Predicting High Frequency Failure Components: Costs, and First Occurrence

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Data provided by DOT

- Repair cost information was provided by DOT for years 2005 to 2013
- Actual historical costs needed to be adjusted to level the playing field.
  - Inflation
  - Labor rates
    - In 2005 the hourly rate was $28.27
    - In 2013 the hourly rate was $42.37
- The adjustment was done so that a vehicle that was 2 years old in 2005 could be compared to a similarly aged vehicle in 2013.

Research Scope

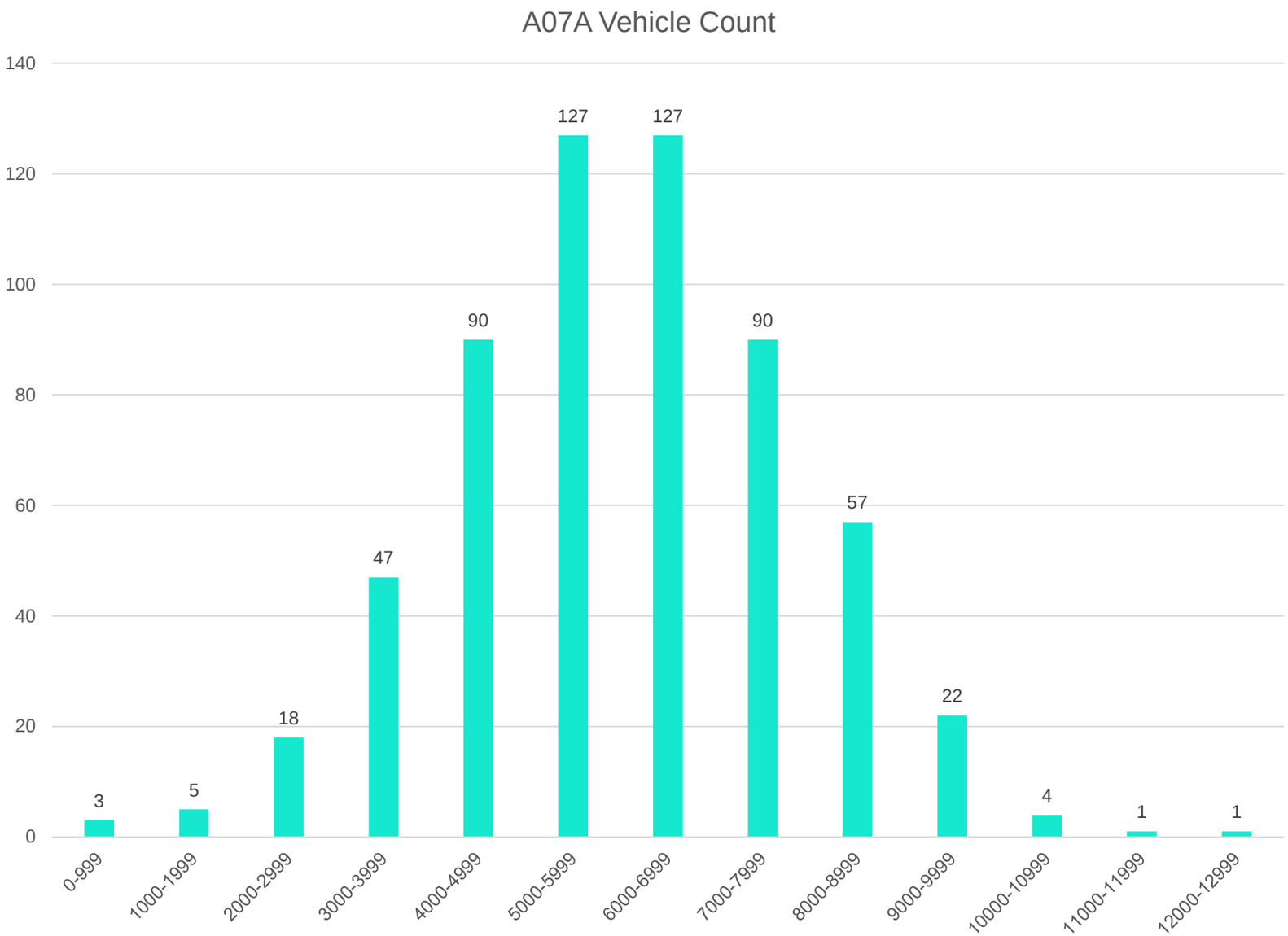
- Descriptive analytics of vehicle repair data
- Repair rate of various types of repairs at any point during the life of an equipment
- Determine the trend in repair rate
- Determine variability of repair cost over equipment life
- Classify and identify repairs based on type and cost
- Analyze patterns of repair events to predict repairs

