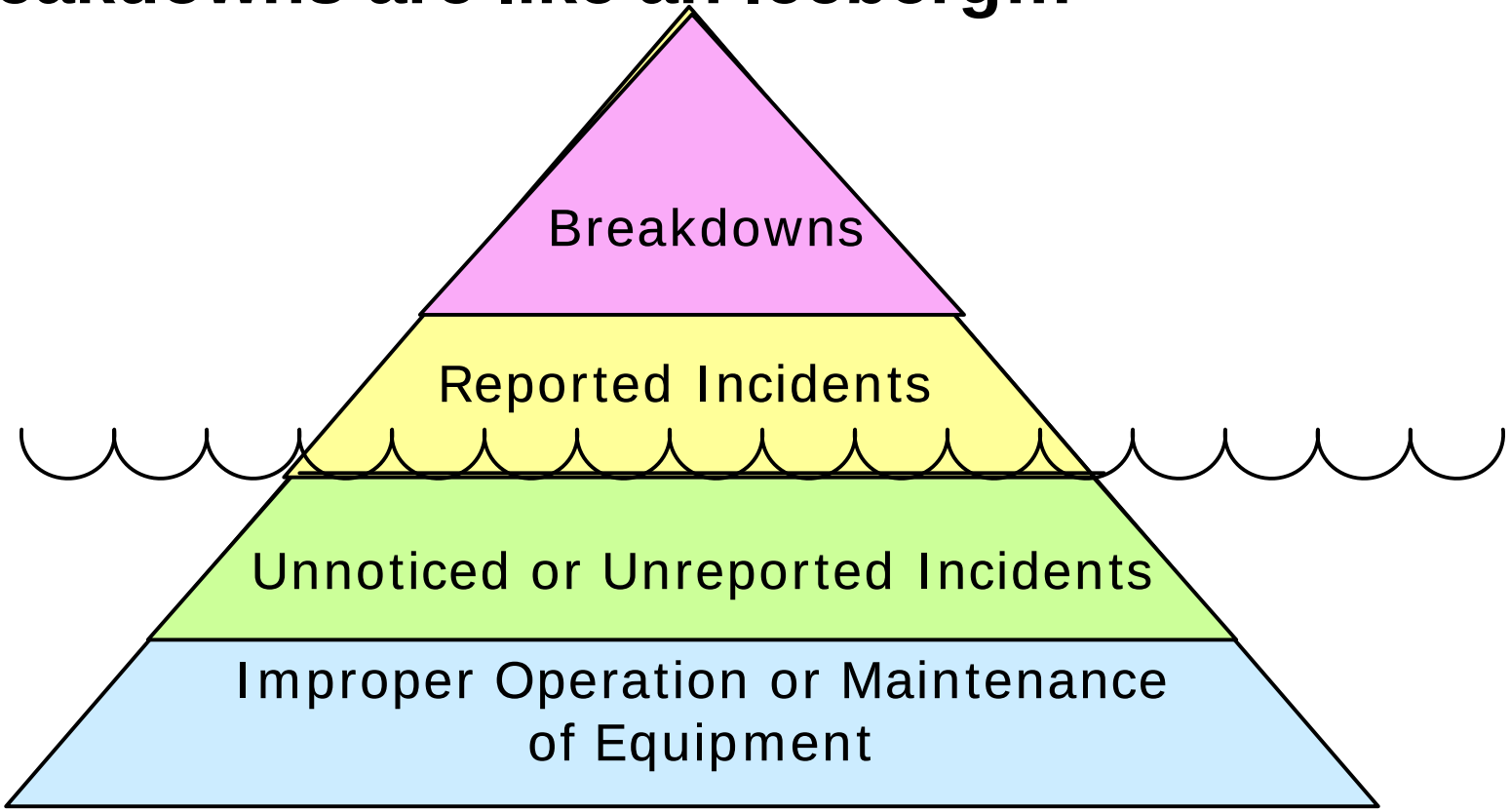
Causes of Breakdowns

5.

"Breakdowns are like an Iceberg…



… most of the support is below the surface."

Noting this, the team decided to focus on incident reports that lead to breakdowns.

Identify Data Collection Needs

The team developed a data collection spreadsheet…each row is an *Incident Report*.

Miami Dade Transit Bus Incident Summary

BCB	DEMOGRAPHICS															
	WHAT				WHERE					WHO			FIX			
	B	C	D	E	F	G	H	I	J	K	L	N	O	P	Q	R
Line #	Incident Report #	Brkdwn Symptm Code	Breakdown Symptom Description	Breakdown System	Route	Run	Location at Time of Break-down	BTC	Division	Bus Oper	DISP	Bus #	Repair Order	Repair Order Comments	Repair Code	Repair Description
				% A/C												
				19%												
Q1																
1	716948	MISC	WON'T MOVE	WON'T MOV	8	3171	SW 8ST &	LATRECE	Coralway	03984	L	02001	752236	BUS WON'T MOV	TRANP	CK'D TRA:NO PR
2	717123	ENG6	ENGINE SMOK	ENGINE	1	3803	115AVE &	LATRECE	Coralway	2525	R	02001	752272	ENGINE STALLE	COL30	R/R COOLANT HO
3	717327	ELE5	FIRE ALARM	ELECTRICAL	71	3229	INTERNAT	DTORRES	Coralway	2810	R	02001	752358	EXTINGUISHER \	SRV24	PREPARE FOR S

FIX				MILESTONE DATES						DURATION			OUTCOMES		
T	U	V	W	X	Y	Z	AA	AI	AJ	AK= Z-X	AL= AI-Z	AM	AR= AI-Z+1	AT='Y' if AR<=1	BB
Labor Hours	Labor Costs	Parts Cost	Total Cost	1- Breakdown Reported Date	Day	2- Repair Order Open Date	Day	3- Repair Order Closed Date	Day	Brkdn Rptd TO Rpr Ordr Open	Rpr Ordr Open TO Rpr Ordr Closed	Lost Revenue Time	# of Days Bus Out-of-Service	Bus Returned to Service Timely?	Comments
Avg					% Mo		% Mo		% Mo	Avg # of Days		Avg # Min	Avg Days	%Y	
2.2	$ 161.22	$ 622.79	$ 465.56		19.7		16.3		15.4	0.0	0.8	57.8	1.8	65.1	
										P1	P2	Q2	P3	Q3	
1.5	53.44		$53.44	7/20/2012	Fr	7/20/2012	Fr	7/20/2012	Fr	0	0	0	1	Y	
7	$249.38	$20.33	$269.71	7/21/2012	Sa	7/21/2012	Sa	7/21/2012	Sa	0	0	60	1	Y	
1.5	46.20		$46.20	7/23/2012	Mo	7/23/2012	Mo	7/23/2012	Mo	0	0	77	1	Y	

