Fleet Operations: Preventive Maintenance

June 2, 2009

CountyStat

CountyStat Principles

- **Require Data Driven Performance**
- **Promote Strategic Governance**
- **Increase Government Transparency**
- **Foster a Culture of Accountability**

Agenda

- Introductions and meeting purpose
- Montgomery County performance
- Improving performance for transit vehicles
- Improving performance for administrative vehicles
- Wrap-up

Meeting Goal

Establish strategies for preventive maintenance for transit, public safety, and administrative vehicles to cost-effectively maximize mean distance between failure and/or turnaround times.

This meeting responds to the following items:

- **CountyStat follow-up item dated November 14, 2008:** Analyze fleet maintenance and replacement schedule options and costs to either maximize mean distance between failure performance and/or minimize turnaround time
- **One operational suggestion received by CountyStat:** Monitor vehicle maintenance, especially scheduling of light equipment

Montgomery County Performance: FY08

Equipment Class	Number of Vehicles	Mean Distance Between Failure (miles)	Turnaround Time (days)
Transit	469	2,707	6.9
Heavy Equipment	540	1,469	14.4
Public Safety Light Equipment	1,340	2,517	2.9
Administrative Light Equipment	757	1,943	3.4

Caveats to Data Shown in this Presentation

- **Vehicle mileage at the time of service is prone to error**

	Transit	Light Equipment
% of maintenance work orders that listed a vehicle mileage less than the mileage at the previous visit	**2.2%**	**1.7%**
% of all vehicles affected	**73%**	**11%**

  - Data analysis filtered out these errors to the extent possible or found alternate ways of making calculations to limit their effects
- **Determination of whether transit preventive maintenance occurred on time or late is prone to error**
  - Next preventive maintenance should be scheduled 6,000 miles after the most recent preventive maintenance
  - 30% of the time, the next preventive maintenance mileage was something other than 6,000 miles after the most recent
  - It is possible that missed preventive maintenance is therefore underreported

Caveats to Data Shown in this Presentation

- **Mean distance between failure did not show a relationship with annual maintenance costs**
  - This result is suspect, since it is not likely that vehicles prone to failure are just as expensive to maintain as vehicles that are not prone to failure
  - The mean distance between failure measure itself is prone to error due to errors in recorded mileage
  - The lack of relationship is likely compounded by a definition of “failure” that is too broad
- **Moving forward, a clearer and more stringent definition of failure should be developed, such as**
  - Number of times the vehicle was removed from service
  - More limited number of repair types

Agenda

- Introductions and meeting purpose
- Montgomery County performance
- **Improving performance for transit vehicles**
  - Drivers of performance
  - Improving performance
- Improving performance for administrative vehicles
- Wrap-up

Primary Drivers of Performance in Transit Vehicles

- **Preventive maintenance**
- **Operating environment (e.g. weather and road conditions)**
- **Annual bus mileage**
- **Bus operating speeds**
- **Age of fleet**
- **Mechanical characteristics of bus makes and models**

Source: Judith T. Pierce and Elizabeth K. Moser, "System-Specific Spare Bus Ratios," Synthesis of Transit Practice 11, Transit Cooperative Research Program, Transportation Research Board, Federal Transit Administration, 1995

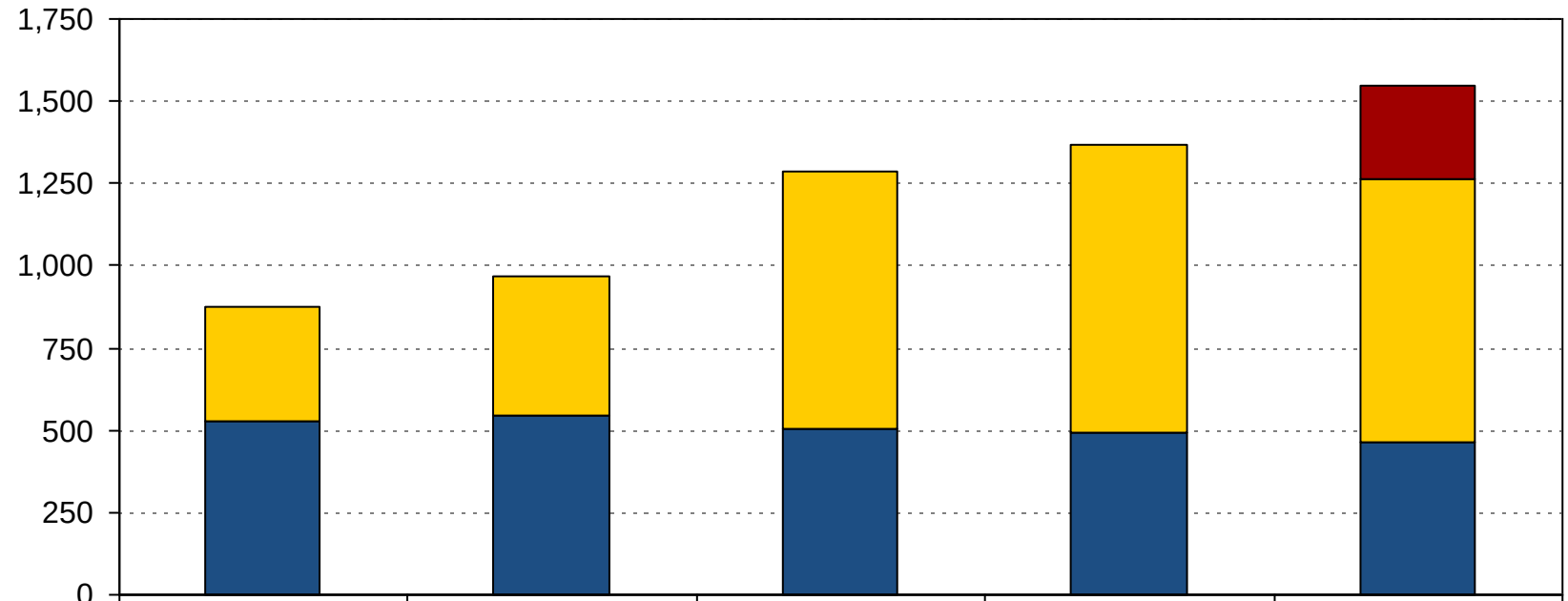
Preventive Maintenance of Transit Equipment

- **Preventive maintenance is performed every 6,000 miles**
  - Mileage interval is set by agreement between the Federal Transit Administration (FTA) and Montgomery County
  - FTA audits Montgomery County every three years to make sure that preventive maintenance intervals are being adhered to
    - 80% of preventive maintenance must occur within 10% of 6,000 miles (i.e. the preventive maintenance is considered late if it occurs after 6,600 miles)
- **Montgomery County has struggled with meeting FTA expectations**
  - Most work each day in transit equipment is unscheduled repairs rather than scheduled maintenance
  - An FTA report from July 2007 found that 83% of preventive maintenance was overdue at one garage, and 60% of preventive maintenance was overdue at the other garage
  - Current Fleet management, which began in FY08, has made getting preventive maintenance under control a priority

FTA funding is dependent upon the findings of the audits.