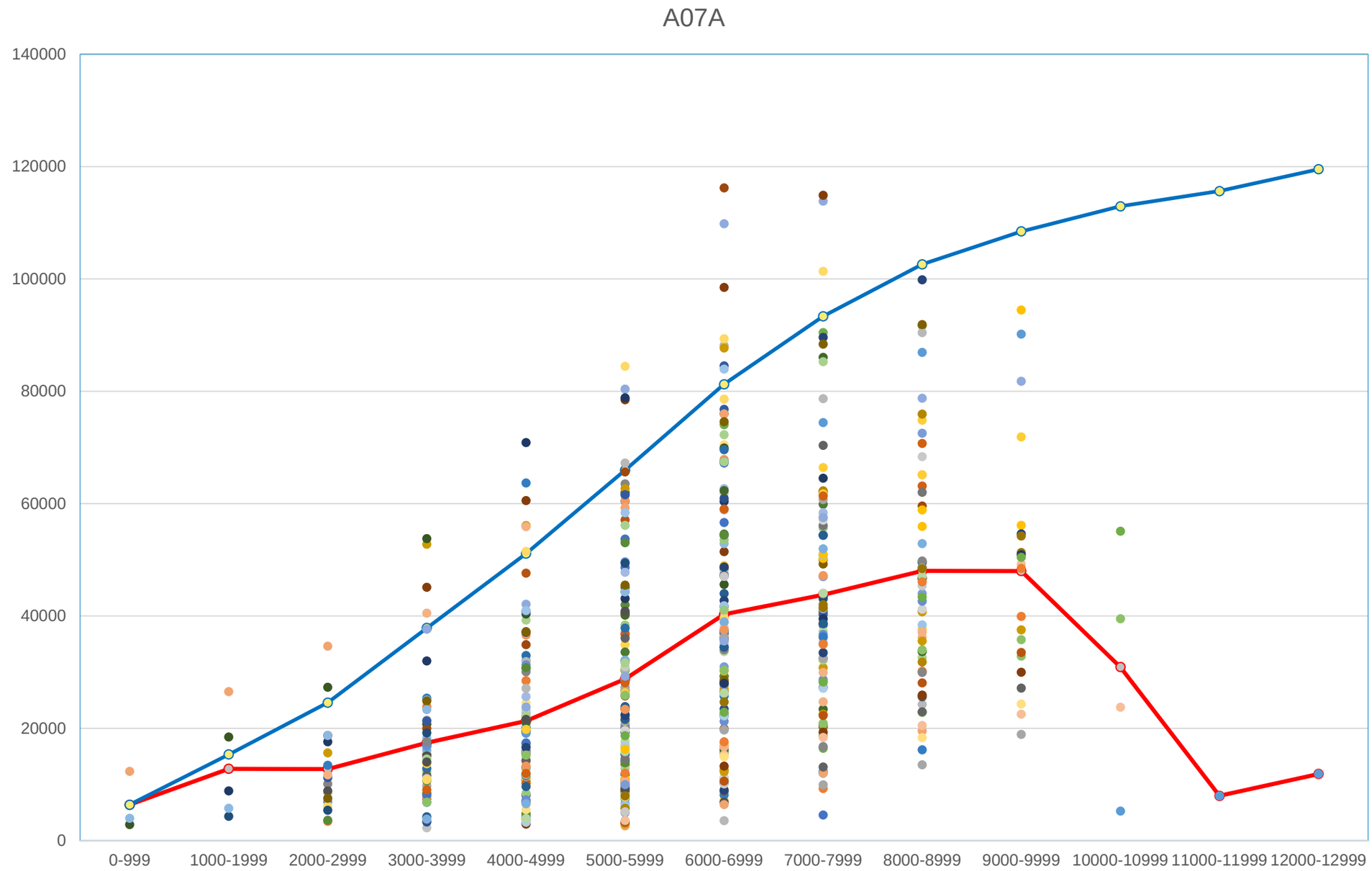
Additional questions

- When does repair rates increase?
- Which components fail frequently to incur heavy costs?
- When will a component fail?
- Do vehicle classes behave differently with respect to repair rates?

OBSERVATION

- Vehicles are reduced in the 7000 hour time block, corresponding to 14 to 16 years old

