Automotive Warranty Data Analysis

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
import datetime as dt
```

In [2]:
```
data = pd.read_excel('/Users/devarajusubramanyam/Downloads/DA -Task 2.xlsx')
```

In [3]:
```
data.shape
```

Out[3]:
```
(100, 52)
```

Dataset Overview

- Total Records: 100
- Total Columns: 52
- Domain : Repair claims data

In [4]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100 entries, 0 to 99
Data columns (total 52 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   VIN                             100 non-null    object
 1   TRANSACTION_ID                  100 non-null    int64
 2   CORRECTION_VERBATIM             100 non-null    object
 3   CUSTOMER_VERBATIM               100 non-null    object
 4   REPAIR_DATE                     100 non-null    datetime64[ns]
 5   CAUSAL_PART_NM                  95 non-null     object
 6   GLOBAL_LABOR_CODE_DESCRIPTION   100 non-null    object
 7   PLATFORM                        100 non-null    object
 8   BODY_STYLE                      100 non-null    object
 9   VPPC                            100 non-null    object
 10  PLANT                           99 non-null     object
 11  BUILD_COUNTRY                   100 non-null    object
 12  LAST_KNOWN_DLR_NAME             100 non-null    object
 13  LAST_KNOWN_DLR_CITY             100 non-null    object
 14  REPAIRING_DEALER_CODE           100 non-null    object
 15  DEALER_NAME                     100 non-null    object
 16  REPAIR_DLR_CITY                 100 non-null    object
 17  STATE                           98 non-null     object
 18  DEALER_REGION                   100 non-null    int64
 19  REPAIR_DLR_POSTAL_CD            98 non-null     object
 20  REPAIR_AGE                      100 non-null    int64
 21  KM                              100 non-null    int64
 22  COMPLAINT_CD_CSI                100 non-null    int64
 23  COMPLAINT_CD                    100 non-null    object
 24  VEH_TEST_GRP                    98 non-null     object
 25  COUNTRY_SALE_ISO                100 non-null    object
 26  ORD_SELLING_SRC_CD              100 non-null    int64
 27  OPTN_FAMLY_CERTIFICATION        90 non-null     object
 28  OPTF_FAMLY_EMISSIOF_SYSTEM      95 non-null     object
 29  GLOBAL_LABOR_CODE               100 non-null    int64
 30  TRANSACTION_CATEGORY            100 non-null    object
 31  CAMPAIGN_NBR                    0 non-null      float64
 32  REPORTING_COST                  100 non-null    float64
 33  TOTALCOST                       94 non-null     float64
 34  LBRCOST                         100 non-null    float64
 35  ENGINE                          100 non-null    object
 36  ENGINE_DESC                     100 non-null    object
 37  TRANSMISSION                    100 non-null    object
 38  TRANSMISSION_DESC               100 non-null    object
 39  ENGINE_SOURCE_PLANT             88 non-null     object
 40  ENGINE_TRACE_NBR                88 non-null     object
 41  TRANSMISSION_SOURCE_PLANT       88 non-null     float64
 42  TRANSMISSION_TRACE_NBR          88 non-null     object
 43  SRC_TXN_ID                      100 non-null    int64
 44  SRC_VER_NBR                     100 non-null    int64
 45  TRANSACTION_CNTR                100 non-null    int64
 46  MEDIA_FLAG                      100 non-null    object
 47  VIN_MODL_DESGTR                 100 non-null    object
 48  LINE_SERIES                     99 non-null     object
 49  LAST_KNOWN_DELVRY_TYPE_CD       98 non-null     float64
 50  NON_CAUSAL_PART_QTY             100 non-null    int64
 51  SALES_REGION_CODE               100 non-null    int64
dtypes: datetime64[ns](1), float64(6), int64(12), object(33)
memory usage: 40.8+ KB
```

In [5]:
```
data.isnull().sum()
```

Out[5]:
```
VIN                              0
TRANSACTION_ID                   0
CORRECTION_VERBATIM              0
CUSTOMER_VERBATIM                0
REPAIR_DATE                      0
CAUSAL_PART_NM                   5
GLOBAL_LABOR_CODE_DESCRIPTION    0
PLATFORM                         0
BODY_STYLE                       0
VPPC                             0
PLANT                            1
BUILD_COUNTRY                    0
LAST_KNOWN_DLR_NAME              0
LAST_KNOWN_DLR_CITY              0
REPAIRING_DEALER_CODE            0
DEALER_NAME                      0
REPAIR_DLR_CITY                  0
STATE                            2
DEALER_REGION                    0
REPAIR_DLR_POSTAL_CD             2
REPAIR_AGE                       0
KM                               0
COMPLAINT_CD_CSI                 0
COMPLAINT_CD                     0
VEH_TEST_GRP                     2
COUNTRY_SALE_ISO                 0
ORD_SELLING_SRC_CD               0
OPTN_FAMLY_CERTIFICATION        10
OPTF_FAMLY_EMISSIOF_SYSTEM       5
GLOBAL_LABOR_CODE                0
TRANSACTION_CATEGORY             0
CAMPAIGN_NBR                   100
REPORTING_COST                   0
TOTALCOST                        6
LBRCOST                          0
ENGINE                           0
ENGINE_DESC                      0
TRANSMISSION                     0
TRANSMISSION_DESC                0
ENGINE_SOURCE_PLANT             12
ENGINE_TRACE_NBR                12
TRANSMISSION_SOURCE_PLANT       12
TRANSMISSION_TRACE_NBR          12
SRC_TXN_ID                       0
SRC_VER_NBR                      0
TRANSACTION_CNTR                 0
MEDIA_FLAG                       0
VIN_MODL_DESGTR                  0
LINE_SERIES                      1
LAST_KNOWN_DELVRY_TYPE_CD        2
NON_CAUSAL_PART_QTY              0
SALES_REGION_CODE                0
dtype: int64
```

In [6]:
```
unique_counts = data.nunique()
display(unique_counts)
```

```
VIN                                98
TRANSACTION_ID                     32
CORRECTION_VERBATIM                93
CUSTOMER_VERBATIM                 100
REPAIR_DATE                        29
CAUSAL_PART_NM                     18
GLOBAL_LABOR_CODE_DESCRIPTION       4
PLATFORM                           11
BODY_STYLE                          6
VPPC                               26
PLANT                              11
BUILD_COUNTRY                       3
LAST_KNOWN_DLR_NAME               100
LAST_KNOWN_DLR_CITY                94
REPAIRING_DEALER_CODE              95
DEALER_NAME                       100
REPAIR_DLR_CITY                    93
STATE                              39
DEALER_REGION                       2
REPAIR_DLR_POSTAL_CD               92
REPAIR_AGE                         35
KM                                100
COMPLAINT_CD_CSI                    1
COMPLAINT_CD                        7
VEH_TEST_GRP                       23
COUNTRY_SALE_ISO                    6
ORD_SELLING_SRC_CD                  7
OPTN_FAMLY_CERTIFICATION            3
OPTF_FAMLY_EMISSIOF_SYSTEM          8
GLOBAL_LABOR_CODE                   4
TRANSACTION_CATEGORY                2
CAMPAIGN_NBR                        0
REPORTING_COST                    100
TOTALCOST                          94
LBRCOST                            99
ENGINE                             12
ENGINE_DESC                        12
TRANSMISSION                       19
TRANSMISSION_DESC                  20
ENGINE_SOURCE_PLANT                 9
ENGINE_TRACE_NBR                   88
TRANSMISSION_SOURCE_PLANT           6
TRANSMISSION_TRACE_NBR             88
SRC_TXN_ID                        100
SRC_VER_NBR                        10
TRANSACTION_CNTR                    1
MEDIA_FLAG                          2
VIN_MODL_DESGTR                    41
LINE_SERIES                        22
LAST_KNOWN_DELVRY_TYPE_CD          11
NON_CAUSAL_PART_QTY                 2
SALES_REGION_CODE                   2
dtype: int64
```

COLUMN WISE DETAILED ANALYSIS

A. Identification Columns VIN (Vehicle Identification Number)

- Data Type: String
- No missing values
- 98 unique VINs

TRANSACTION_ID

- Data Type : String
- No missing values
- 32 Unique values

SRC_TXN_ID

- Data Type : Int
- No Missing values
- 100 Unique values

B. Free Text Description Columns

CUSTOMER_VERBATIM

- Data type : string
- No missing values
- 100 unique values

CORRECTION_VERBATIM

- Data type : String
- No missing values
- 90 unique values

C. Temporal Columns

REPAIR_DATE

- Data Type: Timestamp
- No missing values
- 100 unique values
- Range : 2024-01-02 to 2024-02-07

In [7]:
```
data['REPAIR_DATE'].describe()
```

Out[7]:
```
count                    100
mean     2024-01-22 07:26:24
min      2024-01-02 00:00:00
25%      2024-01-12 00:00:00
50%      2024-01-24 12:00:00
75%      2024-02-01 00:00:00
max      2024-02-07 00:00:00
Name: REPAIR_DATE, dtype: object
```

In [8]:
```
data['REPAIR_AGE'].describe()
```

Out[8]:
```
count    100.000000
mean      14.940000
std       12.367945
min        0.000000
25%        5.000000
50%       12.000000
75%       21.000000
max       50.000000
Name: REPAIR_AGE, dtype: float64
```

REPAIR_AGE

- Data Type: Int
- No missing values
- 35 distinct values
- Range : 0 - 50

D. Part & Repair Classification

In [9]:
```
data['CAUSAL_PART_NM'].value_counts(dropna=False)
```

Out[9]:
```
CAUSAL_PART_NM
WHEEL ASM-STRG *JET BLACK                       45
WHEEL ASM-STRG *BLACK                           12
WHEEL ASM-STRG *VERY DARK AT                     7
WHEEL ASM-STRG *BACKEN BLACKK                    5
NaN                                              5
MODULE ASM-STRG WHL HT CONT                      5
HARNESS ASM-STRG WHL HORN SW WRG                 4
COVER-STRG WHL SPOKE *HI GLOSS V-C               3
APPLIQUE ASM-STRG WHL TR SPOKE CVR *VULCAN       2
APPLIQUE ASM-STRG WHL TR SPOKE CVR *SYNTHESIS    2
WHEEL ASM-STRG * JET BLACK                       2
COVER-STRG WHL SPOKE *LINEAR GALAXD              1
COVER-STRG WHL AIRBAG ACC HOLE *JET BLACK        1
APPLIQUE ASM-STRG WHL TR SPOKE CVR *JET BLACK    1
WHEEL ASM-STRG *FAWN                             1
WHEEL,STRG *JET BLACK                            1
WHEEL ASM-STRG *DARK TITANIU                     1
WHEEL ASM,STRG                                   1
WHEEL ASM-STRG *DARK GALVANIE                    1
Name: count, dtype: int64
```

