In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
rcParams.update({'figure.autolayout': True})
import seaborn as sns
import joblib
from sklearn.feature_selection import SelectFromModel
from sklearn.linear_model import LassoCV
from sklearn.base import BaseEstimator, TransformerMixin
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import FunctionTransformer, OneHotEncoder, LabelEncoder
from sklearn.utils.multiclass import type_of_target
from sklearn.utils import check_X_y
from sklearn.model_selection import train_test_split, GridSearchCV, cross_val_score, RepeatedStratifiedKFold, KFold
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, roc_auc_score
%run './python/Chicago_Car_Crashes.py'
```

DATA COLLECTION

In [103…
```
crashes = pd.read_csv('./data/Traffic_Crashes_-_Crashes.csv.gz', index_col=0)
print(f"{'Dataset contains shape'}\n{'Rows':10}{crashes.shape[0]}\n{'Columns':10}{crashes.shape[1]}")
```

```
Dataset contains shape
Rows      490128
Columns   49
```

In [4]:
```
crashes.CRASH_DATE = pd.to_datetime(crashes.CRASH_DATE)
df = crashes[(crashes.CRASH_DATE.dt.year == 2020)].drop('Unnamed: 0', axis=1).copy()
df.to_csv('./data/Chicago_Traffic_Crashes_2020.csv.gz',index=False, compression='gzip')
```

In [2]:
```
df = pd.read_csv('./data/Chicago_Traffic_Crashes_2020.csv.gz', low_memory=False)
```

DESCRIPTIVE STATISTICS

In [3]:
```
df.head()
```

Out[3]:

	CRASH_RECORD_ID	RD_NO	CRASH_DATE_EST_I	CRASH_DATE	POSTED_SPEED_LIMIT	TRAFFIC_CONTROL
0	ee9283eff3a55ac50ee58f3d9528ce1d689b1c4180b4c4...	JD292400	NaN	2020-07-10 10:25:00	30	TRAFFI
1	f8960f698e870ebdc60b521b2a141a5395556bc3704191...	JD293602	NaN	2020-07-11 01:00:00	30	NO C
2	8eaa2678d1a127804ee9b8c35ddf7d63d913c14eda61d6...	JD290451	NaN	2020-07-08 14:00:00	20	NO C
3	f636d4a51a88015ac89031159b1f1952b8d92e49d11aeb...	JD293237	NaN	2020-07-10 22:20:00	30	NO C
4	76aabcf7c2219a5c90259c96fe94b33834ddb53e0dbcd3...	JD291826	NaN	2020-07-09 17:06:00	10	NO C

5 rows × 49 columns

In [4]:
```
df.describe()
```

Out[4]:

	POSTED_SPEED_LIMIT	LANE_CNT	STREET_NO	BEAT_OF_OCCURRENCE	NUM_UNITS	INJURIES_TOTAL	INJURIES_FATAL	INJURIES_INCA
count	92092.000000	12.000000	92092.000000	92092.000000	92092.00000	91858.000000	91858.000000	9
mean	28.532793	2.250000	3860.405985	1216.832732	2.04831	0.215060	0.001698	
std	5.761715	0.965307	2905.455298	697.276831	0.50948	0.600362	0.044480	
min	0.000000	1.000000	0.000000	111.000000	1.00000	0.000000	0.000000	
25%	30.000000	2.000000	1401.000000	633.000000	2.00000	0.000000	0.000000	
50%	30.000000	2.000000	3407.000000	1121.000000	2.00000	0.000000	0.000000	
75%	30.000000	2.250000	5749.000000	1731.000000	2.00000	0.000000	0.000000	
max	70.000000	4.000000	13799.000000	6100.000000	15.00000	19.000000	3.000000	

DATA SCRUBBING

prima di inziare ad esplorare i dati dobbiamo individuare le variable da escludere in particolare quelli con i dati mancanti e quelli che hanno poca rilevanza per il nostro modello.

In [5]:
```
dfi = Dframe(df)
```

In [6]:
```
dfi.df_info()
```

```
Data Entries                    92092
Data Columns                    49
DataFrame items                 4,512,508
DataFrame Null                  948953  Null values
DataFrame contain               21.03% Null Values

 #   Column                     Null Count &  Percent   Dtype
---  ------                     ---------------------   -------
0    CRASH_RECORD_ID            0                    0.00    % object
1    RD_NO                      0                    0.00    % object
2    CRASH_DATE_EST_I           85,157               92.47   % object
3    CRASH_DATE                 0                    0.00    % object
4    POSTED_SPEED_LIMIT         0                    0.00    % int64
5    TRAFFIC_CONTROL_DEVICE     0                    0.00    % object
6    DEVICE_CONDITION           0                    0.00    % object
7    WEATHER_CONDITION          0                    0.00    % object
8    LIGHTING_CONDITION         0                    0.00    % object
9    FIRST_CRASH_TYPE           0                    0.00    % object
10   TRAFFICWAY_TYPE            0                    0.00    % object
11   LANE_CNT                   92,080               99.99   % float64
12   ALIGNMENT                  0                    0.00    % object
13   ROADWAY_SURFACE_COND       0                    0.00    % object
14   ROAD_DEFECT                0                    0.00    % object
15   REPORT_TYPE                2,623                2.85    % object
16   CRASH_TYPE                 0                    0.00    % object
17   INTERSECTION_RELATED_I     69,300               75.25   % object
18   NOT_RIGHT_OF_WAY_I         87,489               95.00   % object
19   HIT_AND_RUN_I              60,165               65.33   % object
20   DAMAGE                     0                    0.00    % object
21   DATE_POLICE_NOTIFIED       0                    0.00    % object
22   PRIM_CONTRIBUTORY_CAUSE    0                    0.00    % object
23   SEC_CONTRIBUTORY_CAUSE     0                    0.00    % object
24   STREET_NO                  0                    0.00    % int64
25   STREET_DIRECTION           0                    0.00    % object
26   STREET_NAME                0                    0.00    % object
27   BEAT_OF_OCCURRENCE         0                    0.00    % float64
28   PHOTOS_TAKEN_I             90,961               98.77   % object
29   STATEMENTS_TAKEN_I         90,310               98.06   % object
30   DOORING_I                  91,834               99.72   % object
31   WORK_ZONE_I                91,662               99.53   % object
32   WORK_ZONE_TYPE             91,760               99.64   % object
33   WORKERS_PRESENT_I          91,975               99.87   % object
34   NUM_UNITS                  0                    0.00    % int64
35   MOST_SEVERE_INJURY         235                  0.26    % object
36   INJURIES_TOTAL             234                  0.25    % float64
37   INJURIES_FATAL             234                  0.25    % float64
38   INJURIES_INCAPACITATING    234                  0.25    % float64
39   INJURIES_NON_INCAPACITATING 234                 0.25    % float64
40   INJURIES_REPORTED_NOT_EVIDENT 234               0.25    % float64
41   INJURIES_NO_INDICATION     234                  0.25    % float64
42   INJURIES_UNKNOWN           234                  0.25    % float64
43   CRASH_HOUR                 0                    0.00    % int64
44   CRASH_DAY_OF_WEEK          0                    0.00    % int64
45   CRASH_MONTH                0                    0.00    % int64
46   LATITUDE                   588                  0.64    % float64
47   LONGITUDE                  588                  0.64    % float64
48   LOCATION                   588                  0.64    % object
```

In [7]:
```
to_drop_cols    = set()
excluded_cols   = set()
category_cols   = set()
numeric_cols    = set()
encoding_cols   = set()
features_cols   = set()
statistic_cols  = set()
```

In [8]:
```
excluded_cols.update([
    'Unnamed: 0','Unnamed: 0.1','CRASH_RECORD_ID','RD_NO','CRASH_DATE_EST_I','LANE_CNT',
    'REPORT_TYPE','DAMAGE','PHOTOS_TAKEN_I','STATEMENTS_TAKEN_I','LOCATION',
    'WORK_ZONE_TYPE', 'BEAT_OF_OCCURRENCE', 'DATE_POLICE_NOTIFIED', 'CRASH_TYPE', 'SEC_CONTRIBUTORY_CAUSE'])
```

In [9]:
```
TransformerDate = DateTransformer()
df.CRASH_DATE =  TransformerDate.fit_transform(df.CRASH_DATE)
```

In [10]:
```
ImputerCat_with_Unknown  = SimpleImputer(missing_values=np.nan, strategy='constant', fill_value='unknown')
df.loc[:,dfi.NaN_obj_colmns] = ImputerCat_with_Unknown.fit_transform(df.loc[:,dfi.NaN_obj_colmns] )
```

In [11]:
```
ImputerMostFrequent = SimpleImputer(missing_values=np.NaN, strategy='most_frequent')
df.loc[:,dfi.NaN_num_columns] = ImputerMostFrequent.fit_transform(df.loc[:,dfi.NaN_num_columns])
```

FEATURES ENGINEERING

POSTED_SPEED_LIMIT

Acceleration is a major cause of car accidents, which is why we consider it a very important factor for our model.

unfortunately the information provided in the dataset relating to the variable "POSTED_SPEED_LIMIT" is somewhat confused and anomalous for this reason we refer to the official Illinois statute section Vehicle Code no. (625 ILCS 5 /) as a reliable source to sort our data as appropriately as possible.

