Samsara_Data_Analyst_Exercise

December 19, 2019

```
In [1268]: import os
           import re
           import pandas as pd
           import numpy as np
           import seaborn as sns
           import matplotlib.pyplot as plt

           %matplotlib inline
```

0.1 Pre-Processing Data

```
In [1269]: # absolute path to retrieve test files
           path=os.path.abspath("Coding Challenges/Samsara/GPS Test Data/")

In [1270]: # list of data files within GPS Test Data folder
           all_files=os.listdir(path)
           data_folders=[folder for folder in all_files if folder[0]!='.']
           data_folders

Out[1270]: ['LI5-1843685M',
            'LI5-1834230M',
            'LI5-1843682M',
            'LI5-1843681M',
            'LI5-1834411M',
            'LI5-1834871M']

In [1271]: # retrieve count of all .txt files with GPS Test Data
           txt_files=[]
           for root, dirs, files in os.walk(path):
               for file in files:
                   if file.endswith(".txt"):
                       txt_files.append(file)

           len(txt_files)

Out[1271]: 2180
```

In [1272]:
```
# dataframe to store initial relevant features from the GPS Test Data (.txt files)

# features:
# - Date: date log was created
# - Serial Number: unique serial number of gateway device
# - Total Time: total time to complete test (hr,min,sec)
# - GPS Detect Time: time to detect GPS module (sec)
# - GPS Enable Time: time to enable GPS module (sec)
# - GPS Signal Test Time: time to complete GPS signal test (sec)
# - TTFF: time to first fix time (sec)
# - SNR (1 - 8): Signal to noise ratio
# - GPS Signal Test: whether the GPS passed signal test

data = pd.DataFrame(columns=['Date', 'Serial Number', 'Total Time', 'GPS Detect Time
                             'GPS Enable Time', 'GPS Signal Test Time', 'TTFF', 'SNI
                             'SNR5', 'SNR6', 'SNR7', 'SNR8', 'GPS Signal Test'])
data.head()
```

Out[1272]:
```
Empty DataFrame
Columns: [Date, Serial Number, Total Time, GPS Detect Time, GPS Enable Time, GPS Sig
Index: []
```

In [1273]:
```
# function to extract all relevant data from the GPS Test Data.
# run this function while parsing through each .txt file

def data_extraction(text):
    # null value = -100.0
#     instance_info = {'Date':' ', 'Serial Number':' ', 'Total Time':' ', 'GPS Dete
#                      'GPS Enable Time':' ', 'GPS Signal Test Time':' ', 'TTFF':'
#                      'SNR2':' ', 'SNR3':' ', 'SNR4':' ','SNR5':' ', 'SNR6':' ', '
#                      'SNR8':' ', 'GPS Signal Test':' '}

    instance_info = {'Date':np.NaN, 'Serial Number':np.NaN, 'Total Time':np.NaN, 'GI
                     'GPS Enable Time':np.NaN, 'GPS Signal Test Time':np.NaN, 'TTFF
                     'SNR2':np.NaN, 'SNR3':np.NaN, 'SNR4':np.NaN,'SNR5':np.NaN, 'SNI
                     'SNR8':np.NaN, 'GPS Signal Test': np.NaN}

    """ Extract Date """
    date_pattern = re.compile(r'\d{4}[-]\d{2}[-]\d{2}')
    date = re.match(date_pattern, text).group()
    instance_info['Date'] = date

    """ Extract Serial Number """
    serial_pattern = re.compile(r'Input SN : ([A-Z0-9]+-[A-Z0-9]+-[A-Z0-9]+)')
    serial = re.search(serial_pattern, text).group(1)
    instance_info['Serial Number'] = serial

    """ Extract Total Time """
```

```python
time_pattern= re.compile(r'Total Time ([0-9]+:[0-9]+:[0-9]+)')
time = re.search(time_pattern, text).group(1)
instance_info['Total Time'] = time

""" Extract TTFF signal test
    TTFF = Time to First Fix
    TTFF - time interval between start up (power on) to the first valid nagivat
           derived from the simulation
"""
ttff_pattern = re.compile(r'TTFF = ([0-9]+.[0-9]+)')
ttff = re.search(ttff_pattern, text).group(1)
instance_info['TTFF'] = float(ttff)

""" Extract the GPS Module Detect Time  """
detect_time_pattern = re.compile(r'Detect OK! Use time = ([0-9]+.[0-9]+)')
detect_time = re.search(detect_time_pattern, text).group(1)
instance_info['GPS Detect Time'] = float(detect_time)

""" Extract the GPS Module Enable Time """
enable_time_pattern = re.compile(r'Enable GPS Module OK! Use time = ([0-9]+.[0-
enable_time = re.search(enable_time_pattern, text).group(1)
instance_info['GPS Enable Time'] = float(enable_time)

""" Extract the GPS Signal Test Time """
signal_test_time_pattern = re.compile(r'GPS Signal Test PASS! Use time = ([0-9]+
signal_test_time = re.search(signal_test_time_pattern, text).group(1)
instance_info['GPS Signal Test Time'] = float(signal_test_time)

""" Extract GPS Signal Test """
gps_test_pattern = re.compile(r'GPS Signal Test ([A-z]{4,})')
gps_test = re.search(gps_test_pattern, text).group(1)
instance_info['GPS Signal Test'] = gps_test

""" Extract SNR signal test
    SNR = Signal to Noise Ratio
    SNR - signal strength (higher value is better)
        - signal minus the noise

    The further a received signal is from the noise floor,
    the better the signal quality. Signals close to the noise
    floor can be subject to data corruption,
"""
for _ in range(1,9):
    snr_pattern = re.compile(r'SNR'+str(_)+' = ([0-9]+)')
    snr = re.search(snr_pattern, text)

    if (snr_pattern == re.compile('SNR1 = ([0-9]+)')) & (snr != None):
        snr1 = snr.group(1)
```

```python
                    instance_info['SNR1'] = float(snr1)
                elif (snr_pattern == re.compile('SNR2 = ([0-9]+)')) & (snr !=  None):
                    snr2 = snr.group(1)
                    instance_info['SNR2'] = float(snr2)
                elif (snr_pattern == re.compile('SNR3 = ([0-9]+)')) & (snr != None):
                    snr3 = snr.group(1)
                    instance_info['SNR3'] = float(snr3)
                elif (snr_pattern == re.compile('SNR4 = ([0-9]+)')) & (snr != None):
                    snr4 = snr.group(1)
                    instance_info['SNR4'] = float(snr4)
                elif (snr_pattern == re.compile('SNR5 = ([0-9]+)')) & (snr != None):
                    snr5 = snr.group(1)
                    instance_info['SNR5'] = float(snr5)
                elif (snr_pattern == re.compile('SNR6 = ([0-9]+)')) & (snr != None):
                    snr6 = snr.group(1)
                    instance_info['SNR6'] = float(snr6)
                elif (snr_pattern == re.compile('SNR7 = ([0-9]+)')) & (snr != None):
                    snr7 = snr.group(1)
                    instance_info['SNR7'] = float(snr7)
                elif (snr_pattern == re.compile('SNR8 = ([0-9]+)')) & (snr != None):
                    snr8 = snr.group(1)
                    instance_info['SNR8'] = float(snr8)

        return instance_info
```

In [1274]:
```python
# parsing through all .txt files within each data folder in GPS Test Data
# opening the file and calling 'data_extraction'

for file_folder in data_folders:
    for file in os.listdir(path+'/'+file_folder+'/PASS/'):
        if file.endswith('.txt'):
            with open(path+'/'+file_folder+'/PASS/'+file+'') as f:
                data = data.append(data_extraction(f.read()), ignore_index=True)
```

In [1275]:
```python
data.head(2)
```

Out[1275]:

```
         Date Serial Number Total Time  GPS Detect Time  GPS Enable Time  \
0  2018-04-20  GBXT-HMX-C3Z   00:01:21          680.897             3.57
1  2018-04-14  GVGG-P3N-S8H   00:01:13         2143.789             0.61

   GPS Signal Test Time  TTFF  SNR1  SNR2  SNR3  SNR4  SNR5  SNR6  SNR7  SNR8  \
0                 40.76  38.0  44.0  44.0  44.0  44.0   NaN   NaN   NaN   NaN
1                 40.25  36.0  44.0  44.0  44.0  44.0  46.0  46.0  47.0  46.0

  GPS Signal Test
0            PASS
1            PASS
```

In [1276]:
```python
# adding an additional feature
# converting Total Time to a numeric value (sec)
```

```python
def convert_time_seconds(text):
    """ Convert Total Time to Seconds """
    ftr = [3600,60,1]
    seconds = sum([a*b for a,b in zip(ftr, map(int, text.split(':')))])
    return seconds

data['Total Time (sec)'] = data['Total Time'].apply(convert_time_seconds)
```