CAUSAL_PART_NM

- Data Type: String
- 5 missing values
- 18 distinct parts
- Top Value: Various steering wheel assemblies

GLOBAL_LABOR_CODE_DESCRIPTION

- Data Type: String (Categorical)
- No missing values
- 4 Unique repair types
- Distribution: Steering Wheel Replacement: 78% Steering Wheel Spoke Cover Replacement: 11% Heated Steering Wheel Module Replacement: 6% Horn Switch Wiring Harness Replacement: 5%

In [10]:
```
data['GLOBAL_LABOR_CODE_DESCRIPTION'].value_counts()
```

Out[10]:
```
GLOBAL_LABOR_CODE_DESCRIPTION
Steering Wheel Replacement                                78
Steering Wheel Spoke Cover Replacement                    11
Heated Steering Wheel Module Replacement                   6
Steering Wheel Horn Switch Wiring Harness Replacement      5
Name: count, dtype: int64
```

In [11]:
```
grouped_data = data.groupby(['CAUSAL_PART_NM', 'GLOBAL_LABOR_CODE_DESCRIPTION'], dropna=False).size().reset_index(name='count')
display(grouped_data)
```

	CAUSAL_PART_NM	GLOBAL_LABOR_CODE_DESCRIPTION	count
0	APPLIQUE ASM-STRG WHL TR SPOKE CVR *JET BLACK	Steering Wheel Spoke Cover Replacement	1
1	APPLIQUE ASM-STRG WHL TR SPOKE CVR *SYNTHESIS	Steering Wheel Spoke Cover Replacement	2
2	APPLIQUE ASM-STRG WHL TR SPOKE CVR *VULCAN	Steering Wheel Spoke Cover Replacement	2
3	COVER-STRG WHL AIRBAG ACC HOLE *JET BLACK	Steering Wheel Spoke Cover Replacement	1
4	COVER-STRG WHL SPOKE *HI GLOSS V-C	Steering Wheel Spoke Cover Replacement	3
5	COVER-STRG WHL SPOKE *LINEAR GALAXD	Steering Wheel Spoke Cover Replacement	1
6	HARNESS ASM-STRG WHL HORN SW WRG	Steering Wheel Horn Switch Wiring Harness Repl...	4
7	MODULE ASM-STRG WHL HT CONT	Heated Steering Wheel Module Replacement	5
8	WHEEL ASM,STRG	Steering Wheel Replacement	1
9	WHEEL ASM-STRG * JET BLACK	Steering Wheel Replacement	2
10	WHEEL ASM-STRG *BACKEN BLACKK	Steering Wheel Replacement	5
11	WHEEL ASM-STRG *BLACK	Steering Wheel Replacement	12
12	WHEEL ASM-STRG *DARK GALVANIE	Steering Wheel Replacement	1
13	WHEEL ASM-STRG *DARK TITANIU	Steering Wheel Replacement	1
14	WHEEL ASM-STRG *FAWN	Steering Wheel Replacement	1
15	WHEEL ASM-STRG *JET BLACK	Steering Wheel Replacement	45
16	WHEEL ASM-STRG *VERY DARK AT	Steering Wheel Replacement	7
17	WHEEL,STRG *JET BLACK	Steering Wheel Replacement	1
18	NaN	Heated Steering Wheel Module Replacement	1
19	NaN	Steering Wheel Horn Switch Wiring Repl...	1
20	NaN	Steering Wheel Replacement	2
21	NaN	Steering Wheel Spoke Cover Replacement	1

GLOBAL_LABOR_CODE

- Data Type: Integer
- No missing Values
- Unique Values: 4 codes (130, 2400, 20, 2320)

In [12]:
```
data['GLOBAL_LABOR_CODE'].value_counts()
```

Out[12]:
```
GLOBAL_LABOR_CODE
130     78
50      11
2400     6
20       5
Name: count, dtype: int64
```

COMPLAINT_CD & COMPLAINT_CD_CSI

- Data Type: String & Integer
- No missing values
- Unique Values: 7 codes & 1 value (constant 0)
- Significance: complaint codes

In [13]:
```
data['COMPLAINT_CD'].value_counts()
```

Out[13]:
```
COMPLAINT_CD
0-0890    40
0-0310    33
0-0312    12
0-0621     7
0-0313     4
0-0316     2
0-0315     2
Name: count, dtype: int64
```

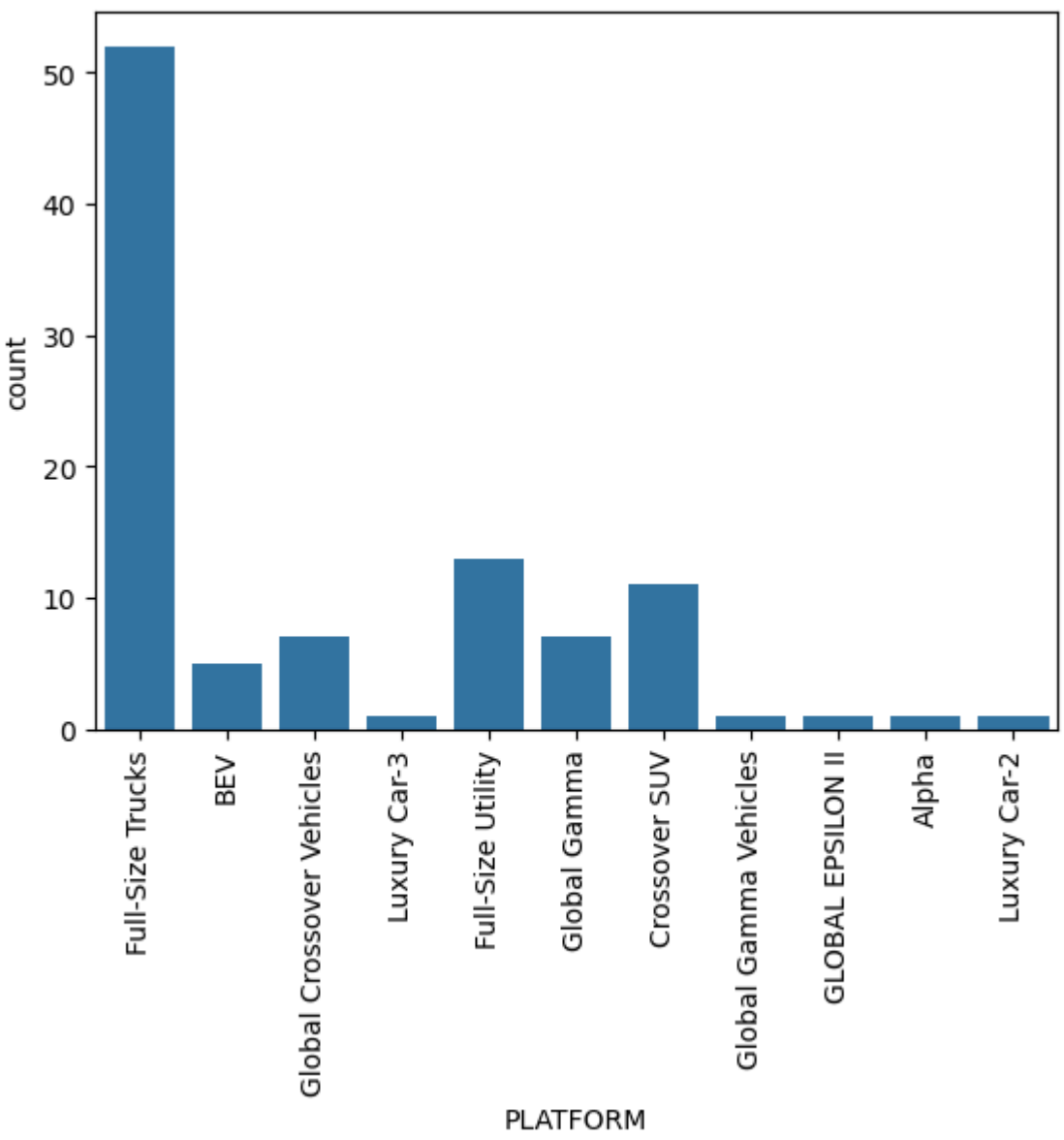
E. Vehicle Specification Columns

PLATFORM

- Data Type: String (Categorical)

- No missing values
- Unique Values: 11 platforms
- Top Platform: Full-Size Trucks (52%)
- Distribution: Trucks (52%), Full-Size Utility (13%), Crossover SUV (11%)
- Significance: Vehicle architecture family *Stakeholder Value: Identify platform-level design issues