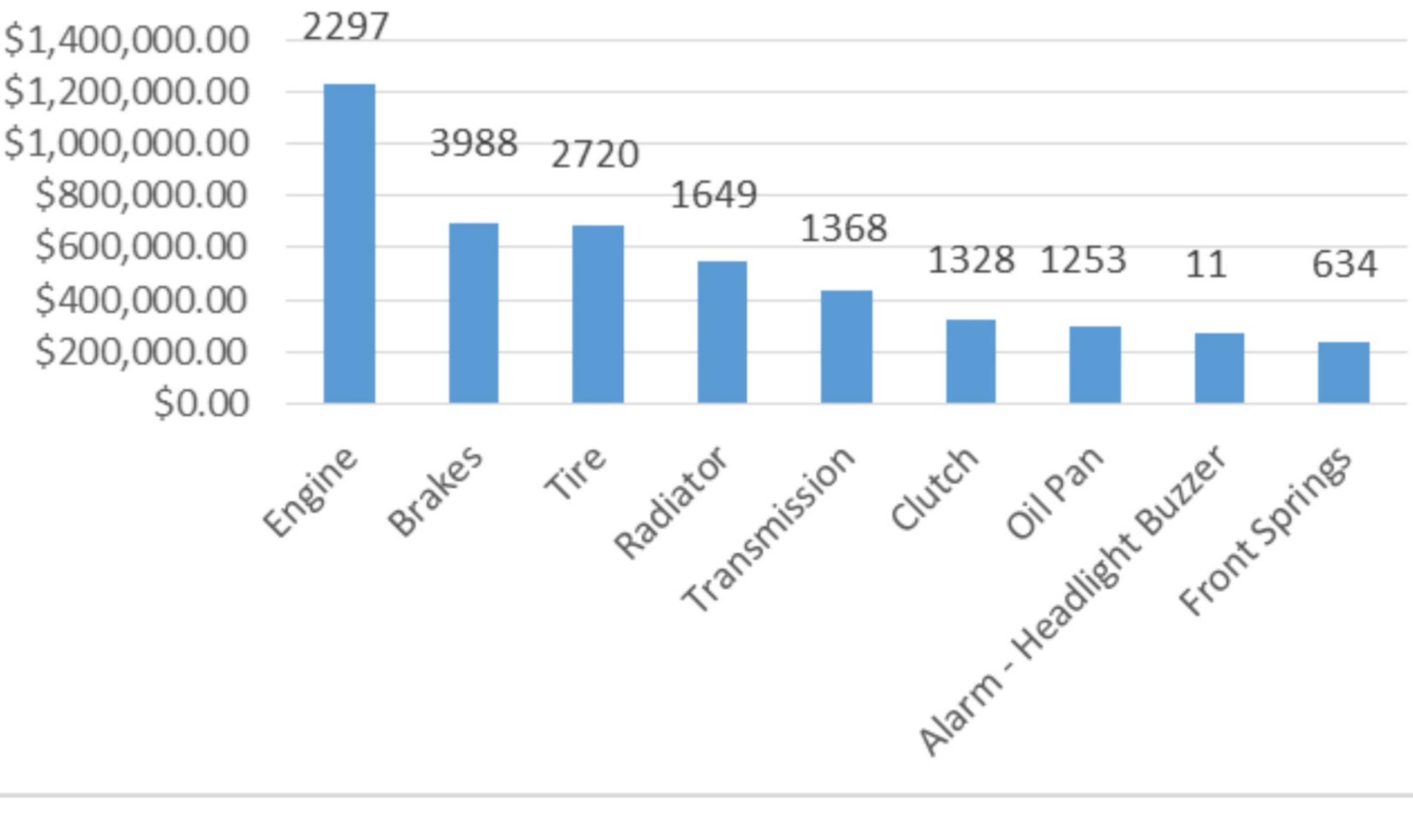




LEGEND

Denotation	Entity
	Average of Total Adjusted Event Cost
	Average Event Cost
	Each color circle denotes event cost of each vehicle over its life usage period

A07 Count and Total Cost for Major Repair Types

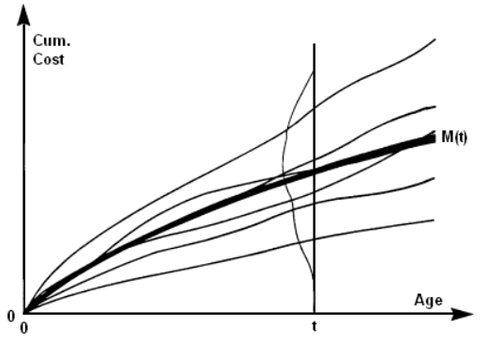


Sample Data

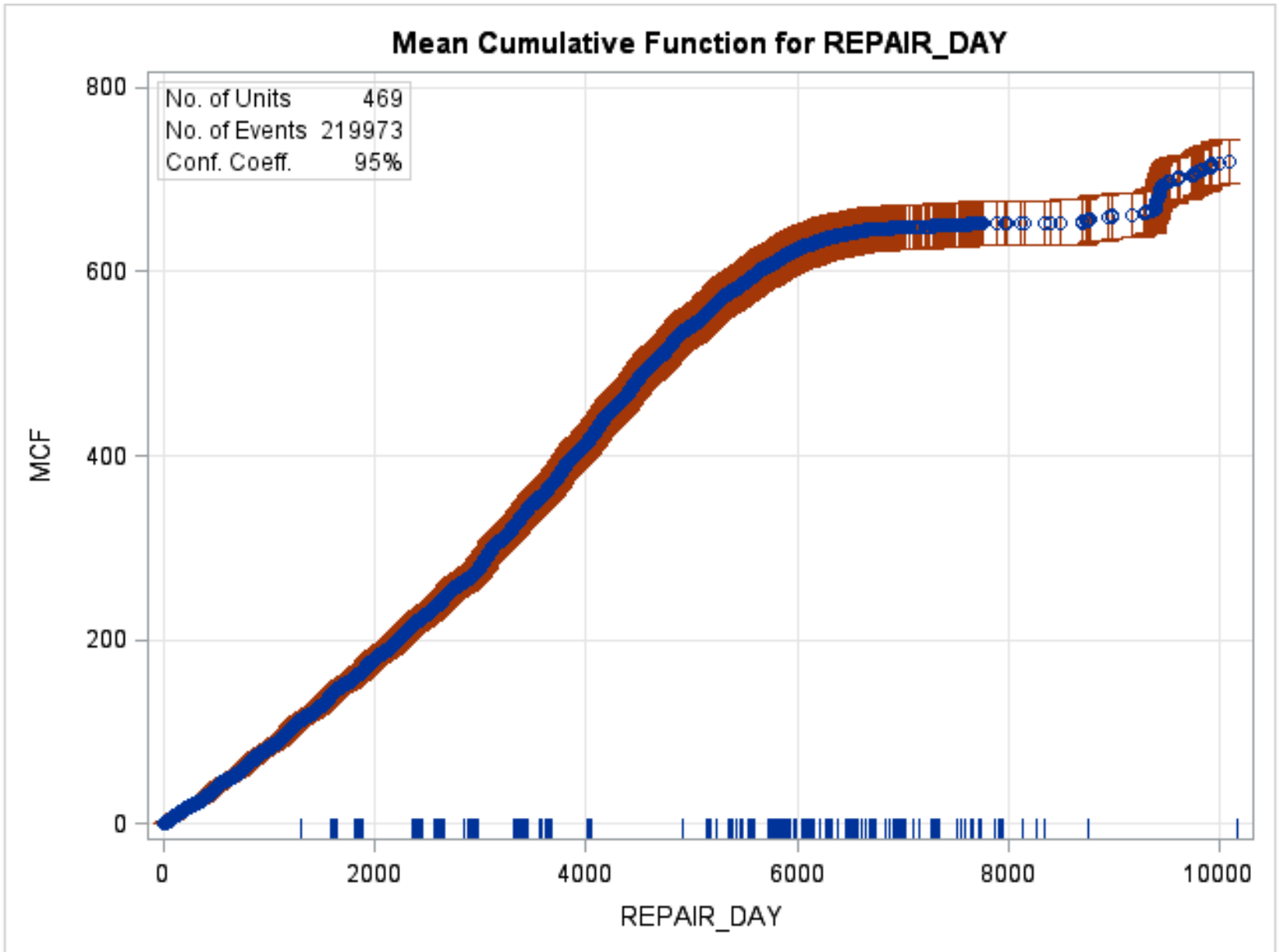
A_NUM	REPAIR_DATE	REPAIR_DAY	OCCURENCE	EVENT_COST	REPAIR_TYPE
A28043	2005-12-21 00:00:00	4,384	1	1,024.31	Engine
A28043	2005-12-21 00:00:00	4,384	1	512.15	Engine
A28043	2006-09-28 00:00:00	4,665	1	1,351.85	Engine
A28043	2006-09-06 00:00:00	4,643	1	44.84	Engine
A28043	2006-10-12 00:00:00	4,679	1	1,065.5	Engine
A28043	2006-09-19 00:00:00	4,656	1	687.55	Engine
A28043	2006-09-21 00:00:00	4,658	1	1,183.7	Engine
A28043	2006-01-25 00:00:00	4,419	1	223.15	Engine
A28043	2006-01-18 00:00:00	4,412	1	951.72	Engine
A28043	2006-01-25 00:00:00	4,419	1	132.54	Engine
A28043	[NULL]	6,742	-1	-1	Engine