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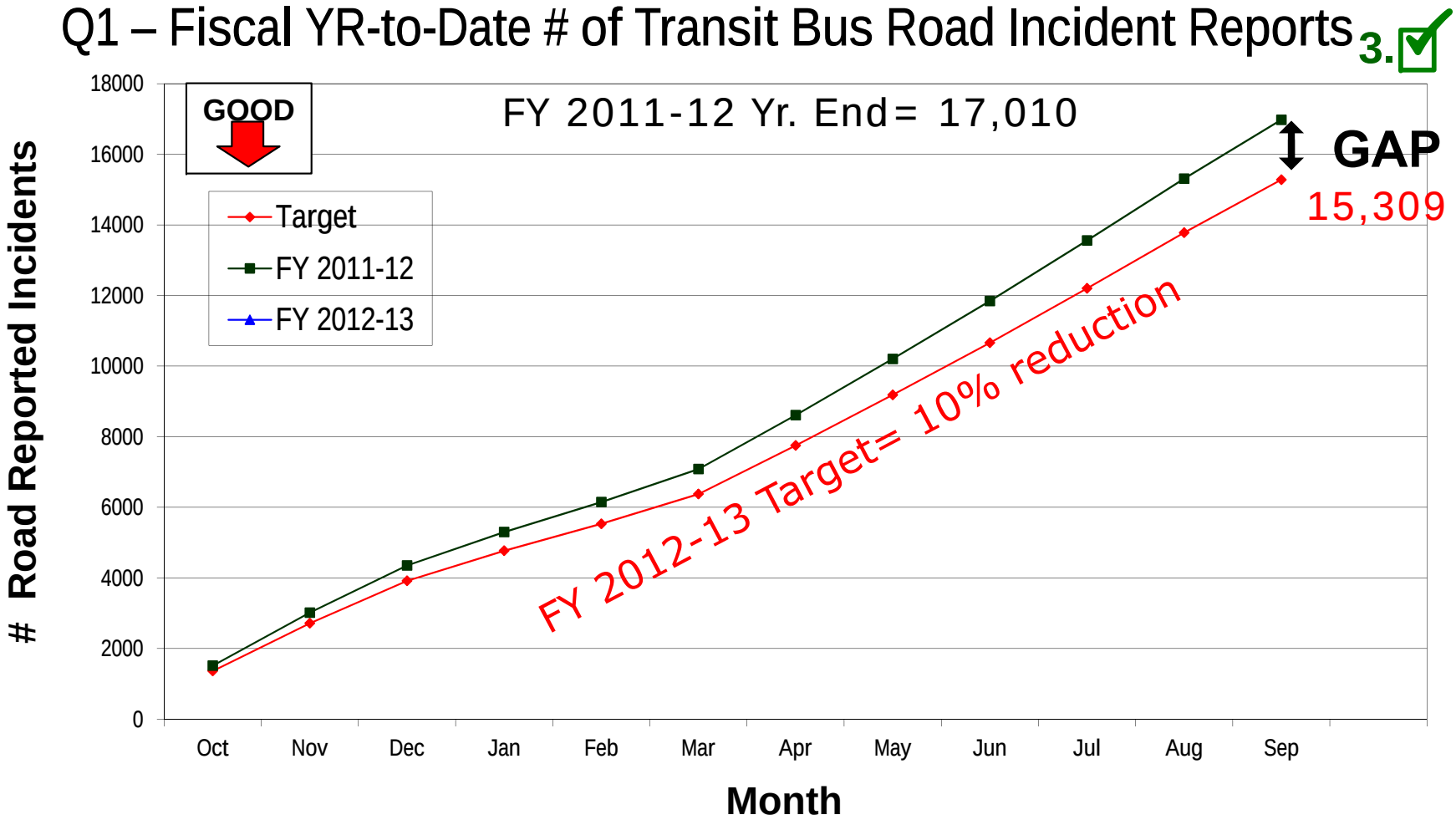
Review Selected Indicator

The team collected Q1 indicator data and reviewed performance trends:

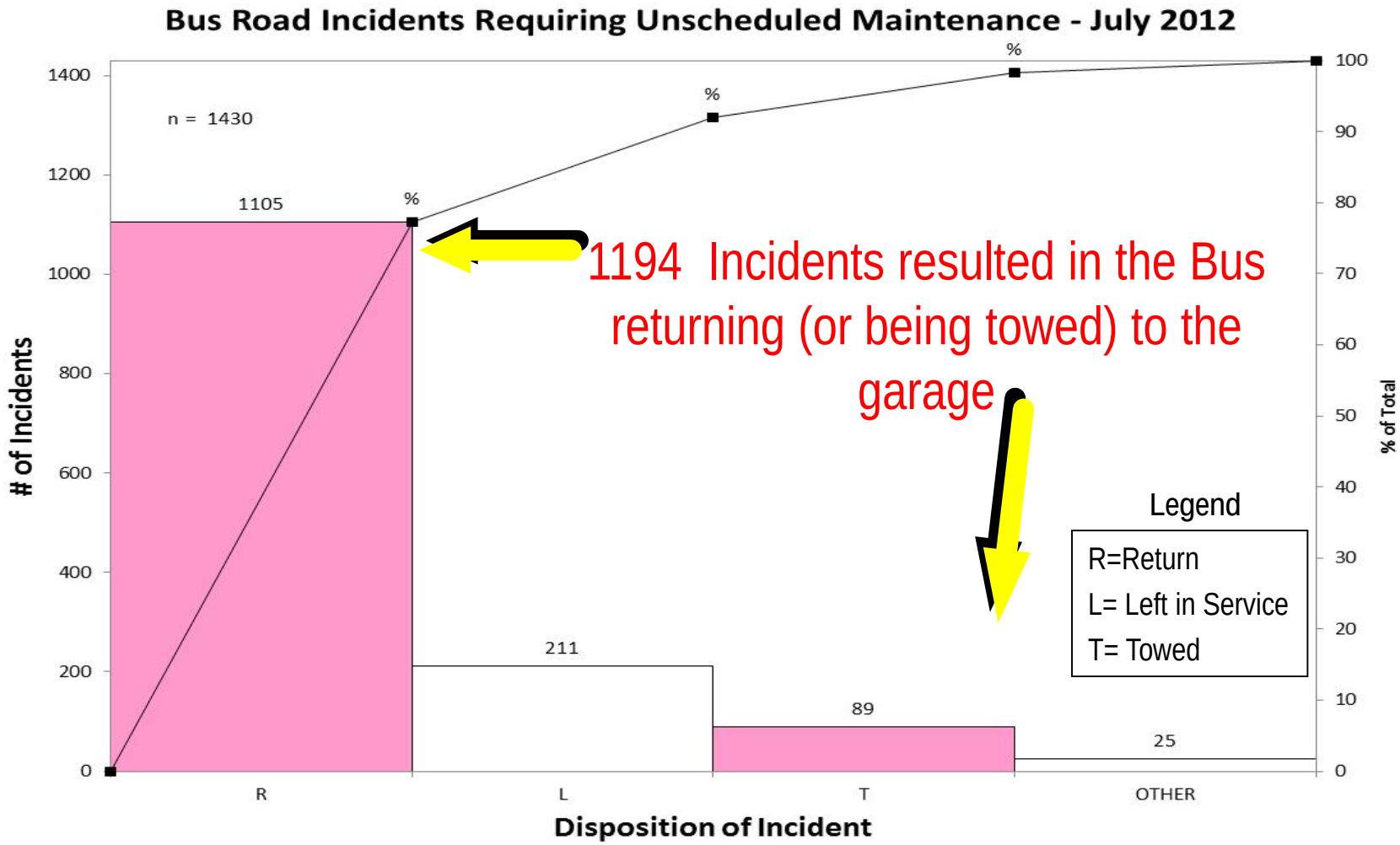


The team next looked closer at the Gap.