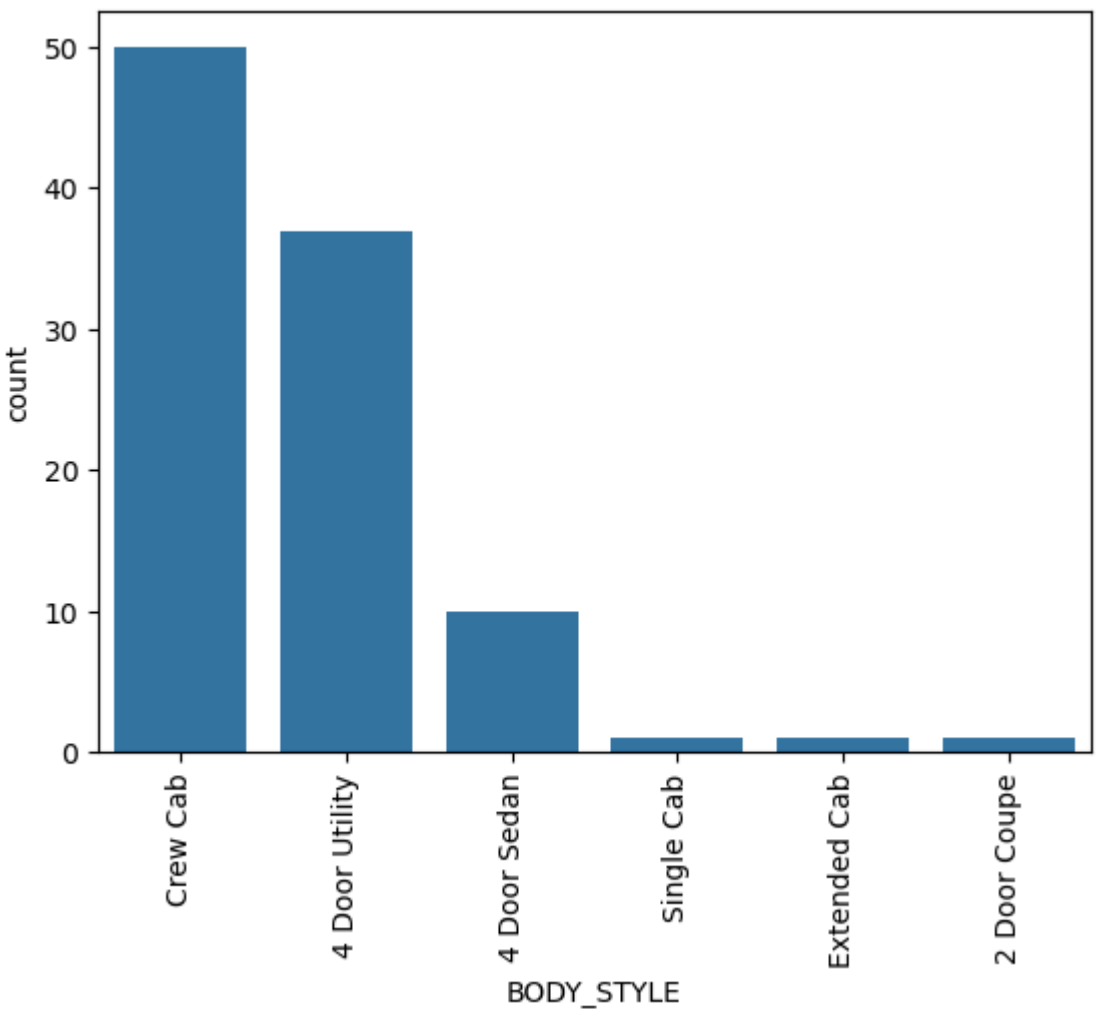
In [14]:
```
sns.countplot(data=data, x='PLATFORM')
plt.xticks(rotation=90)
plt.show()
```



BODY_STYLE

- No missing values
- Unique Values: 6 styles
- Significance: Vehicle body configuration
- Stakeholder Value: Manufacturing process correlation, design review

In [15]:
```
sns.countplot(data=data, x='BODY_STYLE')
plt.xticks(rotation=90)
plt.show()
```



ENGINE & ENGINE_DESC

- Data Type: String (Code & Description)
- No Missing values
- Unique Values: 12 engine types
- "EN0" = "NONE" for BEV vehicles
- Significance: Engine specification

In [16]:
```
Enginedata = data.groupby(['ENGINE', 'ENGINE_DESC']).size().reset_index(name='count')
Enginedata
```

Out[16]:

	ENGINE	ENGINE_DESC	count
0	EN0	NONE	12
1	L5P	DIESEL, 8 CYL, 6.6L, DI, V8, TURBO, DURAMAX, G...	9
2	L84	GAS, 8 CYL, 5.3L, V8, DI, DFM, ALUM, GEN 5	24
3	L87	GAS, 8 CYL, V8, 6.2L, DI, DFM, ALUM, GEN 5	17
4	L8T	GAS, 8 CYL, 6.6L, SIDI, VVT, CAST IRON	4
5	LFY	GAS, 6 CYL, V6, 3.6L, SIDI, DOHC, ATSS, GEN 1+	5
6	LGX	GAS, 6 CYL, 3.6L, V6, DI, DOHC, VVT, ALUM, GEN 2	11
7	LM2	DIESEL, 6 CYL, 3.0L, CRI, L6, DOHC, TURBO, VGT...	7
8	LSY	GAS, 4 CYL, L4, 2.0L, SIDI, DOHC, VVT, ALUM, T...	5
9	LT1	GAS, 8 CYL, 6.2L, DI, AFM, VVT, HO, ALUM, GMNA	1
10	LUV	GAS, 4 CYL, 1.4L, MFI, DOHC, TURBO, VVT, ALUM,...	1
11	LZ0	DIESEL, 6 CYL, 3.0L, CRI, L6, DOHC, TURBO, VGT...	4

TRANSMISSION & TRANSMISSION_DESC

- Data Type: String (Code & Description)
- No missing values
- Unique Values: 19 transmission types
- "MF1" = "NONE" for BEV vehicles
- Significance: Transmission specification

In [17]:
```
Enginedata = data.groupby(['TRANSMISSION', 'TRANSMISSION_DESC']).size().reset_index(name='count')
Enginedata
```

Out[17]:

	TRANSMISSION	TRANSMISSION_DESC	count
0	M3G	BYT 9 SPD, 9T60, ETRS GEN 1	1
1	M3H	BYT 9 SPD, 9T50, ETRS GEN 1	1
2	M3T	EU:N:X:Z|TRANSMISSION BYT 9 SPD, 9T60, GEN 1	1
3	M3V	BYT 9 SPD, 9T65, GEN 1	4
4	M3W	TRANSMISSION BYT 9 SPD, 9T65, ETRS GEN 1	12
5	M5N	BYT 8 SPD, 8L45, BAS+	1
6	MF1	NONE	5
7	MGM	BYT 10 SPD, 10R1000, GRX, GEN 1, VAR 1	9
8	MH8	BYT 6 SPD, HMD, X23F	1
9	MHS	BYT 10 SPD, 10L80, GRX, GEN 1, ATSS, ETRS, VAR 1	28
10	MHT	BYT 10 SPD, 10R80, GRX, GEN 1, ATSS, VAR 1	2
11	MI2	BYT 10 SPD, 10L80, GRX, VAR 1, GEN 1	1
12	MKM	BYT 10 SPD, RWD 4.54 1ST, 2.86 2ND, 2.06 3RD, ...	3
13	MMF	BYT, ELECTRIC, GM, GEM, GEN 2, DRIVE UNIT, X68F	7
14	MQ2	BYT 10 SPD, 10L60, GEN 1, ATSS, ETRS, VAR 1	1
15	MQB	BYT 10 SPD, 10L80, ATSS, CPA, GEN 2	7
16	MQC	BYT 10 SPD, 10L80, ATSS, ETRS, CPA, GEN 2	10
17	MQC	BYT 10 SPD, 10R80, ATSS, ETRS, CPA, GEN 2	1
18	MQE	BYT 8 SPD, 8L90, ATSS, CPA, GEN 1	4
19	MYD	BYT 6 SPD, HMD, 6L90	1

VPPC

- Data Type: String
- No missing values
- Unique Values: 26 codes

LINE_SERIES

- Data Type: String
- 1 missing value
- Unique Values: 22

VIN_MODL_DESGTR

- Data Type: String
- No missing values
- Unique Values: 41 values
- Significance: Model code

F. Manufacturing & Build Information

PLANT

- Data Type: String (3-letter code)
- 1 missing value
- Unique Values: 11 plants
- Significance: Manufacturing facility

In [18]:
```
data['PLANT'].value_counts(dropna=False)
```

Out[18]:
```
PLANT
SIL    19
FTW    17
SHT    15
ARL    13
FLT    11
ORI     8
DEL     5
OS2     4
LGR     3
RAM     3
NaN     1
FAI     1
Name: count, dtype: int64
```

STATE

- Data Type: String
- 2 missing values
- Unique Values: 39 US states
- Significance: US state of repair location

DEALER_REGION & SALES_REGION_CODE

- Data Type: Integer
- No missing values
- Unique Values: 2 values each (1, 4)
- Range: 1-4
- Significance: Regional classification for dealers and sales

In [19]:
```
Dealerdata = data.groupby(['DEALER_REGION', 'SALES_REGION_CODE']).size().reset_index(name='count')
Dealerdata
```

Out[19]:

	DEALER_REGION	SALES_REGION_CODE	count
0	1	1	97
1	4	4	3

REPAIR_DLR_POSTAL_CD

- Data Type: Integer
- 2 missing values
- Unique Values: 92 unique codes
- Significance: Zip/postal code of repair location

H. Cost & Financial Columns

In [20]:
```
data['REPORTING_COST'].describe()
```

Out[20]:
```
count     100.000000
mean      531.193200
std       411.161608
min        27.690000
25%       305.432500
50%       433.970000
75%       554.062500
max      2457.450000
Name: REPORTING_COST, dtype: float64
```

REPORTING_COST

- Data Type: Float
- No missing values
- Range: 27.69 - 2,457.45
- Mean: $531.19
- Significance: Cost reported for warranty claim

In [21]:
```
data['TOTALCOST'].describe()
```

Out[21]:
```
count      94.000000
mean      561.162128
std       452.796836
min        27.690000
25%       320.105000
50%       457.225000
75%       606.905000
max      3205.450000
Name: TOTALCOST, dtype: float64
```

TOTALCOST

- Data Type: Float
- 6 missing values
- Range: 27.69 - 3,205.45
- Mean: 561.16
- Significance: Total repair cost

In [22]:
```
data['LBRCOST'].describe()
```

Out[22]:
```
count     100.000000
mean      106.344900
std       113.223074
min        20.000000
25%        61.855000
50%        78.560000
75%       108.055000
max      1012.670000
Name: LBRCOST, dtype: float64
```

LBRCOST

- Data Type: Float
- No missing values
- Range: 20.00 - 1,012.67
- Mean: 106.34
- Significance: Labor cost

I. Usage Columns

In [23]:
```
data['KM'].describe()
```

Out[23]:
```
count       100.000000
mean      24914.230000
std       20747.078206
min           3.000000
25%        8883.250000
50%       21962.000000
75%       35493.250000
max      107905.000000
Name: KM, dtype: float64
```

KM (Kilometers)

- Data Type: Integer
- Completeness: 100%
- Range: 3 to 107,905 km
- Mean: 24,914 km
- Significance: Vehicle KMs driven at the time of repair

J. Regulatory & Compliance Columns

VEH_TEST_GRP

- Data Type: String
- 2 missing values
- Unique Values: 23 test groups

COUNTRY_SALE_ISO

- Data Type: String
- Completeness: 100%
- Unique Values: 6 countries
- Significance: Country where vehicle was sold