Overdue Preventive Maintenance: Transit Equipment

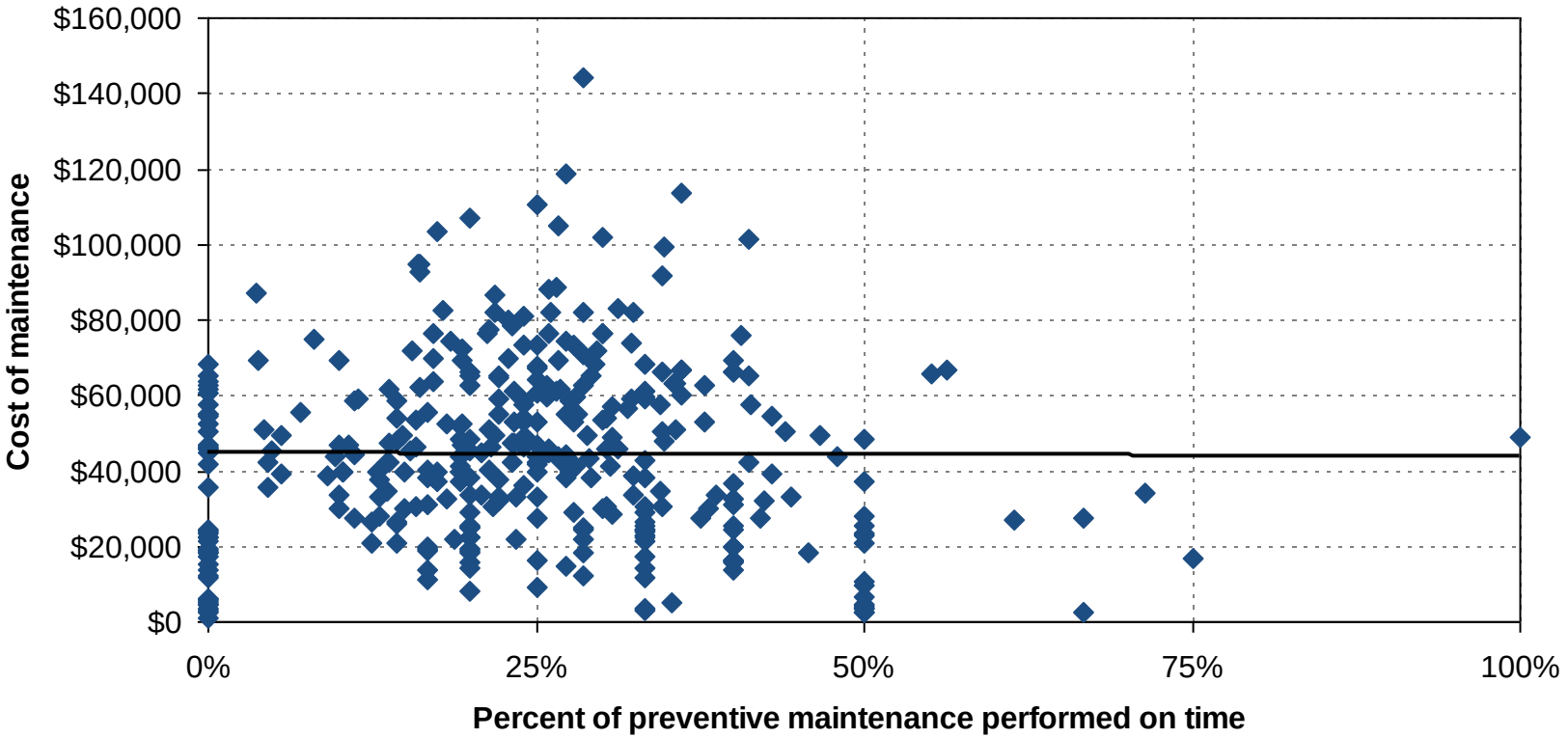
Number of missed preventive maintenance events



	FY04	FY05	FY06	FY07	FY08
STS					281
TES	346	420	781	874	801
BMF	530	545	506	491	463

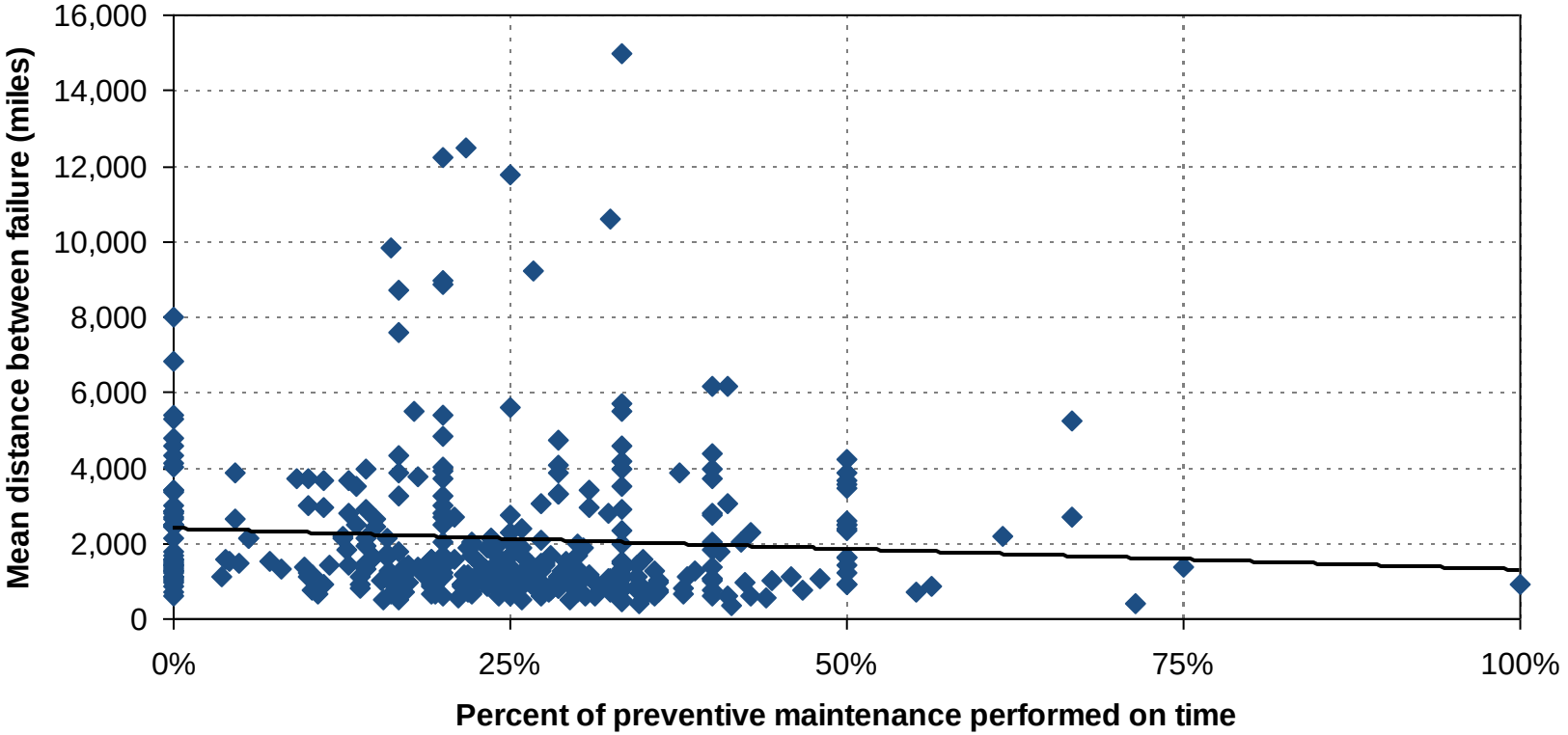
STS = Small Transit Shop (small bus maintenance at Nicholson Court)
TES = Transit Equipment Section (large bus maintenance at Crabbs Branch Way)
BMF = Bus Maintenance Facility (large bus maintenance in Silver Spring)