```
70 mph - Rural interstates and tollways.
65 mph - Highways with four lanes.
```

```
55 mph - Other highways and rural areas.
45 mph - Urban freeways and interstates through downtown Chicago.
30 mph - Urban Districts - City/Town Areas.
20 mph - School Zones (on school days between 7 a.m. and 4 p.m.
15 mph - Urban Alleys.
```

For more info: Illinois Compiled Statutes

In [12]:
```
df.POSTED_SPEED_LIMIT.unique()
```

Out[12]:
```
array([30, 20, 10, 15, 25, 35, 55, 45,  5, 50,  0, 40, 39, 65,  1, 34,  3,
       12, 60,  9, 26, 33, 49, 70, 11, 36, 32, 24,  2, 14, 31, 29])
```

In [13]:
```
TransformSpeed = SpeedTransformer()
df['POSTED_SPEED_LIMIT'] = TransformSpeed.fit_transform(df['POSTED_SPEED_LIMIT'])
```

In [14]:
```
df.POSTED_SPEED_LIMIT.sort_values().unique()
```

Out[14]:
```
array(['15', '20', '30', '45', '55', '65', '70'], dtype=object)
```

PRIM CONTRIBUTORY CAUSE

In [15]:
```
df.PRIM_CONTRIBUTORY_CAUSE.unique()
```

Out[15]:
```
array(['FAILING TO YIELD RIGHT-OF-WAY', 'UNABLE TO DETERMINE',
       'OPERATING VEHICLE IN ERRATIC, RECKLESS, CARELESS, NEGLIGENT OR AGGRESSIVE MANNER',
       'IMPROPER BACKING', 'IMPROPER OVERTAKING/PASSING',
       'IMPROPER LANE USAGE', 'DISREGARDING TRAFFIC SIGNALS',
       'NOT APPLICABLE', 'IMPROPER TURNING/NO SIGNAL',
       'FOLLOWING TOO CLOSELY', 'DRIVING SKILLS/KNOWLEDGE/EXPERIENCE',
       'ROAD CONSTRUCTION/MAINTENANCE', 'WEATHER',
       'PHYSICAL CONDITION OF DRIVER',
       'FAILING TO REDUCE SPEED TO AVOID CRASH',
       'EVASIVE ACTION DUE TO ANIMAL, OBJECT, NONMOTORIST',
       'HAD BEEN DRINKING (USE WHEN ARREST IS NOT MADE)',
       'DISTRACTION - FROM INSIDE VEHICLE',
       'DRIVING ON WRONG SIDE/WRONG WAY',
       'VISION OBSCURED (SIGNS, TREE LIMBS, BUILDINGS, ETC.)',
       'EQUIPMENT - VEHICLE CONDITION', 'DISREGARDING STOP SIGN',
       'TEXTING', 'DISTRACTION - FROM OUTSIDE VEHICLE',
       'DISREGARDING YIELD SIGN', 'CELL PHONE USE OTHER THAN TEXTING',
       'UNDER THE INFLUENCE OF ALCOHOL/DRUGS (USE WHEN ARREST IS EFFECTED)',
       'TURNING RIGHT ON RED', 'DISREGARDING ROAD MARKINGS',
       'DISREGARDING OTHER TRAFFIC SIGNS', 'ANIMAL',
       'RELATED TO BUS STOP', 'ROAD ENGINEERING/SURFACE/MARKING DEFECTS',
       'OBSTRUCTED CROSSWALKS',
       'DISTRACTION - OTHER ELECTRONIC DEVICE (NAVIGATION DEVICE, DVD PLAYER, ETC.)',
       'PASSING STOPPED SCHOOL BUS',
       'BICYCLE ADVANCING LEGALLY ON RED LIGHT',
       'MOTORCYCLE ADVANCING LEGALLY ON RED LIGHT'], dtype=object)
```

In [16]:
```
df.PRIM_CONTRIBUTORY_CAUSE = Target_Grouper().fit_transform(df.PRIM_CONTRIBUTORY_CAUSE)
```

In [17]:
```
df.PRIM_CONTRIBUTORY_CAUSE.unique()
```

Out[17]:
```
array(['FAILING TO YIELD RIGHT-OF-WAY', 'UNABLE TO DETERMINE',
       'OPERATING VEHICLE IN ERRATIC, RECKLESS, CARELESS, NEGLIGENT OR AGGRESSIVE MANNER',
       'IMPROPER_MANEUVER', 'DISREGARDING', 'NOT APPLICABLE',
       'DRIVING_SKILLS/KNOWLEDGE/EXPERIENCE', 'ROAD_CONDITION', 'WEATHER',
       'PHYSICAL CONDITION OF DRIVER',
       'FAILING TO REDUCE SPEED TO AVOID CRASH', 'ANIMAL',
       'ALCOHOL_DRUGS', 'DISTRACTION', 'EQUIPMENT - VEHICLE CONDITION',
       'TURNING RIGHT ON RED', 'RELATED TO BUS STOP',
       'PASSING STOPPED SCHOOL BUS',
       'BICYCLE ADVANCING LEGALLY ON RED LIGHT',
       'MOTORCYCLE ADVANCING LEGALLY ON RED LIGHT'], dtype=object)
```

In [18]:
```
df[sorted(set(df.columns)-excluded_cols)].info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 92092 entries, 0 to 92091
Data columns (total 35 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   ALIGNMENT                       92092 non-null  object
 1   CRASH_DATE                      92092 non-null  datetime64[ns]
 2   CRASH_DAY_OF_WEEK               92092 non-null  int64
 3   CRASH_HOUR                      92092 non-null  int64
 4   CRASH_MONTH                     92092 non-null  int64
 5   DEVICE_CONDITION                92092 non-null  object
 6   DOORING_I                       92092 non-null  object
 7   FIRST_CRASH_TYPE                92092 non-null  object
 8   HIT_AND_RUN_I                   92092 non-null  object
 9   INJURIES_FATAL                  92092 non-null  float64
 10  INJURIES_INCAPACITATING         92092 non-null  float64
 11  INJURIES_NON_INCAPACITATING     92092 non-null  float64
 12  INJURIES_NO_INDICATION          92092 non-null  float64
 13  INJURIES_REPORTED_NOT_EVIDENT   92092 non-null  float64
 14  INJURIES_TOTAL                  92092 non-null  float64
 15  INJURIES_UNKNOWN                92092 non-null  float64
 16  INTERSECTION_RELATED_I          92092 non-null  object
```