OPTN_FAMLY_CERTIFICATION

- Data Type: String
- Completeness: 10 missing values
- Unique Values: 3 codes

OPTF_FAMLY_EMISSIOF_SYSTEM

- Data Type: String
- Completeness: 5 missing values
- Unique Values: 8 systems

In [24]:
```
data['ORD_SELLING_SRC_CD'].describe()
```

Out[24]:
```
count    100.000000
mean      24.590000
std       17.822976
min       11.000000
25%       13.000000
50%       13.000000
75%       48.000000
max       72.000000
Name: ORD_SELLING_SRC_CD, dtype: float64
```

ORD_SELLING_SRC_CD

- Data Type: Integer
- No missing values
- Unique Values: 7 codes
- Range: 11 to 72

In [25]:
```
data['LAST_KNOWN_DELVRY_TYPE_CD'].value_counts(dropna = False)
```

Out[25]:
```
LAST_KNOWN_DELVRY_TYPE_CD
10.0    59
18.0    11
16.0     8
15.0     6
21.0     4
37.0     3
23.0     3
NaN      2
34.0     1
32.0     1
35.0     1
14.0     1
Name: count, dtype: int64
```

LAST_KNOWN_DELVRY_TYPE_CD

- Data Type: Integer
- Completeness: 2 missing values
- Unique Values: 11 delivery types
- Significance: How vehicle was delivered to customer

K. System Columns

TRANSACTION_CATEGORY

- Data Type: String
- No missing values
- Unique Values: 2 categories
- Significance: Transaction classification

In [26]:
```
data['TRANSACTION_CATEGORY'].value_counts()
```

Out[26]:
```
TRANSACTION_CATEGORY
FREG        89
FREG_POL    11
Name: count, dtype: int64
```

SRC_VER_NBR

- Data Type: Integer
- No missing values
- Unique Values: 10 versions

TRANSACTION_CNTR

- Data Type: Integer
- No missing values
- Unique Values: 1
- Significance: Transaction account

In [27]:
```
data['MEDIA_FLAG'].value_counts()
```

Out[27]:
```
MEDIA_FLAG
N    62
Y    38
Name: count, dtype: int64
```

MEDIA_FLAG

- Data Type: String
- No missing values
- Unique Values: 2 values
- Significance: Indicates if media attached

In [28]:
```
data['NON_CAUSAL_PART_QTY'].value_counts()
```

Out[28]:
```
NON_CAUSAL_PART_QTY
0    93
1     7
Name: count, dtype: int64
```

NON_CAUSAL_PART_QTY

- Data Type: Integer
- No Missing values
- Unique Values: 2 values
- Significance: If non casual part is used

Data Cleaning

Replace None to No Engine_DESC in ENGINE and TRANSMISSION_DESC

In [29]:
```
data['ENGINE_DESC'] = data['ENGINE_DESC'].replace('NONE', 'No engine')
```

In [30]:
```
data['TRANSMISSION_DESC'] = data['TRANSMISSION_DESC'].replace('NONE', 'No engine')
```

In [31]:
```
cols = ['ENGINE_DESC','TRANSMISSION_DESC']
for i in cols:
  print(data[i].isnull().sum())
```

```
0
0
```

CAUSAL_PART_NM column has null values but when we look at the GLOBAL_LABOR_CODE_DESCRIPTION the replacement part used for the particular repair was mentioned.

In [32]:
```
data['CASUAL_PART'] = data['GLOBAL_LABOR_CODE_DESCRIPTION'].str.replace('Replacement', '')
```

State has 2 missing values.Fill the missing values using mode

In [33]:
```
data['STATE'].fillna(data['STATE'].mode()[0], inplace=True)
```

```
/var/folders/j9/5cfyrfh95f7b6l3x9spqz61w0000gn/T/ipykernel_8705/2138785523.py:1: FutureWarning: A value is trying to be set on a copy of a DataFrame or Series through chained assignment using an inplace method.
The behavior will change in pandas 3.0. This inplace method will never work because the intermediate object on which we are setting values always behaves as a copy.

For example, when doing 'df[col].method(value, inplace=True)', try using 'df.method({col: value}, inplace=True)' or df[col] = df[col].method(value) instead, to perform the operation inplace on the original object.


  data['STATE'].fillna(data['STATE'].mode()[0], inplace=True)
```

In [34]:
```
data['STATE'].isnull().sum()
```

Out[34]:
```
np.int64(0)
```

Missing values in TotalCost Column , So REPORTING_COST is considered for analysis

In [35]:
```
duplicated_vin_values = data['VIN'][data['VIN'].duplicated(keep=False)].unique()
display(duplicated_vin_values)
```

```
array(['1HRFFHEL8RZ133325', '3HRS9EED0LH255650'], dtype=object)
```

In [36]:
```
data.sample(5)
```

Out[36]:

	VIN	TRANSACTION_ID	CORRECTION_VERBATIM	CUSTOMER_VERBATIM	REPAIR_DATE	CAUSAL_PART_NM	GLOBAL_LABOI
56	1H1FW6S02N4102661	13054	REPLACE HEATED STEERING MODULE	HEATED VOLAN DEVARQUE BY ITSELF INTERMITTENT C...	2024-01-26	MODULE ASM-STRG WHL HT CONT	Heatec
44	1HR19SEY5RF265525	13054	DIAGNOSIS OF OPEN CIRCUIT INSIDE WHEEL. REPLAC...	CHECK AND REPORT STEERING WHEEL ONLY STAYS LUK...	2024-01-19	WHEEL ASM-STRG *JET BLACK	Stee
38	1HKS2JKL9MR285352	13030	WHEEL COMING APART AT STITCHING. REPLACE STEER...	CUSTOMER STATES THAT THE STEERING WHEEL COVER ...	2024-01-17	WHEEL ASM-STRG *JET BLACK	Stee
68	3HRFFCER2NH609121	13043	REMOVED OLD STEERING WHEEL AND INSTALLED NEW O...	CUSTOMER STATES HEATED STEERING WHEEL ONLY GET...	2024-01-31	WHEEL ASM-STRG *BLACK	Stee
15	1HKS1JKL0SR282668	13024	VERIFIED CUSTOMER CONCERN ABOUT A HORN INOP. I...	CUSTOMER STATES CK HORN ON THE STEERING WHEEL ...	2024-01-11	HARNESS ASM-STRG WHL HORN SW WRG	Steering W

5 rows × 53 columns

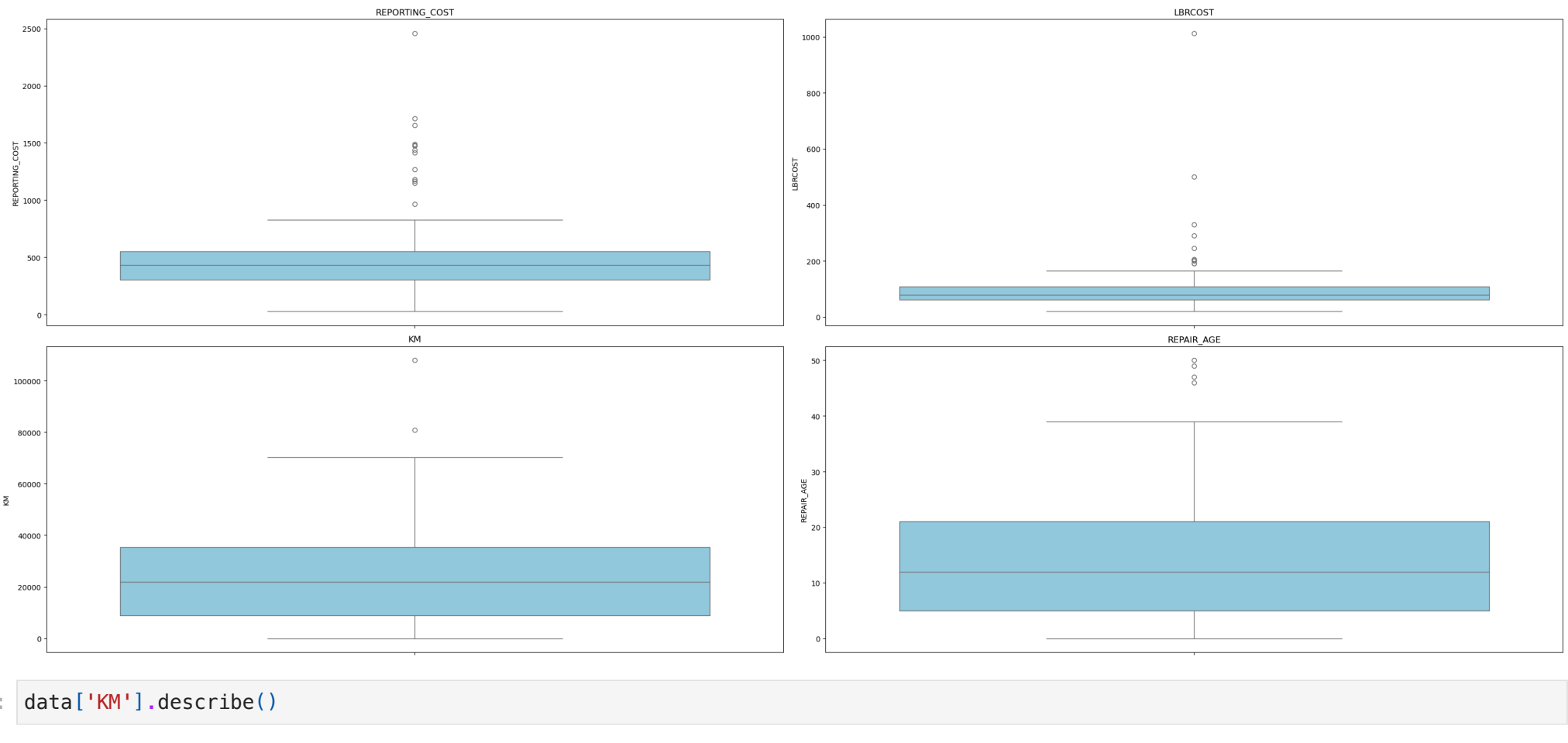
Checking for OutLiers in Reporting Cost , LBR cost & KM

In [37]:
```
Outlier_columns = ['REPORTING_COST', 'LBRCOST', 'KM','REPAIR_AGE']
```