Cost of Missed Preventive Maintenance
Maintenance Cost 5/1/2008 – 4/30/2009, by Vehicle



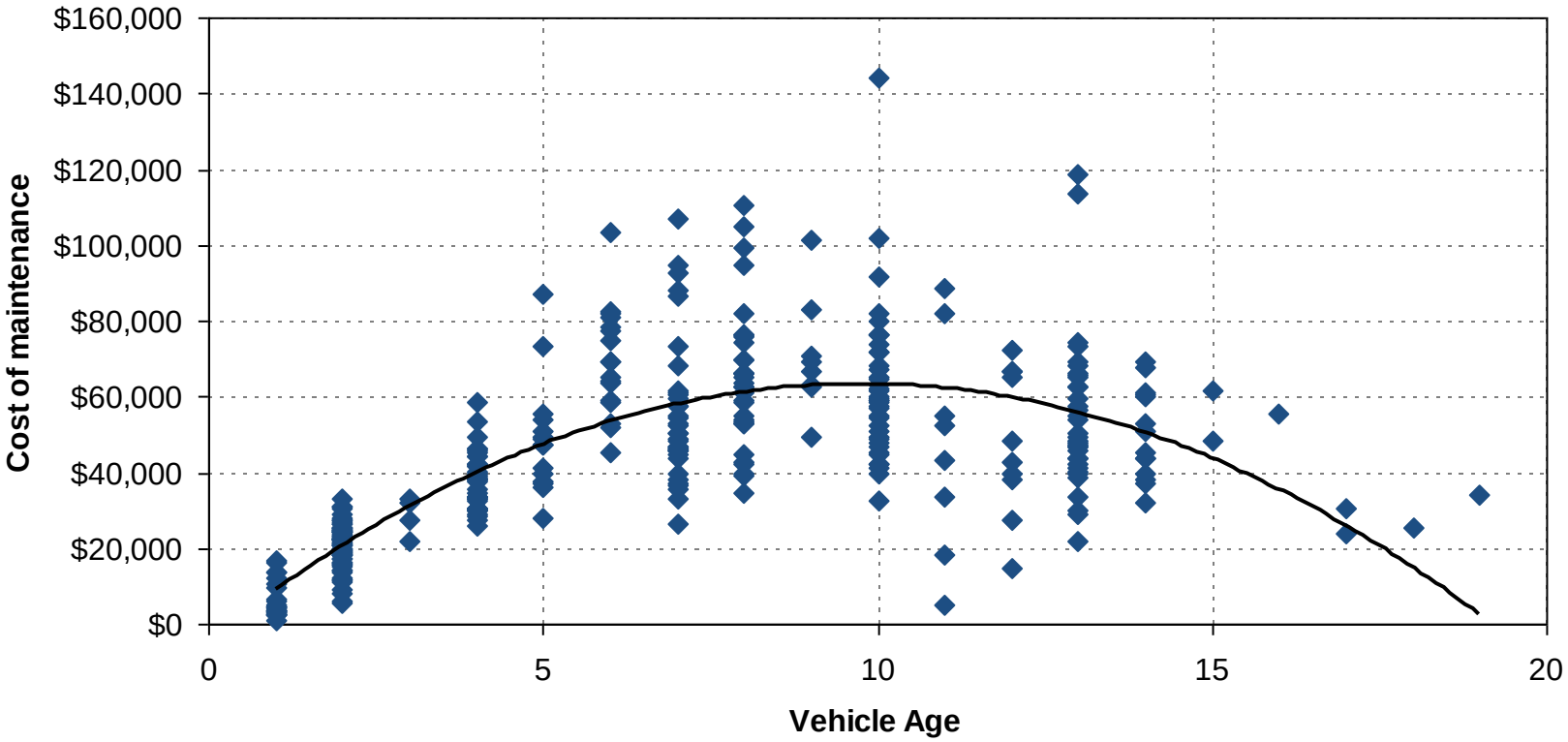
There is essentially no relationship in this data between adherence to preventive maintenance and annual vehicle cost.

Cost of Missed Preventive Maintenance
Mean Distance Between Failure, by Vehicle



Adherence to preventive maintenance improves mean distance between failure somewhat.

Cost of Maintaining an Aging Fleet
Maintenance Cost 5/1/2008 – 4/30/2009, by Vehicle