```
 17  LATITUDE                    92092 non-null  float64
 18  LIGHTING_CONDITION          92092 non-null  object
 19  LONGITUDE                   92092 non-null  float64
 20  MOST_SEVERE_INJURY          92092 non-null  object
 21  NOT_RIGHT_OF_WAY_I          92092 non-null  object
 22  NUM_UNITS                   92092 non-null  int64
 23  POSTED_SPEED_LIMIT          92092 non-null  object
 24  PRIM_CONTRIBUTORY_CAUSE     92092 non-null  object
 25  ROADWAY_SURFACE_COND        92092 non-null  object
 26  ROAD_DEFECT                 92092 non-null  object
 27  STREET_DIRECTION            92092 non-null  object
 28  STREET_NAME                 92092 non-null  object
 29  STREET_NO                   92092 non-null  int64
 30  TRAFFICWAY_TYPE             92092 non-null  object
 31  TRAFFIC_CONTROL_DEVICE      92092 non-null  object
 32  WEATHER_CONDITION           92092 non-null  object
 33  WORKERS_PRESENT_I           92092 non-null  object
 34  WORK_ZONE_I                 92092 non-null  object
dtypes: datetime64[ns](1), float64(9), int64(5), object(20)
memory usage: 24.6+ MB
```

In [19]:
```
statistic_cols.update(['CRASH_DATE','CRASH_DAY_OF_WEEK','CRASH_HOUR','CRASH_MONTH', 'DOORING_I',
                       'HIT_AND_RUN_I','INJURIES_FATAL','INJURIES_INCAPACITATING',
                       'INJURIES_NON_INCAPACITATING','INJURIES_NO_INDICATION','INJURIES_REPORTED_NOT_EVIDENT',
                       'INJURIES_TOTAL','INJURIES_UNKNOWN','LATITUDE','LONGITUDE','MOST_SEVERE_INJURY',
                       'NUM_UNITS','STREET_DIRECTION','STREET_NAME','STREET_NO'])
```

In [20]:
```
features_cols.update(set(df.columns)-excluded_cols.union(statistic_cols))
```

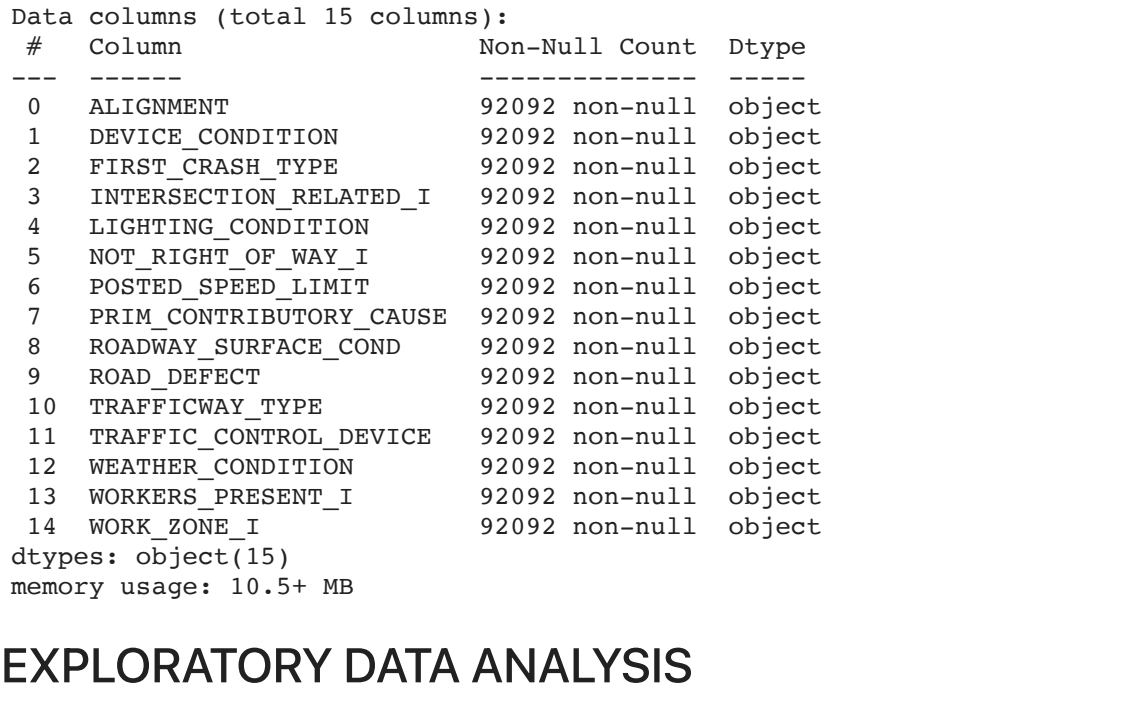
In [21]:
```
df[sorted(features_cols)].info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 92092 entries, 0 to 92091
Data columns (total 15 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   ALIGNMENT                92092 non-null  object
 1   DEVICE_CONDITION         92092 non-null  object
 2   FIRST_CRASH_TYPE         92092 non-null  object
 3   INTERSECTION_RELATED_I   92092 non-null  object
 4   LIGHTING_CONDITION       92092 non-null  object
 5   NOT_RIGHT_OF_WAY_I       92092 non-null  object
 6   POSTED_SPEED_LIMIT       92092 non-null  object
 7   PRIM_CONTRIBUTORY_CAUSE  92092 non-null  object
 8   ROADWAY_SURFACE_COND     92092 non-null  object
 9   ROAD_DEFECT              92092 non-null  object
 10  TRAFFICWAY_TYPE          92092 non-null  object
 11  TRAFFIC_CONTROL_DEVICE   92092 non-null  object
 12  WEATHER_CONDITION        92092 non-null  object
 13  WORKERS_PRESENT_I        92092 non-null  object
 14  WORK_ZONE_I              92092 non-null  object
dtypes: object(15)
memory usage: 10.5+ MB
```

EXPLORATORY DATA ANALYSIS

CRASH TYPE

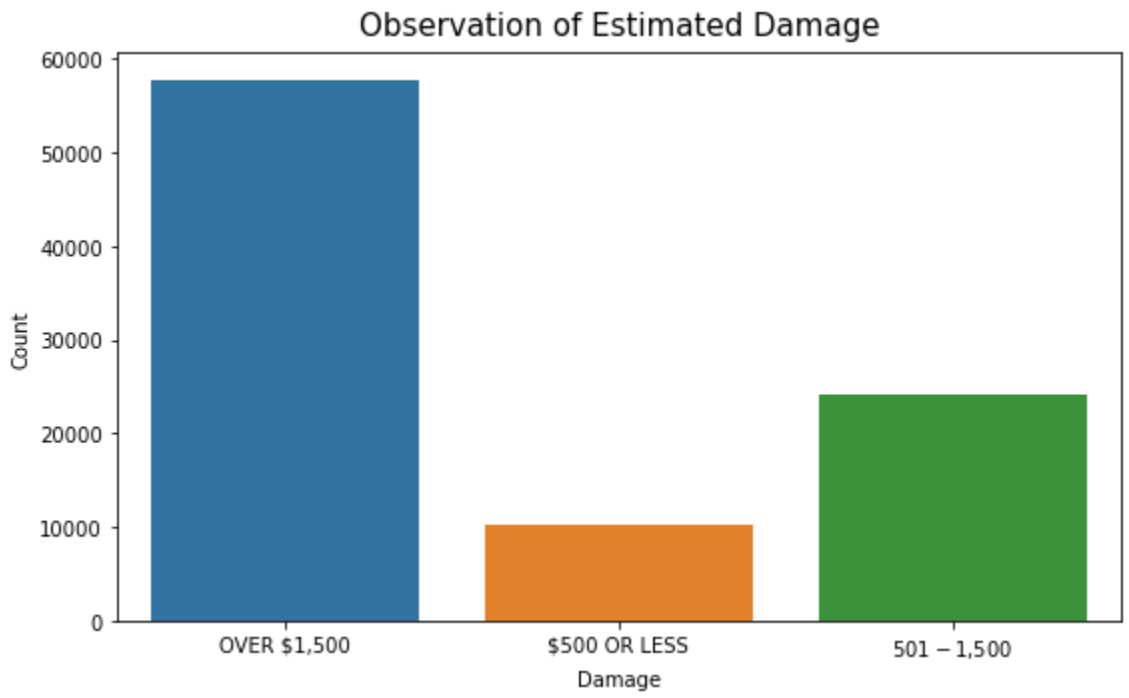
In [19]:
```
fig, ax = plt.subplots(figsize=(8,5))
sns_crach_type = sns.countplot(x=df.CRASH_TYPE, ax=ax)
ax.set_title("Type of first collision in crash", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Crash Type')
ax.set_ylabel('Count')
plt.savefig('./img/crach_type.jpg',format="jpg")
plt.show()
```



ESTIMATED DAMAGE

In [20]:
```
fig, ax = plt.subplots(figsize=(8,5))
sns_crach_type = sns.countplot(x=df.DAMAGE, ax=ax)
ax.set_title("Observation of Estimated Damage", fontsize=15, ha='center', va='bottom')
```

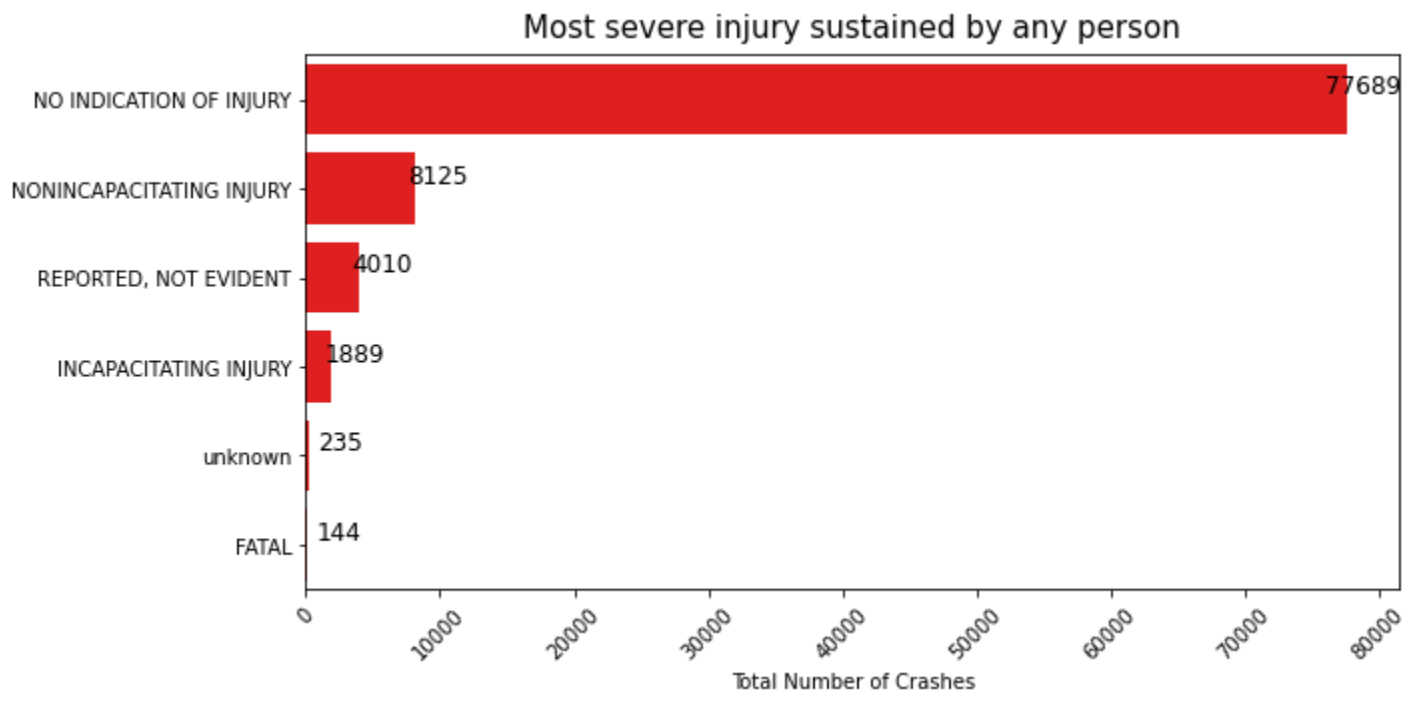
```
ax.set_xlabel('Damage')
ax.set_ylabel('Count')
plt.savefig('./img/damage.jpg',format="jpg")
plt.show()
```



MOST SEVERE INGURY

In [24]:

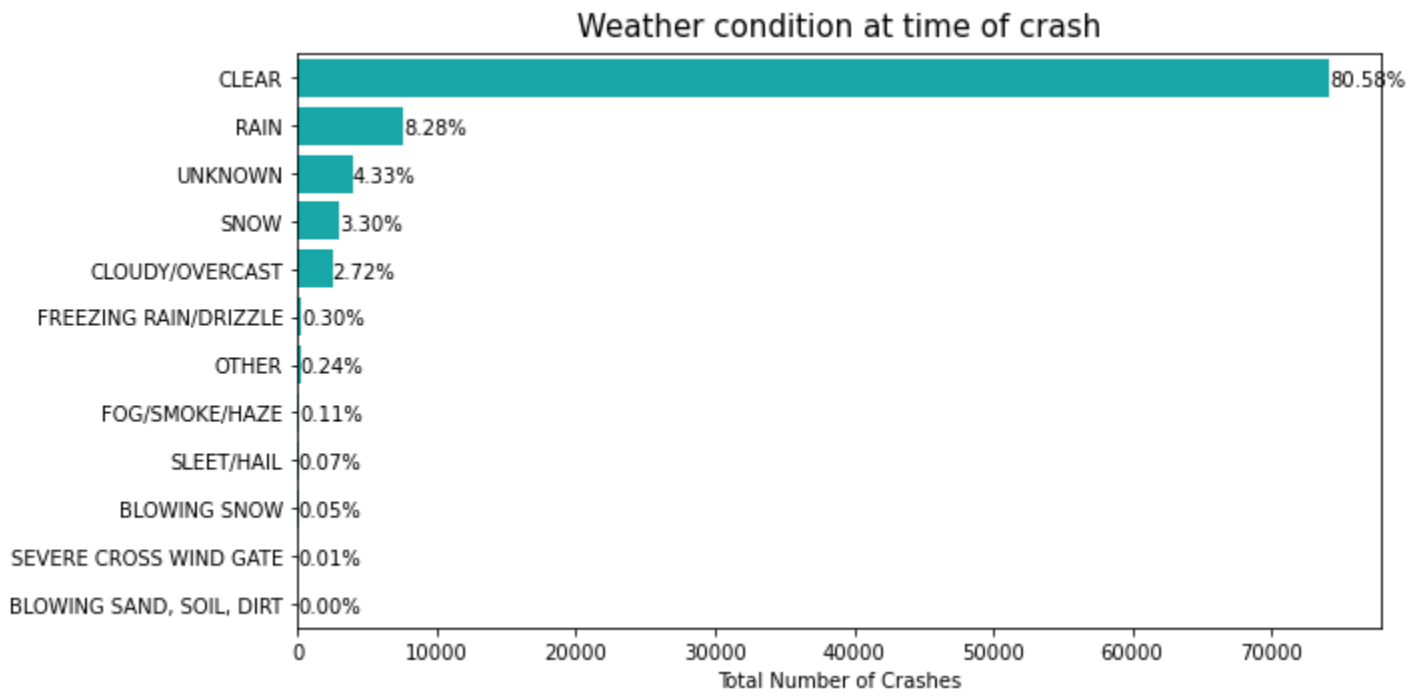
```
fig, ax = plt.subplots(figsize=(10,5))
msi = sns.barplot(x=df.MOST_SEVERE_INJURY.value_counts().values,
                  y=df.MOST_SEVERE_INJURY.value_counts().index, color='red', ax=ax)

