Import library

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
sns.set_theme(style='ticks')
%matplotlib inline
```

Import airfoils data

In [2]:
```
df = pd.read_csv('AirfoilsCluster.csv')
df.head()
```

Out[2]:

	Airfoils	t0.75c	Cd	Cl/Cd	cluster
0	NACA 63A010	0.05090	0.01236	40.453074	2
1	NACA 63012A	0.06052	0.01244	40.192926	2
2	NACA 63-015A	0.07462	0.01364	36.656892	2
3	NACA 63-210	0.04332	0.01117	44.762757	0
4	NACA 63-212	0.05112	0.01127	44.365572	0

Calculate statistics

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

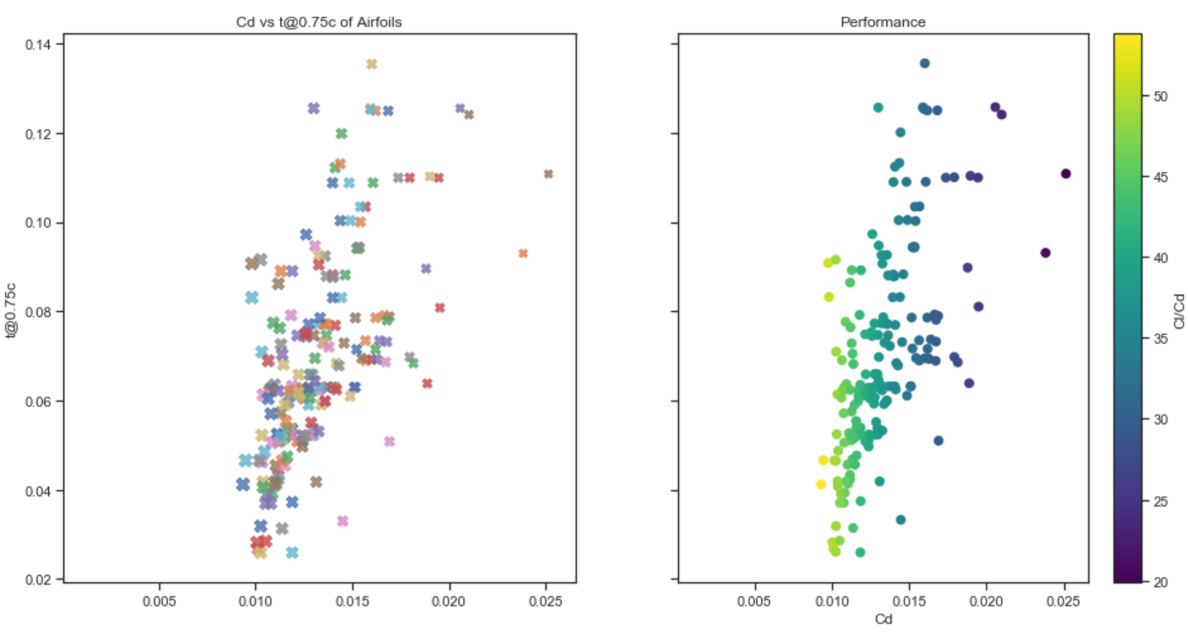
Out[3]:

	t0.75c	Cd	Cl/Cd	cluster
count	194.000000	194.000000	194.000000	194.000000
mean	0.069950	0.013306	38.808295	1.036082
std	0.022935	0.002583	6.580826	0.847879
min	0.025972	0.009300	19.888624	0.000000
25%	0.053413	0.011362	34.435458	0.000000
50%	0.065243	0.012780	39.123631	1.000000
75%	0.080600	0.014520	44.004407	2.000000
max	0.135580	0.025140	53.763441	2.000000

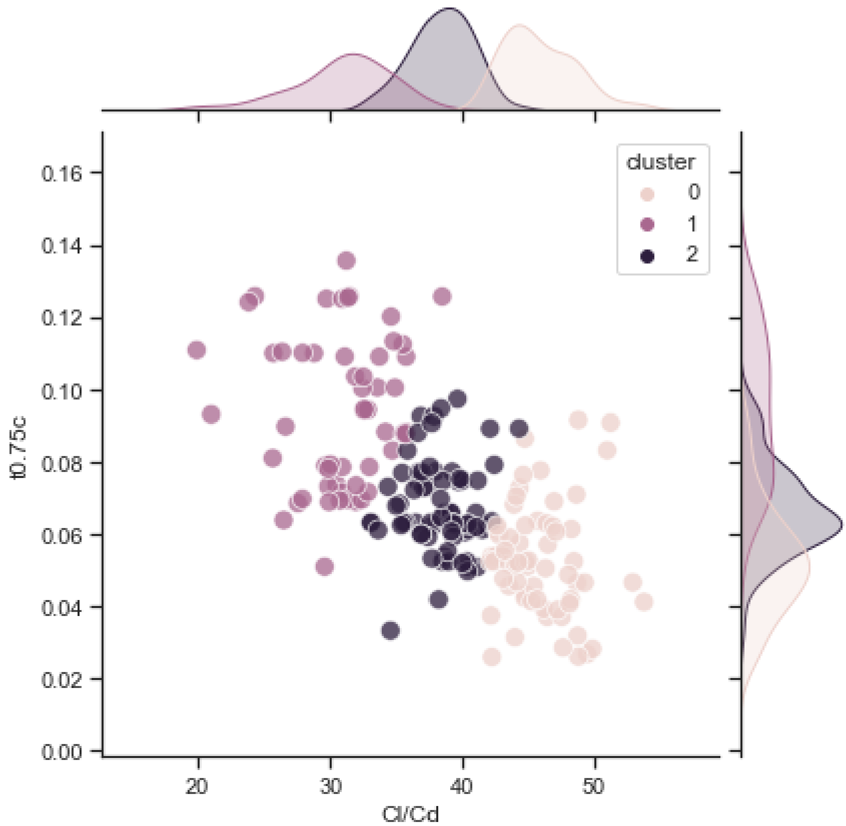
Data visualization

In [4]:

```
n=8
fig, f= plt.subplots(nrows=1, ncols=2, sharex=True, sharey=True, figsize=(2*n,
1*n))

for i in range(len(df)):
    f[0].scatter(df['Cd'][i], df['t0.75c'][i], s=df['Cl/Cd'][i]*2, marker='X',
alpha=0.8)

f[0].set_title('Cd vs t@0.75c of Airfoils')
f[0].set_ylabel('t@0.75c')

f[1].scatter(df['Cd'], df['t0.75c'], c=df['Cl/Cd'], s=50, cmap='viridis', alph
a=0.7)
f[1].set_xlabel('Cd')
f[1].set_title('Performance')
ax = f[1]

performance = ax.scatter(df['Cd'], df['t0.75c'], c=df['Cl/Cd'], cmap='viridis'
)
cb = fig.colorbar(performance, ax=ax)
cb.set_label('Cl/Cd')

plt.show()
```

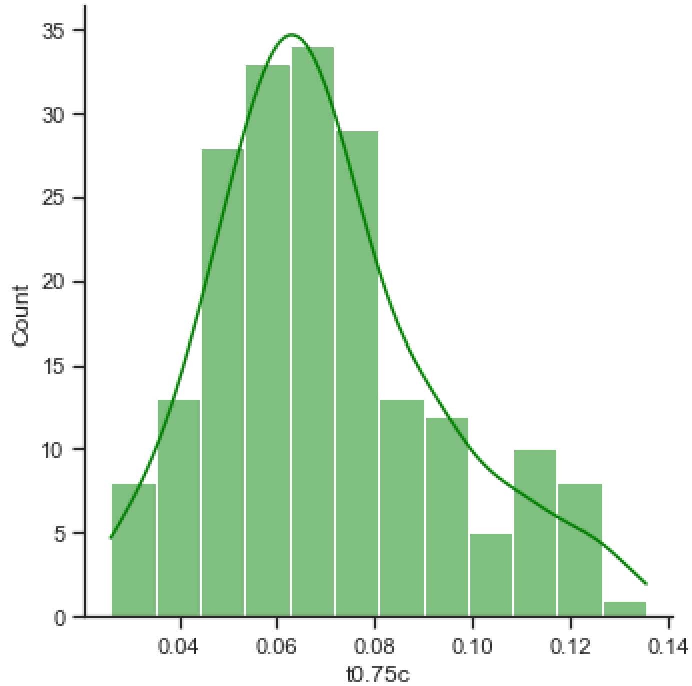


In [5]:
```
graph1 = sns.jointplot(x=df['Cl/Cd'], y=df['t0.75c'], s=100, hue=df['cluster'
], alpha=0.75)
graph1.savefig("jointplots.png")
```



Hypothesis Part

In [6]:
```
dis = sns.displot(df['t0.75c'], kde=True, color='green')
```



In [7]:
```
t = pd.read_csv('airfoil_cluster_1.csv')
t.head()
```

Out[7]:

	Airfoils	t0.75c	Cd	Cl/Cd	cluster
0	NACA 66-021	0.12502	0.01682	29.726516	1
1	NACA 63(4)-221	0.08318	0.01440	34.722222	1
2	NACA 64(4)-221	0.08830	0.01462	34.199726	1
3	NACA 64(4)-421	0.08826	0.01397	35.790981	1
4	NACA 65(3)-218	0.08790	0.01405	35.587189	1

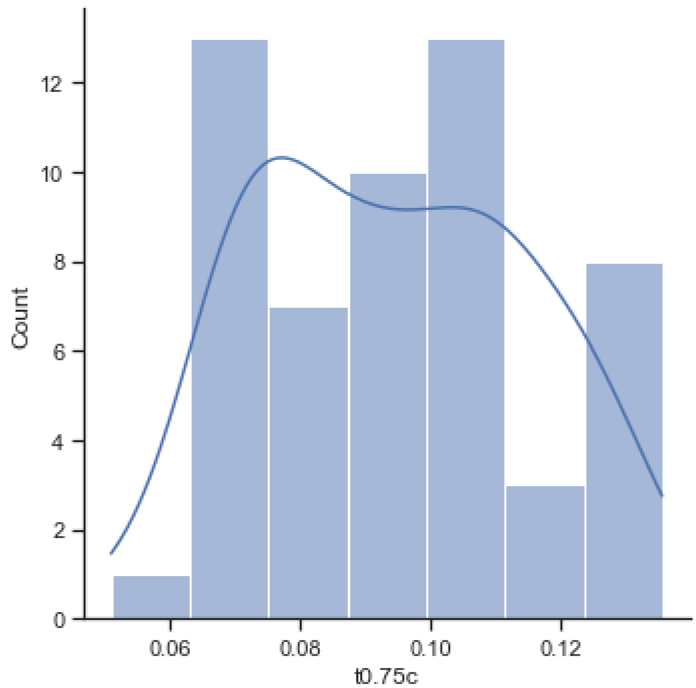
In [8]:
```
t.describe()
```

Out[8]:

	t0.75c	Cd	Cl/Cd	cluster
count	55.000000	55.000000	55.000000	55.0
mean	0.094136	0.016465	30.878222	1.0
std	0.020716	0.002334	3.746153	0.0
min	0.051000	0.013000	19.888624	1.0
25%	0.075886	0.015185	29.612105	1.0
50%	0.094310	0.016000	31.250000	1.0
75%	0.109990	0.016885	32.927320	1.0
max	0.135580	0.025140	38.461538	1.0

In [9]:
```
sns.displot(t['t0.75c'], kde=True)
```

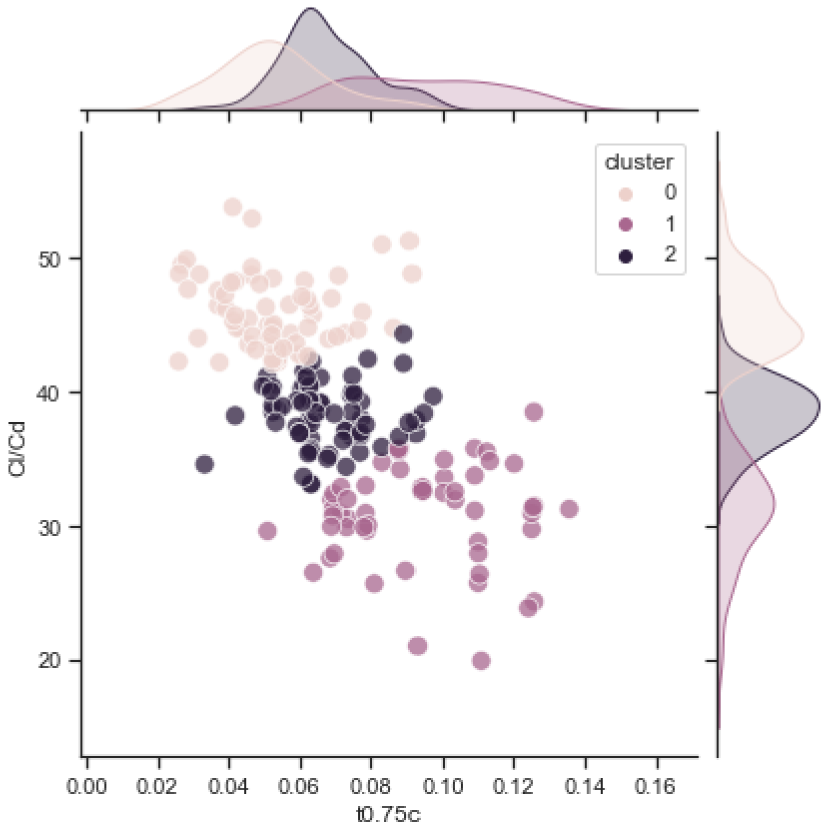
Out[9]: <seaborn.axisgrid.FacetGrid at 0x24af9f4ed88>



In [10]:
```
num_mean = t['t0.75c'].count() - t[t['t0.75c'] < 0.075886].count() - t[t['t0.7
5c'] > 0.109990 + 0.020716].count()
print(num_mean)
```