Define | Measure | Analyze | Improve | Control

Stratify the Problem

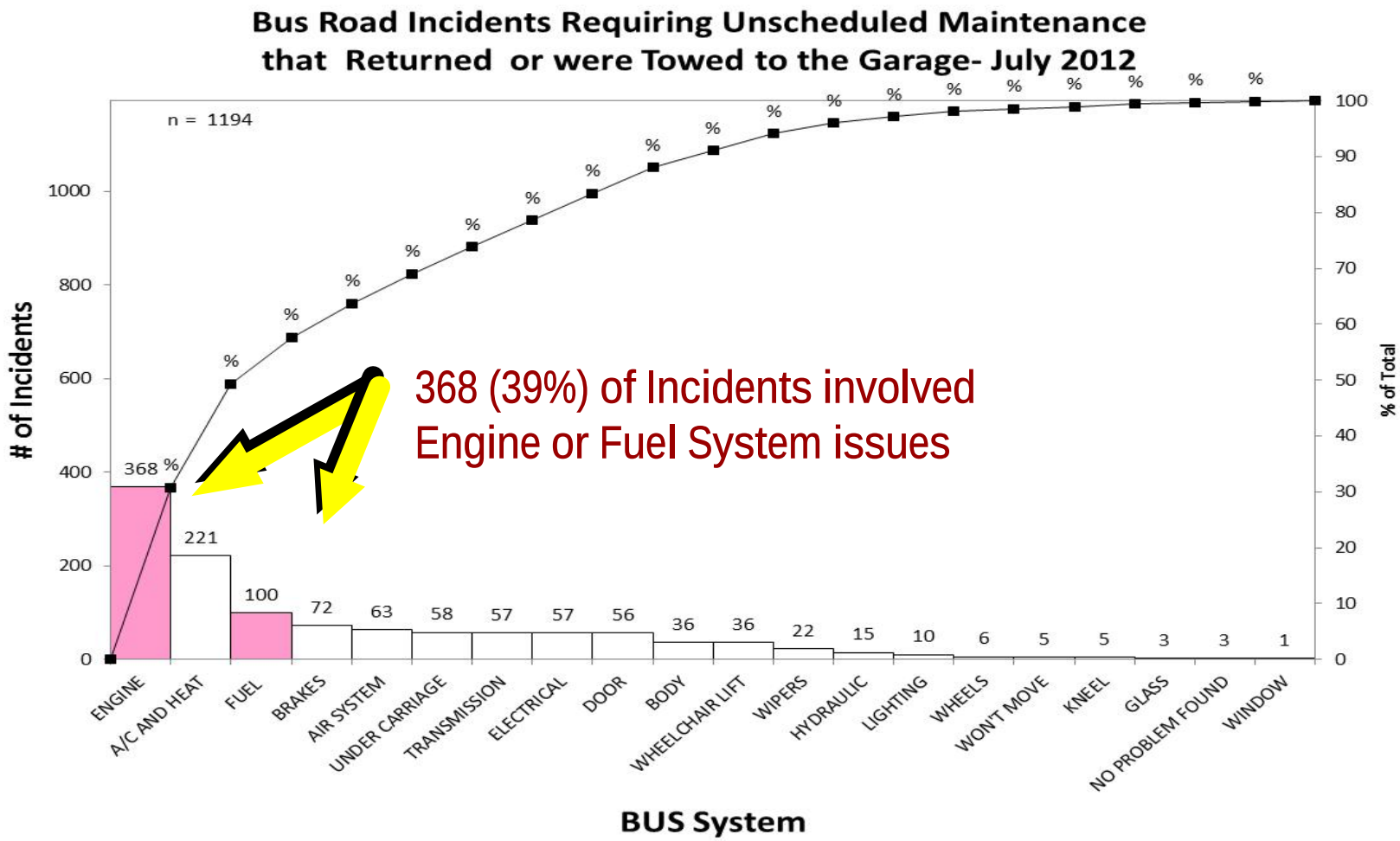
The team stratified the July Bus Road Incidents and found…



The team looked closer at 1194 R and T Incidents.

Stratify the Problem

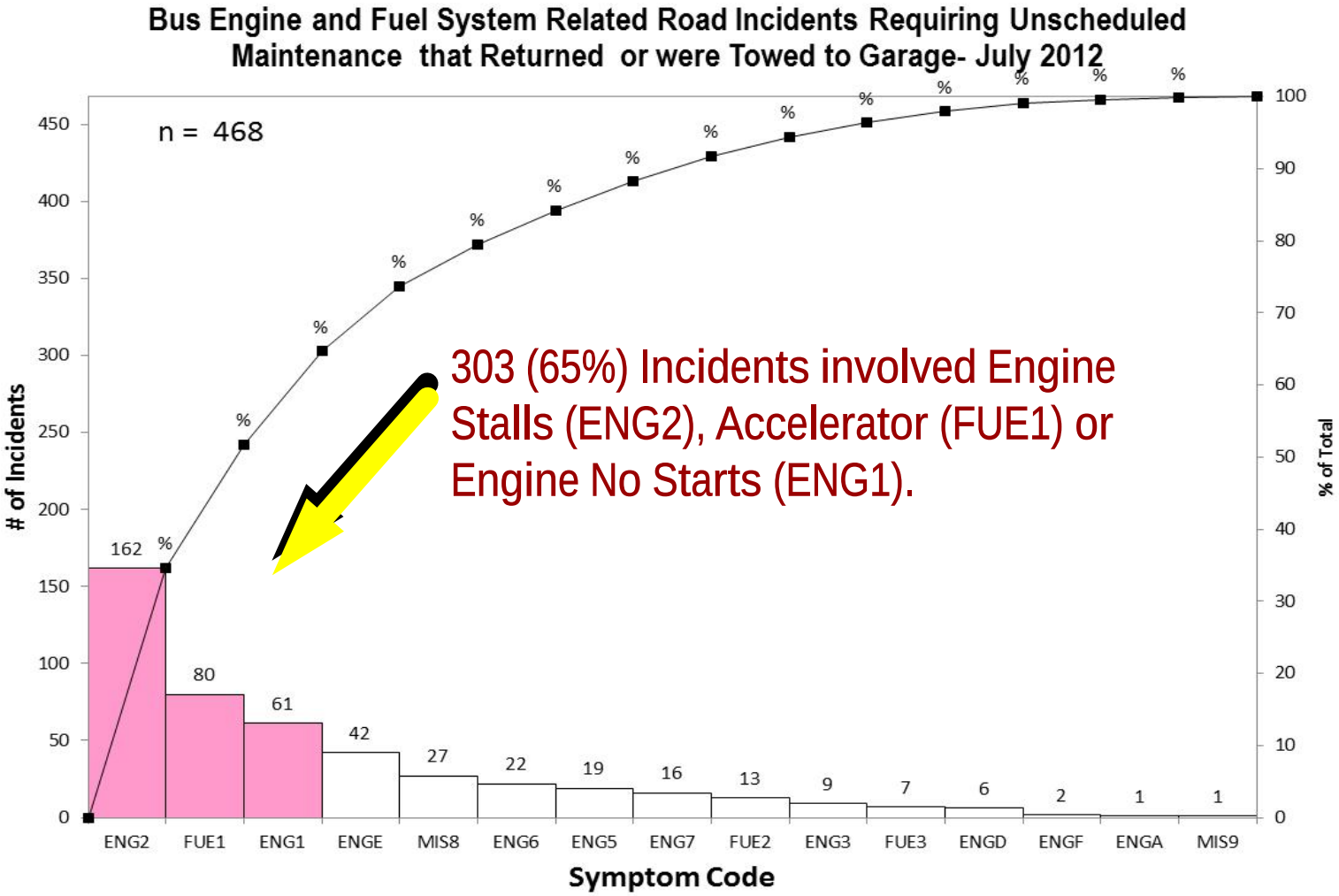
The team stratified the 1194 Bus Road Incidents many ways and found…



The team looked more closely at the 468 Engine and Fuel System related incidents.