Methodology

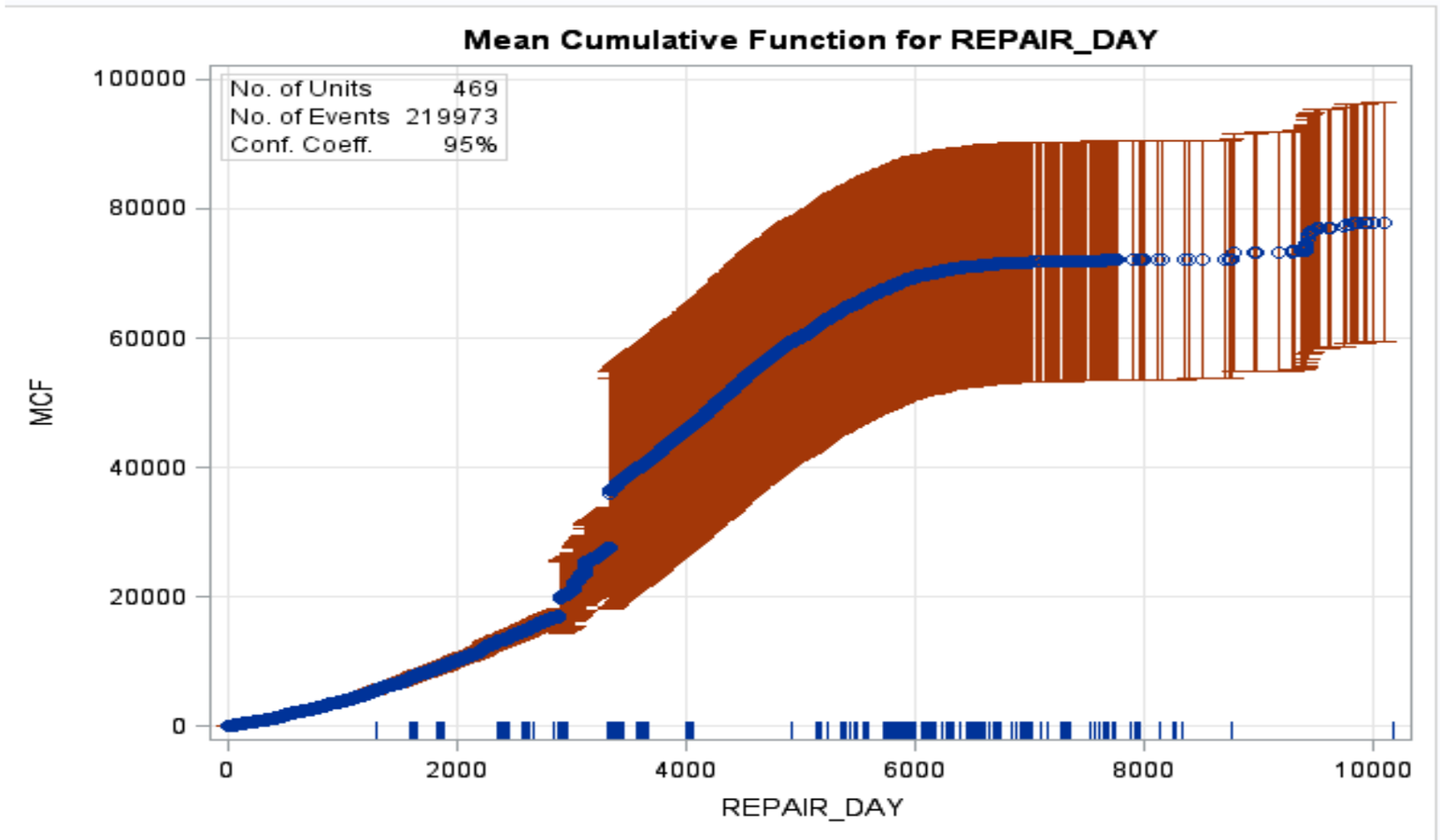
- Mean Cumulative Function Plots
- Non-parametric method for reliability analysis
- As life of an equipment/product increases, so does the number of repairs and the cost associated with it

