# LOS_Methodology_pdf

November 14, 2024

[1]:

```
import networkx as nx
import osmnx as ox
from IPython.display import IFrame
import geopandas as gdp
import numpy as np
import pandas as pd
import matplotlib.pyplot as plot
from shapely import wkt
ox.config(use_cache=True, log_console=True)
%matplotlib inline
ox.__version__
```

```
c:\ProgramData\Miniconda3\envs\ox\lib\site-packages\osmnx\utils.py:192:
UserWarning: The `utils.config` function is deprecated and will be removed in a
future release. Instead, use the `settings` module directly to configure a
global setting's value. For example, `ox.settings.log_console=True`.
  warnings.warn(
```

[1]:

```
'1.2.2'
```

[2]:

```
place = "Trier, Germany"
G = ox.graph_from_place(place, network_type="drive")
```

[3]:

```
# impute speed on all edges missing data
G = ox.add_edge_speeds(G)

# calculate travel time (seconds) for all edges
G = ox.add_edge_travel_times(G)
```

[4]:

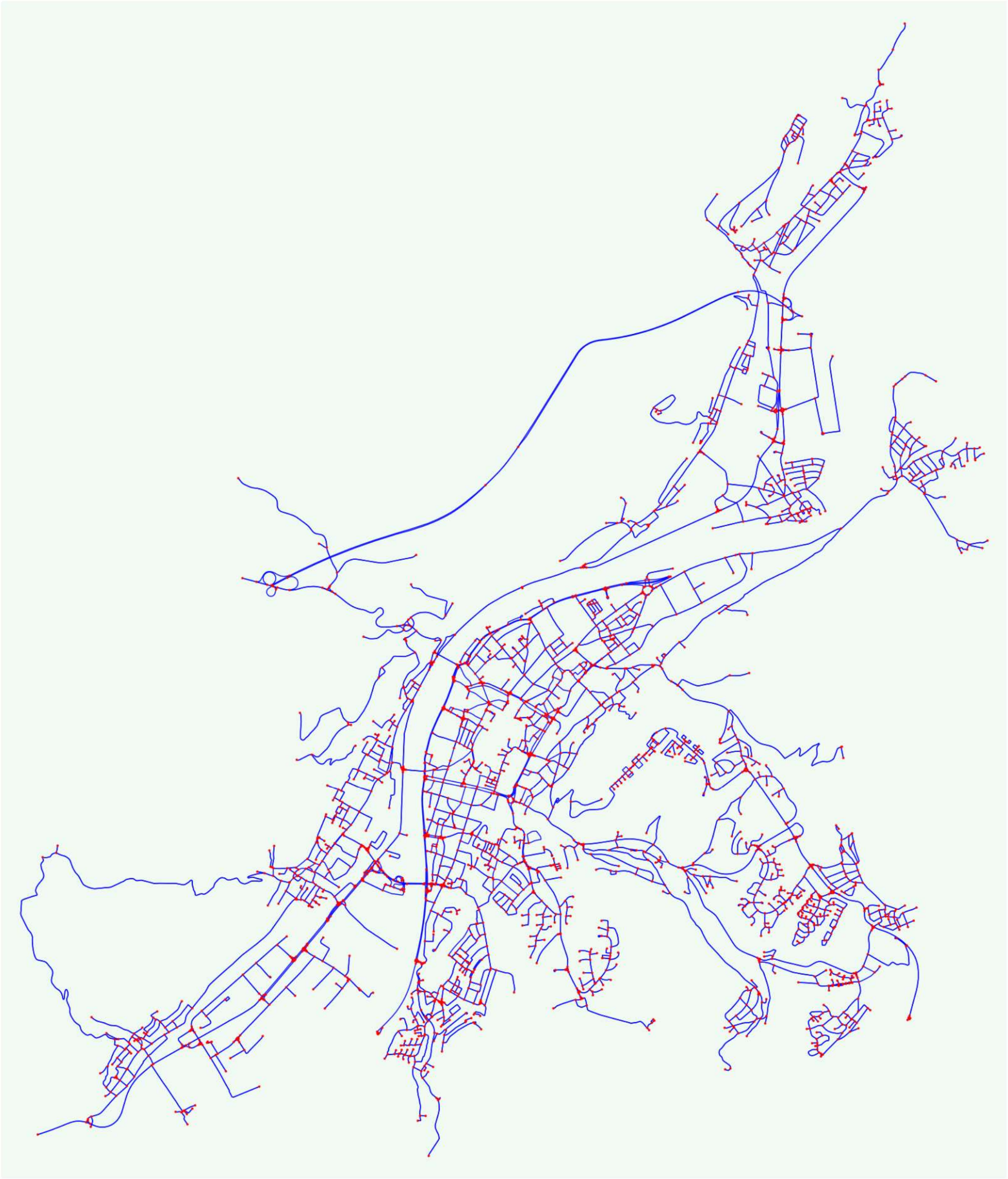
```
## 1. convert the graph to geodataframe
gdf_nodes, gdf_edges = ox.graph_to_gdfs(G)
```