```
Airfoils    40
t0.75c      40
Cd          40
Cl/Cd       40
cluster     40
dtype: int64
```

In [11]:
```
graph2 = sns.jointplot(x=df['t0.75c'], y=df['Cl/Cd'], s=100, hue=df['cluster'
], alpha=0.75)
graph2.savefig("jointplots.png")
```



In [12]:
```
st = pd.read_csv('airfoil_cluster_0.csv')
st
```

Out[12]:

	Airfoils	t0.75c	Cd	Cl/Cd	cluster
0	NACA 63-210	0.04332	0.01117	44.762757	0
1	NACA 63-212	0.05112	0.01127	44.365572	0
2	NACA 63-412	0.05108	0.01113	44.923630	0
3	NACA 64-008A	0.04234	0.01118	44.722719	0
4	NASA-LANGLEY 64-012	0.05390	0.01185	42.194093	0
...	...	...	...	...	...
61	FX 71-L-150/20 AIRFOIL	0.05054	0.01080	46.296296	0
62	FX 79-L-120	0.04876	0.01041	48.030740	0
63	WORTMANN FX 75-141	0.06064	0.01062	47.080979	0
64	FX 71-L-150/25 AIRFOIL	0.05542	0.01157	43.215212	0
65	FX 63-120 AIRFOIL	0.04080	0.01039	48.123195	0

66 rows × 5 columns

In [13]:
```
st.describe()
```

Out[13]:

	t0.75c	Cd	Cl/Cd	cluster
count	66.000000	66.000000	66.000000	66.0
mean	0.052812	0.010944	45.838953	0.0
std	0.015193	0.000626	2.717912	0.0
min	0.025972	0.009300	42.087542	0.0
25%	0.042025	0.010433	43.917461	0.0
50%	0.052279	0.011080	45.126685	0.0
75%	0.061335	0.011385	47.927817	0.0
max	0.091546	0.011880	53.763441	0.0

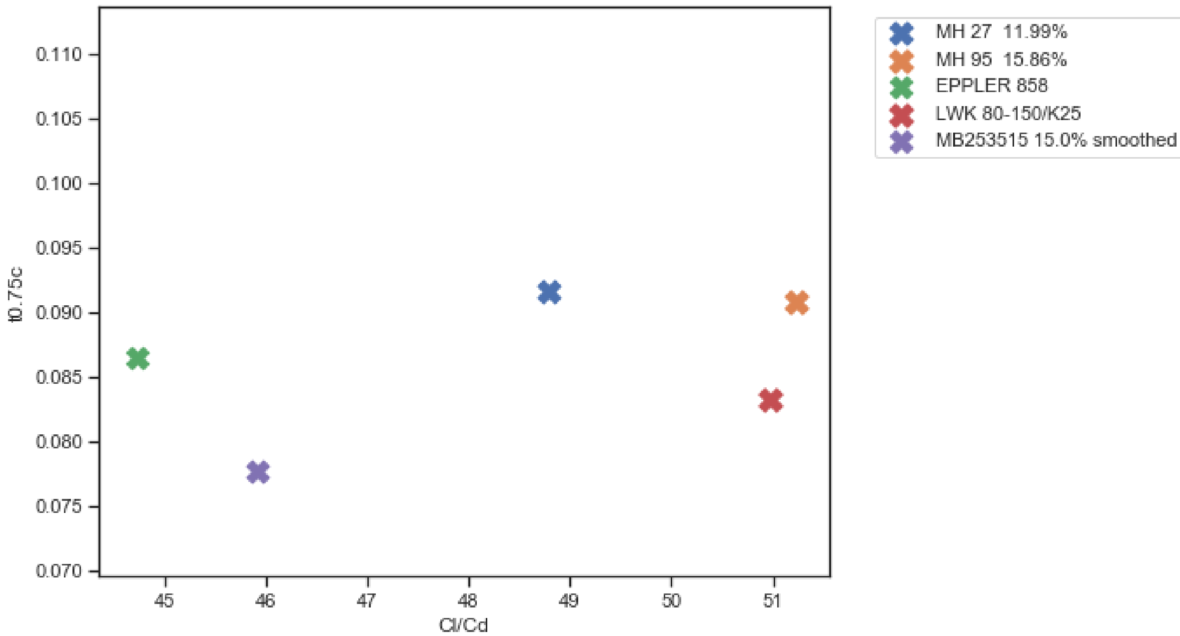
In [14]:
```
st_sort = st.sort_values(by=['t0.75c','Cl/Cd'])[:-6:-1]