In [1277]:
```python
print('Number of instance: ', data.shape[0])
print('Number of features: ', data.shape[1])
```

```
Number of instance:  2180
Number of features:  17
```

In [1278]:
```python
data.describe()
```

Out[1278]:

	GPS Detect Time	GPS Enable Time	GPS Signal Test Time	TTFF
count	2180.000000	2180.000000	2180.000000	2180.000000
mean	3585.844755	2.030627	47.031405	36.682569
std	4040.925989	1.481934	26.203304	19.649152
min	1.642000	0.600000	0.110000	0.000000
25%	721.245750	0.610000	33.480000	29.000000
50%	2241.373500	0.610000	37.735000	34.000000
75%	5023.983750	3.570000	43.092500	37.000000
max	22564.477000	3.830000	121.300000	120.000000

	SNR1	SNR2	SNR3	SNR4	SNR5
count	2151.00000	2151.000000	2150.000000	2149.000000	1963.000000
mean	41.97629	42.040911	42.128372	42.149372	41.607234
std	4.66146	4.604770	4.541754	4.451218	4.817367
min	26.00000	26.000000	26.000000	26.000000	26.000000
25%	41.00000	41.000000	41.000000	41.000000	40.000000
50%	43.00000	43.000000	43.000000	43.000000	42.000000
75%	45.00000	45.000000	45.000000	45.000000	45.000000
max	49.00000	49.000000	49.000000	49.000000	49.000000

	SNR6	SNR7	SNR8	Total Time (sec)
count	1963.000000	1962.000000	1808.000000	2180.000000
mean	41.641365	41.305810	41.103429	79.761468
std	4.893646	5.245066	5.189580	29.288033
min	26.000000	26.000000	26.000000	18.000000
25%	40.000000	40.000000	40.000000	60.000000
50%	42.000000	42.000000	42.000000	75.000000
75%	45.000000	45.000000	45.000000	83.000000
max	49.000000	49.000000	49.000000	177.000000

In [1279]:
```python
data.dtypes
```

Out[1279]:
```
Date                       object
Serial Number              object
Total Time                 object
GPS Detect Time           float64
GPS Enable Time           float64
GPS Signal Test Time      float64
TTFF                      float64
SNR1                      float64
SNR2                      float64
SNR3                      float64
SNR4                      float64
SNR5                      float64
SNR6                      float64
SNR7                      float64
SNR8                      float64
GPS Signal Test            object
Total Time (sec)            int64
dtype: object
```

In [1280]:
```
data.isnull().sum()
```

Out[1280]:
```
Date                      0
Serial Number             0
Total Time                0
GPS Detect Time           0
GPS Enable Time           0
GPS Signal Test Time      0
TTFF                      0
SNR1                     29
SNR2                     29
SNR3                     30
SNR4                     31
SNR5                    217
SNR6                    217
SNR7                    218
SNR8                    372
GPS Signal Test           0
Total Time (sec)          0
dtype: int64
```

In [1161]:
```
# percentage of null values per feature is high to remove
print('Percentage of null SNR1 - SNR2: ', (29/2180)*100)
print('Percentage of null SNR3:        ', (30/2180)*100)
print('Percentage of null SNR4:        ', (31/2180)*100)
print('Percentage of null SNR5 - SNR6: ', (217/2180)*100)
print('Percentage of null SNR7:        ', (218/2180)*100)
print('Percentage of null SNR8:        ', (372/2180)*100)
```

```
Percentage of null SNR1 - SNR2:  1.3302752293577982
Percentage of null SNR3:         1.3761467889908259
```

```
Percentage of null SNR4:         1.4220183486238533
Percentage of null SNR5 - SNR6:  9.954128440366974
Percentage of null SNR7:         10.0
Percentage of null SNR8:         17.06422018348624
```

In [1317]:
```python
# extracting initial dataset to csv in order to plot EDA
data.to_csv(r'/Users/danielmartin/Desktop/samsara_initial_data.csv', header=True)
```

0.2 Exploratory Data Analysis

In [1281]:
```python
# dataframe consisting of only instances of defective serial numbers
defective_serial_numbers = ['GN6U-8EF-FZ9', 'GPZ2-4A8-M7D', 'GSYM-W78-JX8', 'G8FF-3A
                            'GBZT-SPM-42E', 'GK2U-998-B72', 'GRVJ-YHK-92D', 'G8Y3-T
                            'G2G9-WKX-4AD', 'GVSH-4VS-KRM', 'GHVT-NK3-JFZ', 'GJR7-U

defective_data = data.loc[data['Serial Number'].isin(defective_serial_numbers), :]
defective_data
```

Out[1281]:
```
            Date Serial Number Total Time  GPS Detect Time  GPS Enable Time  \
1350  2018-04-04  GEFH-Z25-ZWX   00:02:26          824.166             0.60
1369  2018-04-04  GVSH-4VS-KRM   00:02:17         6514.009             0.60
1376  2018-04-04  G2G9-WKX-4AD   00:02:20         4848.140             3.57
1510  2018-04-04  GRV2-47G-N3B   00:02:48          393.932             3.58
1542  2018-04-04  GJR7-UNB-RAB   00:02:41          735.489             3.58
1609  2018-04-04  GSYM-W78-JX8   00:02:18         2965.074             0.60
1720  2018-04-04  G8FF-3AH-VYX   00:02:20         1716.300             3.57
1724  2018-04-04  G8Y3-TJ8-SA8   00:02:21         1562.072             3.58
1767  2018-04-30  GRVJ-YHK-92D   00:02:16          142.812             0.60
1816  2018-04-04  GN6U-8EF-FZ9   00:02:23         2792.650             0.60
1870  2018-04-04  GRVJ-YHK-92D   00:02:17         1863.930             0.61
1924  2018-04-03  GPZ2-4A8-M7D   00:02:20         7123.482             3.54
1931  2018-04-03  GHVT-NK3-JFZ   00:02:17          353.348             0.60
1978  2018-04-04  GK2U-998-B72   00:02:43          973.040             3.58
2007  2018-04-04  GBZT-SPM-42E   00:02:38          147.612             3.58
2015  2018-04-04  GG42-C6K-82K   00:02:17         1815.810             0.60

      GPS Signal Test Time   TTFF  SNR1  SNR2  SNR3  SNR4  SNR5  SNR6  SNR7  \
1350               120.060  119.0  42.0  42.0  42.0  42.0  41.0  40.0  33.0
1369               120.050  119.0  44.0  43.0  44.0  44.0  44.0  43.0  44.0
1376               120.090  119.0  41.0  41.0  40.0  41.0  40.0  40.0  41.0
1510               120.200  120.0  39.0  39.0  39.0  39.0   NaN   NaN   NaN
1542               120.420  119.0  36.0  36.0  36.0  36.0  36.0  36.0  36.0
1609               120.720  120.0  46.0  46.0  47.0  46.0  43.0  43.0  43.0
1720               120.230  120.0  31.0  31.0  31.0  31.0  32.0  32.0  31.0
1724               120.150  119.0  47.0  47.0  47.0  47.0  47.0  47.0  47.0
1767               120.460  120.0   NaN   NaN   NaN   NaN  35.0  36.0  35.0
1816               120.301  120.0  40.0  40.0  40.0  40.0  41.0  41.0  41.0
```

```
1870              120.110  119.0  44.0  44.0  44.0  44.0  44.0  44.0  44.0
1924              120.840  120.0  40.0  40.0  40.0  41.0  41.0  41.0  41.0
1931              120.050  119.0   NaN   NaN   NaN   NaN  41.0  41.0  41.0
1978              120.180  120.0  34.0  33.0  34.0  34.0  33.0  33.0  34.0
2007              120.610  120.0  35.0  35.0  35.0  35.0   NaN   NaN   NaN
2015              120.340  119.0  44.0  44.0  44.0  44.0  44.0  44.0  44.0

      SNR8 GPS Signal Test  Total Time (sec)
1350  41.0            PASS               146
1369  44.0            PASS               137
1376  40.0            PASS               140
1510   NaN            PASS               168
1542  36.0            PASS               161
1609  44.0            PASS               138
1720  28.0            PASS               140
1724  47.0            PASS               141
1767  36.0            PASS               136
1816  41.0            PASS               143
1870  44.0            PASS               137
1924  32.0            PASS               140
1931  41.0            PASS               137
1978  33.0            PASS               163
2007   NaN            PASS               158
2015   NaN            PASS               137
```

In [1282]:
```
print('Number of instance: ', defective_data.shape[0])
print('Number of features: ', defective_data.shape[1])
```

```
Number of instance:  16
Number of features:  17
```