[5]:

```
G_proj = ox.project_graph(G)
nodes_proj = ox.graph_to_gdfs(G_proj, edges=False)
graph_area_m = nodes_proj.unary_union.convex_hull.area
ox.basic_stats(G_proj, area=graph_area_m, clean_int_tol=15)
```

```
[5]: {'n': 2737,
      'm': 6231,
      'k_avg': 4.55316039459262,
      'edge_length_total': 763533.6570000027,
      'edge_length_avg': 122.53790033702498,
      'streets_per_node_avg': 2.701132626963829,
      'streets_per_node_counts': {0: 0, 1: 520, 2: 61, 3: 1888, 4: 256, 5: 9, 6: 3},
      'streets_per_node_proportions': {0: 0.0,
       1: 0.18998903909389842,
       2: 0.022287175739861116,
       3: 0.689806357325539,
       4: 0.09353306540007307,
       5: 0.003288271830471319,
       6: 0.0010960906101571063},
      'intersection_count': 2217,
      'street_length_total': 427981.4179999994,
      'street_segment_count': 3699,
      'street_length_avg': 115.70192430386575,
      'circuity_avg': 1.0816266545095323,
      'self_loop_proportion': 0.010813733441470668,
      'clean_intersection_count': 1507,
      'node_density_km': 25.142187800766045,
      'intersection_density_km': 20.36544769978017,
      'edge_density_km': 7013.849688162131,
      'street_density_km': 3931.4538496872997,
      'clean_intersection_density_km': 13.843360254203299}
```

```
[6]: fig, ax = ox.plot_graph(G, figsize=(30, 50), bgcolor="#f0faf3", node_size=15,␣
      ↪edge_color="b",node_color='r', edge_linewidth=1.5)
```



```
[7]: gdf_nodes.head(5)
```

```
[7]:                      y         x  street_count highway  ref  \
     osmid
     10602396  49.750094  6.637228             4     NaN  NaN
     10602410  49.749518  6.640148             4     NaN  NaN
     10602412  49.753874  6.642488             3     NaN  NaN
```

```
10602431  49.754348  6.644230             3     NaN  NaN
10602432  49.753833  6.645809             3     NaN  NaN

                          geometry
osmid
10602396  POINT (6.63723 49.75009)
10602410  POINT (6.64015 49.74952)
10602412  POINT (6.64249 49.75387)
10602431  POINT (6.64423 49.75435)
10602432  POINT (6.64581 49.75383)
```