for index, row in df.MOST_SEVERE_INJURY.value_counts().iteritems():
    msi.text(x=4000+row, y=df.MOST_SEVERE_INJURY.value_counts().index.get_loc(index),
             s=round(row), color='black', va='bottom',  ha="right", fontsize=12)

ax.set_title("Most severe injury sustained by any person", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Total Number of Crashes')
# ax.set_ylabel('Count')
plt.xticks(rotation=45)
fig.tight_layout()
plt.savefig('./img/Most_Severe_Injury.jpg', dpi=150, format="jpg")
plt.show()
```



WEATHER CONDITION

In [28]:

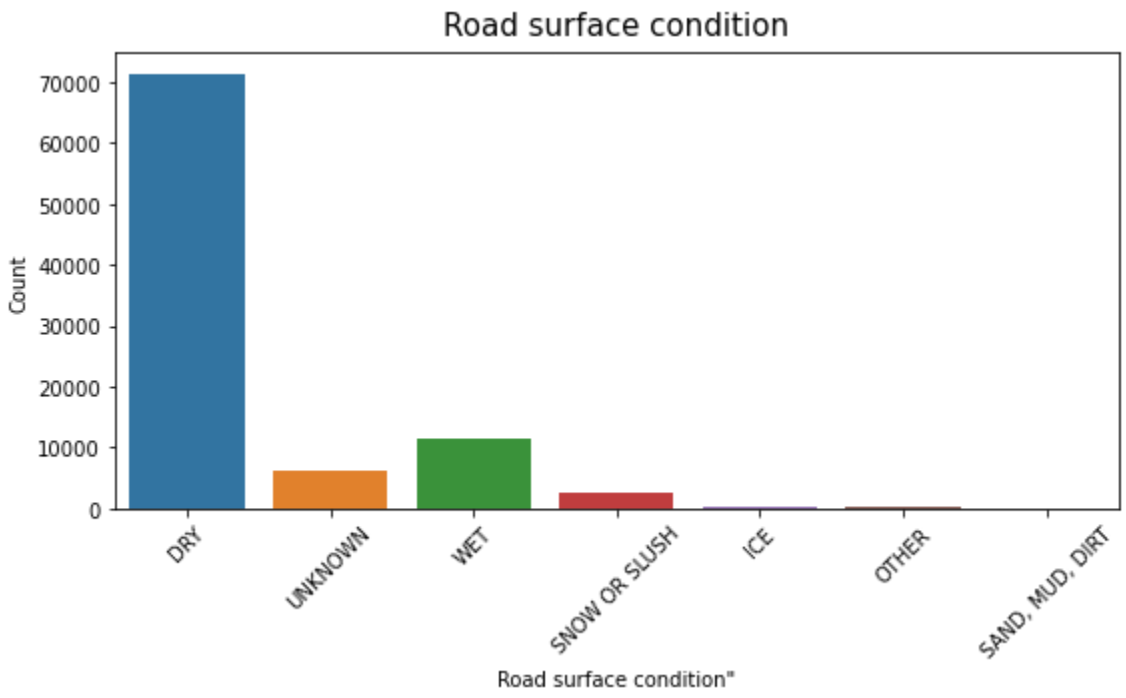
```
fig, ax = plt.subplots(figsize=(10,5))
wc = sns.barplot(x=df.WEATHER_CONDITION.value_counts().values,
                 y=df.WEATHER_CONDITION.value_counts().index, color='c', ax=ax)

for index, row in df.WEATHER_CONDITION.value_counts().iteritems():
    wc.text(x=row,
            y=df.WEATHER_CONDITION.value_counts().index.get_loc(index),
            s='{0:.2f}%'.format(round((row/df.shape[0]*100),2)),
            color='black', fontsize=10, rotation_mode='anchor',
            verticalalignment='center_baseline', horizontalalignment='left')

ax.set_title("Weather condition at time of crash", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Total Number of Crashes')
plt.savefig('./img/Weathercondition.jpg',format="jpg")
plt.show()
```



ROAD SURFACE CONDITION

In [93]:

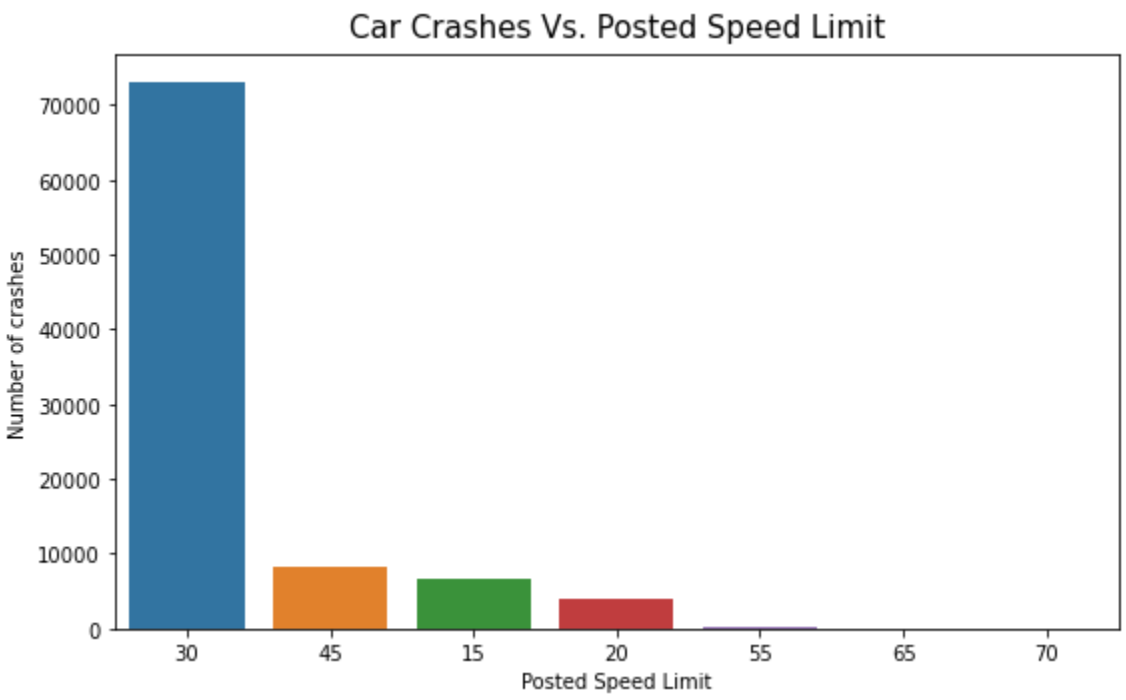
```
fig, ax = plt.subplots(figsize=(8,5))
sns_crach_type = sns.countplot(x=df.ROADWAY_SURFACE_COND, ax=ax)
ax.set_title("Road surface condition", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Road surface condition"')
ax.set_ylabel('Count')
plt.xticks(rotation=45)
plt.savefig('./img/road_surface_condition.jpg', dpi=150, format="jpg")
plt.show()
```



Posted Speed Limit Analysis

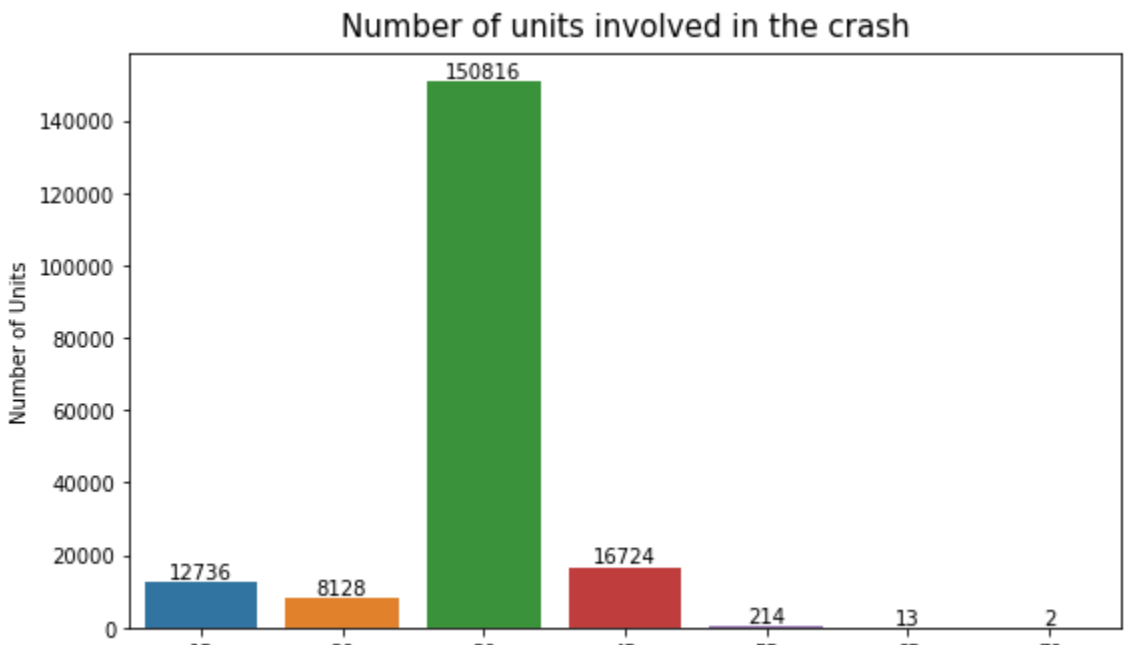
In [86]:

```
fig, ax = plt.subplots(figsize=(8,5))
sns.barplot(x=df.POSTED_SPEED_LIMIT.value_counts().index, y=df.POSTED_SPEED_LIMIT.value_counts(), ax=ax)
ax.set_title("Car Crashes Vs. Posted Speed Limit", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Posted Speed Limit')
ax.set_ylabel('Number of crashes')
plt.savefig('./img/speed_number_of_crashes.jpg',format="jpg")
plt.show()
```



Speed Limit by Number of units-related

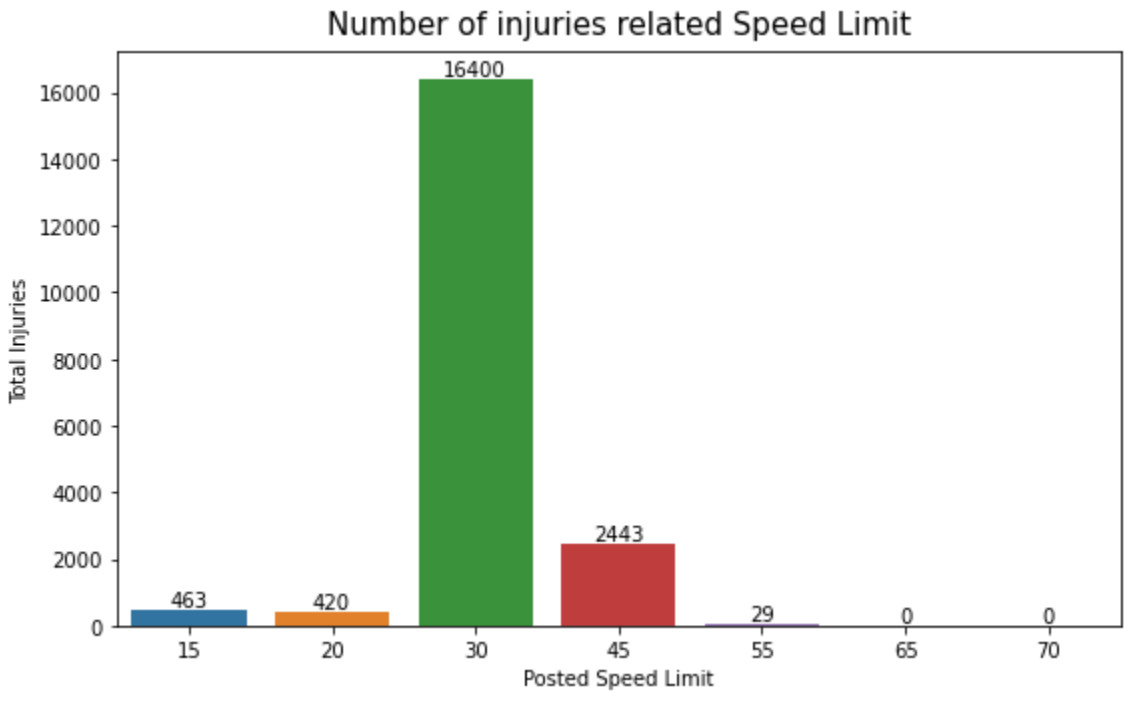
In [87]:
```
speed_unit = df.groupby('POSTED_SPEED_LIMIT', as_index=False).agg({'NUM_UNITS': 'sum'})

fig, ax = plt.subplots(figsize=(8,5))
sns_speed_unit=sns.barplot(x='POSTED_SPEED_LIMIT', y='NUM_UNITS', data=speed_unit, ax=ax)
for index, row in speed_unit.iterrows():
    sns_speed_unit.text(x=row.name,
                        y=row.NUM_UNITS,
                        s=round(row.NUM_UNITS),
                        color='black', va='bottom',  ha="center", fontsize=10)
ax.set_title("Number of units involved in the crash", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Posted Speed Limit')
ax.set_ylabel('Number of Units')
plt.savefig('./img/speed_unit.jpg',format="jpg")
plt.show()
```



INJURIES ANALYSIS

Number of injuries by Speed Limit-related

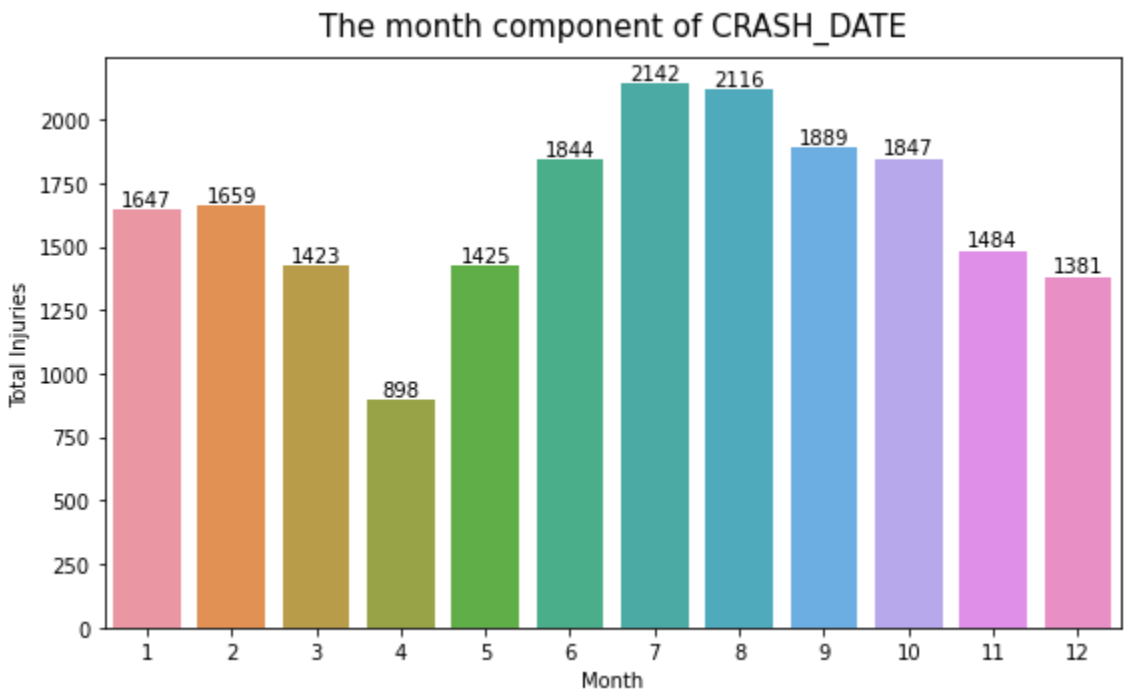
In [88]:
```
speed_injuries = df.groupby('POSTED_SPEED_LIMIT', as_index=False).agg({'INJURIES_TOTAL': 'sum'})

fig, ax = plt.subplots(figsize=(8,5))
sns_speed_injured=sns.barplot(x='POSTED_SPEED_LIMIT', y='INJURIES_TOTAL', data=speed_injuries, ax=ax)
for index, row in speed_injuries.iterrows():
    sns_speed_injured.text(x=row.name,
                           y=row.INJURIES_TOTAL,
                           s=round(row.INJURIES_TOTAL),
                           color='black', va='bottom',  ha="center", fontsize=10)
ax.set_title("Number of injuries related Speed Limit", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Posted Speed Limit')
ax.set_ylabel('Total Injuries')
plt.savefig('./img/speed_injures.jpg',format="jpg")
plt.show()
```



Number of injuries by Month-related

In [89]:
```
injuries_month = df.groupby('CRASH_MONTH', as_index=False).agg({'INJURIES_TOTAL': 'sum'})