In [1283]:
```
# mean of SNR(1-8) values for Defective data
for _ in range(1,9):
    print('SNR'+str(_)+' Mean: ', round(defective_data['SNR'+str(_)].mean(),2))
```

```
SNR1 Mean:  40.21
SNR2 Mean:  40.07
SNR3 Mean:  40.21
SNR4 Mean:  40.29
SNR5 Mean:  40.14
SNR6 Mean:  40.07
SNR7 Mean:  39.64
SNR8 Mean:  39.0
```

In [1284]:
```
# replace null values with the mean of SNR
for _ in range(1,9):
    mean=round(defective_data['SNR'+str(_)].mean(),2)
    defective_data['SNR'+str(_)].fillna(mean, inplace=True)
```

In [1285]: defective_data.isnull().sum()

```
Out[1285]: Date                    0
           Serial Number           0
           Total Time              0
           GPS Detect Time         0
           GPS Enable Time         0
           GPS Signal Test Time    0
           TTFF                    0
           SNR1                    0
           SNR2                    0
           SNR3                    0
           SNR4                    0
           SNR5                    0
           SNR6                    0
           SNR7                    0
           SNR8                    0
           GPS Signal Test         0
           Total Time (sec)        0
           dtype: int64
```

In [1286]:

```python
# dataframe excluding the known defective serial numbers
clean_data = data.loc[~data['Serial Number'].isin(defective_serial_numbers), :]
clean_data.head(2)
```

Out[1286]:

```
         Date Serial Number Total Time  GPS Detect Time  GPS Enable Time  \
0  2018-04-20  GBXT-HMX-C3Z   00:01:21          680.897             3.57
1  2018-04-14  GVGG-P3N-S8H   00:01:13         2143.789             0.61

   GPS Signal Test Time  TTFF  SNR1  SNR2  SNR3  SNR4  SNR5  SNR6  SNR7  SNR8  \
0                 40.76  38.0  44.0  44.0  44.0  44.0   NaN   NaN   NaN   NaN
1                 40.25  36.0  44.0  44.0  44.0  44.0  46.0  46.0  47.0  46.0

  GPS Signal Test  Total Time (sec)
0            PASS                81
1            PASS                73
```

In [1287]:

```python
print('Number of instance: ', clean_data.shape[0])
print('Number of features: ', clean_data.shape[1])
```

```
Number of instance:  2164
Number of features:  17
```

In [1288]:

```python
# mean of SNR(1-8) values for Clean data
for _ in range(1,9):
    print('SNR'+str(_)+' Mean: ', round(clean_data['SNR'+str(_)].mean(),2))
```

```
SNR1 Mean:  41.99
SNR2 Mean:  42.05
```

```
SNR3 Mean:  42.14
SNR4 Mean:  42.16
SNR5 Mean:  41.62
SNR6 Mean:  41.65
SNR7 Mean:  41.32
SNR8 Mean:  41.12
```

In [1289]:
```python
# replace null values with the mean of SNR
for _ in range(1,9):
    mean=round(clean_data['SNR'+str(_)].mean(),2)
    clean_data['SNR'+str(_)].fillna(mean, inplace=True)
```

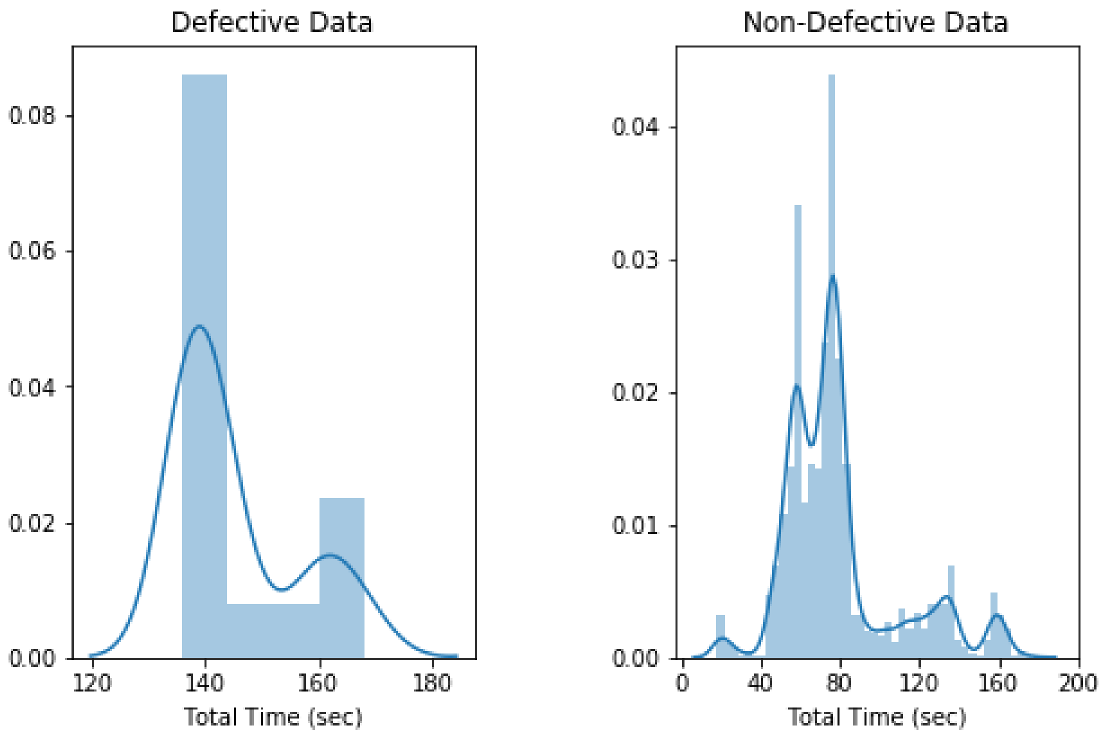
In [1290]:
```python
clean_data.isnull().sum()
```

Out[1290]:
```
Date                    0
Serial Number           0
Total Time              0
GPS Detect Time         0
GPS Enable Time         0
GPS Signal Test Time    0
TTFF                    0
SNR1                    0
SNR2                    0
SNR3                    0
SNR4                    0
SNR5                    0
SNR6                    0
SNR7                    0
SNR8                    0
GPS Signal Test         0
Total Time (sec)        0
dtype: int64
```

0.3 Visualizations

In [1291]:
```python
# distribution plots of Total Time (sec) for both
# defective and non-defective data

plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['Total Time (sec)'])


plt.subplot(1,2,2)
plt.title('Non-Defective Data')
g=sns.distplot(a=clean_data['Total Time (sec)'])
g.set_xticks(np.linspace(0,200,6))
```

```
plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



In [1292]:
```
# outliers - Total Time (sec) values 0-50
TT_outliers = clean_data.loc[data['Total Time (sec)']<=40, :]
TT_outliers.shape
```

Out[1292]: (44, 17)

In [1293]:
```
# Ship to Vendors - Total Time (sec) values 50-120
TT_ship_to_vendor = clean_data.loc[(clean_data['Total Time (sec)']>40)&
                                   (clean_data['Total Time (sec)']<=100), :]
TT_ship_to_vendor.shape
```

Out[1293]: (1738, 17)

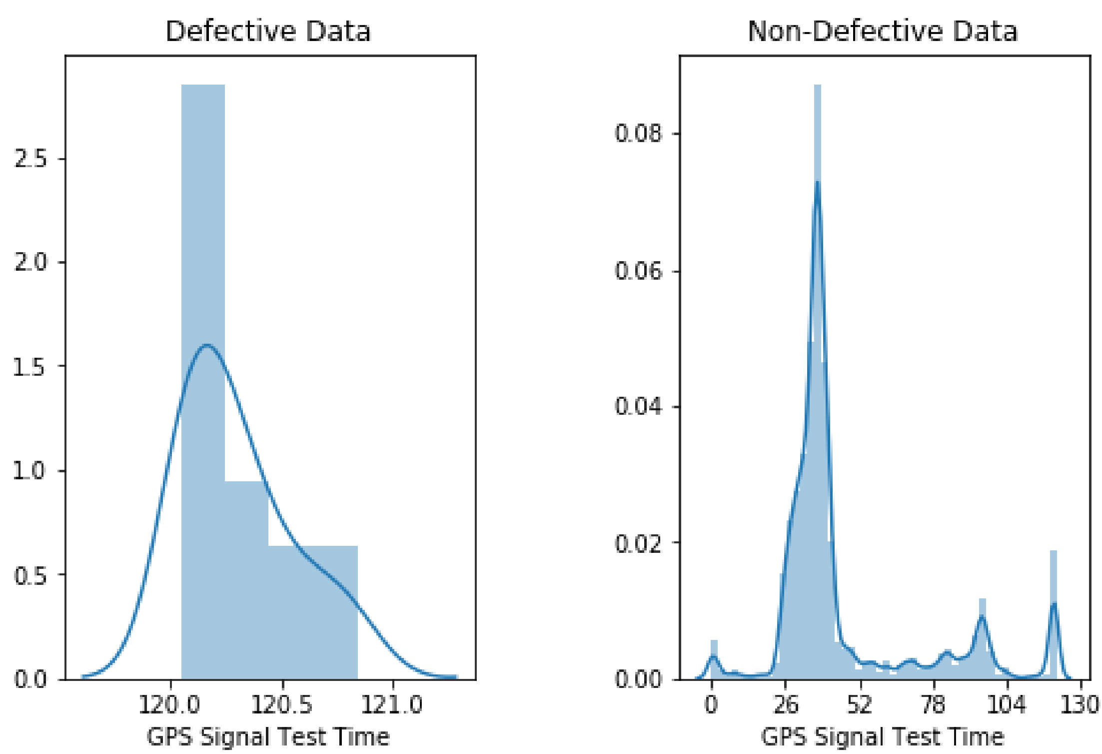
In [1294]:
```
# Screening - Total Time (sec) values 120-130
TT_screening = clean_data.loc[(clean_data['Total Time (sec)']>100)&
                              (clean_data['Total Time (sec)']<=130), :]
TT_screening.shape
```

Out[1294]: (178, 17)

In [1295]:
```
# Return from Field - Total Time (sec) values >130
TT_return_from_field = clean_data.loc[clean_data['Total Time (sec)']>130, :]
TT_return_from_field.shape
```