Stratify the Problem

The team stratified the 468 Road incidents many ways and found…

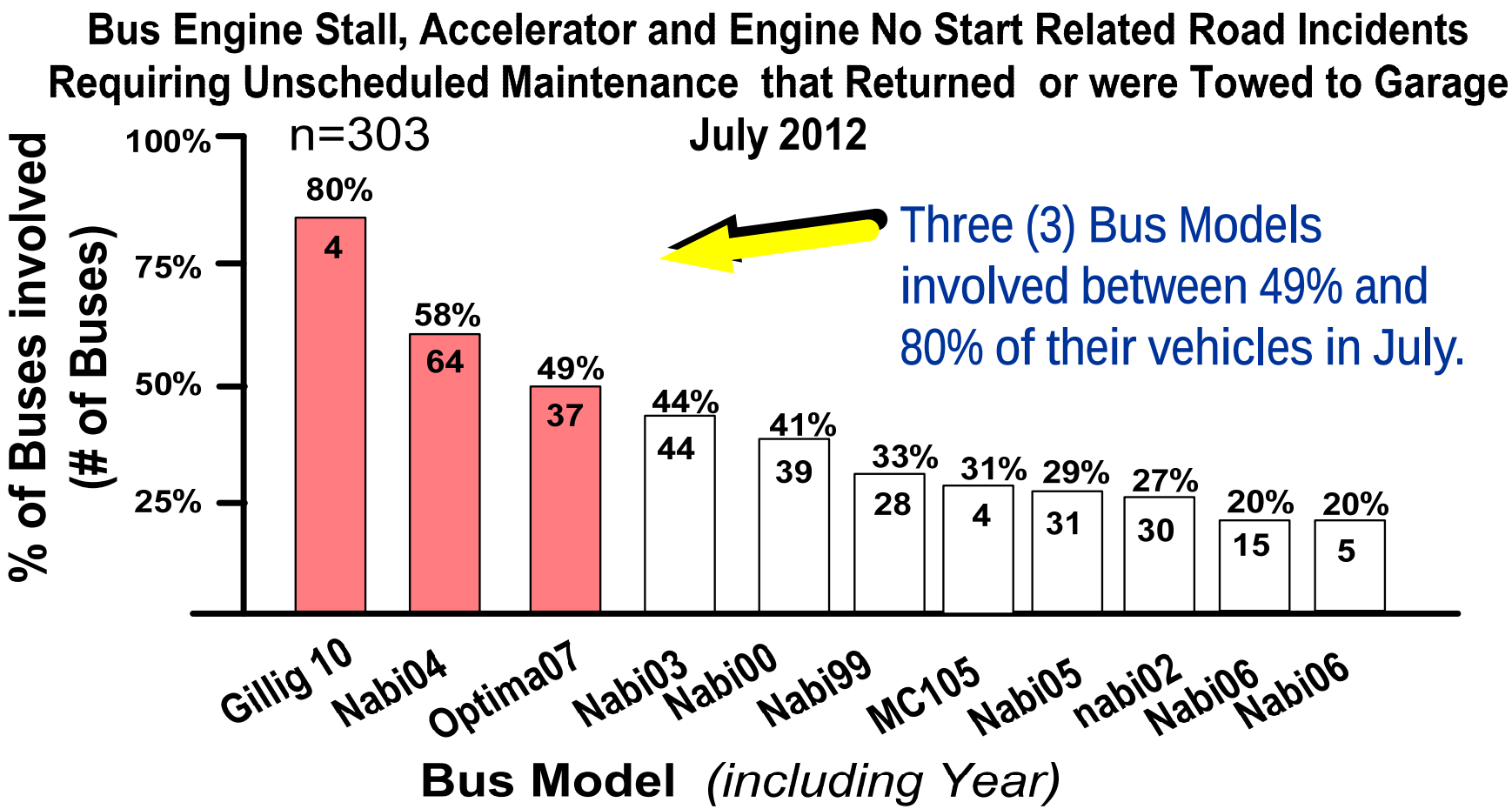


The team looked closer at the Engine Stalls, Accelerator, Engine No Starts Incidents.

Stratify the Problem

5.

The team stratified the 303 incidents many ways and found…



Problem Statement: *"105 July 2012 Road Incidents where Bus returned or were towed to the Garage for Engine Stall, Accelerator or Engine No Start symptoms involved Gillig10, Nabi04 and Optima07 Bus Models".*

Identify Potential Root Causes

9.

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

Single Case Bore Analysis

Problem Statement: "105 July 2012 Road Incidents where Bus Retrnd or towed to Garage for Engine Stall, Accel/Engine No Start symptoms involved Gillig10,

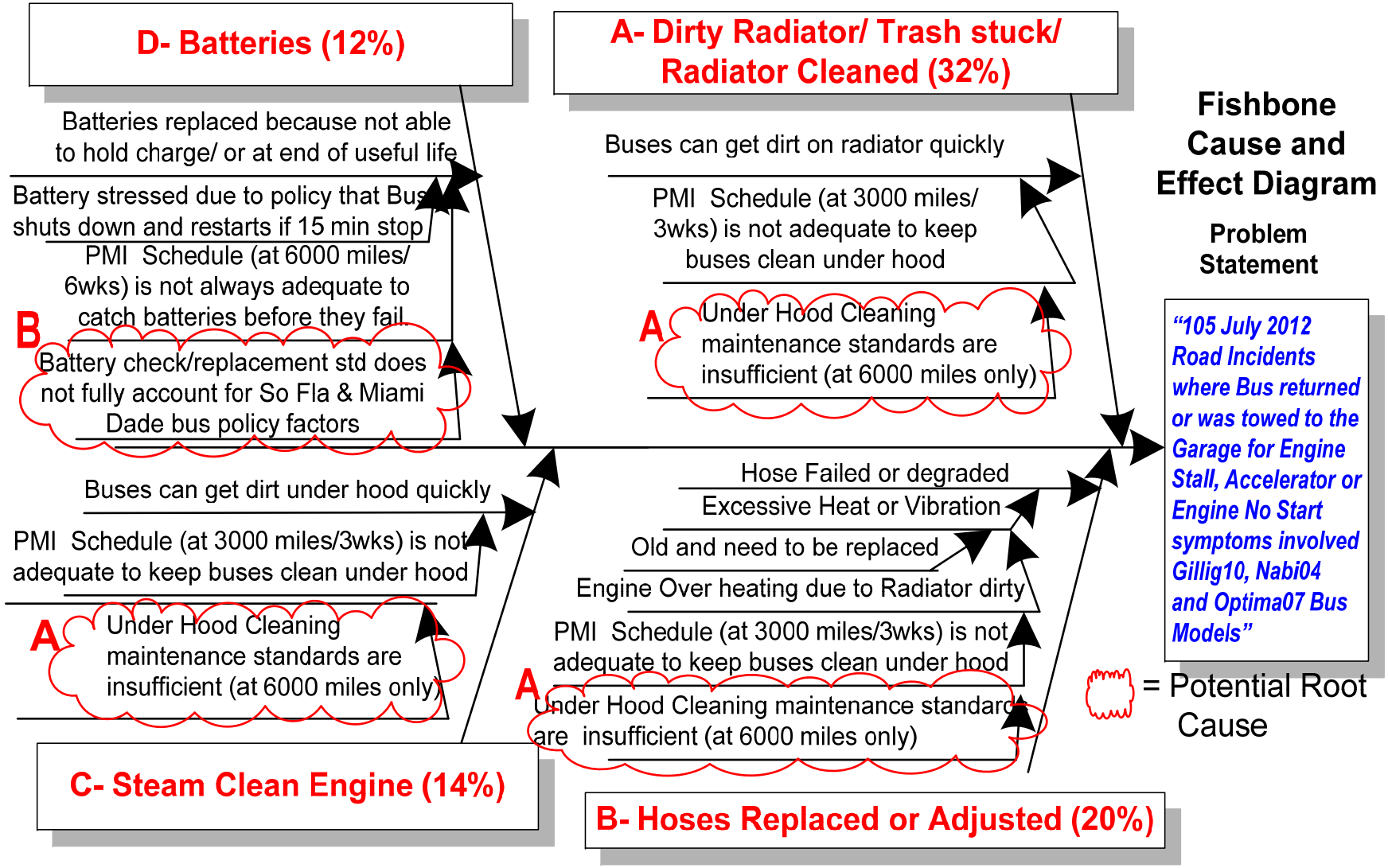
52 of 105 Incidents Sampled

| Reasons or Factors (That possibly contributed to the Bus being returned including parts replaced) | GILLIG 10 | | NABI 04 | | |

Identify Potential Root Causes

9.,10. ☑

The team completed Cause and Effect Analysis and found…



The team next looked to verify these two (2) Potential Root Causes.