[8]:

```
gdf_edges.head(5)
```

[8]:

```
                                         osmid  oneway lanes  \
u        v          key
10602396 268656889  0      [620480498, 6073765]    True     1
         3328610208 0                  44503497    True   NaN
         20909583   0                 113363975    True     1
10602410 3212415597 0                   6073363   False   NaN
         10602396   0     [348744826, 44181036]    True     3

                                          name  \
u        v          key
10602396 268656889  0     [Germanstraße, Neustraße]
         3328610208 0                  Kaiserstraße
         20909583   0                           NaN
10602410 3212415597 0                           NaN
         10602396   0                  Kaiserstraße

                                              highway reversed   length  \
u        v          key
10602396 268656889  0     [residential, living_street]    False  249.956
         3328610208 0                        secondary    False  153.907
         20909583   0                   secondary_link    False   36.470
10602410 3212415597 0                      residential    False   28.040
         10602396   0                        secondary    False  219.652

                         maxspeed  \
u        v          key
10602396 268656889  0          50
         3328610208 0          50
         20909583   0          50
10602410 3212415597 0         NaN
         10602396   0          50

                                                                  geometry  \
u        v          key
```

```
10602396 268656889  0    LINESTRING (6.63723 49.75009, 6.63724 49.75015…
         3328610208 0    LINESTRING (6.63723 49.75009, 6.63711 49.75012…
         20909583   0    LINESTRING (6.63723 49.75009, 6.63717 49.75006…
10602410 3212415597 0    LINESTRING (6.64015 49.74952, 6.64008 49.74938…
         10602396   0    LINESTRING (6.64015 49.74952, 6.64005 49.74955…

                         speed_kph  travel_time    ref width bridge junction  \
u        v          key
10602396 268656889  0         50.0         18.0    NaN   NaN    NaN      NaN
         3328610208 0         50.0         11.1  L 143   NaN    NaN      NaN
         20909583   0         50.0          2.6    NaN   NaN    NaN      NaN
10602410 3212415597 0         33.8          3.0    NaN   NaN    NaN      NaN
         10602396   0         50.0         15.8  L 143   NaN    NaN      NaN

                        access tunnel
u        v          key
10602396 268656889  0      NaN    NaN
         3328610208 0      NaN    NaN
         20909583   0      NaN    NaN
10602410 3212415597 0      NaN    NaN
         10602396   0      NaN    NaN
```

[9]:

```
def shortest_path(origin, destination, G):
    x_orig = origin['lon']
    y_origin = origin['lat']
    x_dest = destination['lon']
    y_dest = destination['lat']
    orig = ox.distance.nearest_nodes(G, X = x_orig, Y = y_origin) # saarstraße
    dest = ox.distance.nearest_nodes(G, X = x_dest, Y = y_dest) # germanstraße,␣
 ↪gervasiusstraße
    route = ox.shortest_path(G, orig, dest, weight = "travel_time")
    #m = ox.plot_route_folium(G, route, weight=10)
    #filepath = r'C:\Users\looka\OneDrive\Desktop\RCS\shortest_1.html'
    #m.save(filepath)
    #IFrame(filepath, width=600, height = 500)
    return route
```

[10]:

```
# getting the nodes of non degreded shortest route
def get_nodes(short_route):
    node_df = gdp.GeoDataFrame()
    for i in short_route:
        node_df = node_df.append((gdf_nodes.loc[[i]]))
    return node_df
```

[11]:

```
def get_edges(short_route):
    edge_df = gdp.GeoDataFrame()
    for i in short_route:
        edge_df = edge_df.append(gdf_edges.loc[(i, slice(None), slice(None)),:])
    return edge_df
```

[13]:

```
# simplify the dataset
def simplify_dataset(edges, short_route):
    new_df = gdp.GeoDataFrame(data=None, index=None, columns=['u', 'v','osmid',␣
 ↪'oneway', 'lanes', 'name', 'highway', 'reversed', 'length',
            'maxspeed', 'geometry'])
    c = 0
    new_route = short_route[0:]
    new_orig = short_route[0]

    for i in new_route:

        for index, j in edges.iterrows():
                if index[0] == new_orig and index[1] == i:
                    src = index[0]
                    dest = index[1]
                    osmid = j['osmid']
                    one_way = j['oneway']
                    lanes = j['lanes']
                    name = j['name']
                    highway = j['highway']
                    reveresed = j['reversed']
                    length = j['length']
                    max_speed = j['maxspeed']
                    geometry = j['geometry']
                    new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' :␣
 ↪osmid, 'oneway': one_way, 'lanes' : lanes, 'name' : name, 'highway' :␣
 ↪highway, 'reversed' : reveresed, 'length' : length,
                                                'maxspeed' : max_speed,␣
 ↪'geometry' : geometry}, ignore_index=True)
        new_orig = i
    return new_df
```