fig, ax = plt.subplots(figsize=(8,5))
sns_injuries_month=sns.barplot(x='CRASH_MONTH', y='INJURIES_TOTAL', data=injuries_month, ax=ax)
for index, row in injuries_month.iterrows():
    sns_injuries_month.text(x=row.name,
                            y=row.INJURIES_TOTAL,
                            s=round(row.INJURIES_TOTAL),
                            color='black', va='bottom',  ha="center", fontsize=10)
ax.set_title("The month component of CRASH_DATE", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Month')
```

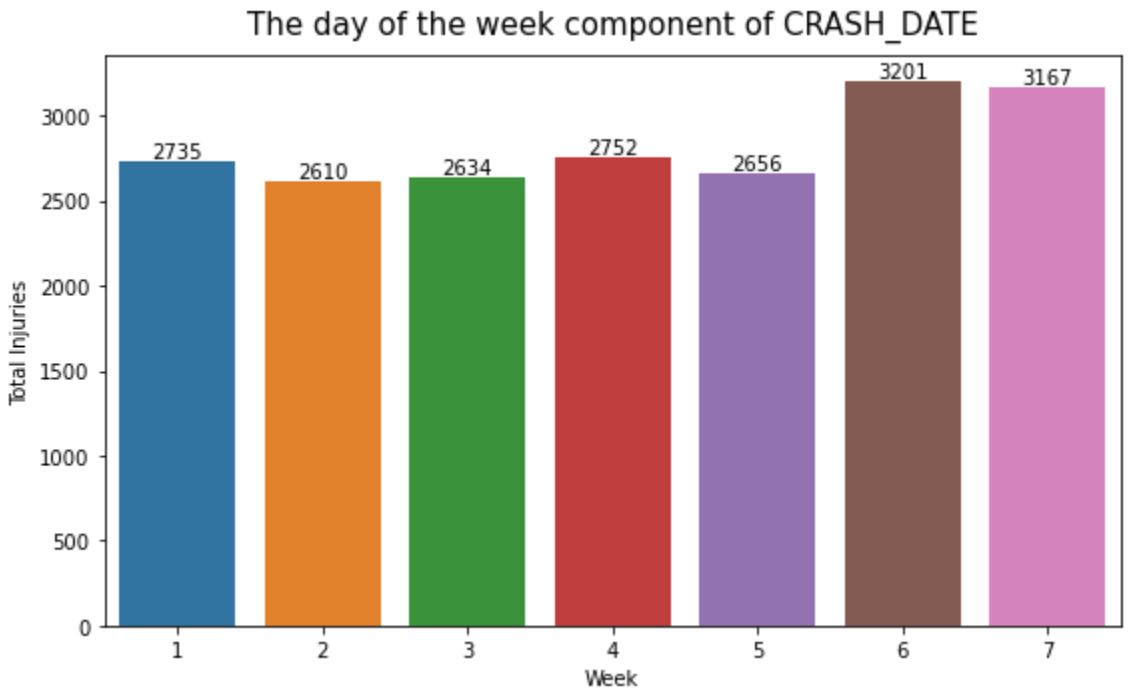
```
ax.set_ylabel('Total Injuries')
plt.savefig('./img/injuries_month.jpg',format="jpg")
plt.show()
```



Number of injuries by Day of Week-related

In [90]:

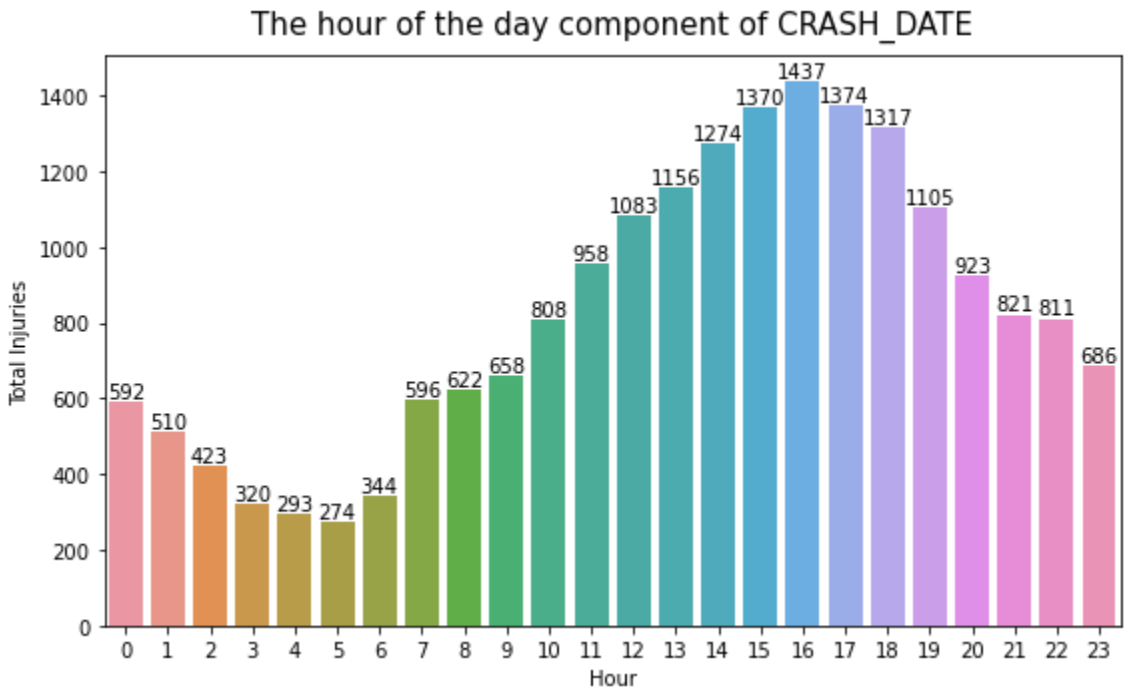
```
injuries_week = df.groupby('CRASH_DAY_OF_WEEK', as_index=False).agg({'INJURIES_TOTAL': 'sum'})
fig, ax = plt.subplots(figsize=(8,5))
sns_injuries_week=sns.barplot(x='CRASH_DAY_OF_WEEK', y='INJURIES_TOTAL', data=injuries_week, ax=ax)
for index, row in injuries_week.iterrows():
    sns_injuries_week.text(x=row.name,
                           y=row.INJURIES_TOTAL,
                           s=round(row.INJURIES_TOTAL),
                           color='black', va='bottom',  ha="center", fontsize=10)
ax.set_title("The day of the week component of CRASH_DATE", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Week')
ax.set_ylabel('Total Injuries')
plt.savefig('./img/injuries_week.jpg',format="jpg")
plt.show()
```



Number of injuries by Hour-related

In [91]:

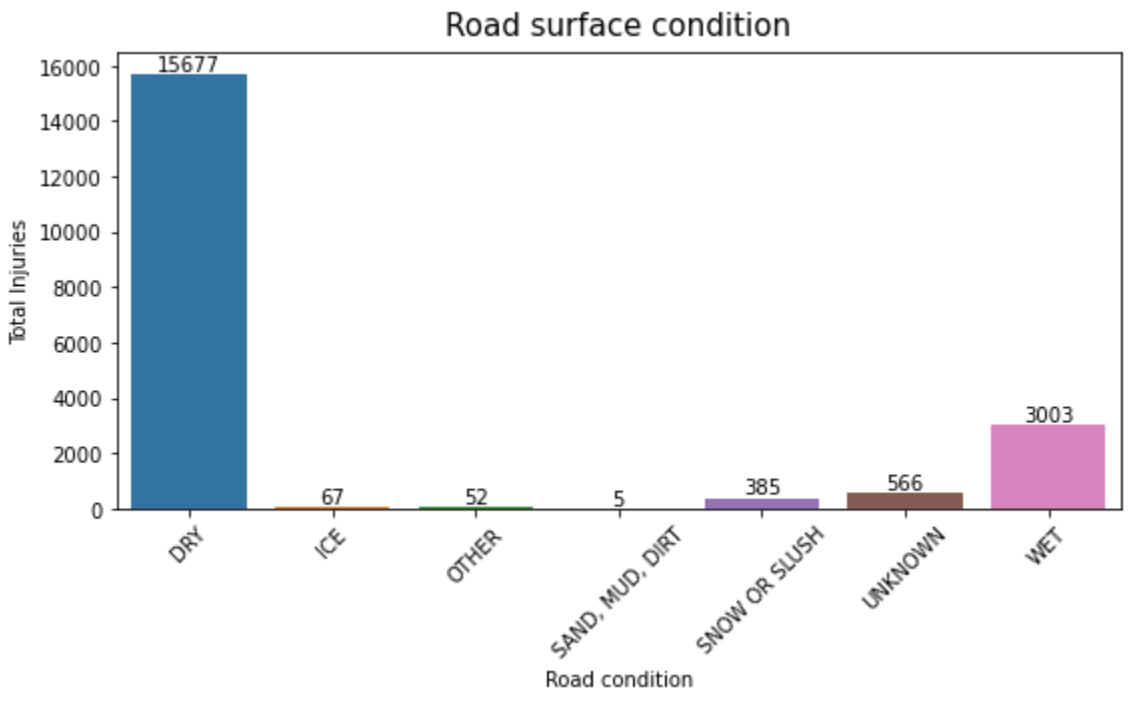
```
injuries_hour = df.groupby('CRASH_HOUR', as_index=False).agg({'INJURIES_TOTAL': 'sum'})
fig, ax = plt.subplots(figsize=(8,5))
sns_injuries_hour=sns.barplot(x='CRASH_HOUR', y='INJURIES_TOTAL', data=injuries_hour, ax=ax)
for index, row in injuries_hour.iterrows():
    sns_injuries_hour.text(x=row.name,
                           y=row.INJURIES_TOTAL,
                           s=round(row.INJURIES_TOTAL),
                           color='black', va='bottom',  ha="center", fontsize=10)
ax.set_title("The hour of the day component of CRASH_DATE", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Hour')
ax.set_ylabel('Total Injuries')
plt.savefig('./img/injuries_hour.jpg',format="jpg")
plt.show()
```



Number of injuries by Roadway Condition-related

In [92]:

```
injuries_road = df.groupby('ROADWAY_SURFACE_COND', as_index=False).agg({'INJURIES_TOTAL': 'sum'})
fig, ax = plt.subplots(figsize=(8,5))
sns_injuries_road=sns.barplot(x='ROADWAY_SURFACE_COND', y='INJURIES_TOTAL', data=injuries_road, ax=ax)
for index, row in injuries_road.iterrows():
    sns_injuries_road.text(x=row.name,
                           y=row.INJURIES_TOTAL,
                           s=round(row.INJURIES_TOTAL),
                           color='black', va='bottom', ha="center", fontsize=10)
    sns.barplot(x='ROADWAY_SURFACE_COND', y='INJURIES_TOTAL', data=injuries_road, ax=ax)
plt.xticks(rotation=45)
ax.set_title("Road surface condition", fontsize=15, ha='center', va='bottom')
ax.set_xlabel('Road condition')
ax.set_ylabel('Total Injuries')
plt.savefig('./img/Road_surface_condition.jpg', format="jpg")
plt.show()
```



PREPROCESSING

In [35]:

```
df_features = df[sorted(features_cols)].copy()
```

In [36]:

```
df_features_info = Dframe(df_features)
```

In [37]:

```
df_features.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 92092 entries, 0 to 92091
Data columns (total 15 columns):
 #   Column                   Non-Null Count  Dtype 
---  ------                   --------------  ----- 
 0   ALIGNMENT                92092 non-null  object
 1   DEVICE_CONDITION         92092 non-null  object
 2   FIRST_CRASH_TYPE         92092 non-null  object
 3   INTERSECTION_RELATED_I   92092 non-null  object
 4   LIGHTING_CONDITION       92092 non-null  object
 5   NOT_RIGHT_OF_WAY_I       92092 non-null  object
 6   POSTED_SPEED_LIMIT       92092 non-null  object
 7   PRIM_CONTRIBUTORY_CAUSE  92092 non-null  object
 8   ROADWAY_SURFACE_COND     92092 non-null  object
 9   ROAD_DEFECT              92092 non-null  object
 10  TRAFFICWAY_TYPE          92092 non-null  object
 11  TRAFFIC_CONTROL_DEVICE   92092 non-null  object
 12  WEATHER_CONDITION        92092 non-null  object
 13  WORKERS_PRESENT_I        92092 non-null  object
 14  WORK_ZONE_I              92092 non-null  object
dtypes: object(15)
memory usage: 10.5+ MB
```

In [38]:
```
category_cols.update(('TRAFFIC_CONTROL_DEVICE', 'DEVICE_CONDITION', 'WEATHER_CONDITION', 'LIGHTING_CONDITION',
                      'FIRST_CRASH_TYPE', 'TRAFFICWAY_TYPE', 'ALIGNMENT', 'ROADWAY_SURFACE_COND', 'ROAD_DEFECT',
                       'INTERSECTION_RELATED_I', 'NOT_RIGHT_OF_WAY_I','WORK_ZONE_I', 'WORKERS_PRESENT_I','POSTED_SPEED_LIM
```

Features Transformation using OneHotEncoder

In [39]:
```
ohe_features = OneHotEncoder(sparse=False, drop='first')
ohe_features.fit(df_features[category_cols])

df_features_ohe = pd.concat([df_features.drop(labels=category_cols, axis=1),
                             pd.DataFrame(ohe_features.transform(df_features[category_cols]),
                                          columns=ohe_features.get_feature_names(list(category_cols)))],
                            axis=1)
df_features_ohe.drop(labels=['PRIM_CONTRIBUTORY_CAUSE'], axis=1, inplace=True)
```

Target Transformation using OneHotEncoder

In [40]:
```
ohe_target     = OneHotEncoder(handle_unknown='ignore', sparse=False)
df_target_ohe  = pd.DataFrame(ohe_target.fit_transform(df_features.PRIM_CONTRIBUTORY_CAUSE.values.reshape(-1,1)),
                              columns=ohe_target.categories_)
df_target_ohe.columns = df_target_ohe.columns.get_level_values(0).str.replace(' ', '_')
```

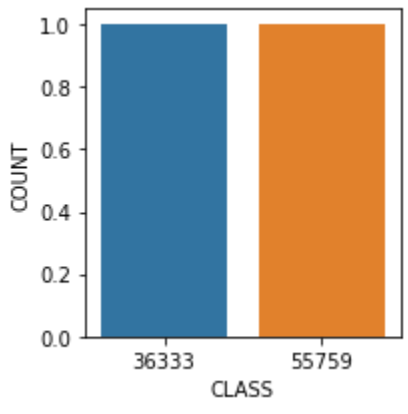
In [41]:
```
lc_prim_contributory_cause =  LabelEncoder()
df_target_encoded = pd.DataFrame(lc_prim_contributory_cause.fit_transform(df_features['PRIM_CONTRIBUTORY_CAUSE']),
                                 columns=['PRIM_CONTRIBUTORY_CAUSE'])
y_encoded_dict = dict(zip(lc_prim_contributory_cause.classes_,
                          lc_prim_contributory_cause.transform(lc_prim_contributory_cause.classes_)))
```

MODELING

it's broad clear we're dealing with a multi-class & multi-label imbalanced dataset with 99% of categorical data except for POSTED_SPEED_LIMIT. we end up with 102 features our goal is to validate one of the main features of car crashes which is "UNABLE_TO_DETERMINE", that rappresents about 40% of "PRIM_CONTRIBUTORY_CAUSE". the dataset.

In [42]:
```
fig, ax = plt.subplots(figsize=(3,3))
sns.countplot(x=df_target_ohe.UNABLE_TO_DETERMINE.value_counts())
ax.set_xlabel('CLASS')
ax.set_ylabel('COUNT')
```

Out[42]:
```
Text(0, 0.5, 'COUNT')
```



FEATURE SELECTION

Since we're dealing with a remarkably large dataset with 102 features, we're going to process our features by removing irrelevant and redundant data in order to reduce computation time and improve learning accuracy.

In [432…
```
alphas = np.logspace(-3, -1, 100)
lasso = LassoCV(alphas=alphas, max_iter=100_000, n_jobs=6, random_state=264, cv=5)
sfm = SelectFromModel(lasso, threshold=0.0001)
sfm.fit_transform(df_features_ohe, np.ravel(np.array(df_target_ohe['UNABLE_TO_DETERMINE'])))
feature_selection_col = df_features_ohe.columns[sfm.get_support()]
```

In [43]:
```
X = df_features_ohe
y = np.ravel(np.array(df_target_ohe['UNABLE_TO_DETERMINE']))
print(f"Type of Target : {type_of_target(y)}")
```

```
Type of Target : binary
```

In [44]:
```
x_train, x_test, y_train, y_test = train_test_split(X, y,test_size=.25, random_state=264, stratify=y)
x_train.shape, x_test.shape, y_train.shape, y_test.shape
```

Out[44]:
```
((69069, 107), (23023, 107), (69069,), (23023,))
```

In [112…
```
x_train, y_train = check_X_y(x_train, y_train)
```

Decision Tree

In [272…
```
class_weight = get_class_weight(x_train, y_train)
```

In [273…
```
dc_param={
    'criterion': 'entropy',
    'class_weight': class_weight,
    'random_state': 264 }
```

In [199…
```
joblib.dump(dc_param, './pkl/DecisionTree_params.pkl')
```

Out[199…
```
['./pkl/DecisionTree_params.pkl']
```

In [274…
```
cls_tree = DecisionTreeClassifier(**dc_param)
```

In [278…
```
cls_tree.fit(x_train, y_train)
```

Out[278…
```
DecisionTreeClassifier(class_weight={0.0: 0.8258088428704656,
                                     1.0: 1.2673211009174312},
                       criterion='entropy', random_state=264)
```

In [297…
```
model1_y_train_pred = model_metric(cls_tree, x_train, y_train)
```

```
ROC_AUC SCORE   0.7376198010166575
ACCURACY SCORE  0.7403610881871752
```

Random Forest

In [298…
```
cls_rf = RandomForestClassifier(class_weight=class_weight, n_jobs=6, random_state=264)
```

In [299…
```
cls_rf.fit(x_train, np.ravel(np.array(y_train)))
```

Out[299…
```
RandomForestClassifier(class_weight={0.0: 0.8258088428704656,
                                     1.0: 1.2673211009174312},
                       n_jobs=6, random_state=264)
```

In [300…
```
model2_y_train_pred = model_metric(cls_rf, x_train, y_train)
```

```
ROC_AUC SCORE   0.7360246988386605
ACCURACY SCORE  0.7416496546931329
```

RandomForestClassifier: Hyperparameters with GridSearchCV

In [146…
```
rfc_params = {
    'n_estimators': [2000],
    'criterion': ['gini', 'entropy'],
    'max_depth': [150],
    'max_features': [30],
    'bootstrap': [True],
    'oob_score': [True],
    'n_jobs': [6],
    'class_weight': [class_weight],
    'random_state': [264]}
```

In [588…
```
cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=1, random_state=264)
grid_search = GridSearchCV(cls_rf, param_grid=rfc_params, scoring='roc_auc', n_jobs=6, cv=cv)
```

In [589…
```
grid_search.fit(x_train, np.ravel(np.array(y_train)))
```

Out[589…
```
GridSearchCV(cv=RepeatedStratifiedKFold(n_repeats=1, n_splits=10, random_state=264),
             estimator=RandomForestClassifier(class_weight={0.0: 0.8258088428704656,
                                                            1.0: 1.2673211009174312},
                                              n_jobs=6, random_state=264),
             n_jobs=6,
             param_grid={'bootstrap': [True],
                         'class_weight': [{0.0: 0.8258088428704656,
                                           1.0: 1.2673211009174312}],
                         'criterion': ['gini', 'entropy'], 'max_depth': [150],
                         'max_features': [30], 'n_estimators': [2000],
                         'n_jobs': [6], 'oob_score': [True],
                         'random_state': [264]},
             scoring='roc_auc')
```

In [698…
```
rf_best_params=grid_search.best_params_
joblib.dump(rf_best_params, './pkl/RF_Grid_Search_best_params.pkl', compress=9)
```

In [148…
```
cls_rf = RandomForestClassifier(**rf_best_params)
model3_train = cls_rf.fit(x_train, y_train)
```

In [150…
```
model3_y_train_pred = model_metric(cls_rf, x_train, y_train)
```