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Verify Root Causes

The team collected data to verify the 2 root causes and found…. **11.,12.** ☑

	Root Cause Verification Matrix		
	Potential Root Cause	**How Verified?**	**Root Cause or Symptom**
A	Under Hood Cleaning maintenance standards Are insufficient (at 6000 miles only)	Team reviewed the PMI Procedures and Checklists for Protocol for Cleaning under the hood and verified the frequency currently recommended to check for and clean under hood was 6000 miles.	Root Cause
B	Battery check/replacement std does not fully account for So Fla & Miami Dade bus policy factors	Team reviewed the PMI Procedures and Checklists for Protocol for Checking Batteries and verified the frequency currently recommended to check for and replace batteries was too long.	Root Cause

…both potential root cause was validated as a root cause.

Identify and Select Countermeasures

13.,14.

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

Countermeasures Matrix

Legend: 5=Extremely 4=Very 3=Moderately 2=Somewhat 1=Little or

Problem Statement	Verified Root Causes	Countermeasures	Ratings: Effectiveness	Feasibility	Overall	Take Action? Yes/No
"105 July 2012 Road Incidents where Bus returned or was towed to the Garage for Engine Stall, Accelerator or Engine No Start symptoms involved Gillig10, Nabi04 and Optima07 Bus Models"	A - Under Hood Cleaning maintenance standards Are insufficient (at 6000 miles only)	A1- Install easy to Clean Bug Screens	3	5	15	Y
		A2- Spray Radiators with Non StickScaler	4	1	4	N
		A3- Install Radiators on Top of Bus	5	2	10	N
		A4-Create Radiator Cleaning Station	4	3	12	N
		A1- Establish Weekly Radiator Cleaning Protocol	4	4	16	Y
	B -Battery check/replacement std does not fully account for So Fla & Miami Dade bus policy factors	B1- Install Solar Panels on buses	4	3	12	Y
		B2- Initiate Battery Failure Analysis and determine Actual Useful Life for Batteries and Revise standards	5	4	20	Y
		B3- Study policy impact on Batteries of Auto shutdown after 15 minutes versus Bus leave running	4	4	16	Y
		B4- Require Batteries 18 months or older to be checked every 2 weeks	4	3	12	N
		B5- Require Batteries be checked at 3000 miles point	4	4	16	Y

The team selected 6 countermeasures for implementation.

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Savings Due to Radiator Cleaning Countermeasures

5.

The team estimated Annual Cost Savings Reducing Road Reported incidents by keeping Radiators clean.

Estimated Annual Savings = **# of July Road Reported Incidents Requiring Radiator Cleanings/ Total # July Incidents)** X **% Radiator Cleaning Incidents estimated to be reduced** (slide #15) X **Estimated cost per unscheduled Maint. Road incident** (slide #7) X **Annual # of Road Reported incidents**

Estimated Annual Savings = **548/1,714** X **32%** X **$142.78** X **17,010**

Estimated Annual Savings = **$248,479.98**

Note: Average Monthly Road Reported incidents for 2012=1,417. Incidents reported in July 2012 was at 1,714.

Identify Barriers and Aids

15.

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

Countermeasure(s): Implement 6 Countermeasures to Reduce Bus Road Reported

Barriers		Aids	
Impact (H, M, L)	Forces against Implementation		Forces For Implementation	
H	1) Limited manpower *(Supported by Aid:A,B,C,D,E)*	A)	Cost Savings could be significant
M	2) Cost/Overtime *(Supported by Aid:A,B,C,D, E)*	B)	Management very supportive of team's efforts in saving costs
L	3) Possible Worker Pushback *(Supported by Aid: A,B,C,D,E)*	C)	Extends Life of Equipment Assets
		D)	More Reliable Transit Service
H	4) Procurement time could be lengthy (Supported by Aid:B)	E)	Technology exists for countermeasures

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 6 Counter measures to Reduce Bus Road Reported Incidents

	HOW	WHO	WHEN 2013 Jan–Sep
1	**Develop Countermeasures:**		
	A1 - Install easy to clean bug screens	Will	2/21/13
	A1- Establish weekly radiator cleaning protocol	Will	2/21/13
	B1- Install Solar Panels on buses	Will	2/21/13
	B2- Initiate battery failure analysis and determine actual useful life for batteries and revise standards	Derrick	4/30/13
	B3- Study policy impact on batteries of the 15 minute automatic shutdown versus allowing the bus to idle	Derrick	4/30/13
	B5- Require battery check at 3000 mile point	Derrick	4/30/13
2	**Secure management approval of countermeasures (share benefits and cost savings)**	Team	5/15/13
3	**Communicate/train staff in countermeasures and related policies/procedures (share improved service and cost savings)**	Team	Pilot 5/30/13
4	**Implement countermeasures and pilot**	Team	Pilot 6/30/13
5	**Review pilot and determine benefits and adjust as necessary and present results to management**	Team	7/31/13
6	**Establish on-going responsibilities and standardize countermeasures into operations**	Derrick	On-going

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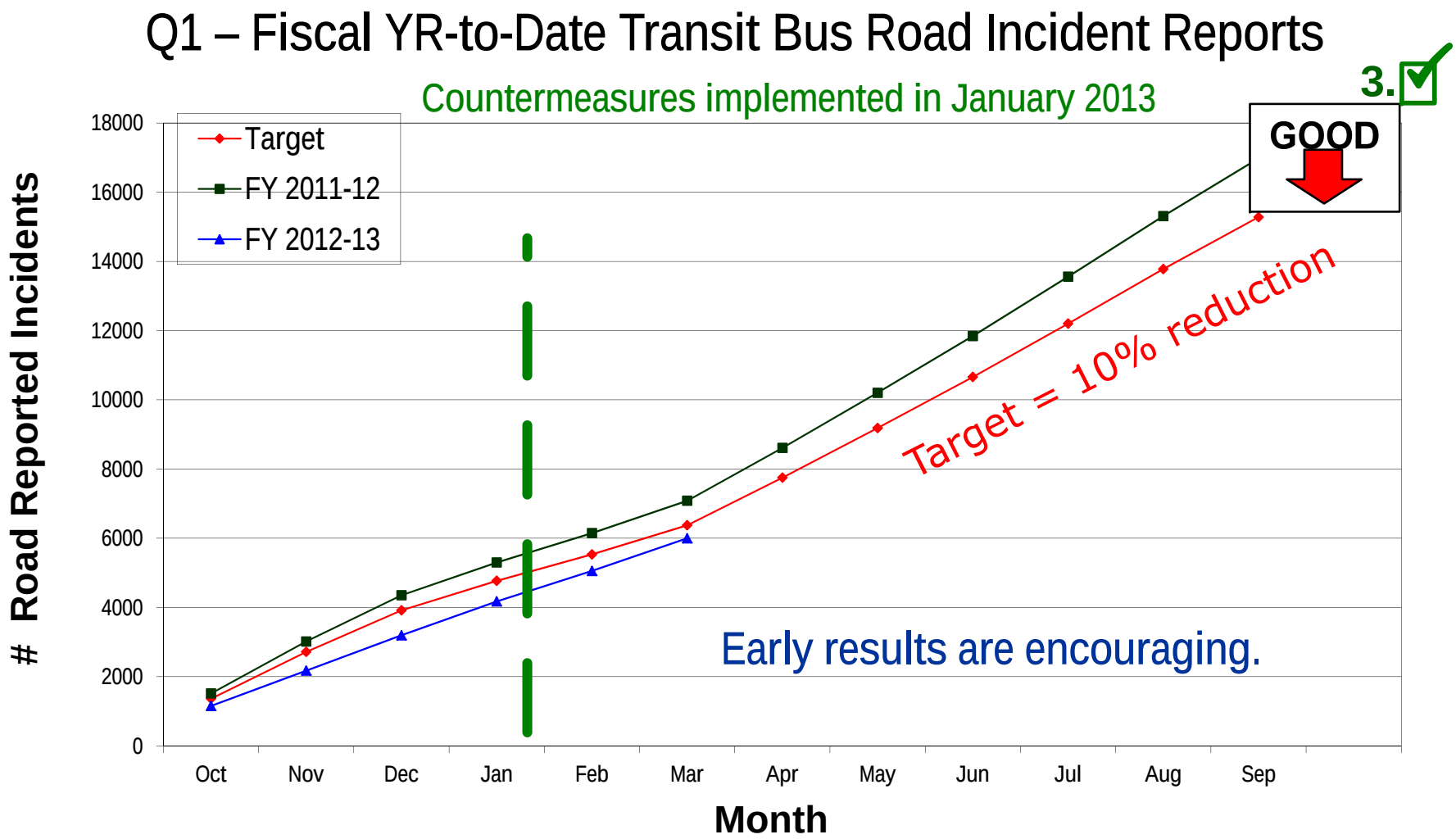
Review Results