### flooded areas

[14]:

```
polygon = wkt.loads('POLYGON((6.63437 49.763703,  6.638514 49.758059,  6.645114␣
 ↪49.762382,  6.639661 49.767222,  6.636431 49.766156,   6.634395 49.
 ↪763687,        6.63437 49.763703))')
G1 = ox.graph_from_polygon(polygon, network_type='drive')
G1 = ox.add_edge_speeds(G1)
G1 = ox.add_edge_travel_times(G1)
gdf_nodes_G1, gdf_edges_G1 = ox.graph_to_gdfs(G1)
```

```
polygon = wkt.loads('POLYGON((6.639661 49.767222, 6.645114 49.762382, 6.651821␣
 ↪49.767041, 6.64843 49.770796, 6.642915 49.769335, 6.639661 49.767222))')
G2 = ox.graph_from_polygon(polygon, network_type='drive')
G2 = ox.add_edge_speeds(G2)
G2 = ox.add_edge_travel_times(G2)
gdf_nodes_G2, gdf_edges_G2 = ox.graph_to_gdfs(G2)



polygon = wkt.loads('POLYGON((6.62815 49.752611, 6.629232 49.752522, 6.632003␣
 ↪49.759481, 6.629493 49.757208, 6.628173 49.752643, 6.62815 49.752611))')
G4 = ox.graph_from_polygon(polygon, network_type='drive')
G4 = ox.add_edge_speeds(G4)
G4 = ox.add_edge_travel_times(G4)
gdf_nodes_G4, gdf_edges_G4 = ox.graph_to_gdfs(G4)


polygon = wkt.loads('POLYGON((6.627751 49.76079, 6.626486 49.760114, 6.627002␣
 ↪49.762076, 6.632373 49.76647,        6.630744 49.764707, 6.627751 49.
 ↪76079))')
G6 = ox.graph_from_polygon(polygon, network_type='drive')
G6 = ox.add_edge_speeds(G6)
G6 = ox.add_edge_travel_times(G6)
gdf_nodes_G6, gdf_edges_G6 = ox.graph_to_gdfs(G6)


flooded_area = gdf_edges.loc[gdf_edges['name'] == 'Römerbrücke']
flooded_area = flooded_area.append(gdf_edges.loc[gdf_edges['name'] ==␣
 ↪'Kaiser-Wilhelm-Brücke'])
```

```
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\69976662.py:32: FutureWarning:
The frame.append method is deprecated and will be removed from pandas in a
future version. Use pandas.concat instead.
  flooded_area = flooded_area.append(gdf_edges.loc[gdf_edges['name'] == 'Kaiser-
Wilhelm-Brücke'])
```

[15]:

```
gdf_nodes_G1_cops = gdf_nodes_G1.copy(deep=True)
gdf_edges_G1_copy = gdf_edges_G1.copy(deep=True)
gdf_nodes_G2_copy = gdf_nodes_G2.copy(deep=True)
gdf_edges_G2_copy = gdf_edges_G2.copy(deep=True)
gdf_edges_G4_copy = gdf_edges_G4.copy(deep=True)
gdf_nodes_G4_copy = gdf_nodes_G4.copy(deep=True)
gdf_nodes_G6_copy = gdf_nodes_G6.copy(deep=True)
gdf_edges_G6_copy =  gdf_edges_G6.copy(deep = True)
dataset_flooded = flooded_area.copy(deep  =True)

gdf_nodes_G1_cops = gdf_nodes_G1_cops.reset_index()
```

```
gdf_edges_G1_copy = gdf_edges_G1_copy.reset_index()
gdf_nodes_G2_copy = gdf_nodes_G2_copy.reset_index()
gdf_edges_G2_copy = gdf_edges_G2_copy.reset_index()
gdf_edges_G4_copy = gdf_edges_G4_copy.reset_index()
gdf_nodes_G4_copy = gdf_nodes_G4_copy.reset_index()
gdf_nodes_G6_copy = gdf_nodes_G6_copy.reset_index()
gdf_edges_G6_copy = gdf_edges_G6_copy.reset_index()
dataset_flooded = dataset_flooded.reset_index()
```