In [38]:
```
plt.figure(figsize=(30, 25))

# Loop and plot
for i, col in enumerate(Outlier_columns, 1):
    plt.subplot(4, 2, i)
    sns.boxplot(y=data[col], color='skyblue')
    plt.title(col)

plt.tight_layout()
plt.show()
```



In [39]:
```
data['KM'].describe()
```

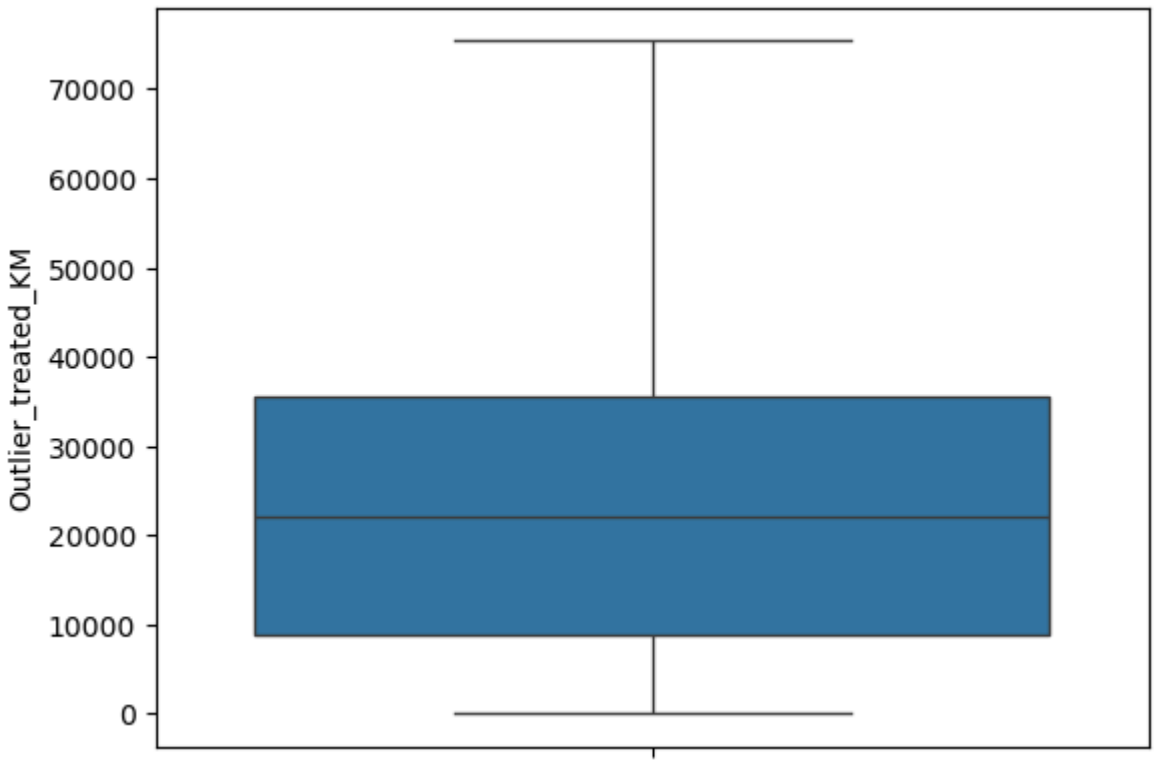
Out[39]:
```
count       100.000000
mean      24914.230000
std       20747.078206
min           3.000000
25%        8883.250000
50%       21962.000000
75%       35493.250000
max      107905.000000
Name: KM, dtype: float64
```

In [40]:
```
Q1 = data['KM'].quantile(0.25)
Q3 = data['KM'].quantile(0.75)
IQR = Q3 - Q1
lower_bound = Q1 - 1.5 * IQR
upper_bound = Q3 + 1.5 * IQR

data['Outlier_treated_KM'] = np.where(data['KM'] > upper_bound, upper_bound, data['KM'])
```

In [41]:
```
sns.boxplot(y=data['Outlier_treated_KM'])
```

Out[41]:
```
<Axes: ylabel='Outlier_treated_KM'>
```



In [42]:
```
data['REPAIR_AGE'].describe()
```

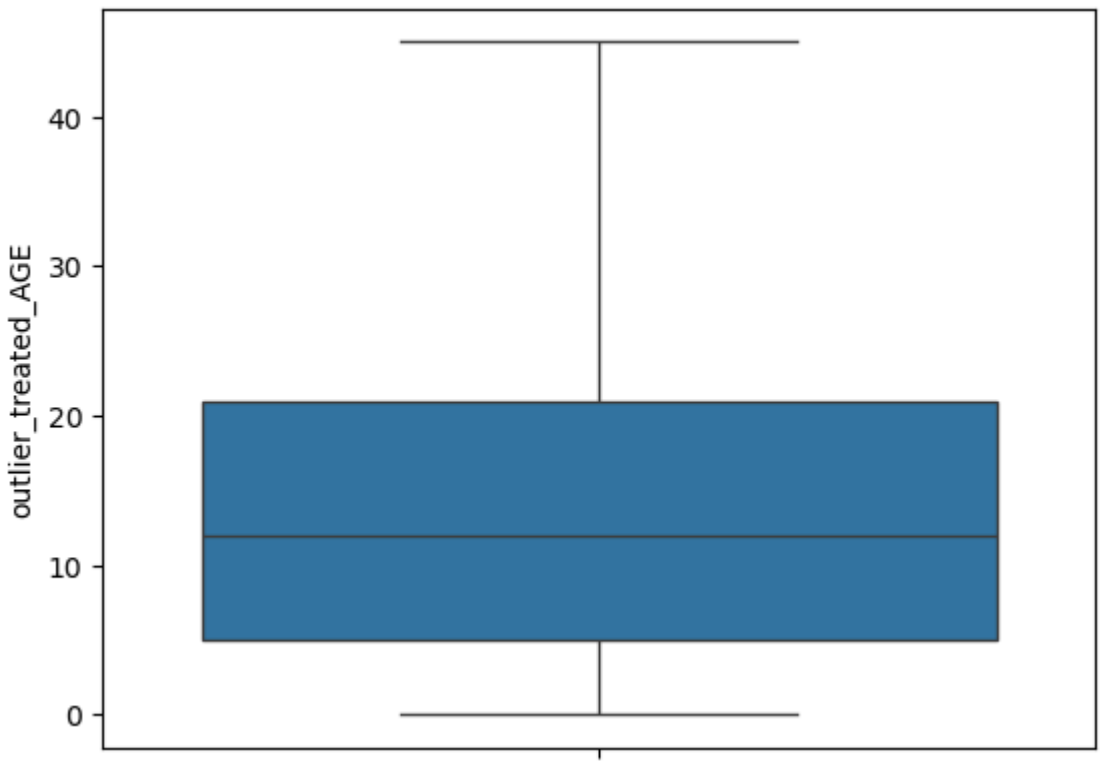
Out[42]:
```
count    100.000000
mean      14.940000
std       12.367945
min        0.000000
25%        5.000000
50%       12.000000
75%       21.000000
max       50.000000
Name: REPAIR_AGE, dtype: float64
```

In [43]:
```
Q1 = data['REPAIR_AGE'].quantile(0.25)
Q3 = data['REPAIR_AGE'].quantile(0.75)
IQR = Q3 - Q1
lower_bound = Q1 - 1.5 * IQR
upper_bound = Q3 + 1.5 * IQR

data['outlier_treated_AGE'] = np.where(data['REPAIR_AGE'] > upper_bound, upper_bound, data['REPAIR_AGE'])
```

In [44]:
```
sns.boxplot(y=data['outlier_treated_AGE'])
```

Out[44]:
```
<Axes: ylabel='outlier_treated_AGE'>
```

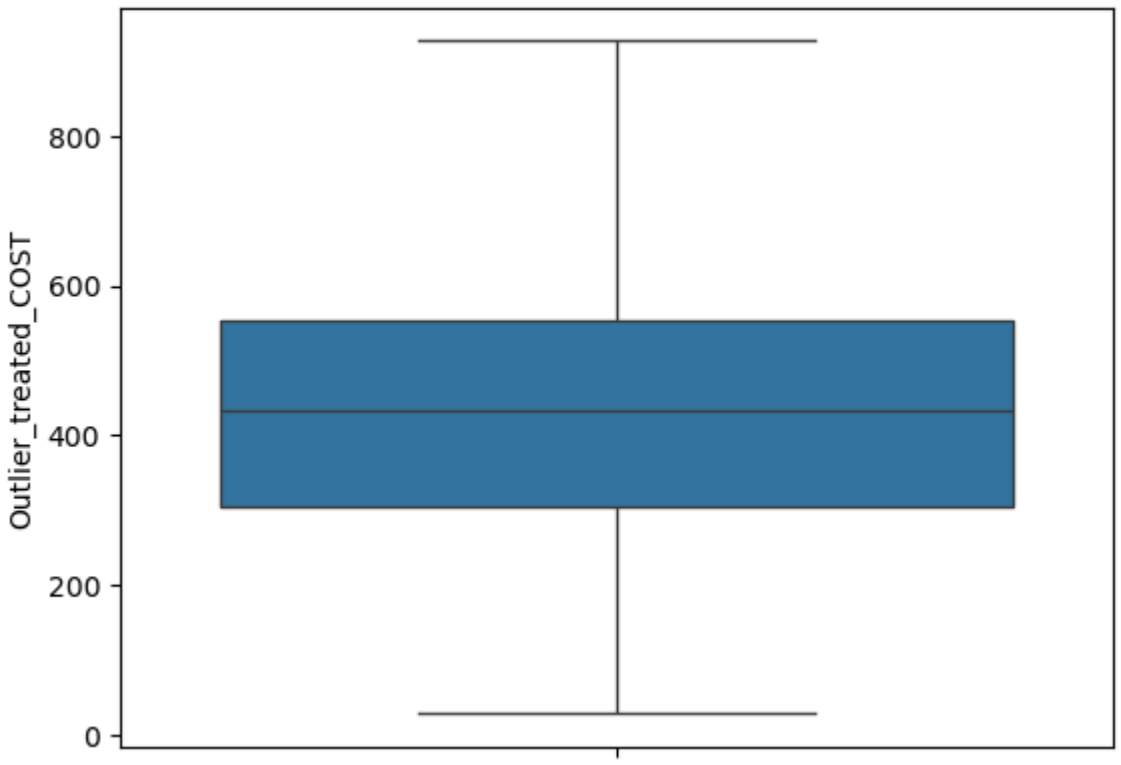


In [45]:
```
Q1 = data['REPORTING_COST'].quantile(0.25)
Q3 = data['REPORTING_COST'].quantile(0.75)
IQR = Q3 - Q1
lower_bound = Q1 - 1.5 * IQR
upper_bound = Q3 + 1.5 * IQR

data['Outlier_treated_COST'] = np.where(data['REPORTING_COST'] > upper_bound, upper_bound, data['REPORTING_COST'])
```