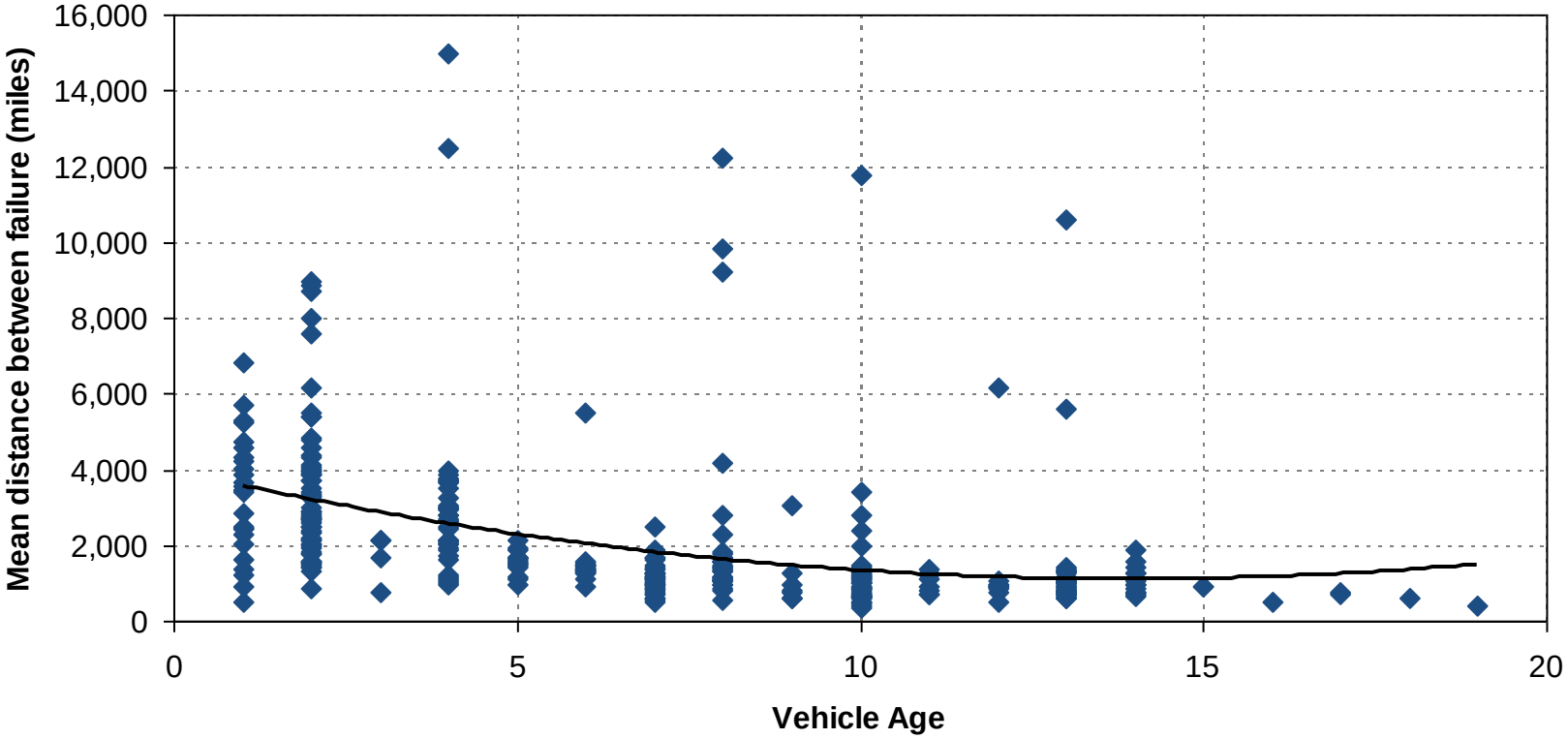


There is a strong relationship between vehicle age and annual vehicle cost. Peak costs occur at age 10.

Predicted Maintenance Cost By Age
Regression Analysis Results

Age	Predicted Maintenance Cost
1	$13,240
2	$25,058
3	$35,454
4	$44,428
5	$51,980
6	$58,110
7	$62,818
8	$66,103
9	$67,967
10	$68,409
11	$67,429
12	$65,027
13	$61,203
14	$55,957
15	$49,289

Cost of Maintaining an Aging Fleet
Mean Distance Between Failure, by Vehicle



There is a relationship between vehicle age and mean distance between failure. Minimum occurs at age 15.

Other Factors That Affect Maintenance Cost and Mean Distance Between Failure

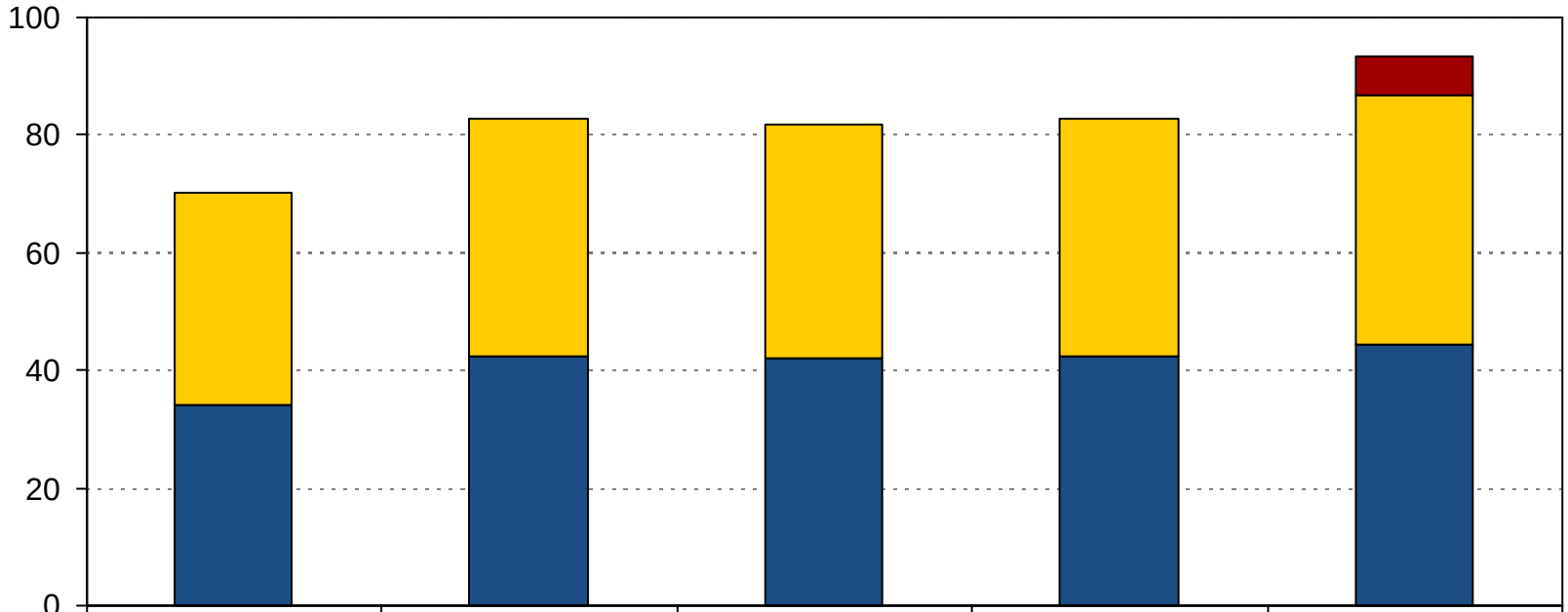
- **Bus class: Hybrid**
  - Higher maintenance costs
  - Lower mean distance between failure
- **Bus make: Orion**
  - Higher maintenance costs

Variable	MDBF Model	Cost Model
Intercept	4,278[99]	-$2,639
MDBF		-$0.12
Vehicle Class		
9HCM (Bus,13-18 Pass,Paratransit,Whlchair)	-167	-$5,278
9HCU (Bus,13-18 Pass,Paratransit,Whlchair)	-324	-$4,563
9OEU (Bus,25-42 Pass,Transit,Whlchair -CNG-)	-291	$1,055
9QEU (Bus,25-42 Pass,Transit,Whlchair,Hybrid)	-1,413[95]	$8,215[85]
Vehicle Make		
Gillig	104	-$2,805
International	738	$4,759
Orion	194	$6,351[85]
Other	-89	-$3,511
Age of Vehicle		
Age	-423[99]	$13,951[99]
Age^2 (Age squared)	14[90]	-$711[99]
Percent of preventive maintenance events performed on time		
0%	-335	-$527
1% - 15%	-219	-$8,380[99]
31% - 45%	-62	-$2,752
45%+	-933[95]	-$856
R^2 of model	**0.219**	**0.613**