[17]:

```
dataset_flooded
```

[17]:

```
            u           v  key                                        osmid  \
0    20834070  9265904903    0  [1004246096, 8069945, 8069947, 308038758]
1  7741552929  9265904903    0                                   1004246097
2  9265904903  7741552926    0                                     23069174
3  9265904903    20834070    0  [1004246096, 8069945, 8069947, 308038758]
4    31942123    78273822    0                                      9810650
5    78273822    31942123    0                                      9810650

  oneway   lanes                  name        highway       reversed  \
0  False  [2, 3]            Römerbrücke  unclassified  [False, True]
1   True       1            Römerbrücke  unclassified          False
2   True       1            Römerbrücke  unclassified          False
3  False  [3, 2]            Römerbrücke  unclassified  [False, True]
4  False       3  Kaiser-Wilhelm-Brücke  primary_link           True
5  False       3  Kaiser-Wilhelm-Brücke  primary_link          False

   length maxspeed                                           geometry  \
0  226.349       50  LINESTRING (6.62810 49.75181, 6.62799 49.75181…
1   25.913       50  LINESTRING (6.62461 49.75198, 6.62470 49.75198…
2   26.138       50  LINESTRING (6.62496 49.75198, 6.62489 49.75201…
3  226.349       50  LINESTRING (6.62496 49.75198, 6.62514 49.75196…
4  292.551       50  LINESTRING (6.63364 49.76367, 6.63105 49.76460…
5  292.551       50  LINESTRING (6.63007 49.76494, 6.63011 49.76493…

  speed_kph  travel_time  ref width   bridge junction access tunnel
0      50.0         16.3  NaN   NaN  viaduct      NaN    NaN    NaN
1      50.0          1.9  NaN   NaN      NaN      NaN    NaN    NaN
2      50.0          1.9  NaN   NaN      NaN      NaN    NaN    NaN
3      50.0         16.3  NaN   NaN  viaduct      NaN    NaN    NaN
4      50.0         21.1  NaN   NaN      yes      NaN    NaN    NaN
5      50.0         21.1  NaN   NaN      yes      NaN    NaN    NaN
```

[19]:

```
dataset_flooded = dataset_flooded.append(gdf_edges_G1_copy)
dataset_flooded = dataset_flooded.append(gdf_edges_G2_copy)
dataset_flooded = dataset_flooded.append(gdf_edges_G4_copy)
dataset_flooded = dataset_flooded.append(gdf_edges_G6_copy)
dataset_flooded = dataset_flooded.reset_index()
```

```
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\1228872713.py:1: FutureWarning:
The frame.append method is deprecated and will be removed from pandas in a
future version. Use pandas.concat instead.
  dataset_flooded = dataset_flooded.append(gdf_edges_G1_copy)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\1228872713.py:2: FutureWarning:
The frame.append method is deprecated and will be removed from pandas in a
future version. Use pandas.concat instead.
  dataset_flooded = dataset_flooded.append(gdf_edges_G2_copy)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\1228872713.py:3: FutureWarning:
The frame.append method is deprecated and will be removed from pandas in a
future version. Use pandas.concat instead.
  dataset_flooded = dataset_flooded.append(gdf_edges_G4_copy)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\1228872713.py:4: FutureWarning:
The frame.append method is deprecated and will be removed from pandas in a
future version. Use pandas.concat instead.
  dataset_flooded = dataset_flooded.append(gdf_edges_G6_copy)
```