In [46]:
```
sns.boxplot(y=data['Outlier_treated_COST'])
```

Out[46]:
```
<Axes: ylabel='Outlier_treated_COST'>
```

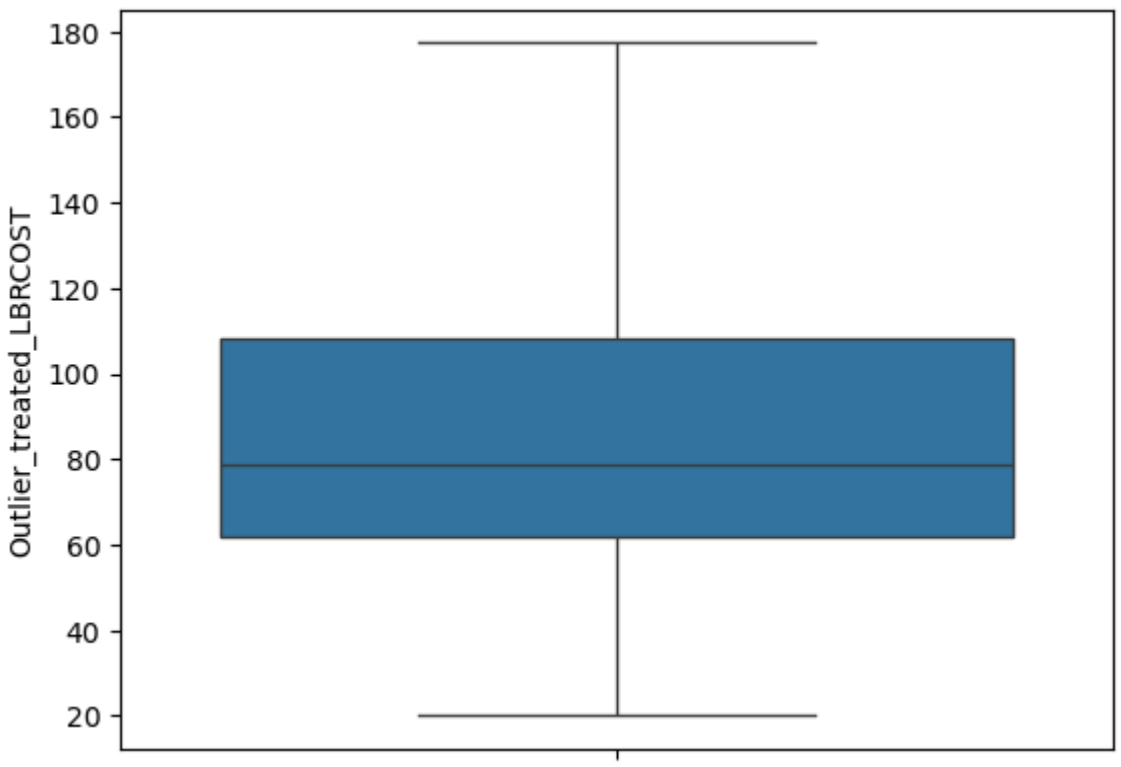


In [47]:
```
Q1 = data['LBRCOST'].quantile(0.25)
Q3 = data['LBRCOST'].quantile(0.75)
IQR = Q3 - Q1
lower_bound = Q1 - 1.5 * IQR
upper_bound = Q3 + 1.5 * IQR

data['Outlier_treated_LBRCOST'] = np.where(data['LBRCOST'] > upper_bound, upper_bound, data['LBRCOST'])
```

In [48]:
```
sns.boxplot(y=data['Outlier_treated_LBRCOST'])
```

Out[48]: <Axes: ylabel='Outlier_treated_LBRCOST'>



In [49]:
```
def ComplaintType(text):

    text = text.lower()

    heat_keywords = ["heat", "warm", "luke warm", "lukewarm", "inop", "smoking"]
    if any(word in text for word in heat_keywords):
        return "heating issue"

    material_keywords = [
        "peel", "bubbl", "fray", "crack", "stitch",
        "leather", "coming apart", "loose", "delam",
        "wrinkle", "trim", "finish", "material"
    ]
    if any(word in text for word in material_keywords):
        return "Material Damage"

    assist_keywords = ["super cruise", "driver assist", "cruise control", "lane"]
    if any(word in text for word in assist_keywords):
        return "Driver Assist Failure"

    horn_keywords = ["horn", "switch", "button", "control"]
    if any(word in text for word in horn_keywords):
        return "Horn"

    noise_keywords = ["noise", "rattl", "rub", "click", "tight"]
    if any(word in text for word in noise_keywords):
        return "Steering Noise"

    if "smok" in text:
        return  "Safety Issue"

    return "Others"
```

```
data['COMPLAINT_TYPE'] = data['CUSTOMER_VERBATIM'].apply(ComplaintType)

data['COMPLAINT_TYPE'].value_counts()
```

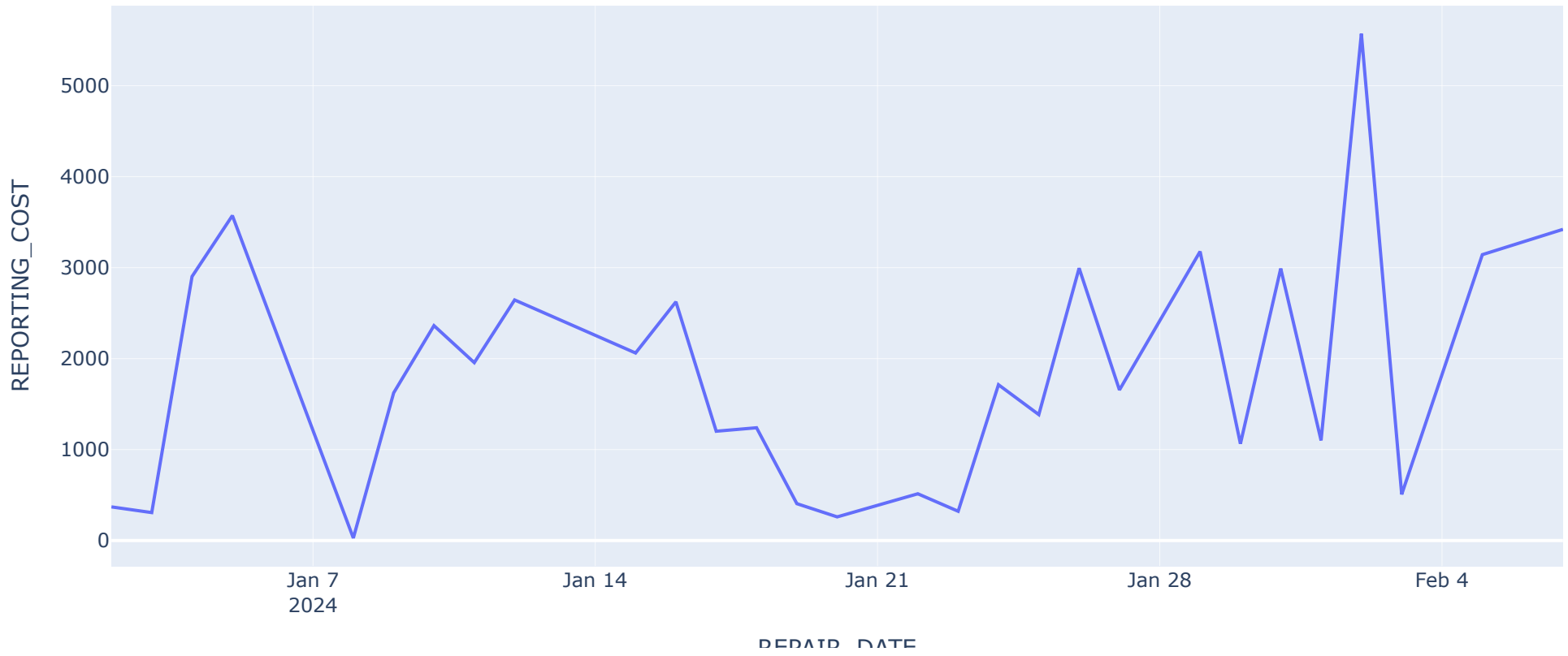
Out[49]:
```
COMPLAINT_TYPE
Material Damage          43
heating issue            27
Others                   15
Driver Assist Failure     7
Steering Noise            4
Horn                      4
Name: count, dtype: int64
```

In [50]:
```
CostData = data.groupby(['REPAIR_DATE']).agg({'REPORTING_COST': 'sum'}).reset_index()
CostData
```