XX – Statistically significant at the XX% level (i.e. .95 is significant at the 95% level)

Fleet Personnel: Transit Equipment

Average number of personnel for transit maintenance



	FY04	FY05	FY06	FY07	FY08
STS					6.6
TES	36.2	40.5	39.5	40.3	42.4
BMF	34.1	42.4	42.2	42.5	44.3

Average number of personnel charging to each facility during that fiscal year

Cost/Benefit of Replacing Aging Transit Vehicles
Comparison of Annual Cost

Methodology

- **Total cost of the vehicle**
  - Year 1: Purchase price + predicted maintenance cost at age 1
  - Remaining years: predicted maintenance cost for each vehicle age
- **Annual cost of having the vehicle = total cost / age at replacement**
- **Goal: minimize the annual cost**

Findings

- **The only vehicle that should be sold early are small buses**
- **Large buses should be held as long as possible**

Annual Maintenance Cost Predicted by Regression Analysis

Age	Predicted Cost
1	$13,240
2	$25,058
3	$35,454
4	$44,428
5	$51,980
6	$58,110
7	$62,818
8	$66,103
9	$67,967
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11	$67,429
12	$65,027
13	$61,203
14	$55,957
15	$49,289

Cost/Benefit of Replacing Aging Transit Vehicles
Comparison of Annual Cost of Owning a Vehicle

Replacement Age	Purchase Price of Vehicle				
	$175,000	$200,000	$225,000	$250,000	$275,000
5	$69,032	$74,032	$79,032	$84,032	$89,032
6	$67,211	$71,378	$75,545	$79,711	$83,878
7	$66,584	$70,155	$73,727	$77,298	$80,869
8	**$66,524**	$69,649	$72,774	$75,899	$79,024
9	$66,684	$69,462	$72,240	$75,017	$77,795
10	$66,857	$69,357	$71,857	$74,357	$76,857
11	$66,909	$69,181	$71,454	$73,727	$76,000
12	$66,752	$68,835	$70,919	$73,002	$75,085
13	**$66,325**	$68,248	$70,171	$72,094	$74,017
14	**$65,584**	$67,370	$69,156	$70,942	$72,727
15	**$64,498**	**$66,165**	**$67,831**	**$69,498**	**$71,165**

Smallest annual cost of having the vehicle are shown in bold.

Fleet Summation of Meaning of Data

- **Data as displayed includes corrective maintenance work not associated with mechanical failures.**
- **DGS/DFMS contracted with an outside consulting firm in December 2008 to audit the Preventive Maintenance Program and provide insight into why PMs are being performed late. MC should have the results of the audit with recommendations in the next few months.**
- **Contributing factors:**
  - **Age of the fleet**
  - **Size and age of the maintenance shops**
  - **Bus to mechanic ratio (staffing)**

Agenda

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- **Improving performance for administrative vehicles**
  - Drivers of performance
  - Improving performance
- Wrap-up

Primary Drivers of Performance in Light Equipment

- **Mechanical characteristics of vehicle makes and models**
- **Training of personnel**
- **Availability of parts**
- **Control of workflow**
  - Amount of unscheduled versus scheduled repairs
  - How often vehicles are brought in on time for scheduled visits

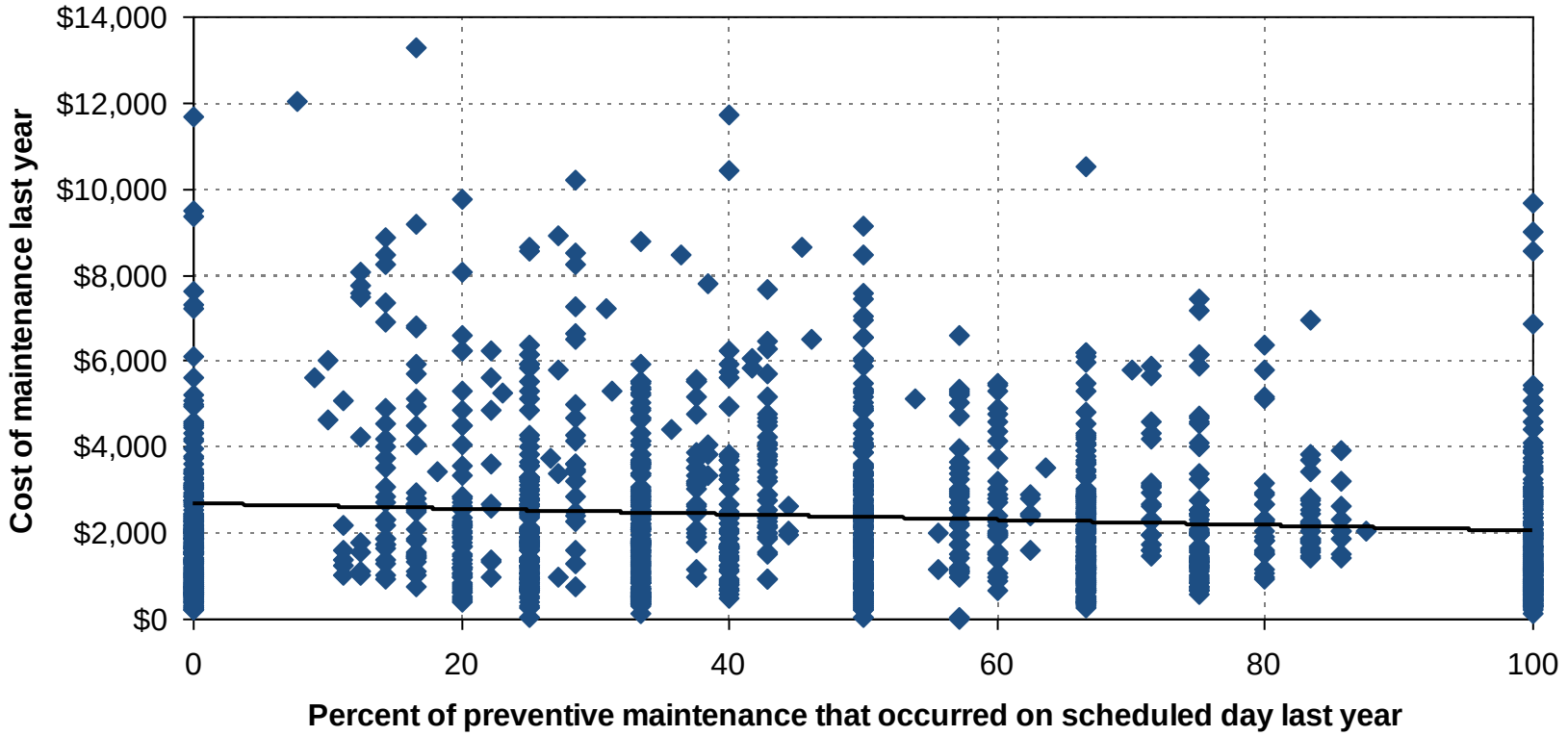
Control of Workflow for Light Equipment

- **Most light equipment work each day is scheduled maintenance rather than unscheduled repairs**
- **Departments are responsible for bringing vehicles in on time for their scheduled maintenance**
  - Fleet sends out quarterly reminders to departments to notify them of upcoming scheduled maintenance
  - Fleet managers within departments can view their upcoming scheduled maintenance online
- **Turnaround time is affected by Fleet's ability to predict and control how much work there is to do on any given day**
  - Departments' adherence to their given schedule
  - Fleet's determination of appropriate service intervals