```
Out[1295]: (204, 17)
```

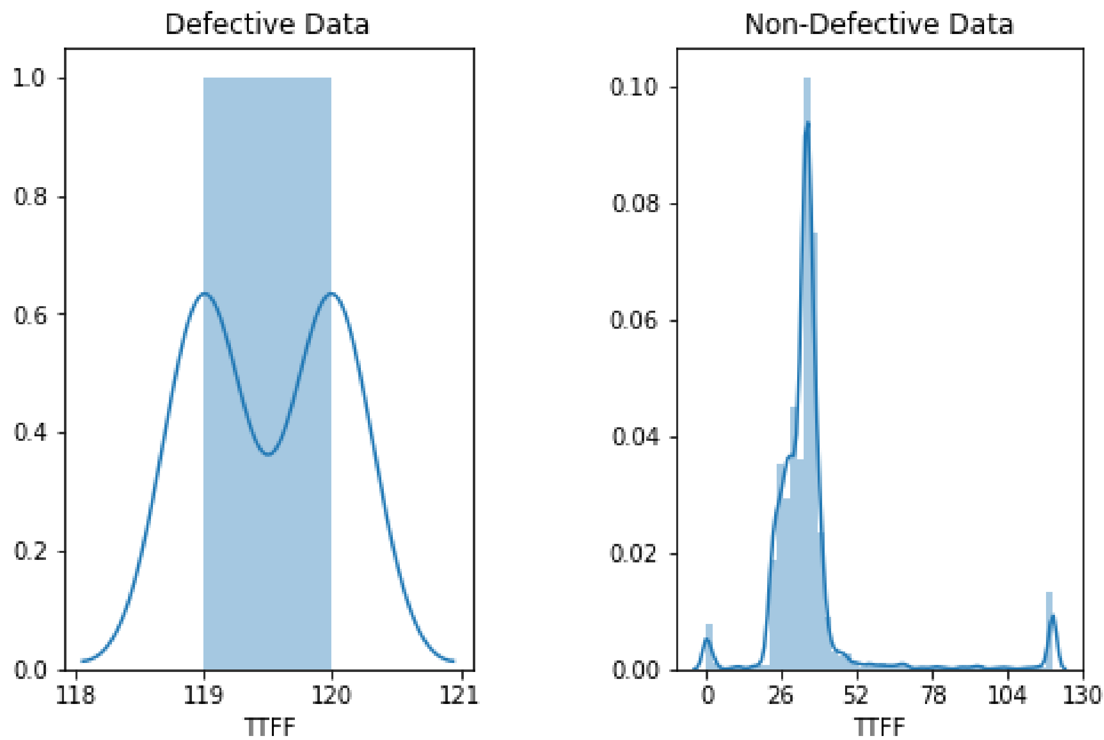
```
In [1296]: # distribution plot of GPS Signal Test Time for both
           # defective and non-defective data

           plt.figure(figsize=(8,5))
           plt.subplot(1,2,1)
           plt.title('Defective Data')
           sns.distplot(a=defective_data['GPS Signal Test Time'])


           plt.subplot(1,2,2)
           plt.title('Non-Defective Data')
           g=sns.distplot(a=clean_data['GPS Signal Test Time'])
           g.set_xticks(np.linspace(0,130,6))

           plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```




```
In [1297]: # outliers - GPS Signal Test Time (sec) values 0-25
           STT_outliers = clean_data.loc[data['GPS Signal Test Time']<26, :]
           STT_outliers.shape
```

```
Out[1297]: (120, 17)
```

```
In [1298]: # Ship to Vendors - GPS Signal Test Time (sec) values 26-55
           STT_ship_to_vendor = clean_data.loc[(clean_data['GPS Signal Test Time']>=26)&
                                           (clean_data['GPS Signal Test Time']<=55), :]
           STT_ship_to_vendor.shape

Out[1298]: (1618, 17)

In [1299]: # Screening - GPS Signal Test Time (sec) values 56-105
           STT_screening = clean_data.loc[(clean_data['GPS Signal Test Time']>55)&
                                     (clean_data['GPS Signal Test Time']<=105), :]
           STT_screening.shape

Out[1299]: (318, 17)

In [1300]: # Return from Field - GPS Signal Test Time (sec) values >104
           STT_return_from_field = clean_data.loc[clean_data['GPS Signal Test Time']>104, :]
           STT_return_from_field.shape

Out[1300]: (110, 17)

In [1301]: # distribution plot of TTFF values for both
           # defective and non-defective data

           plt.figure(figsize=(8,5))
           plt.subplot(1,2,1)
           plt.title('Defective Data')
           sns.distplot(a=defective_data['TTFF'])

           plt.subplot(1,2,2)
           plt.title('Non-Defective Data')
           g=sns.distplot(a=clean_data['TTFF'])
           g.set_xticks(np.linspace(0,130,6))

           plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



In [1302]:
```
# outliers - TTFF (sec) values 0-25
TTFF_outliers = clean_data.loc[data['TTFF']<26, :]
TTFF_outliers.shape
```

Out[1302]: (276, 17)

In [1303]:
```
# Ship to Vendors - GPS Signal Test Time (sec) values 26-55
TTFF_ship_to_vendor = clean_data.loc[(clean_data['TTFF']>=26)&
                                      (clean_data['TTFF']<=55), :]
TTFF_ship_to_vendor.shape
```

Out[1303]: (1768, 17)

In [1304]:
```
# Screening - GPS Signal Test Time (sec) values 56-105
TTFF_screening = clean_data.loc[(clean_data['TTFF']>55)&
                                 (clean_data['TTFF']<=105), :]
TTFF_screening.shape
```

Out[1304]: (45, 17)

In [1305]:
```
# Return from Field - GPS Signal Test Time (sec) values >104
TTFF_return_from_field = clean_data.loc[clean_data['TTFF']>105, :]
TTFF_return_from_field.shape
```

Out[1305]: (75, 17)

0.4 Analysis (Recommendation)

In [1306]:
```
# functions that will categorize the gateway devices in terms of
# Total Time (sec), GPS Signal Test Time, and TTFF values

def total_time_rec(time):
    if time<=40:
        return 'outlier'
    elif (time>40)&(time<=100):
        return 'ship to vendor'
    elif (time>100)&(time<=130):
        return 'screening'
    else:
        return 'return from field'

def signal_time_rec(time):
    if time<26:
        return 'outlier'
    elif (time>=26)&(time<=55):
        return 'ship to vendor'
    elif (time>55)&(time<=105):
        return 'screening'
    else:
        return 'return from field'

def ttff_rec(ttff):
    if ttff<26:
        return 'outlier'
    elif (ttff>=26)&(ttff<=55):
        return 'ship to vendor'
    elif (ttff>55)&(ttff<=105):
        return 'screening'
    else:
        return 'return from field'
```

In [1307]:
```
# applying the functions above to every instance in the dataset
data['Total Time Rec'] = data['Total Time (sec)'].apply(total_time_rec)
data['Signal Time Rec'] = data['GPS Signal Test Time'].apply(signal_time_rec)
data['TTFF Rec'] = data['TTFF'].apply(ttff_rec)
```

In [1308]:
```
# function for my final recommendation
# returning the mode value for Total Time (sec), GPS Signal Test Time, and TTFF
# - if the values are split evenly or if the gateway is categorized as an outlier
#   my final recommendation is to screen the device an additional time

def mode_func(row):
    if len(row[['Total Time Rec', 'Signal Time Rec', 'TTFF Rec']].value_counts()) >
        return 'screening'
    elif row[['Total Time Rec', 'Signal Time Rec', 'TTFF Rec']].mode()[0] == 'outli
```