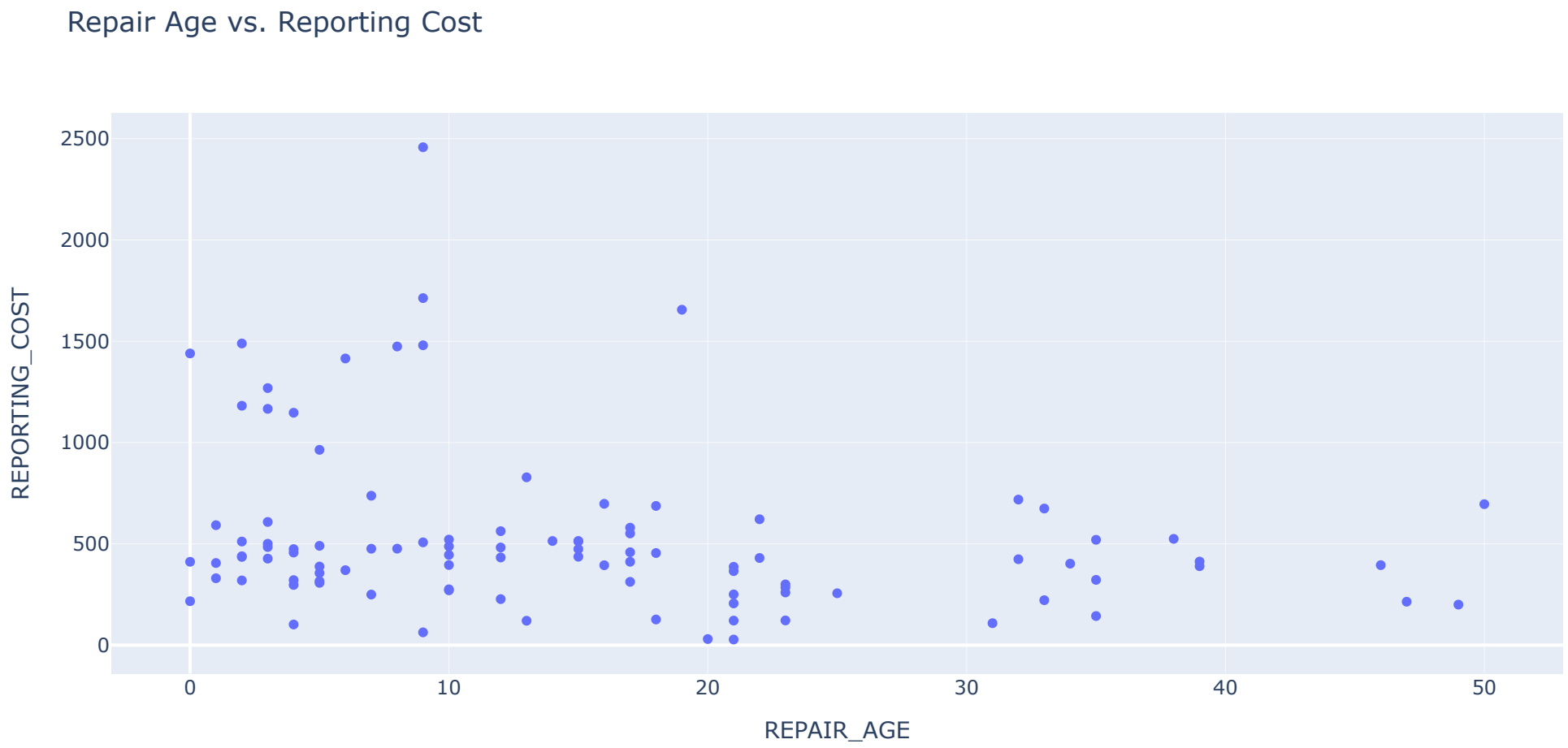
Out[50]:

	REPAIR_DATE	REPORTING_COST
0	2024-01-02	370.03
1	2024-01-03	307.32
2	2024-01-04	2902.73
3	2024-01-05	3572.42
4	2024-01-08	27.69
5	2024-01-09	1623.25
6	2024-01-10	2362.56
7	2024-01-11	1955.72
8	2024-01-12	2644.93
9	2024-01-15	2061.78
10	2024-01-16	2624.29
11	2024-01-17	1201.90
12	2024-01-18	1239.93
13	2024-01-19	405.29
14	2024-01-20	259.93
15	2024-01-22	514.00
16	2024-01-23	321.88
17	2024-01-24	1712.85
18	2024-01-25	1384.43
19	2024-01-26	2994.29
20	2024-01-27	1655.49
21	2024-01-29	3177.57
22	2024-01-30	1063.98
23	2024-01-31	2990.56
24	2024-02-01	1101.04
25	2024-02-02	5571.73
26	2024-02-03	507.32
27	2024-02-05	3143.09
28	2024-02-07	3421.32

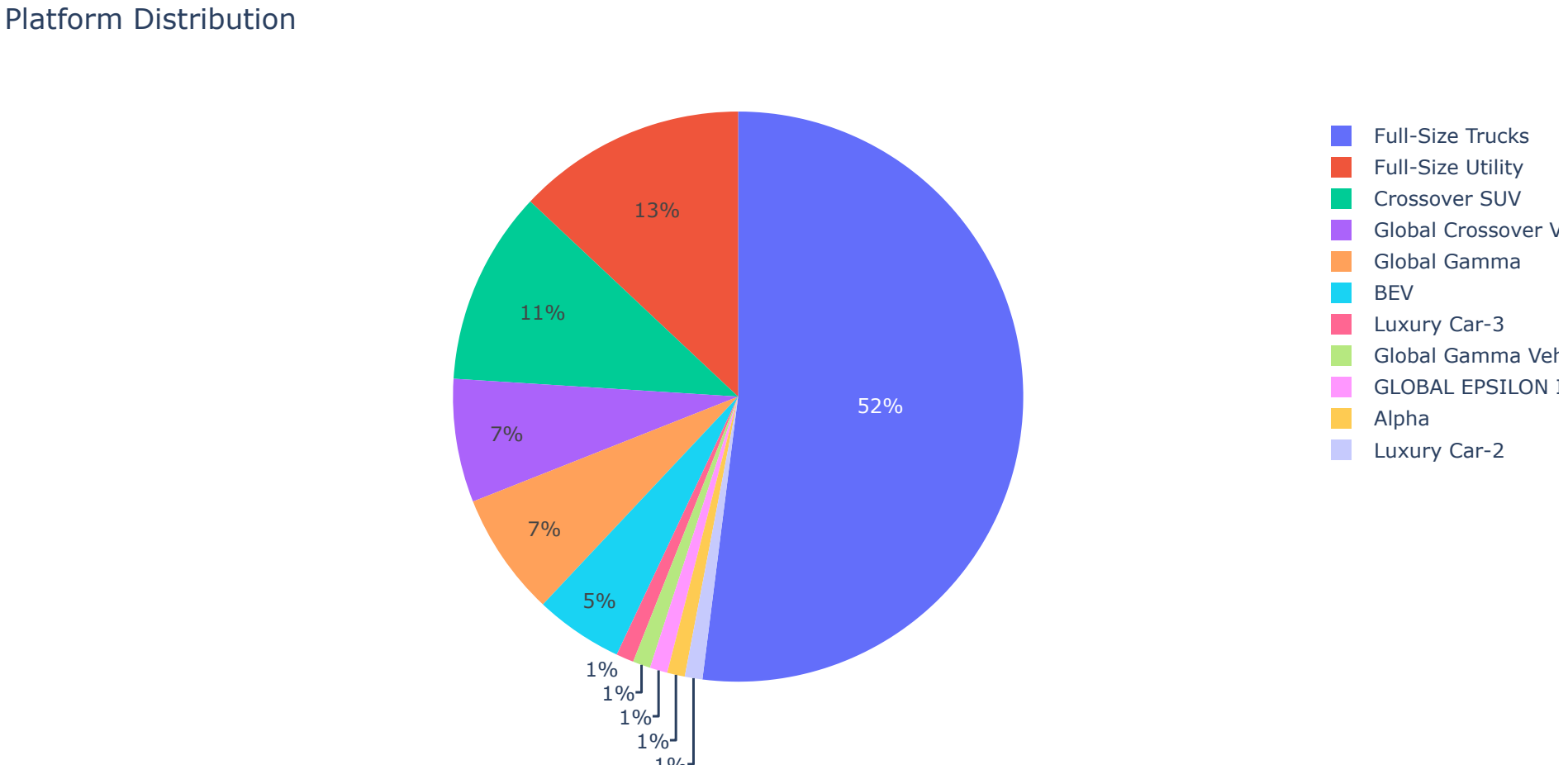
In [51]:
```
px.line(CostData, x='REPAIR_DATE', y='REPORTING_COST', title='Total Reporting Cost Trend by Repair Month')
```



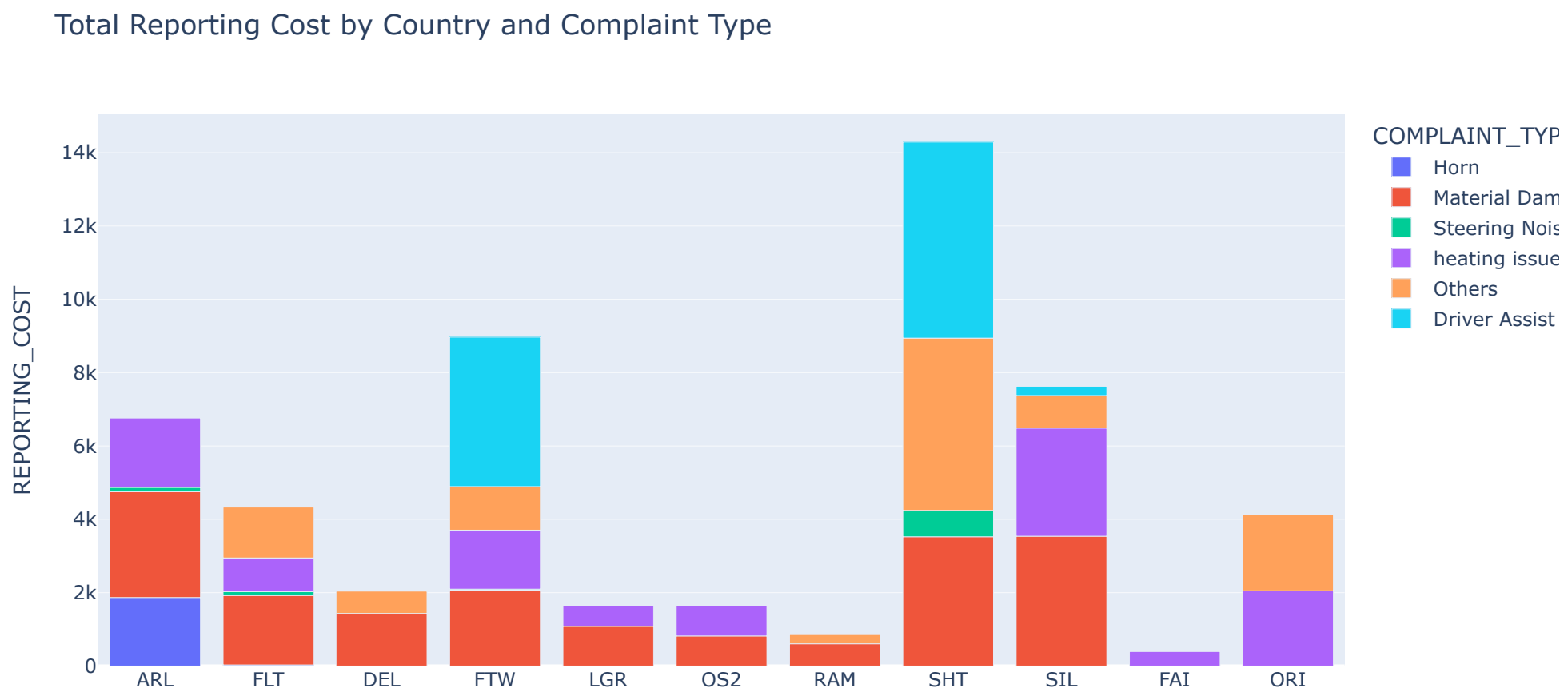
In [52]:
```
fig = px.scatter(data, x='REPAIR_AGE', y='REPORTING_COST', title='Repair Age vs. Reporting Cost')
fig.show()
```