Effect of Adherence to Schedule on Turnaround Time

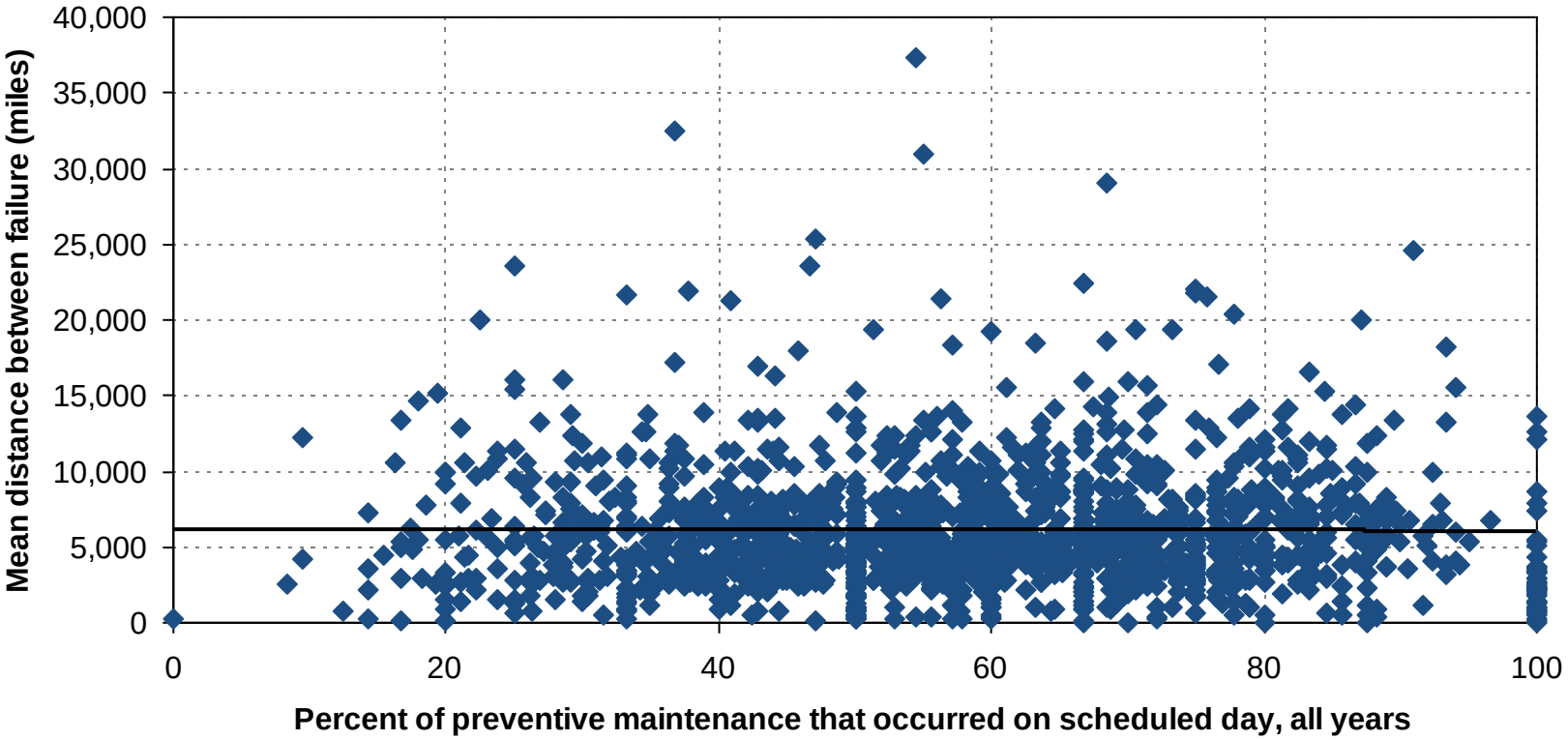
Equipment Class	Turnaround time for vehicles brought in on their designated day	Turnaround time for vehicles brought in late
Public Safety Light Equipment	1.5 days	3.4 days
Administrative Light Equipment	0.6 days	2.6 days

Cost of Not Adhering to Designated Maintenance Day
Maintenance Cost 5/1/2008 – 4/30/2009, by Vehicle