17.,18.,19.,20. ☑

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



The team will continue to monitor the countermeasures and results.

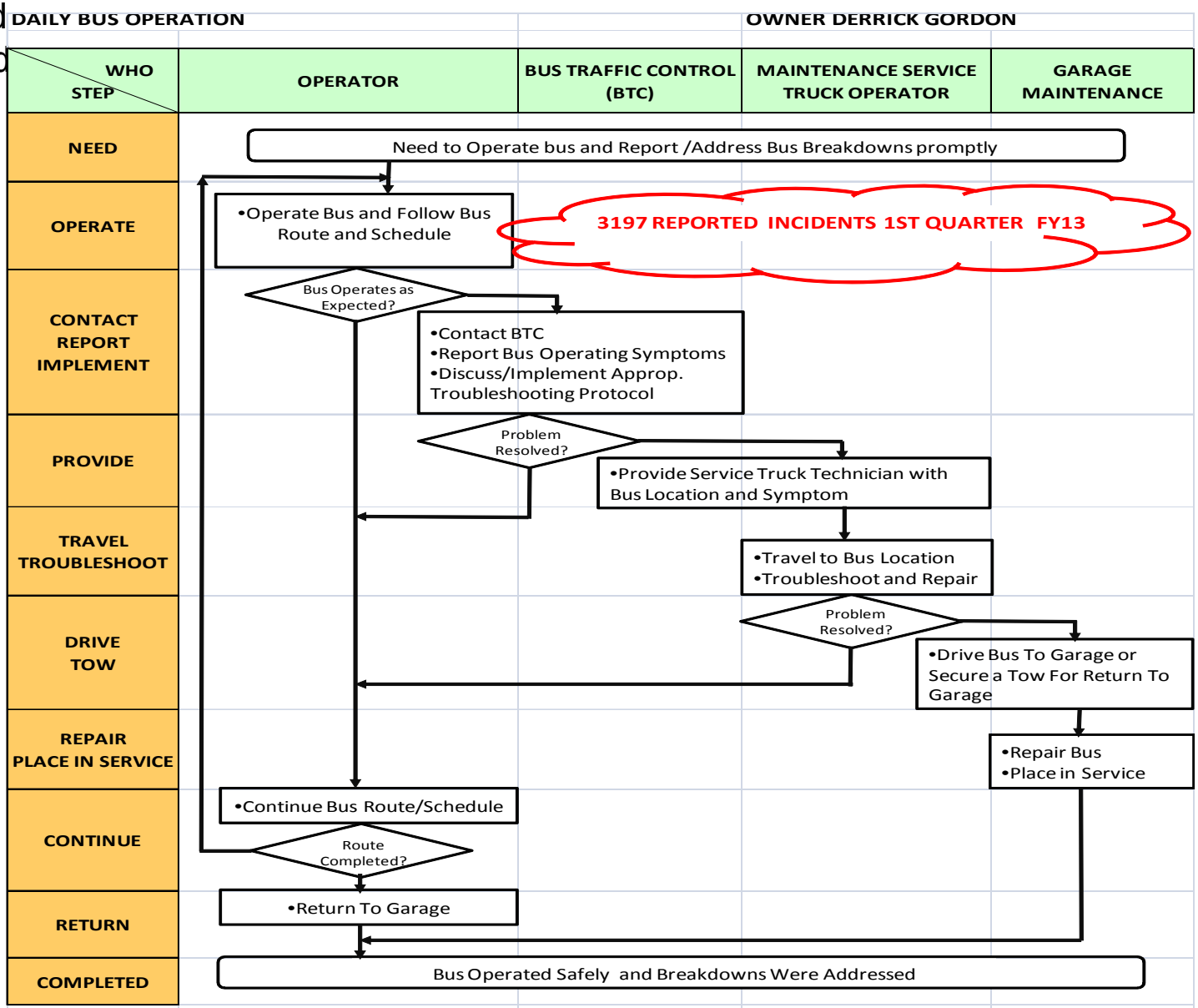
Define → Measure → Analyze → Improve → Control

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



Define > Measure > Analyze > Improve > Control

Standardize Countermeasures

21.,22.,23.

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

Process Control System

Process Name: Operate Bus, Report Incidents and Address Bus Breakdowns	**Process Owner:** Derrick Gordon
Process Customer: Bus Rider, County Taxpayer	**Critical Customer Requirements:** Operate Bus Safely and Without Road Incidents
Process Purpose: Operate Bus and transport riders throughout County	**Current Sigma Level:** TBD
	Outcome Indicators: Q1

Process and Quality Indicators		Checking / Indicator Monitoring			
Process Indicators	Control Limits	Data to Collect	Timeframe (Frequecy)	Responsibility	Contingency Plans/ Misc.
Quality Indicators	Specs/ Targets	What is checking item or indicator calculation?	When to collect data?	Who will check?	• Actions required for exceptions • Procedure references
Q1 Fiscal YTD # of Transit Bus Incidents Reported	1291 per Mo (10% reduction from 2012)	Fiscal YTD of Transit Bus reported Incidents	Monthly	Performance Analysis	Bus Maintenance and Bus Operations / Escalate to Asst. Director

Approved: _____ **Date:** _____ **Rev#** _____ **Rev. Date** _____

The team looked ahead to the future.

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Budget Reduction Measures

24.,25. ☑

Bug Screen

One bug screen has been received and is being tested on bus 5102.

Estimated Costs : $100 each Fleet - $82,200

BENEFITS

Less overheating and road calls

Better on-time performance

Less passenger inconvenience

Define > Measure > Analyze > Improve > Control

Budget Reduction Measures

24.,25. ☑

Radiator Cleaning Protocol

- Radiator Cleaning will be performed on the 3,000 ("O" PM Inspection) and 6,000 ("A" PM Inspection).
- Transit Shop Maintenance Supervisors are assigned and will manage the PM process.
- A team has been selected to periodically physically review PMs for compliance.
- Upon the hiring of new hostlers, one will be assigned at each division to perform regular radiator cleanings.