```
            return 'screening'
        else:
            return row[['Total Time Rec', 'Signal Time Rec', 'TTFF Rec']].mode()
```

In [1309]:
```
data['final rec'] = data.apply(mode_func, axis = 1)
data.head()
```

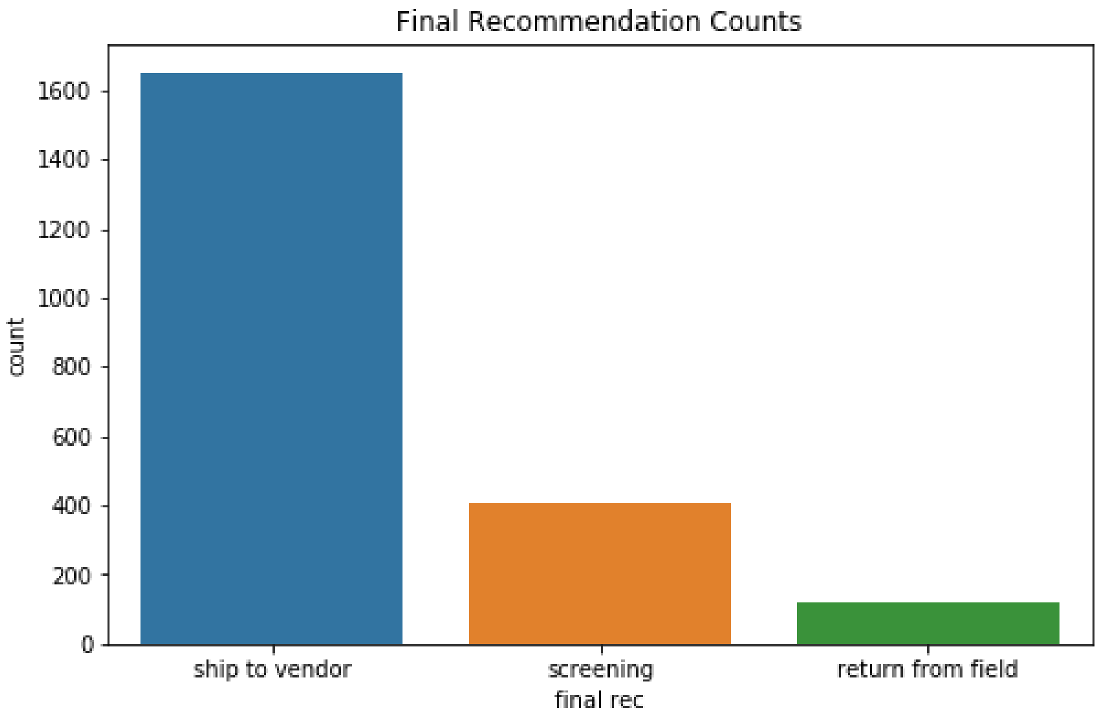
Out[1309]:
```
         Date Serial Number Total Time  GPS Detect Time  GPS Enable Time  \
0  2018-04-20  GBXT-HMX-C3Z   00:01:21          680.897             3.57
1  2018-04-14  GVGG-P3N-S8H   00:01:13         2143.789             0.61
2  2018-04-20  GG95-8CE-W8M   00:02:15          570.095             3.58
3  2018-04-20  GDJK-B45-V6F   00:01:22         2158.762             3.57
4  2018-04-20  GHRT-RF9-E9K   00:00:59           10.912             3.56

   GPS Signal Test Time  TTFF  SNR1  SNR2  SNR3  ...   SNR5  SNR6  SNR7  SNR8  \
0                 40.76  38.0  44.0  44.0  44.0  ...    NaN   NaN   NaN   NaN
1                 40.25  36.0  44.0  44.0  44.0  ...   46.0  46.0  47.0  46.0
2                 93.90  26.0  44.0  44.0  44.0  ...   41.0  41.0  41.0  41.0
3                 38.01  34.0  42.0  42.0  42.0  ...   43.0  42.0  43.0  41.0
4                 36.40  33.0  43.0  43.0  43.0  ...    NaN   NaN   NaN   NaN

   GPS Signal Test Total Time (sec)     Total Time Rec Signal Time Rec  \
0             PASS                81     ship to vendor  ship to vendor
1             PASS                73     ship to vendor  ship to vendor
2             PASS               135  return from field       screening
3             PASS                82     ship to vendor  ship to vendor
4             PASS                59     ship to vendor  ship to vendor

         TTFF Rec       final rec
0  ship to vendor  ship to vendor
1  ship to vendor  ship to vendor
2  ship to vendor       screening
3  ship to vendor  ship to vendor
4  ship to vendor  ship to vendor

[5 rows x 21 columns]
```

In [1311]:
```
# counts per final recommendation value
data.groupby('final rec')['Serial Number'].count()
```

Out[1311]:
```
final rec
return from field     123
screening             407
ship to vendor       1650
Name: Serial Number, dtype: int64
```

In [1315]:
```
# countplot displaying the counts of final recommendations

plt.figure(figsize=(8,5))
```

```
plt.title('Final Recommendation Counts')
sns.countplot(data['final rec']);
```

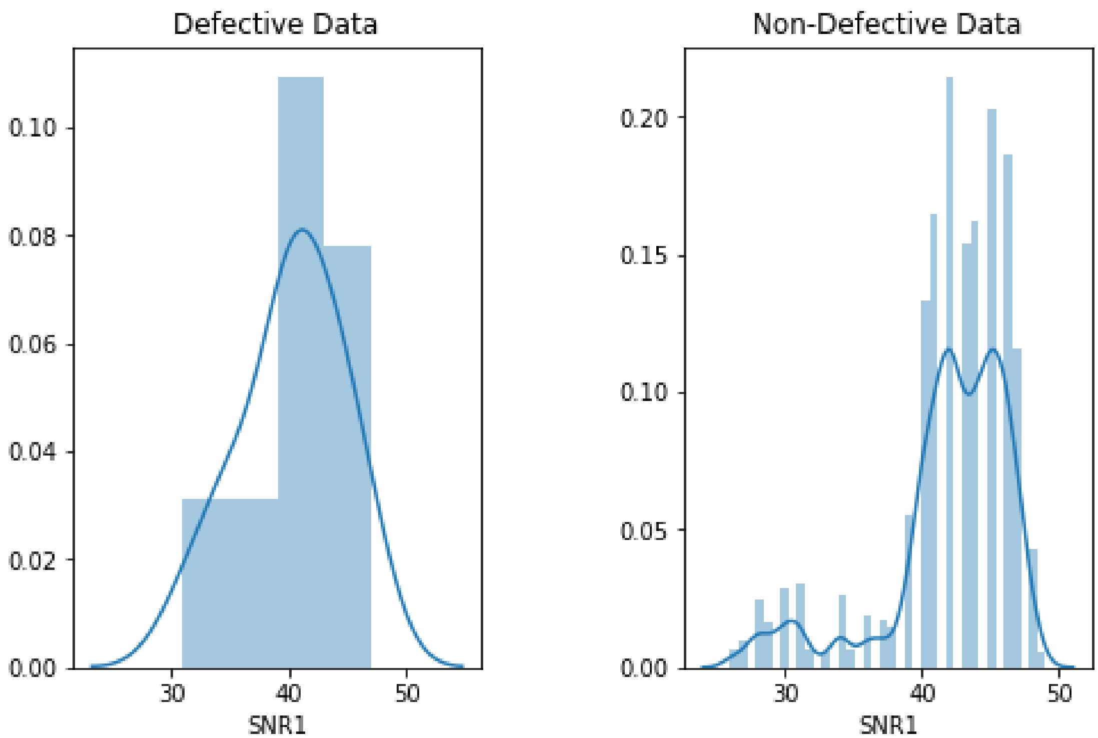