[20]:
```
dataset_flooded['affected'] = 0
```

[21]:
```
dataset_flooded
```

[21]:
```
     index           u           v  key  \
0        0    20834070  9265904903    0
1        1  7741552929  9265904903    0
2        2  9265904903  7741552926    0
3        3  9265904903    20834070    0
4        4    31942123    78273822    0
..     …           …           …  …
168     11  1368987650  1368987661    0
169     12  1368987650   247384490    0
170     13  1368987661  1368987650    0
171     14  1368987661   469788268    0
172     15  1600176507  1368987650    0

                                         osmid  oneway   lanes  \
0    [1004246096, 8069945, 8069947, 308038758]   False  [2, 3]
1                                   1004246097    True       1
2                                     23069174    True       1
3    [1004246096, 8069945, 8069947, 308038758]   False  [3, 2]
4                                      9810650   False       3
..                                         …      …      …
168                                  146776010   False       2
169                                  122530349    True       1
170                                  146776010   False       2
171                                  153647620   False       3
172                                  146776002    True       1
```

```
                      name       highway       reversed  …  \
0              Römerbrücke  unclassified  [False, True]  …
1              Römerbrücke  unclassified          False  …
2              Römerbrücke  unclassified          False  …
3              Römerbrücke  unclassified  [False, True]  …
4    Kaiser-Wilhelm-Brücke  primary_link           True  …
..                     …           …            …  …
168          Bonner Straße       primary          False  …
169                    NaN  primary_link          False  …
170          Bonner Straße       primary           True  …
171          Bonner Straße       primary          False  …
172          Bonner Straße  primary_link          False  …

                                              geometry speed_kph travel_time  \
0    LINESTRING (6.62810 49.75181, 6.62799 49.75181…      50.0        16.3
1    LINESTRING (6.62461 49.75198, 6.62470 49.75198…      50.0         1.9
2    LINESTRING (6.62496 49.75198, 6.62489 49.75201…      50.0         1.9
3    LINESTRING (6.62496 49.75198, 6.62514 49.75196…      50.0        16.3
4    LINESTRING (6.63364 49.76367, 6.63105 49.76460…      50.0        21.1
..                                                 …       …         …
168    LINESTRING (6.62969 49.76391, 6.62977 49.76400)      50.0         0.9
169  LINESTRING (6.62969 49.76391, 6.62965 49.76388…      50.0         3.1
170    LINESTRING (6.62977 49.76400, 6.62969 49.76391)      50.0         0.9
171  LINESTRING (6.62977 49.76400, 6.62996 49.76420…      30.0         8.6
172    LINESTRING (6.62947 49.76364, 6.62969 49.76391)      50.0         2.4

      ref  width   bridge junction access tunnel affected
0     NaN    NaN  viaduct      NaN    NaN    NaN        0
1     NaN    NaN      NaN      NaN    NaN    NaN        0
2     NaN    NaN      NaN      NaN    NaN    NaN        0
3     NaN    NaN  viaduct      NaN    NaN    NaN        0
4     NaN    NaN      yes      NaN    NaN    NaN        0
..    …    …      …      …    …    …      …
168  B 53    NaN      NaN      NaN    NaN    NaN        0
169   NaN    NaN      NaN      NaN    NaN    NaN        0
170  B 53    NaN      NaN      NaN    NaN    NaN        0
171  B 53    NaN      NaN      NaN    NaN    NaN        0
172  B 53    NaN      NaN      NaN    NaN    NaN        0

[173 rows x 22 columns]
```

[23]:

```
#dataset_flooded.afected = dataset_flooded.afected.astype(int)
dataset_flooded.info()
```

```
<class 'geopandas.geodataframe.GeoDataFrame'>
RangeIndex: 173 entries, 0 to 172
Data columns (total 22 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   index        173 non-null    int64
 1   u            173 non-null    int64
 2   v            173 non-null    int64
 3   key          173 non-null    int64
 4   osmid        173 non-null    object
 5   oneway       173 non-null    bool
 6   lanes        100 non-null    object
 7   name         169 non-null    object
 8   highway      173 non-null    object
 9   reversed     173 non-null    object
 10  length       173 non-null    float64
 11  maxspeed     139 non-null    object
 12  geometry     173 non-null    geometry
 13  speed_kph    173 non-null    float64
 14  travel_time  173 non-null    float64
 15  ref          31 non-null     object
 16  width        0 non-null      object
 17  bridge       4 non-null      object
 18  junction     0 non-null      object
 19  access       0 non-null      object
 20  tunnel       2 non-null      object
 21  affected     173 non-null    int64
dtypes: bool(1), float64(3), geometry(1), int64(5), object(12)
memory usage: 28.7+ KB
```