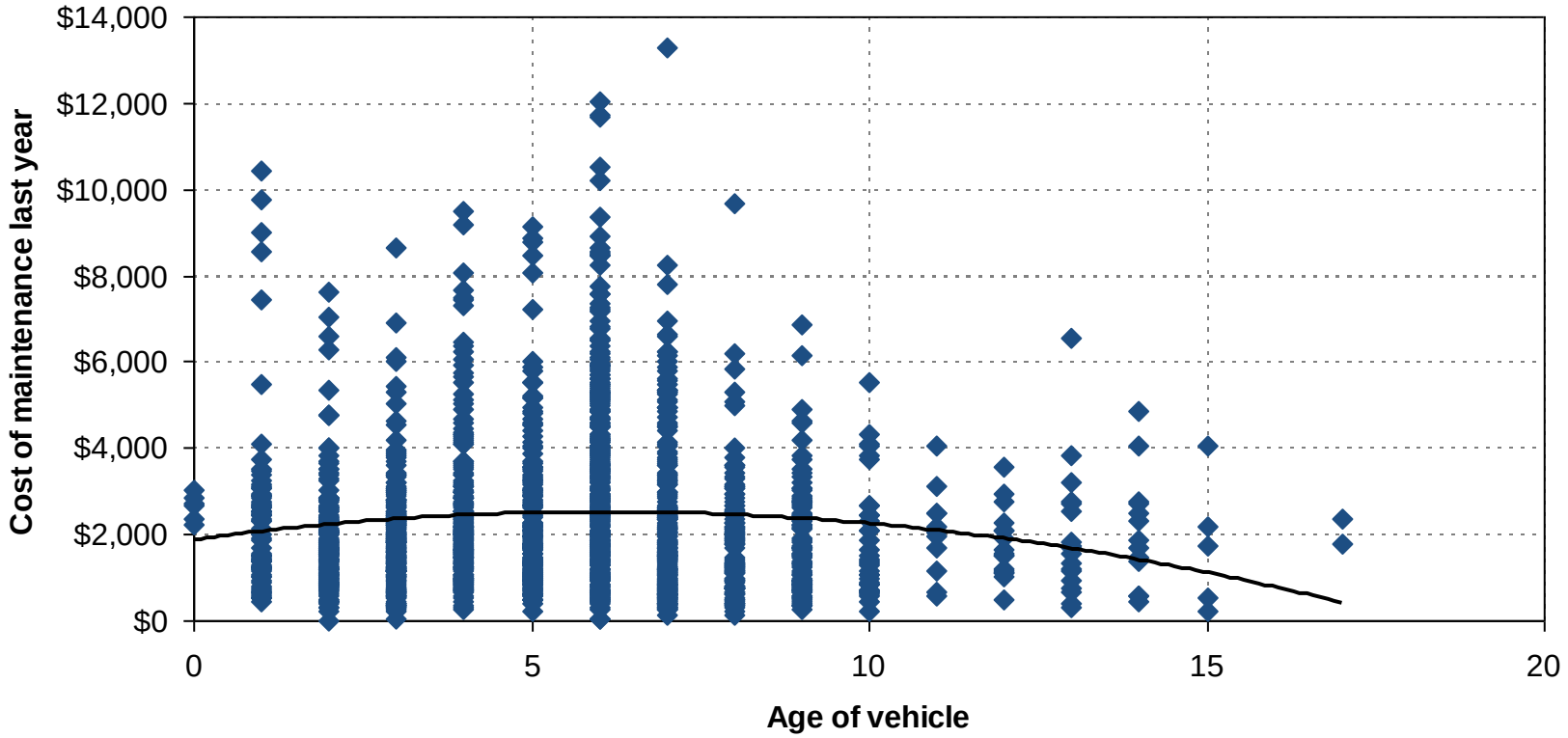
For every percent improvement in adherence to the designated maintenance day, annual vehicle cost decreases $3.67. A 10% improvement across the 1,385 vehicles here that can improve would result in a cost savings of $51,000.

Cost of Not Adhering to Designated Maintenance Day Mean Distance Between Failure, by Vehicle



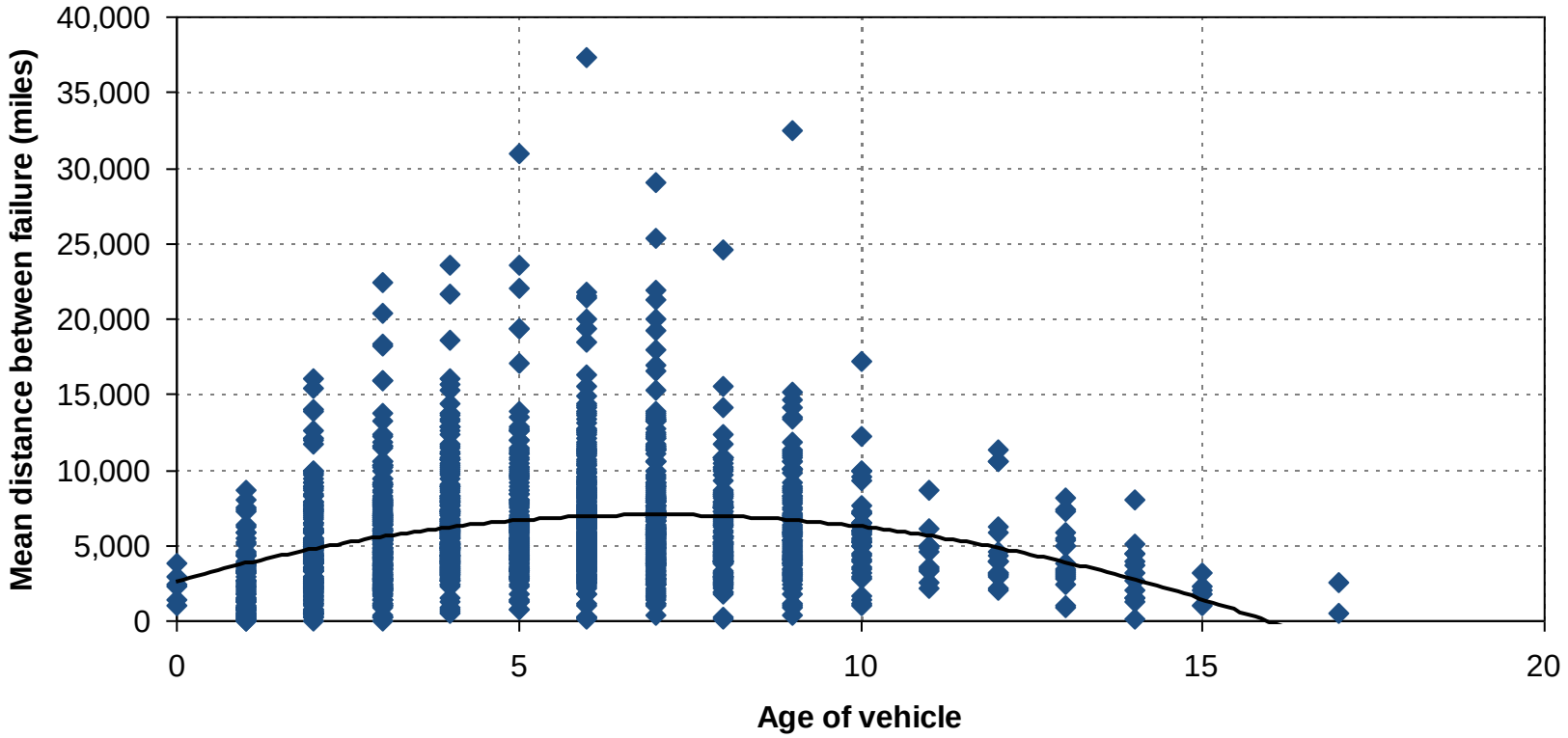
There is essentially no relationship in this data between adherence to the designated preventive maintenance day and mean distance between failure.