```
In [1318]: # extracting final dataset to csv in order to plot EDA
           data.to_csv(r'/Users/danielmartin/Desktop/samsara_final_data.csv', header=True)
```

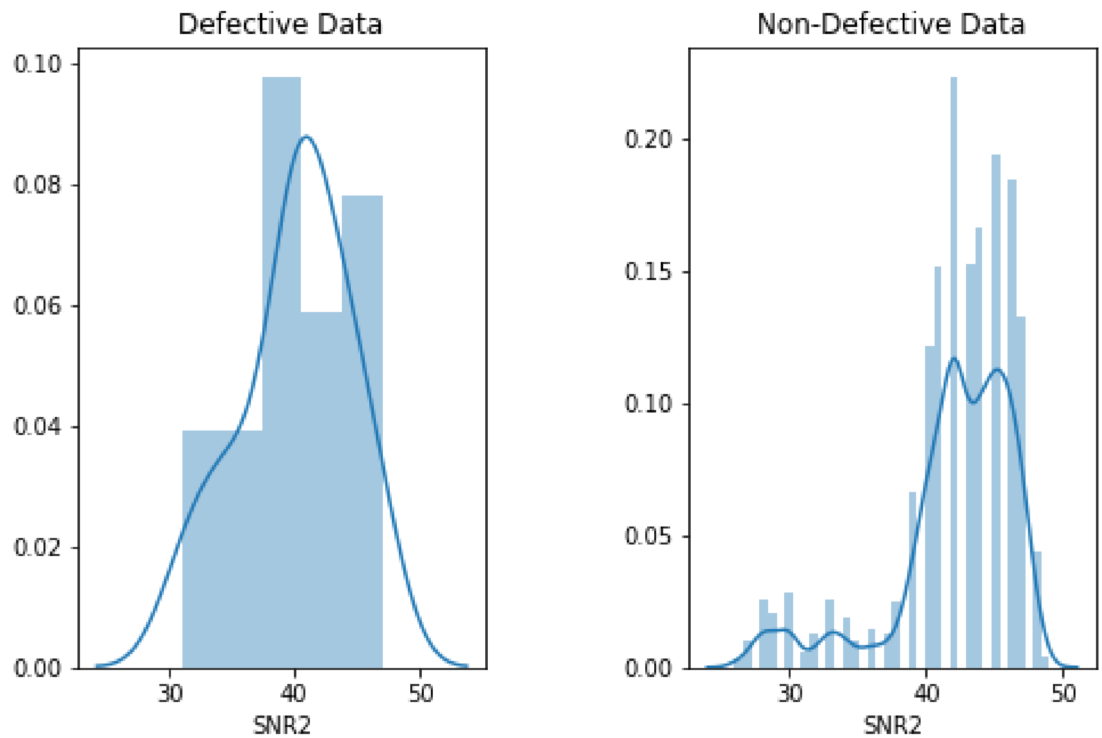
0.4.1 Additional EDA

```
In [1316]: # The following plots did not demonstrate much of an association
           # between defective and non-defective gateways when compared to
           # Total Time (sec), GPS Signal Test Time, and TTFF features.
           # For this reason I excluded the SNR (signal to noise ration)
           # values from the final recommendation.
```

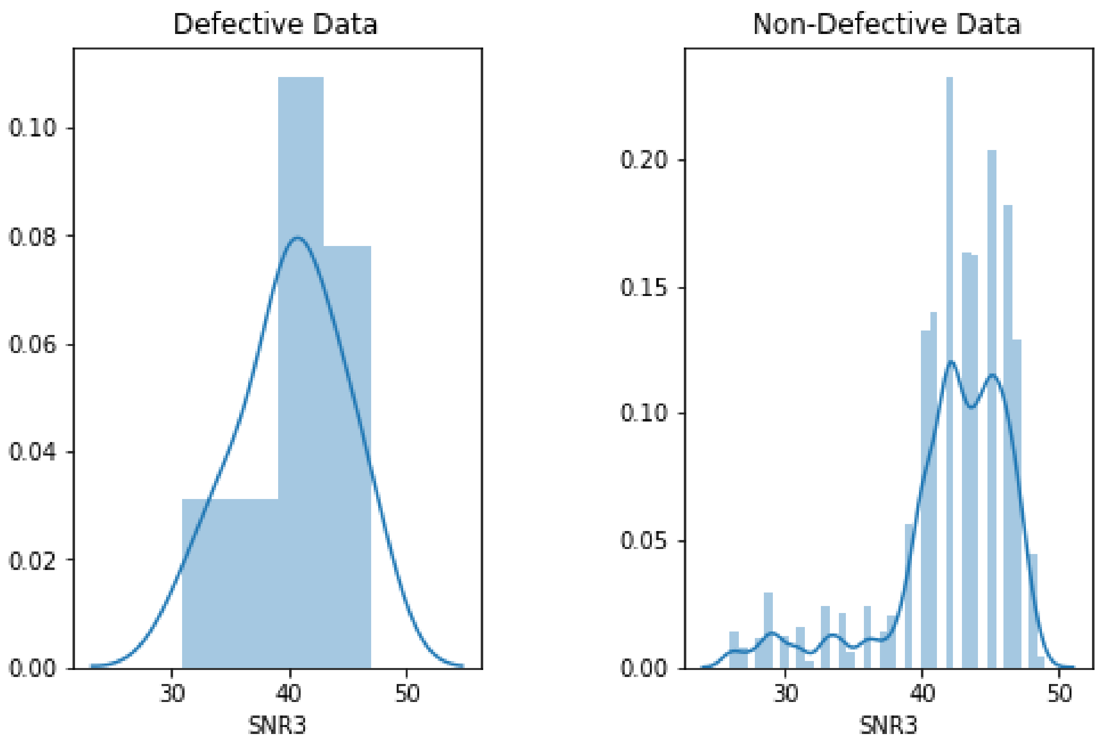
```
In [887]: plt.figure(figsize=(8,5))
          plt.subplot(1,2,1)
          plt.title('Defective Data')
          sns.distplot(a=defective_data['SNR1'])

          plt.subplot(1,2,2)
          plt.title('Non-Defective Data')
          sns.distplot(a=clean_data['SNR1'])

          plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



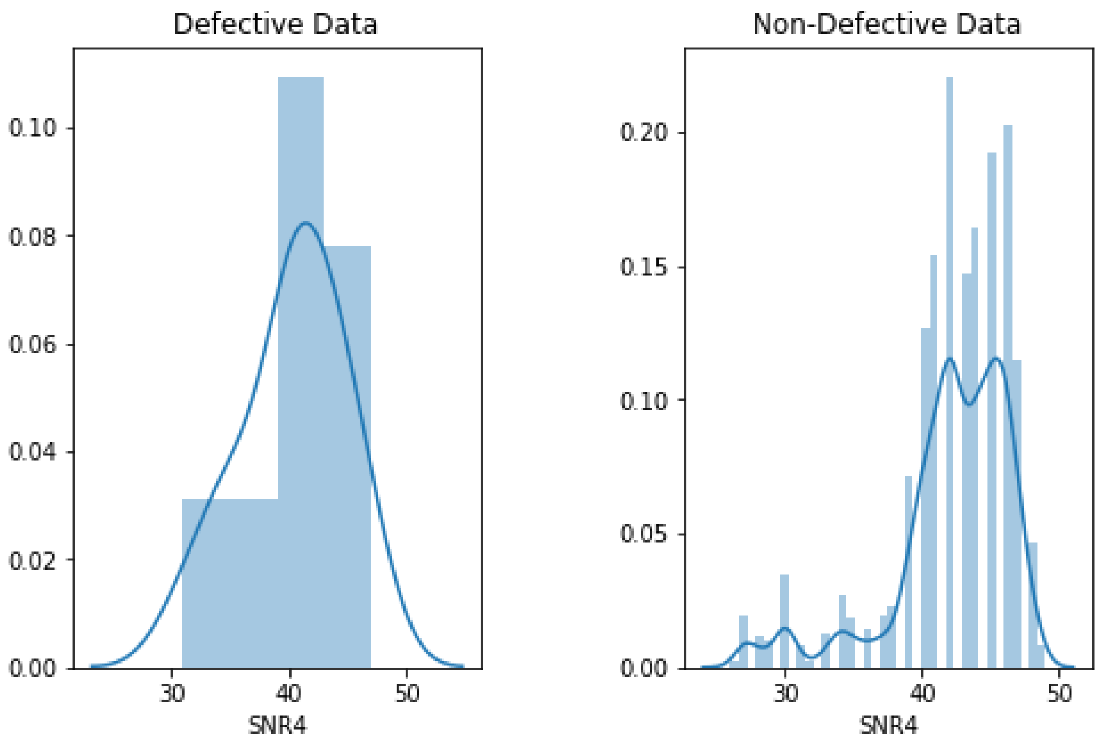
In [888]:
```
plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['SNR2'])

plt.subplot(1,2,2)
plt.title('Non-Defective Data')
sns.distplot(a=clean_data['SNR2'])

plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



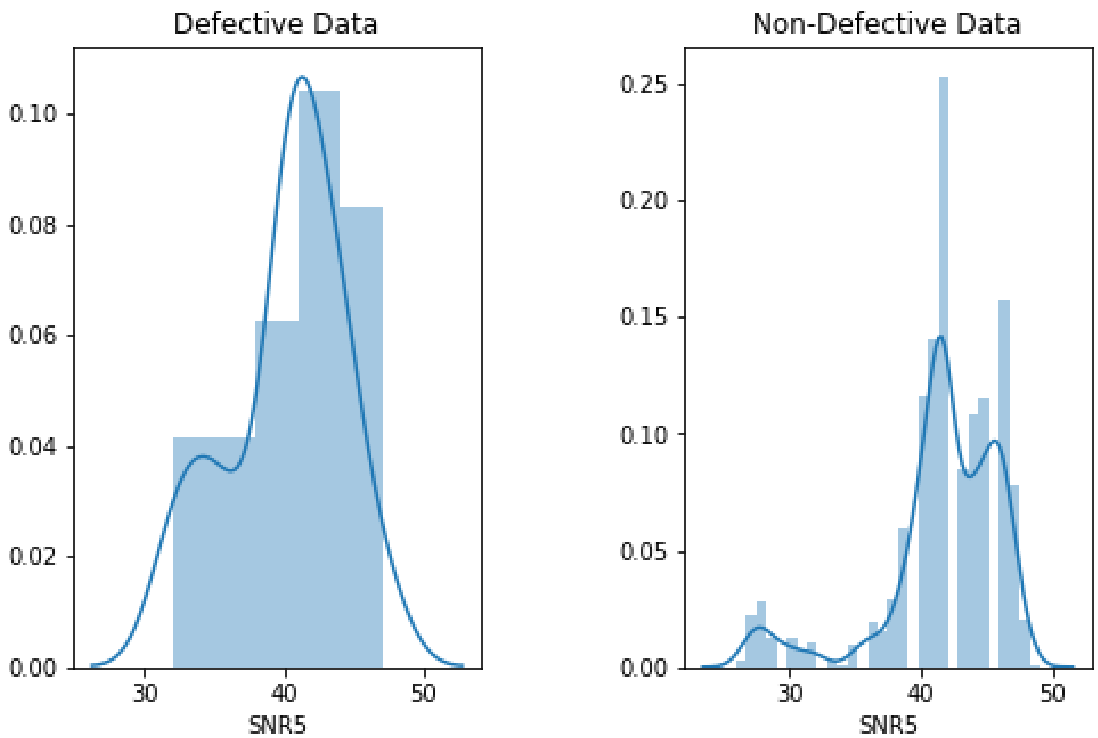
In [889]:
```
plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['SNR3'])