[24]:
```
dataset_flooded.iloc[0]
```

[24]:
```
index                                                          0
u                                                       20834070
v                                                     9265904903
key                                                            0
osmid                  [1004246096, 8069945, 8069947, 308038758]
oneway                                                     False
lanes                                                     [2, 3]
name                                                 Römerbrücke
highway                                             unclassified
reversed                                           [False, True]
length                                                   226.349
maxspeed                                                      50
geometry       LINESTRING (6.628103 49.7518103, 6.6279926 49…
speed_kph                                                   50.0
travel_time                                                 16.3
ref                                                          NaN
width                                                        NaN
bridge                                                   viaduct
```

```
junction                                                      NaN
access                                                        NaN
tunnel                                                        NaN
affected                                                        0
Name: 0, dtype: object
```

```
[26]: dataset_flooded.columns
```

```
[26]: Index(['index', 'u', 'v', 'key', 'osmid', 'oneway', 'lanes', 'name', 'highway',
             'reversed', 'length', 'maxspeed', 'geometry', 'speed_kph',
             'travel_time', 'ref', 'width', 'bridge', 'junction', 'access', 'tunnel',
             'affected'],
            dtype='object')
```

```
[28]: place = "Trier, Germany"
      tags = {"amenity":["hospital", "fire_station"]}
      gdf = ox.geometries_from_place(place, tags)
      df_hosp_fire_station = gdf.reset_index()
```

```
[29]: df_hosp_fire_station.head(10)
```

```
[29]:   element_type      osmid                                          geometry  \
      0          way   29977497  POLYGON ((6.63277 49.75348, 6.63270 49.75332, …
      1          way   45728831  POLYGON ((6.57463 49.72196, 6.57485 49.72192, …
      2          way  149913385  POLYGON ((6.66586 49.77882, 6.66600 49.77869, …
      3          way  158549398  POLYGON ((6.66156 49.74436, 6.66158 49.74427, …
      4          way  160761230  POLYGON ((6.63799 49.74639, 6.63805 49.74655, …
      5          way  168187882  POLYGON ((6.70830 49.78661, 6.70831 49.78662, …
      6          way  210040946  POLYGON ((6.69331 49.78094, 6.69357 49.78102, …
      7          way  249100012  POLYGON ((6.66942 49.76410, 6.66937 49.76398, …
      8          way  257271169  POLYGON ((6.64269 49.76189, 6.64270 49.76186, …
      9          way  331889795  POLYGON ((6.56189 49.74367, 6.56194 49.74362, …

        emergency wheelchair opening_hours  \
      0       yes        yes          24/7
      1       NaN        NaN           NaN
      2       NaN        NaN           NaN
      3       NaN        NaN           NaN
      4       NaN        NaN           NaN
      5       NaN        NaN           NaN
      6       NaN        NaN           NaN
      7       NaN        NaN           NaN
      8       yes        yes          24/7
      9       NaN        NaN           NaN

                                          operator  \
      0                                        NaN
```

```
1                                  Stadt Trier
2                                  Stadt Trier
3                                          NaN
4               Stadtverwaltung Trier - Amt 37
5                                  Stadt Trier
6                                  Stadt Trier
7                                  Stadt Trier
8 Klinikum Mutterhaus der Borromäerinnen gGmbH
9                                  Stadt Trier

                                          name addr:city addr:country  …  \
0 Klinikum Mutterhaus der Borromäerinnen Trier       NaN          NaN  …
1            Freiwillige Feuerwehr Trier-Zewen     Trier           DE  …
2           Freiwillige Feuerwehr Trier-Biewer     Trier           DE  …
3           Freiwillige Feuerwehr Trier-Olewig     Trier           DE  …
4       Freiwillige Feuerwehr Trier-Stadtmitte     Trier          NaN  …
5            Freiwillige Feuerwehr Trier-Ruwer     Trier          NaN  …
6          Freiwillige Feuerwehr Trier-Pfalzel     Trier           DE  …
7           Freiwillige Feuerwehr Trier-Kürenz     Trier           DE  …
8  Klinikum Mutterhaus der Borromäerinnen Nord     Trier           DE  …
9       Freiwillige Feuerwehr Trier-Herresthal     Trier           DE  …

                                              source toilets:wheelchair  \
0                                                NaN                NaN
1                                                NaN                NaN
2                                                NaN                NaN
3                                                NaN                NaN
4                                                NaN                NaN
5                                                NaN                NaN
6                                                NaN                NaN
7                                                NaN                NaN
8 http://www.mutterhaus.de/klinikum-mutterhaus-n…                 yes
9                                                NaN                NaN

                                     contact:website operator:wikidata ways  \
0                                                NaN               NaN  NaN
1                                                NaN               NaN  NaN
2                                                NaN               NaN  NaN
3                                                NaN               NaN  NaN
4                                                NaN               NaN  NaN
5                                                NaN               NaN  NaN
6                                                NaN               NaN  NaN
7                                                NaN               NaN  NaN
8                                                NaN               NaN  NaN
9 https://feuerwehr.trier.de/freiwillige-feuerwe…             Q3138  NaN

  contact:email contact:fax operator:wikipedia short_name type
```

```
0           NaN         NaN                 NaN        NaN  NaN
1           NaN         NaN                 NaN        NaN  NaN
2           NaN         NaN                 NaN        NaN  NaN
3           NaN         NaN                 NaN        NaN  NaN
4           NaN         NaN                 NaN        NaN  NaN
5           NaN         NaN                 NaN        NaN  NaN
6           NaN         NaN                 NaN        NaN  NaN
7           NaN         NaN                 NaN        NaN  NaN
8           NaN         NaN                 NaN        NaN  NaN
9           NaN         NaN                 NaN        NaN  NaN

[10 rows x 41 columns]
```