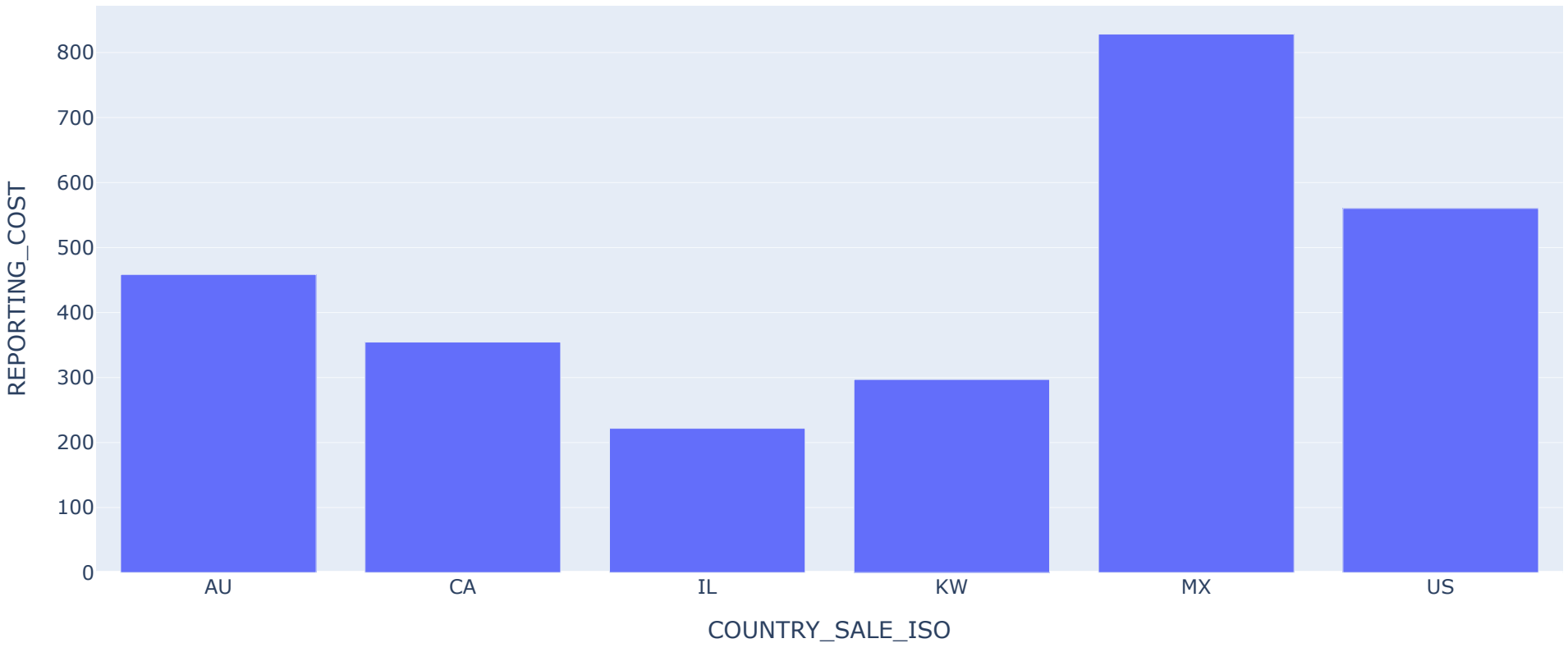
In [53]:
```
px.pie(data, names='PLATFORM', title='Platform Distribution')
```



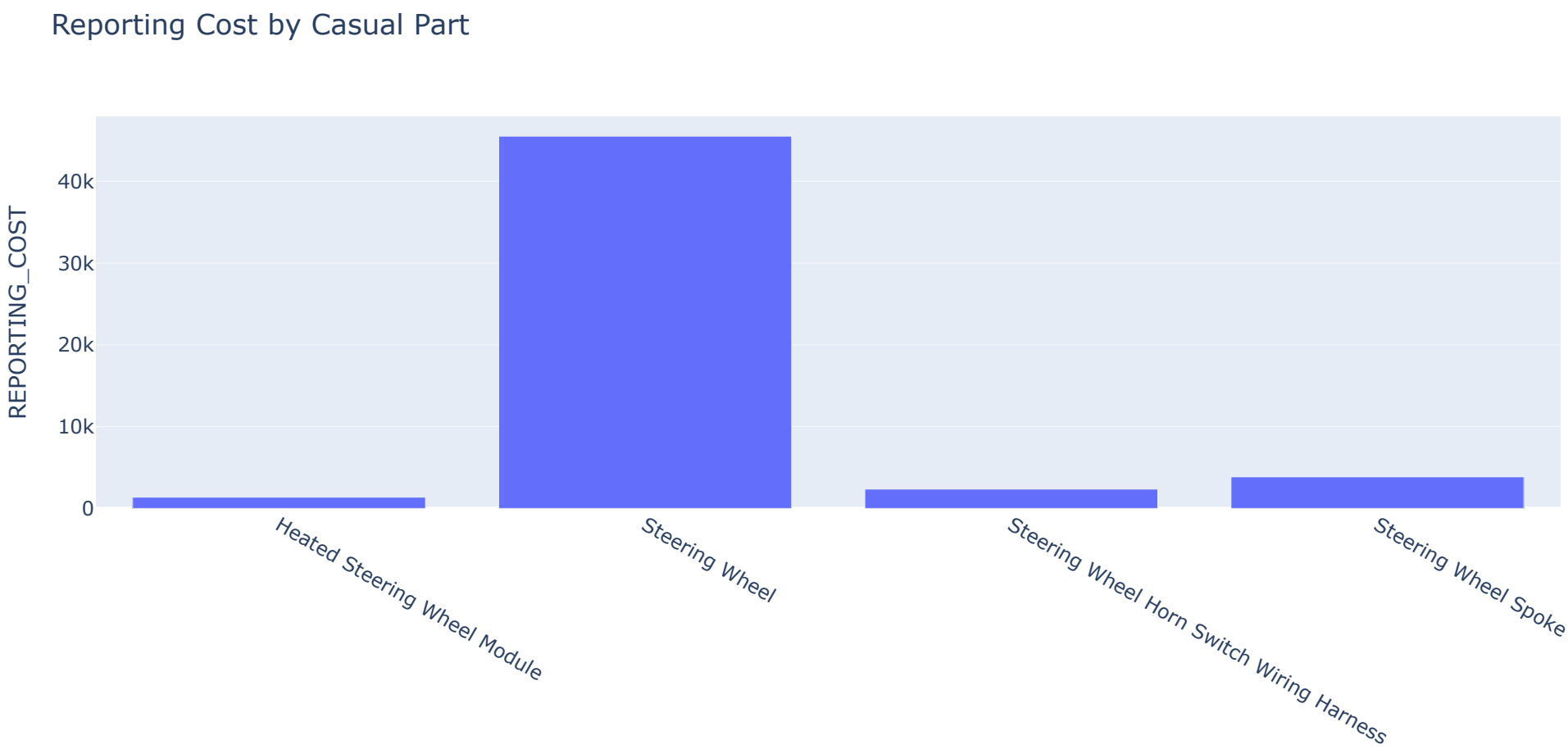
In [54]:
```
grouped_cost_data = data.groupby(['PLANT','COMPLAINT_TYPE']).agg({'REPORTING_COST': 'sum'}).reset_index()
fig = px.bar(grouped_cost_data, x='PLANT', y='REPORTING_COST', color='COMPLAINT_TYPE',
             title='Total Reporting Cost by Country and Complaint Type')
fig.show()
```



In [55]:
```
px.bar(data.groupby('COUNTRY_SALE_ISO')['REPORTING_COST'].mean().reset_index(), x='COUNTRY_SALE_ISO',y='REPORTING_COST', title=
```



In [56]:
```
Partcost = data.groupby('CASUAL_PART').agg({'REPORTING_COST': 'sum'}).reset_index()
px.bar(Partcost, x='CASUAL_PART',y='REPORTING_COST', title='Reporting Cost by Casual Part')
```



TOP 5 COLUMNS

1. REPAIR_AGE

- Directly tied to warranty costs and customer satisfaction
- Early failures (0-6 months): 25% of cases - indicates manufacturing quality issues

---

2. REPORTING_COST

- Direct financial impact: 531 Dollars average per claim
- Wide range ($27-$2,457) indicates varying repair complexity
- It significantly impacts P&L

---

3. PLATFORM

- Full-Size Trucks = 52% of all issues
- Strategic resource allocation for highest-impact fixes

---

4. GLOBAL_LABOR_CODE_DESCRIPTION

- 78% are full steering wheel replacements
- Indicates part-level failures

---

5. COUNTRY_BY_ISO

- Most of the high cost repair claims are from mexico

TAG GENERATION

Failure Mode Tags Extracted

- Driver Assist Failure includes loss of cruise control,driver assist
- Horn includes sounds like Squeaks, rattles, clicks
- Material Damage includes Physical separation/adhesive failures
- Steering Noise includes unusual sounds from steering
- heating issue includes Heated steering wheel malfunctions

KEY INSIGHTS & RECOMMENDATION

- Steering wheel is the dominant failure mode, with 78% requiring complete wheel replacement. This indicates a manufacturing quality issue rather than wear-and-tear.
- Mean repair cost of 531 x 100 cases = $53,100 in this sample alone which cloud make a affect in the P&L
- 25% of failures occur within 6 months of vehicle delivery cost more to fix due to expedited parts and customer dissatisfaction.
- Full-Size Trucks dominate at 52% - given their high transaction prices and profit margins, quality issues here have outsized business impact.

Actionable Recommendations

- Immediate: Audit steering wheel supplier quality for Full-Size Truck platform
- Short-term: Implement enhanced adhesive Quality checks at SIL and SHT plants
- Mid-term: Steering wheel design review focusing on material selection and assembly process