plt.subplot(1,2,2)
plt.title('Non-Defective Data')
sns.distplot(a=clean_data['SNR3'])

plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



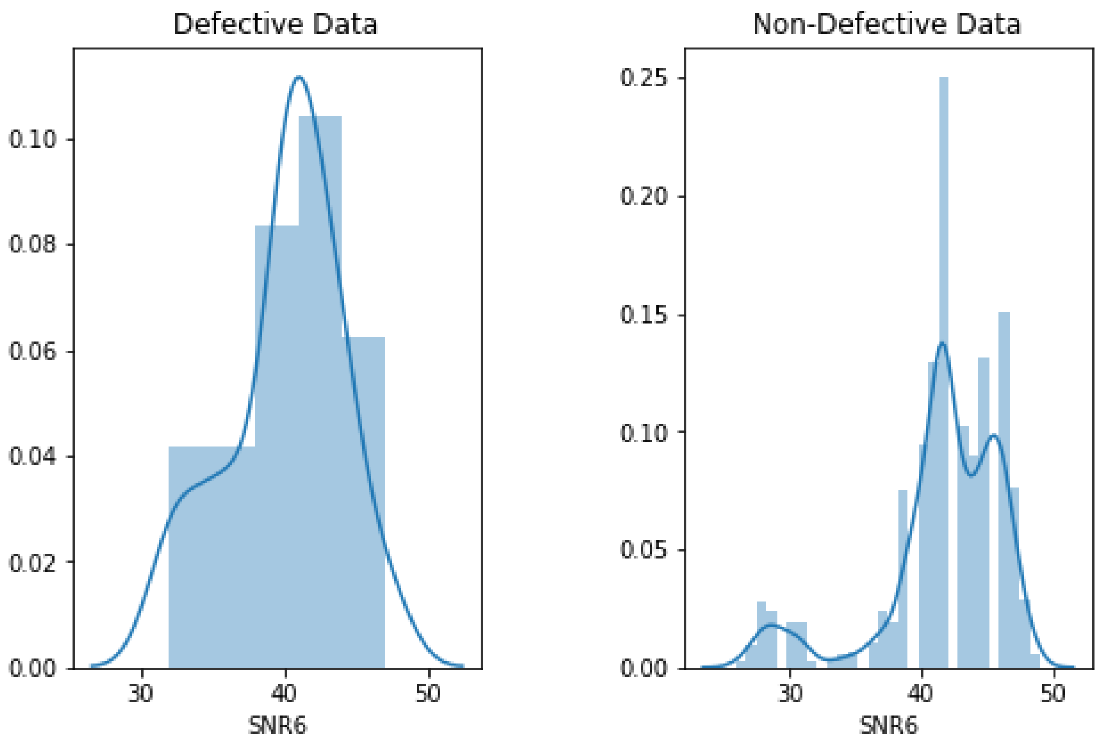
In [890]:
```
plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['SNR4'])

plt.subplot(1,2,2)
plt.title('Non-Defective Data')
sns.distplot(a=clean_data['SNR4'])

plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



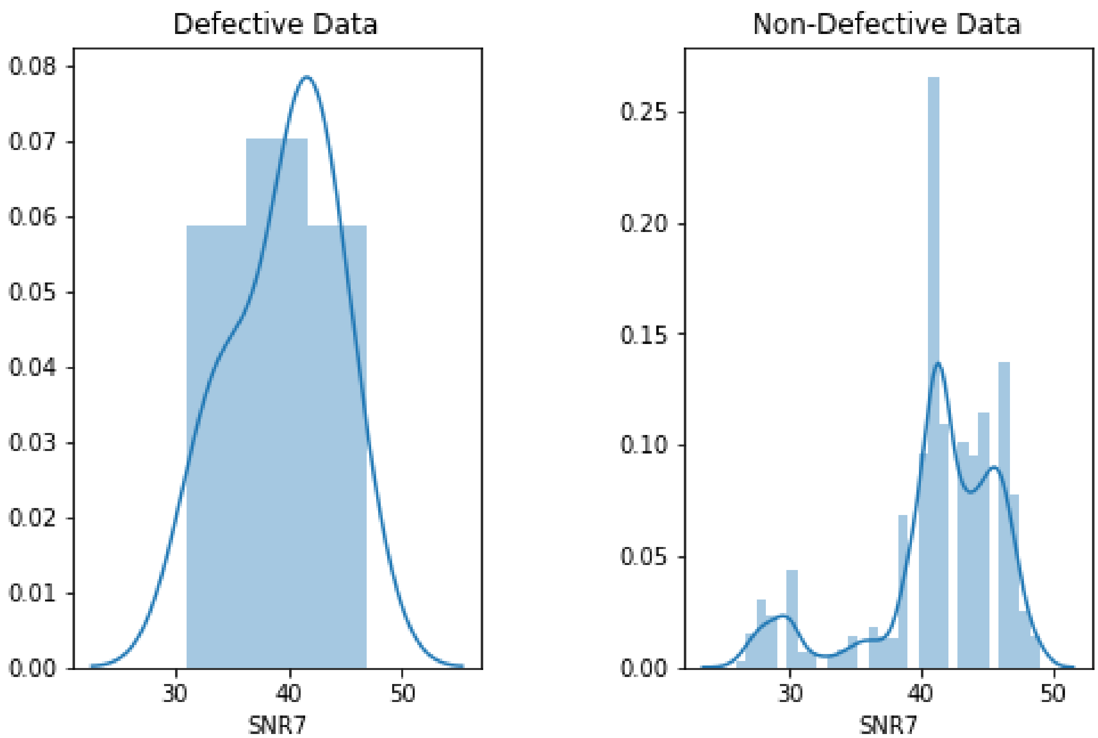