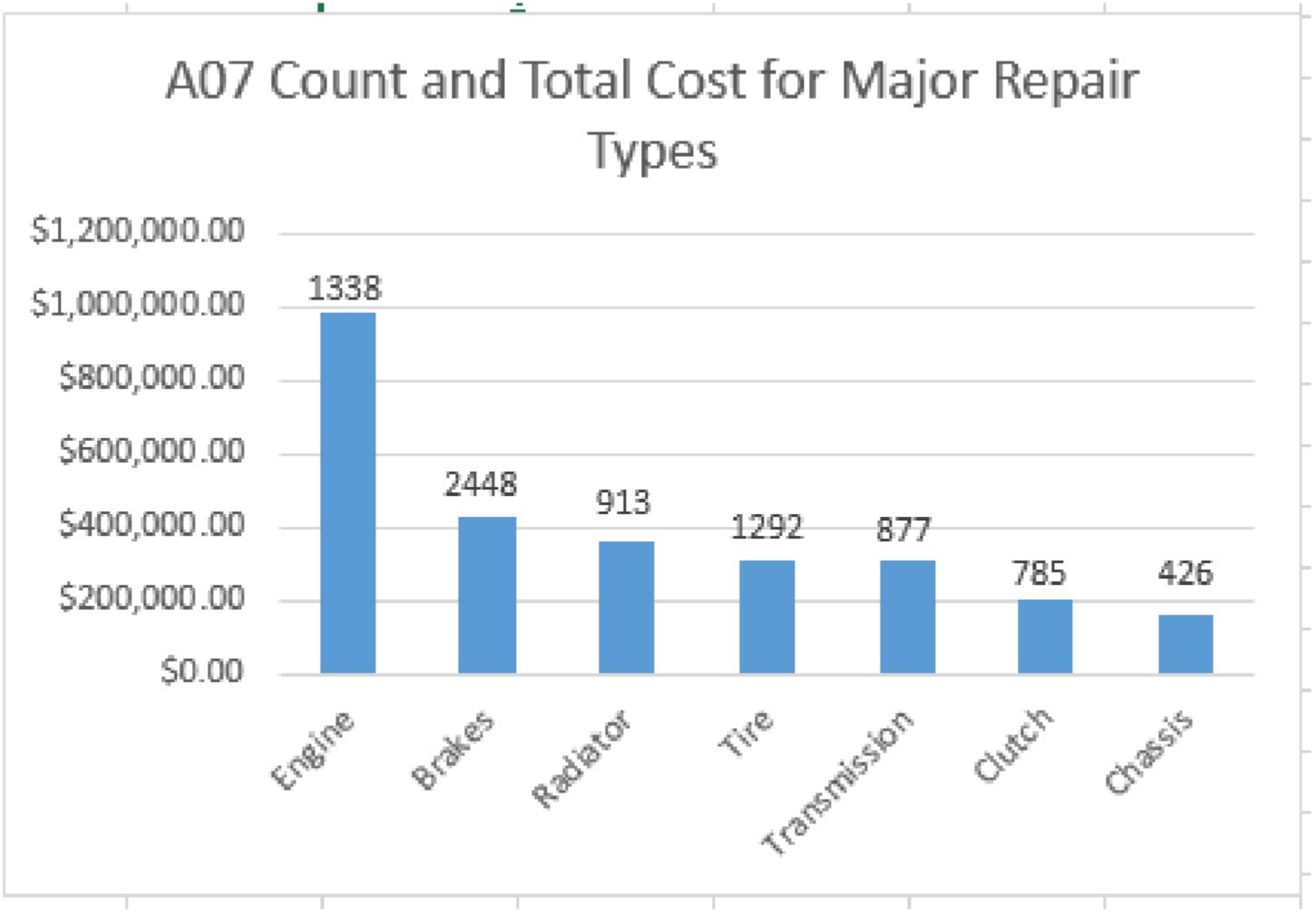


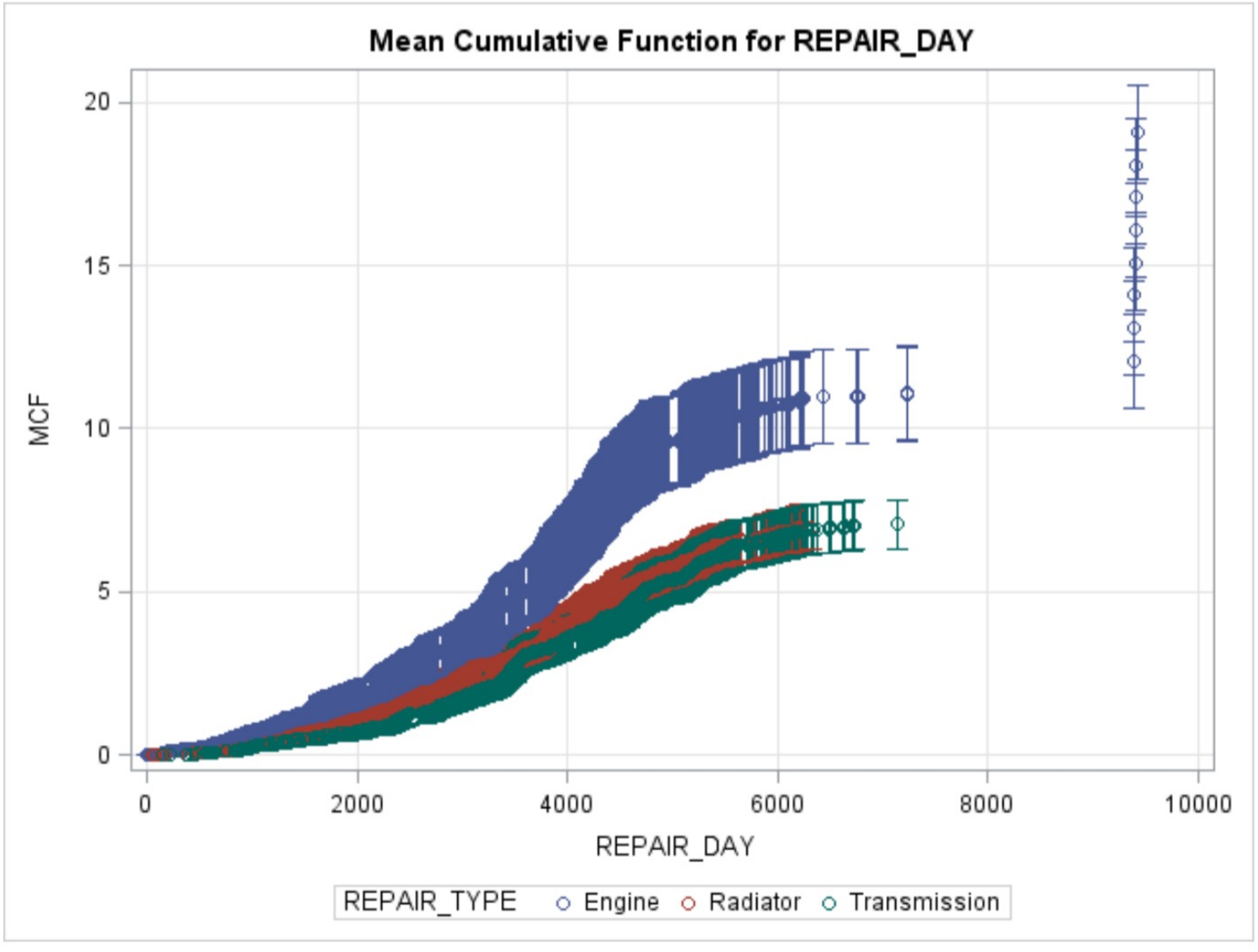
MCF for Repair Day

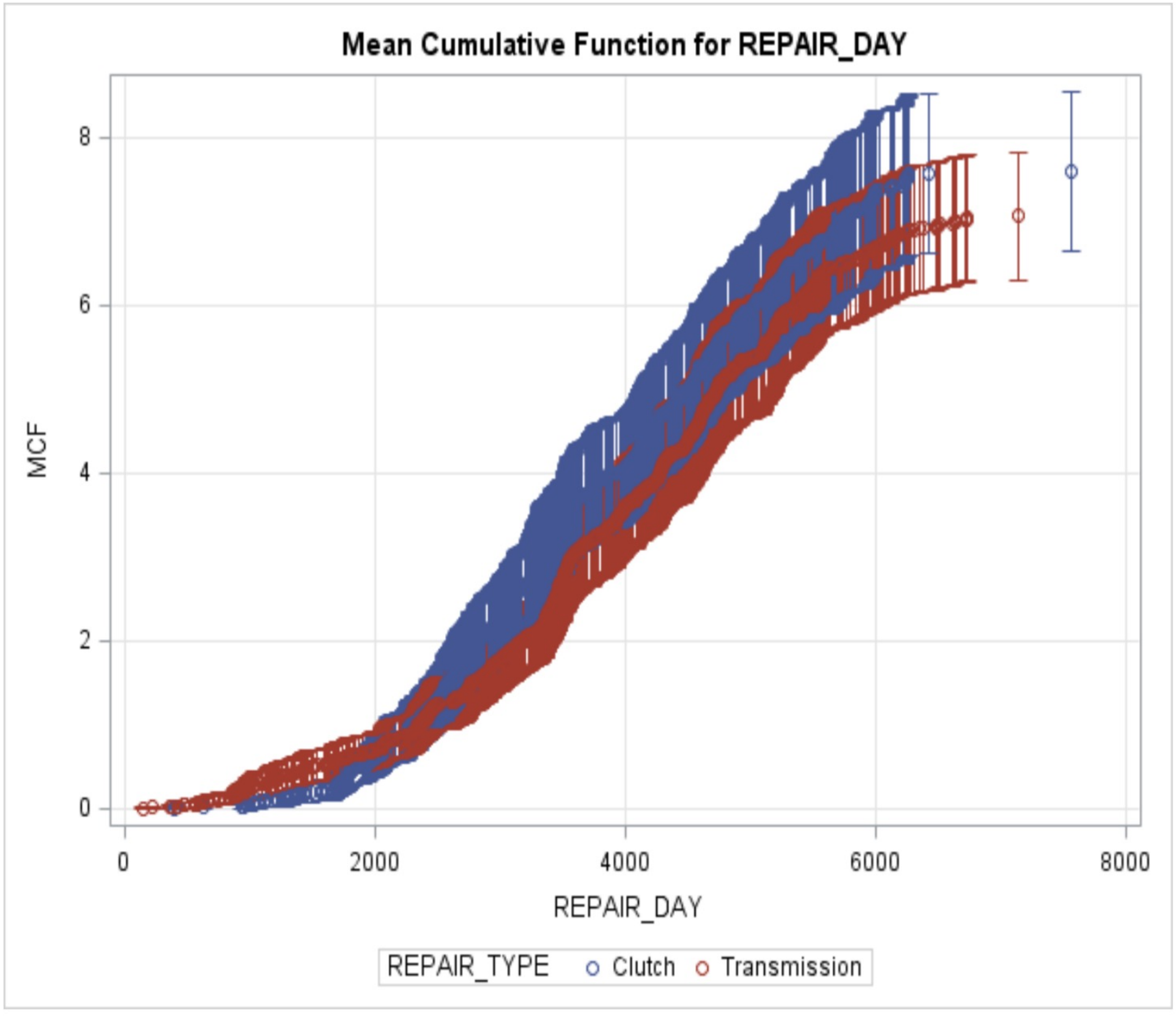


Repair Cost Analysis




A07 Count and Total Cost for Major Repair Types
$1,200,000.00
$1,000,000.00
$800,000.00
$600,000.00
$400,000.00
$200,000.00
$0.00
1338
2448
913
1292
877
785
426
Engine
Brakes
Radiator
Tire
Transmission
Clutch
Chassis


Mean Cumulative Function for REPAIR_DAY
MCF
20
15
10
5
0
0
2000
4000
6000
8000
10000
REPAIR_DAY
REPAIR_TYPE
Engine
Radiator
Transmission


Mean Cumulative Function for REPAIR_DAY
MCF
8
6
4
2
0
0
2000
4000
6000
8000
REPAIR_DAY
REPAIR_TYPE
Clutch
Transmission