```
ROC_AUC SCORE   0.7365930367018547
ACCURACY SCORE  0.7423301336344814
```

In [309…
```
joblib.dump(model3_y_train_pred, './pkl/model3_y_train_predicted.pkl')
```

Out[309…
```
['./pkl/model3_y_train_predicted.pkl']
```

TARGET PREDICTION

In [307…
```
model3_test = cls_rf.fit(x_test, y_test)
model3_y_test_pred = model_metric(cls_rf, x_test, y_test)
```

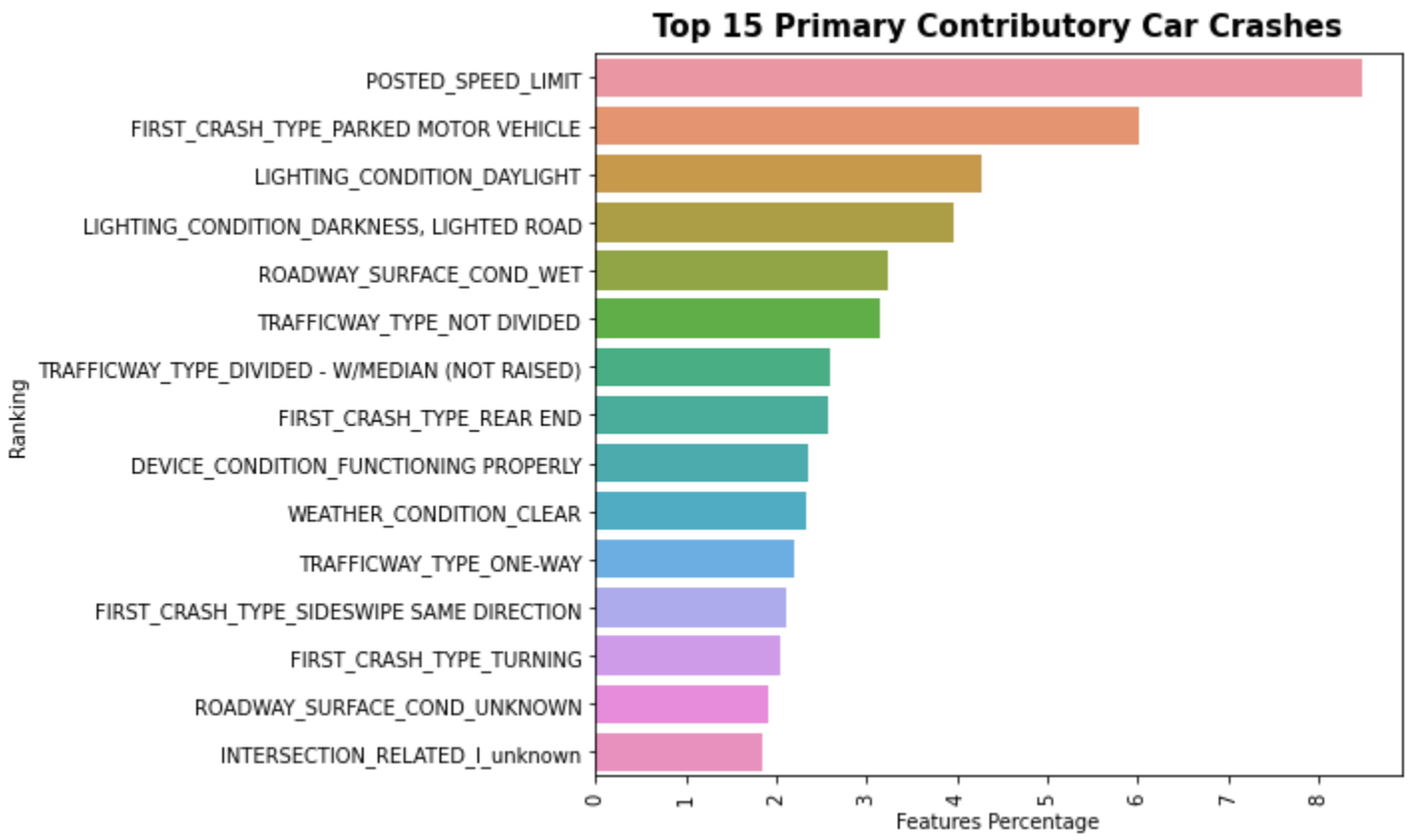
```
ROC_AUC SCORE    0.7728139273851178
ACCURACY SCORE   0.7803500846979108
```

In [308…
```
joblib.dump(model3_y_test_pred, './pkl/model3_y_test_predicted.pkl')
```

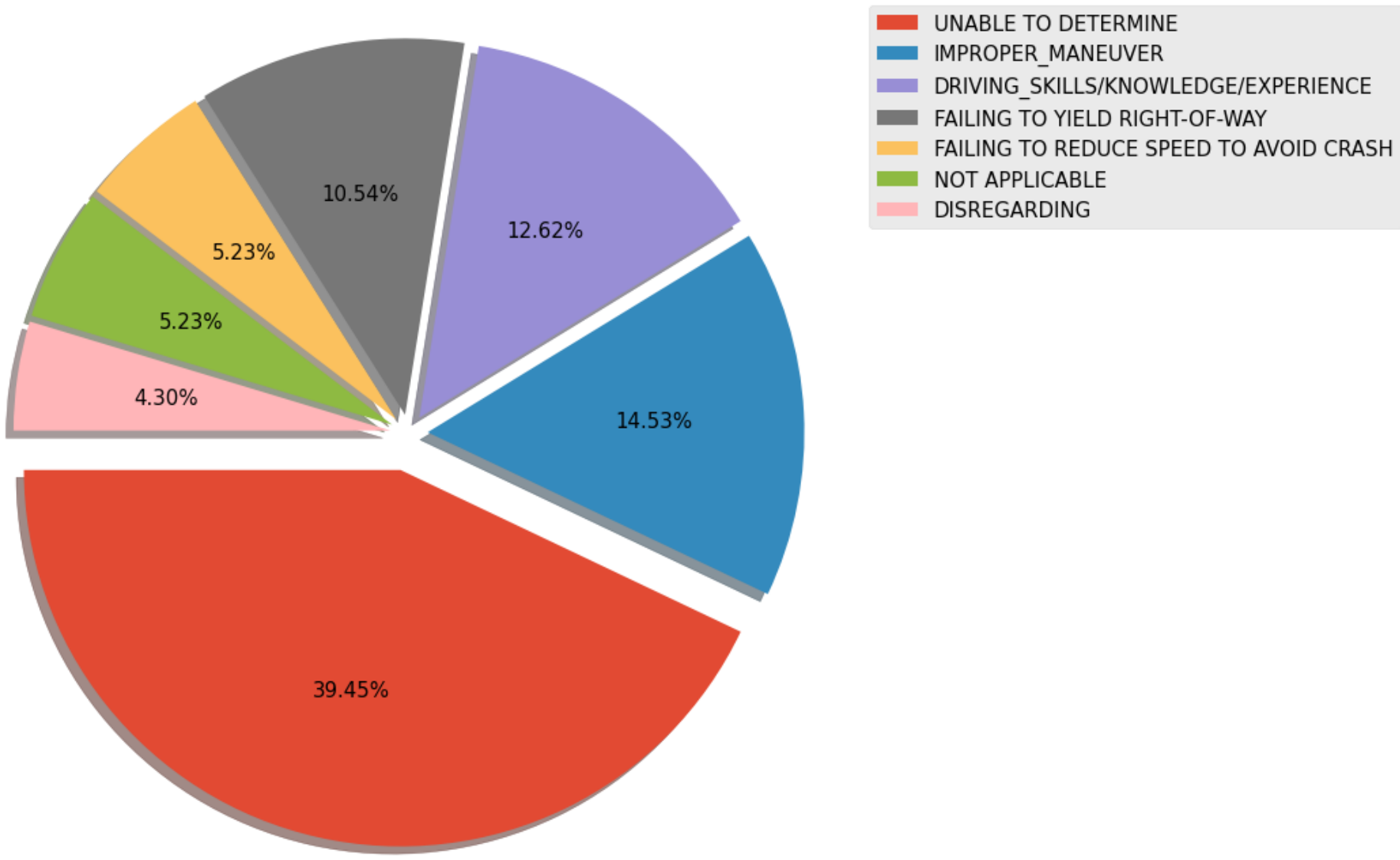
Out[308…
```
['./pkl/model3_y_test_predicted.pkl']
```

In [152…
```
Features_importance_df = pd.DataFrame({'Features': x_train.columns,
                           'Ranking':cls_rf.feature_importances_}).sort_values(by='Ranking',ascending=False)
Features_importance_df['Ranking'] = Features_importance_df['Ranking'].apply(lambda x: x*100)
```

In [154…
```
fig, ax = plt.subplots(figsize=(10,6))
g = sns.barplot(x='Ranking', y='Features', data=Features_importance_df.head(15))
plt.xticks(rotation=90)
ax.set_title("Top 15 Primary Contributory Car Crashes", fontsize=15, weight='bold', ha='center', va='bottom')
ax.set_xlabel('Features Percentage')
ax.set_ylabel('Ranking')
plt.savefig('./img/Y_primary_contributory_crashes.jpg',format="jpg")
plt.show()
```



In [101…
```
pcc = df_features.PRIM_CONTRIBUTORY_CAUSE.value_counts(normalize=True).apply(lambda x:x*100).sort_values(ascending=False
pcc=pcc[pcc>=2]
labels = pcc.index
sizes  = pcc.values
explode = pcc.apply(lambda x:0.05)
explode[0]=0.1
# explode = pcc.apply(lambda x:0.2 if x > 20 else 0)
plt.style.use('ggplot')
fig1, ax1 = plt.subplots(figsize=(15,10))
ax1.pie(x=sizes, explode=explode,
        autopct=lambda v:'{p:.2f}%'.format(p=round(v/100*sizes.sum(),2)),
        shadow=True,
        startangle=180,
        textprops={'fontsize': 15})
ax1.axis('equal')
plt.legend(labels, loc='upper left', bbox_to_anchor=(1, 1), fontsize=15)
ax1.set_title("PRIMARY CONTRIBUTORY CAR CRASHES", fontsize=30, ha='center', va='bottom')
plt.savefig('./img/top_15_contributory.jpg', dpi=200, format="jpg")
plt.show()
```



Interpreting Data

Based on the data, 40% of accidents in the year 2020 are "UN ABLE TO DETERMINE", followed by "FAILING TO YIELD THE RIGHT-OF-WAY" and "FOLLOWING TO CLOSELY" which represent 10% and 9% respectively.

According to our classification model, the road accidents that seem to occur the most are caused by the speeding where the posted speed limit is 30mph.

Random Forest Model predicts car crashes with 78% accuracy even dealing with a multiclass imbalanced dataset. the accuracy score between the 2 models (training model 74.23% - test model 78.03%) are too close which indicates that we avoided over-fitting