```
In [891]: plt.figure(figsize=(8,5))
          plt.subplot(1,2,1)
          plt.title('Defective Data')
          sns.distplot(a=defective_data['SNR5'])

          plt.subplot(1,2,2)
          plt.title('Non-Defective Data')
          sns.distplot(a=clean_data['SNR5'])

          plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



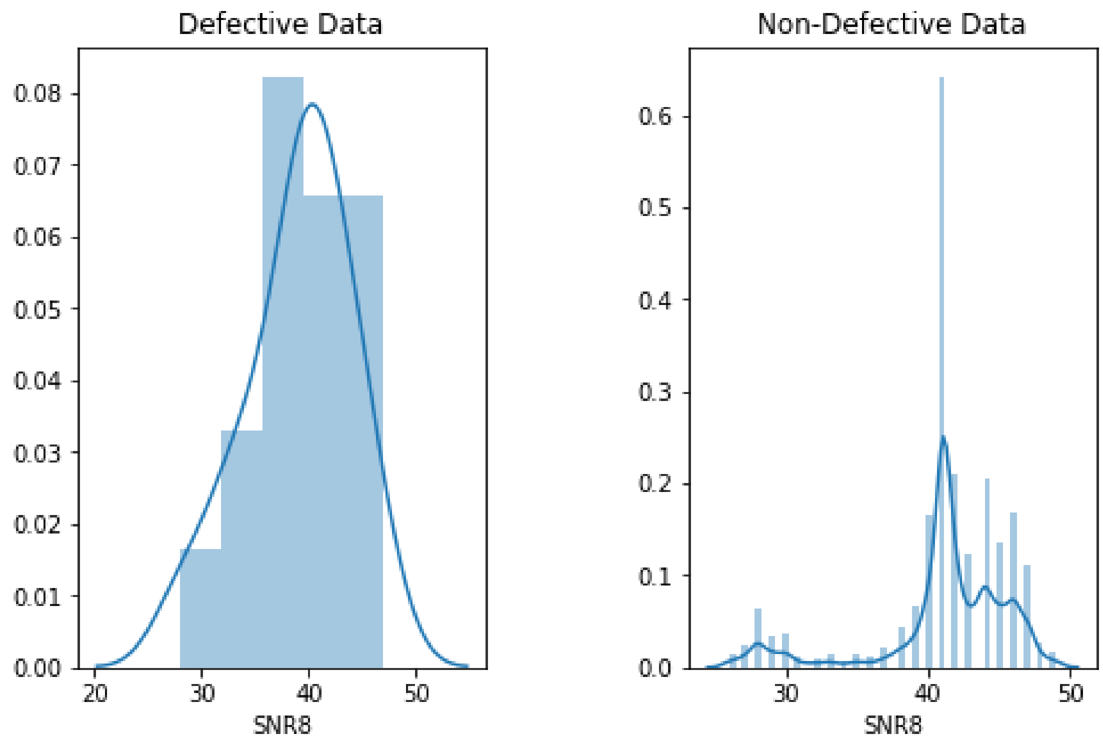

```
In [892]: plt.figure(figsize=(8,5))
          plt.subplot(1,2,1)
          plt.title('Defective Data')
          sns.distplot(a=defective_data['SNR6'])

          plt.subplot(1,2,2)
          plt.title('Non-Defective Data')
          sns.distplot(a=clean_data['SNR6'])

          plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



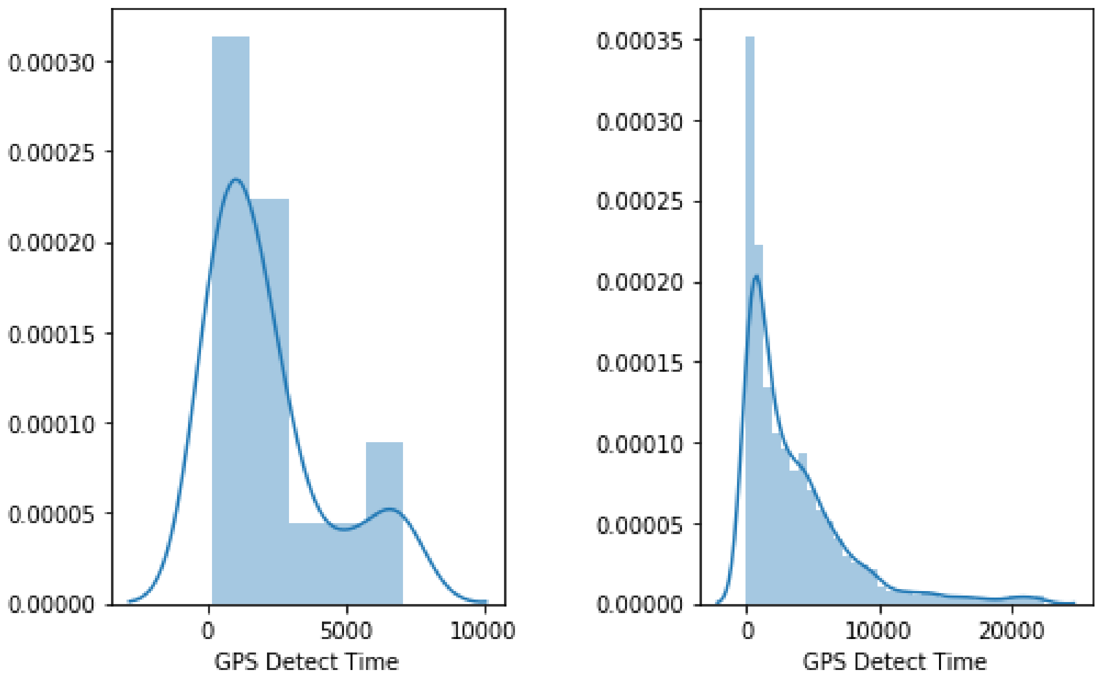
In [893]:
```
plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['SNR7'])

plt.subplot(1,2,2)
plt.title('Non-Defective Data')
sns.distplot(a=clean_data['SNR7'])

plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



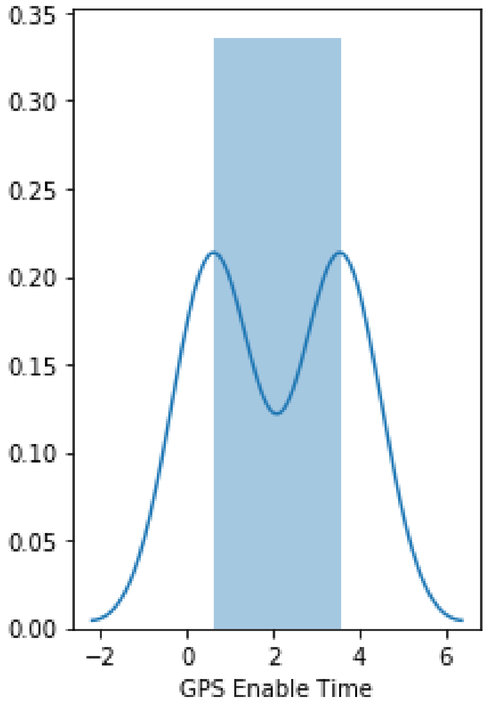
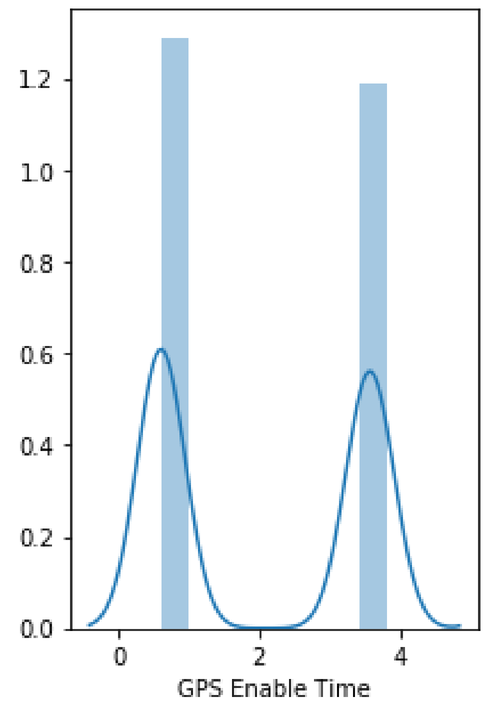
In [894]:
```
plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['SNR8'])

plt.subplot(1,2,2)
plt.title('Non-Defective Data')
sns.distplot(a=clean_data['SNR8'])

plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```




```
In [713]: plt.figure(figsize=(8,5))
          plt.subplot(1,2,1)
          plt.title('Defective Data')
          sns.distplot(a=defective_data['GPS Detect Time'])

          plt.subplot(1,2,2)
          plt.title('Non-Defective Data')
          sns.distplot(a=clean_data['GPS Detect Time'])

          plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```



In [719]:
```
plt.figure(figsize=(8,5))
plt.subplot(1,2,1)
plt.title('Defective Data')
sns.distplot(a=defective_data['GPS Enable Time'])

plt.subplot(1,2,2)
plt.title('Non-Defective Data')
sns.distplot(a=clean_data['GPS Enable Time'])

plt.subplots_adjust(wspace = 0.5, hspace = 0.3);
```


0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
−2
0
2
4
6
GPS Enable Time

1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
GPS Enable Time