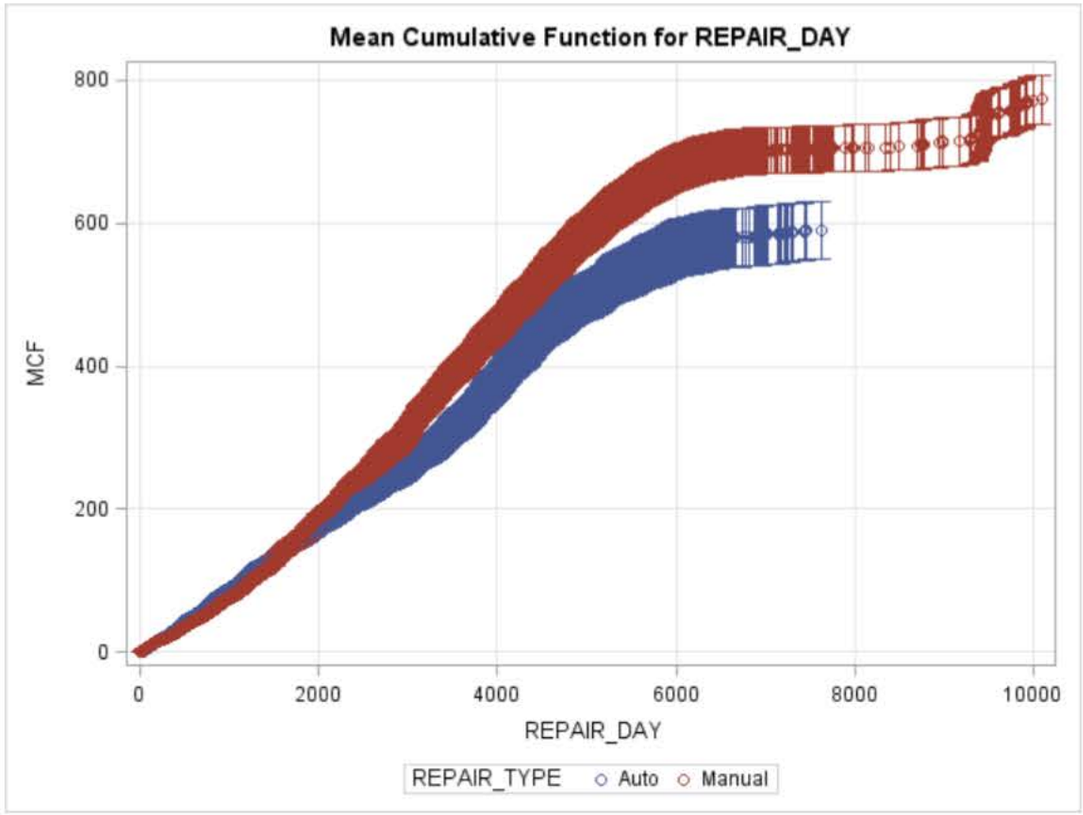


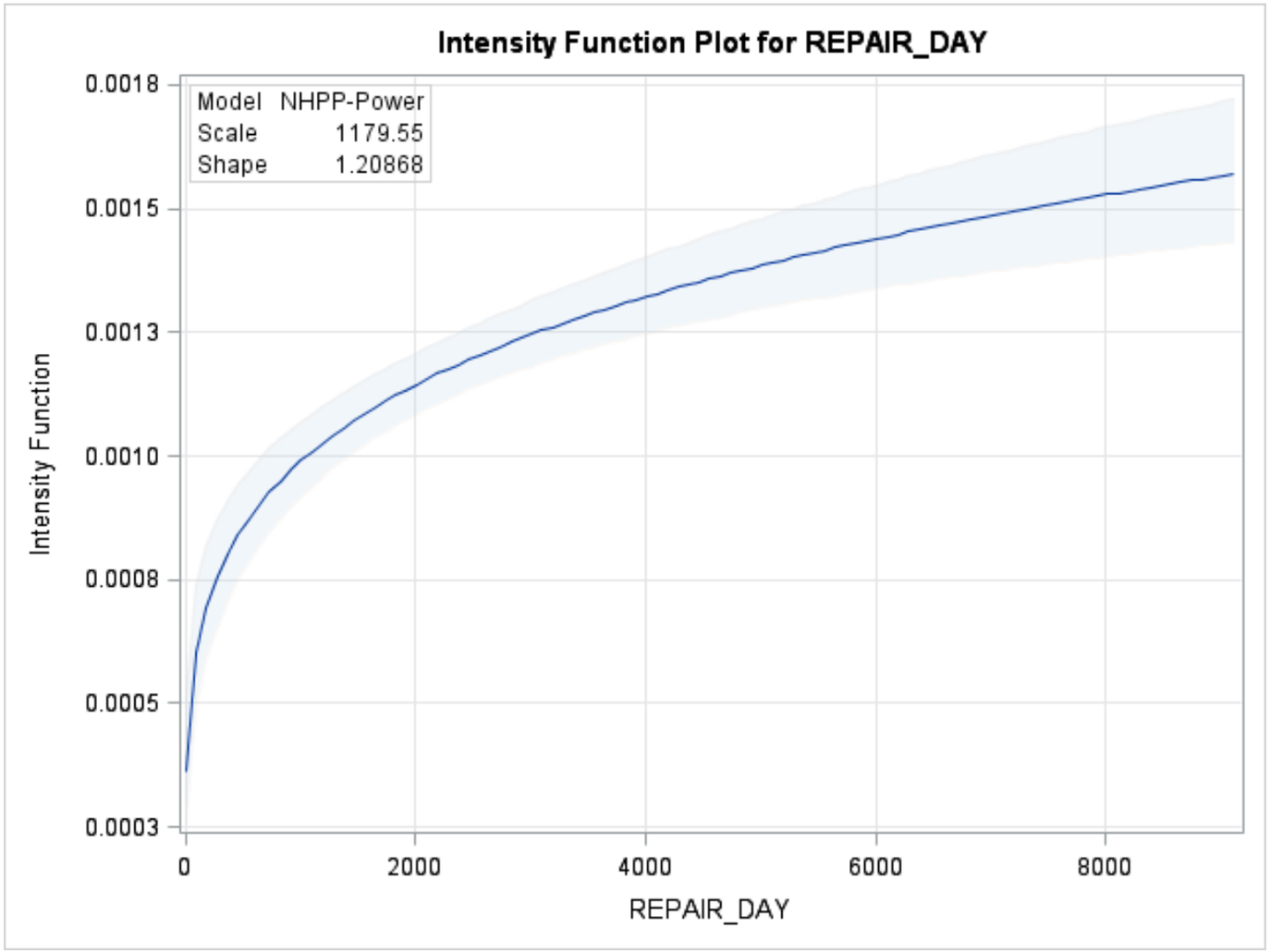
Figure 12

Recurrence Data Summary		
		Group
Input Data Set	WORK.AO7_ENGINE_AUTOMAN	Manual
Observations Used	130525	Manual
Number of Units	190	Manual
Number of Events	130335	Manual

Recurrence Data Summary		
		Group
Input Data Set	WORK.AO7_ENGINE_AUTOMAN	Auto
Observations Used	83068	Auto
Number of Units	246	Auto
Number of Events	82822	Auto

Types of Repair

- Good as New
- Bad as Old (minimal repair)
    - Follows Non-homogeneous Poisson (repair states are not constant)
- Remove Good as New records


Intensity Function Plot for REPAIR_DAY
Model NHPP-Power
Scale 1179.55
Shape 1.20868
Intensity Function
0.0018
0.0015
0.0013
0.0010
0.0008
0.0005
0.0003
0
2000
4000
6000
8000
REPAIR_DAY

The RELIABILITY Procedure

Number of Observations Read	213693
Number of Observations Used	213593

MCF Difference Data Summary	
Input Data Set	WORK.AO7_ENGINE_AUTOMAN
Group 1	Auto
Observations Used	83068
Number of Units	246
Number of Events	82822
Group 2	Manual
Observations Used	130525
Number of Units	190
Number of Events	130335

Tests for Equality of Mean Cumulative Functions					
Weight Function	Statistic	Variance	Chi-Square	DF	Pr > Chi Square
Constant	-8537.847749	3351292	21.751268	1	<.0001
Linear	-5331.165914	1572426	18.074832	1	<.0001

ings from the Research

oth repair rate and repair cost increases at a higher rate between around 3000 to 5000

ys (around 8 years).

ased on cost of repairs, the most failure prone components are Engine, Brakes,

adiator, Tires, and Transmission in that order.

sing the NHPP power model for "Bad as Old" engine repairs, the β (shape parameter)

as found to be 1.2 which signifies that the intensity of failure increases with age.

ased on NHPP power model, the estimate of scale η or typical time to first engine repair

as found to be 1180 days (around 3.2 years).

or repair type Transmission in A07 class, the vehicles with manual transmission had a

gnificantly higher repair rate than the automatic ones. MCF difference plot for manual

d automatic transmission had a p value < 0.0001 which shows the difference is

atistically significant.