Drivers of Cost and MDBF in Light Equipment: Age
Maintenance Cost 5/1/2008 – 4/30/2009, by Vehicle



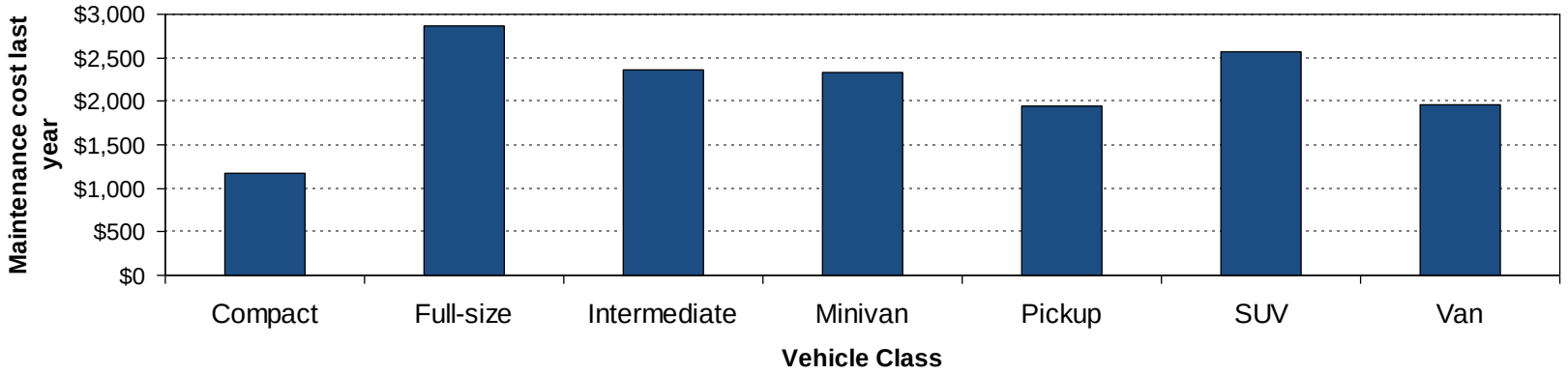
Public safety vehicles are replaced at age 6. Administrative vehicles are generally replaced at age 8.

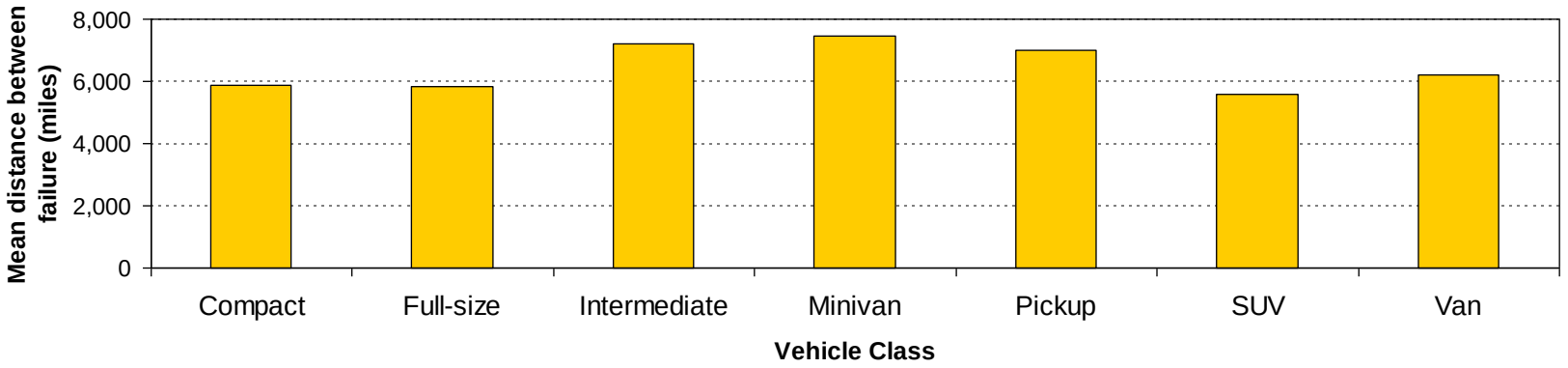
Drivers of Cost and MDBF in Light Equipment: Age Mean Distance Between Failure, by Vehicle



Regression models predict that the effects of age on mean distance between failure peak at age 7.

Drivers of Cost and MDBF in Light Equipment: Class





Vehicle class has a definite effect on maintenance costs, but has less of an effect on mean distance between failure.

Fleet Summary of Meaning of Data

- Automotive/Light Equipment Maintenance Program has been successful
- Continue current practice of scheduling vehicles for preventive maintenance
- Continue notifying departments of missed PMs but will review who the notification are sent to; fleet coordinator vs Director
- Continue to analyze current maintenance schedule to ensure maximum availability at lowest maintenance cost
- Define qualifications for departmental fleet coordinators
- Continue quarterly fleet coordinators meeting to share information and answer questions

Warranty Use in Light Equipment

- **All light duty equipment warranty repairs are performed by the manufactures dealership. The average dealer labor cost is about 97.00 to 107.00 per hour.**
- **Equipment warranties include:**
  - Standard 3 years/36,000 miles on all vehicles
  - Exhaust 8 years/80,000 miles on all vehicles
  - GM Drive train 5 years/100,000 miles on non Police
  - Kia Drive train 10 years/100,000 miles

Service Intervals for Preventive Maintenance of Light Equipment

Equipment Class	Montgomery County Specified PM Interval	Manufacturer Recommended PM Interval
Public Safety Vehicles		
Chevy Impala	3,500 miles	3,000 miles
Ford Crown Victoria		3,000 miles
Dodge Charger		3,000 miles
Administrative Vehicles		
Chevy Cavalier	4,000 miles	7,000 miles
Dodge Caravan		6,000 miles
Chevy Silverado		3,000 miles

Effect of Increasing Service Intervals for Light Equipment

- **Current average actual service intervals**
  - Law enforcement vehicles: 3,158 miles
  - Non-law enforcement vehicles: 2,778 miles
- **Regression analysis showed that increasing service intervals increases annual maintenance costs, on average, $0.16 for every additional mile between service intervals**
  - Models using only law enforcement vehicles did not show a relationship at a statistically significant level
    - Law enforcement vehicles come in for other maintenance more often than administrative vehicles (2.2 times per vehicle vs. 1.5 times per vehicle)
  - Models using only administrative vehicles were effected: $0.38 for every additional mile between service intervals

Tracking Our Progress

- **Meeting Goals:**
  - Establish strategies for preventive maintenance for transit, public safety, and administrative vehicles to cost-effectively maximize mean distance between failure and/or turnaround times

- **How will we measure success**
  - Fleet is using best available data to make purchasing and preventive maintenance decisions

Wrap-up

- **Confirmation of follow-up items**
- **Time frame for next meeting**

Benchmarking: Mean Distance Between Failure (MDBF) for Transit Equipment

Jurisdiction	2007		2008	
	MDBF	Average age	MDBF	Average age
Montgomery County	2,586		2,707	
Fairfax County				
Baltimore County				
WMATA	6,267		6,326	
Albany/Troy	4,500		5,700	
San Francisco			3,400	

Benchmarking: Mean Distance Between Failure (MDBF) and Turnaround Time for Light Equipment

Jurisdiction	2007		2008	
	MDBF	Turnaround Time (days)	MDBF	Turnaround Time (days)
Montgomery County				
Public Safety	2,794	2.1	2,517	2.9
Administrative	2,188	6.0	1,943	2.1
Fairfax County				
Baltimore County				
Prince George's				
Howard				