st_sort.reset_index(inplace=True)
st_sort.drop(['index'], axis=1, inplace=True)
```

In [15]:
```
st_sort.describe()
```

Out[15]:

	t0.75c	Cd	Cl/Cd	cluster
count	5.000000	5.000000	5.000000	5.0
mean	0.085928	0.010378	48.322959	0.0
std	0.005740	0.000638	2.933516	0.0
min	0.077640	0.009760	44.722719	0.0
25%	0.083200	0.009810	45.913682	0.0
50%	0.086440	0.010250	48.780488	0.0
75%	0.090812	0.010890	50.968400	0.0
max	0.091546	0.011180	51.229508	0.0

In [16]:
```
sns.set_theme(style='ticks')
Airfoil_name = st_sort['Airfoils'].tolist()

scale=1.5
plt.figure(figsize=(5*scale,4*scale))

for i in range(len(st_sort)):
    plt.scatter(st_sort['Cl/Cd'][i], st_sort['t0.75c'][i], s=st_sort['Cl/Cd'][
i]*3.5, label=Airfoil_name[i], marker='X')

plt.xlabel('Cl/Cd')
plt.ylabel('t0.75c')
plt.legend(bbox_to_anchor=(1.5, 1))
plt.show()
```



In [17]:
```
# Define alpha at 0.6
# Two ways test, Thus alpha was devide by 2. alhpa = 0.3 for each side.
# H0=t.mean(), H1 != t.mean()

Z = ((st_sort['t0.75c'].mean()-t['t0.75c'].mean())/(st_sort['t0.75c'].mean()*n
p.sqrt(st_sort['t0.75c'].count()))).round(6)

if -0.52 < Z < 0.52: # @alpha=0.3 Z = 0.52
    print(f'Z = {Z}')
    print('Accept H0 @alpha=0.6: Airfoils are thick')
else:
    print(f'Z = {Z}')
    print('Reject H0 @alpha=0.6: Airfoils are thin')
```

```
Z = -0.042723
Accept H0 @alpha=0.6: Airfoils are thick
```