BENEFITS

Less overheating and road calls

Better on-time performance

Less passenger inconvenience

Budget Reduction Measures

24.,25. ☑

Radiator Cleaning Protocol

Expected Outcome

- 39% of all incidents were engine related.
- Coolant leaks and dirty radiators were the root cause 52% of all engine related breakdowns.

Bug screens and cleaning radiators should:

	Savings
Reduce tows by 20%	$46,138.36
Reduce need for Stand-by bus and operator by 20%	$152,618.88
Initial Cost	- $82,200.00

Total Annual Savings: $116,557.24

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Budget Reduction Measures

24.,25. ☑

Batteries

- Battery maintenance will be performed on the 3,000 (“O” Inspection) and 6,000 (“A” Inspection).
- Transit Shop Maintenance Supervisors are assigned and will manage the PM process.
- A team has been selected to periodically physically review PMs for compliance.

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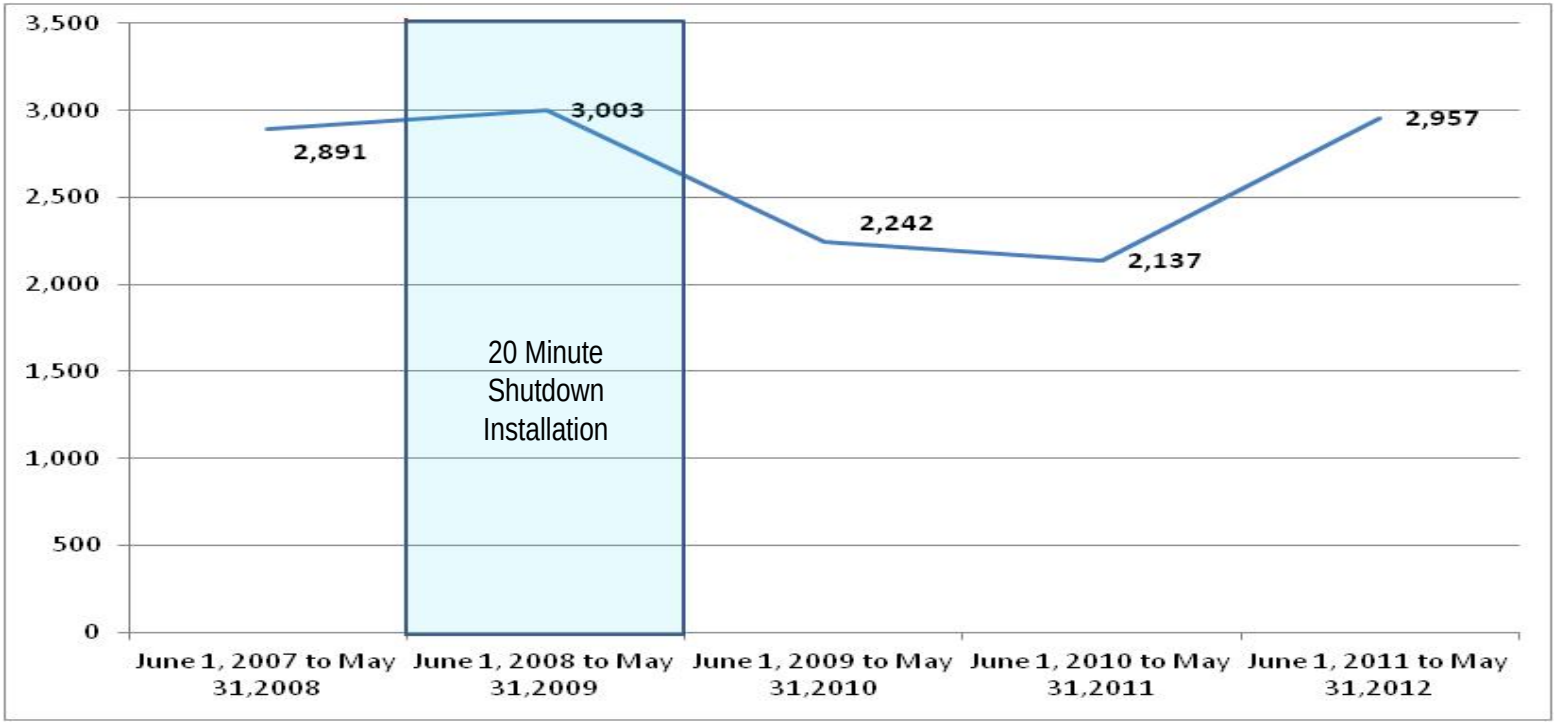
Budget Reduction Measures

24.,25.

Impact of 15 Minute Shutdown

- A 15 minute shutdown system was programmed into all buses from May 2008 to June 2009. This limited idle time to save fuel and to be in compliance with State pollution regulations. It possibly impacted battery usage.

BATTERY USAGE



- A review of battery usage prior to and after the implementation of the 15 minute shut down shows that reduced idle time did not increase battery usage.

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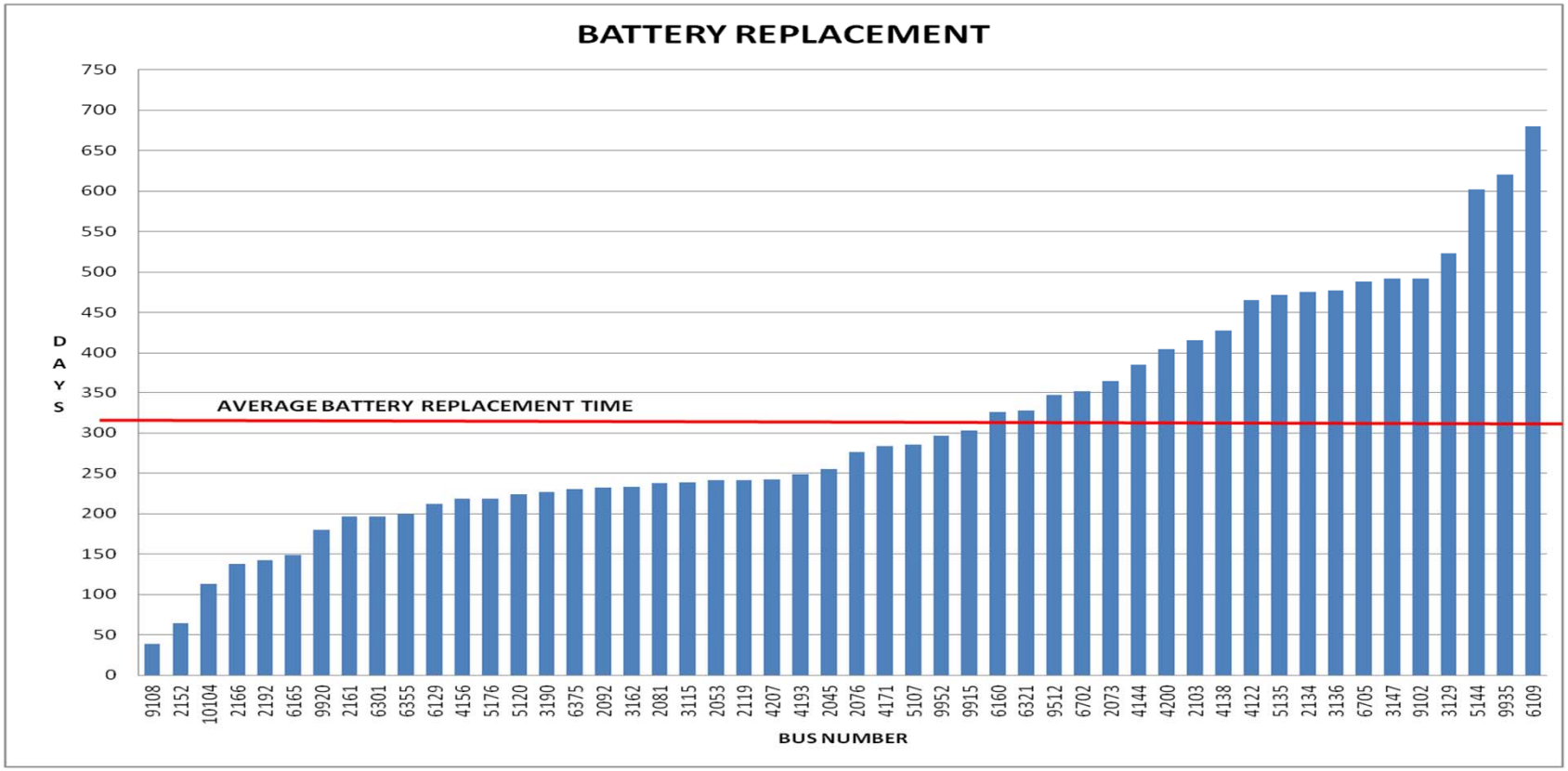
Budget Reduction Measures

24.,25.

Expected Battery Replacement

- Analyzed battery replacement in 50 buses from April 1, 2011 to March 31, 2013.



- Average battery replacement time was 310 days.

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Budget Reduction Measures

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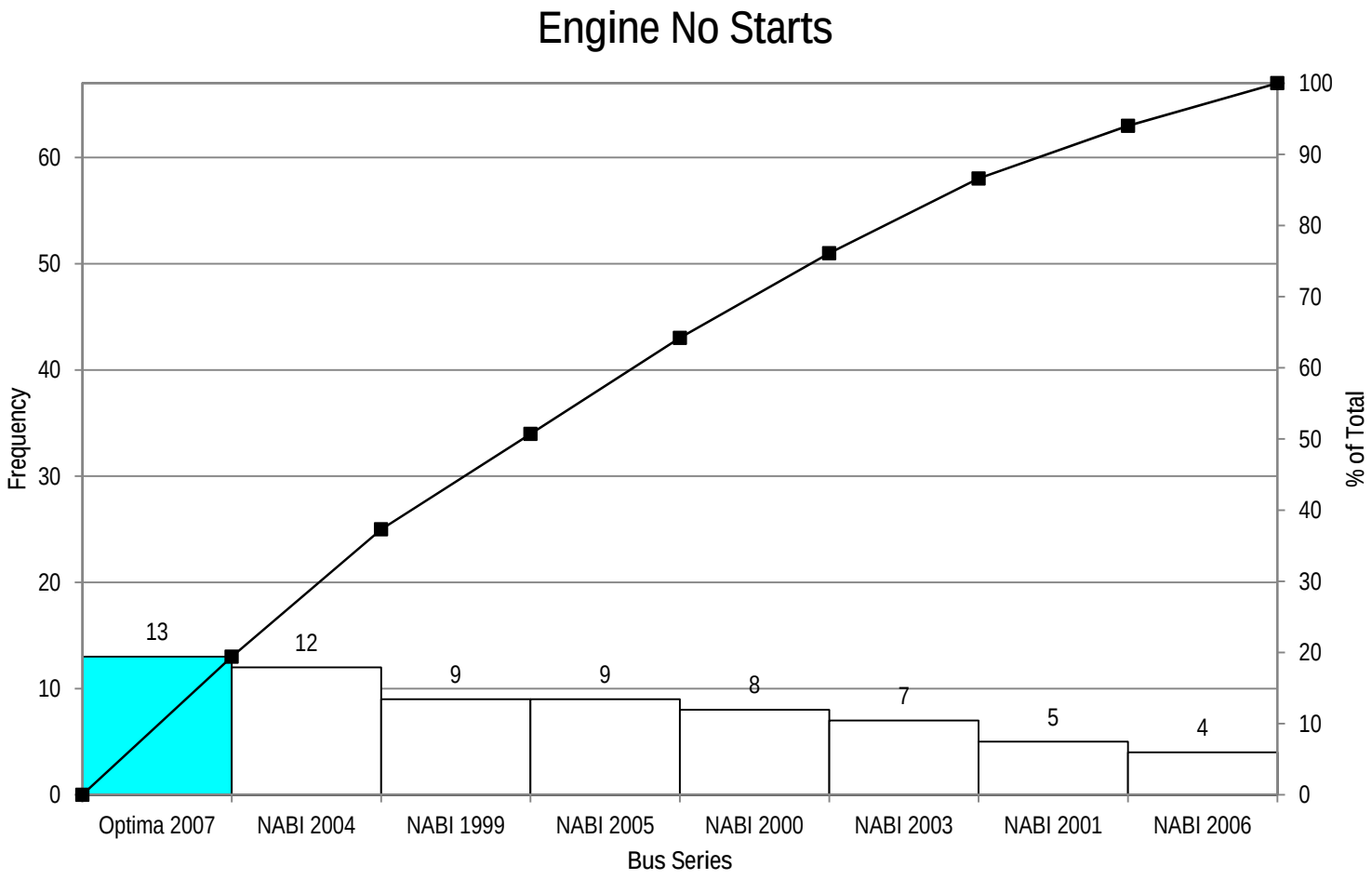
Battery Related Breakdowns



- Optima Bus Fleet accounted for 20% of all engine no start breakdown.

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Budget Reduction Measures

24.,25. ☑

Solar Panels

- Provides constant electrical charge to batteries when the bus is not in operation.
- Electrical charge offsets the parasitic draw of bus electronics allowing batteries to remain fully charged.
- A cost estimate has been received for purchase and installation of solar panels on our Optima bus fleet. (75 buses)

Estimated Cost Installed $1,500.00 per bus.

BENEFITS OF BATTERY MAINTENANCE PROGRAM

Fewer Morning "No Starts"

Fewer End of the Line Breakdowns

Less passenger inconvenience

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Budget Reduction Measures

24.,25. ☑

Solar Panels

Expected Outcome

- Failed batteries resulting in "engine no starts" were the root cause 12% of all engine related incidents.
- The Optima Bus Fleet accounted for 20% of all battery related breakdowns.

Solar Panels should:

	Savings
Reduce "engine no start" related tows by 2.4%	$5,536.60
Reduce need for Stand-by bus and operator by 2.4%	$18,314.27
Annual Cost for six years (75 buses)	- $18,750.00
Annual Savings	$5,100.87

- Initial Cost $112.500.00 Net savings(six years) $30,605.22

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Summary

24.,25. ☑

Installation of bug screens, improvement in the radiator cleaning schedule will reduce road incidents and interruptions in bus service.

Improved battery maintenance and the installation of solar panels on the Optima bus fleet will reduce “no start” conditions that can lead to road incidents, failure to provide buses for pull-out and lack of power for critical bus electronics and electrical systems.

MDT passengers will enjoy service that is safer, more reliable, and courteous.

These changes will also facilitate a savings of approximately $121,658.11 per year for MDT.

Identify Lessons Learned

24.,25. ☑

Lessons Learned

1) Root Cause Analysis tools (Single Case Bore & Fishbone) helped the team identify Potential Root Causes: "Standards that Failed or People Failing Standards"

2) DMAIC Process was systematic and effective for problem Solving. The team learned to trust the process and "Let the Data take you to the Root Causes"

3 Creative Thinking Techniques (including the initial step allowing individuals to silently write potential solutions) can very effectively involve shy employees.

4) Conducting simple "Ice Breakers" at the start of team sessions was fun and an effective way to build team trust and rapport

Next Steps

1) Continue to monitor the countermeasures and performance results.
2) Analyze unscheduled Part Failure rates and determine cost effectiveness of replacing at part failure or at the calculated useful life.