[31]:

```
def is_flooded(x, y):
    for i in range(len(dataset_flooded)):
        if (dataset_flooded.iloc[i]['u'] == x) & (dataset_flooded.iloc[i]['v']␣
 ↪== y):
            # a new road is affected by this subedge
            indx  = dataset_flooded.loc[(dataset_flooded['u'] ==  x) &␣
 ↪(dataset_flooded['v'] == y)].index
            val = dataset_flooded.at[indx[0],'affected']
            val = val + 1
            #dataset_flooded.at[indx[0], 'affected'] = new_travel_time
            dataset_flooded.at[indx[0],'affected'] = val
            return 1
            #print(dataset_flooded.iloc[i])
        else:
            continue
    return 0
```

[32]:

```
## we have chosen some random source and destination points for testing purpose
source_lon = [6.622595, 6.628011, 6.626061,6.624403, 6.633208, 6.633875, 6.
 ↪635747, 6.632228, 6.634921, 6.637989, 6.610126525820767,  6.629738836617678]
source_lat = [49.752827, 49.766791, 49.759599, 49.752016, 49.761907, 49.763605,␣
 ↪49.758674, 49.760306, 49.758419, 49.757587, 49.744800134295545, 49.
 ↪73575878875902]

# ,  6.66123869689957, 6.63746359783197,  6.628322630202485, 6.628365545543469,␣
 ↪6.669092204585972]
# , 49.74455054925949, 49.74735137503003, 49.74732364487551, 49.74690769065566,␣
 ↪49.76445785850041

dest_lon = [6.642641, 6.646807, 6.64662, 6.641397, 6.649413, 6.649651542154602,␣
 ↪6.633000389853001,  6.650509848798512, 6.631326691378884, 6.66123869689957,␣
 ↪6.63746359783197,  6.628322630202485]
```

```
dest_lat = [49.760452, 49.761527, 49.76356, 49.760941, 49.760828, 49.
 ↪75023587640828, 49.75472768501972, 49.7611042295648, 49.75799923434407,49.
 ↪74455054925949, 49.74735137503003, 49.74732364487551]
```

[33]:

```
## for every possible source and destination
# source_lat = gdf_nodes['y'].values
# source_lon = gdf_nodes['x'].values

# dest_lat = gdf_nodes['y'].values
# dest_lon = gdf_nodes['x'].values
```

[35]:

```
#def los_method(source_lon, source_lat, dest_lon, dest_lat, gdf_edges,␣
 ↪gdf_nodes):

los_df = pd.DataFrame(data=None, index=None, columns=['u',␣
 ↪'v','name','affected_path','time_deference','LOS'])

gdf_nodes_copy = gdf_nodes.copy(deep=True)
gdf_edges_copy = gdf_edges.copy(deep=True)


origin = {}
destination = {}
for i in range(len(source_lon)):

    origin['lon'] = source_lon[i]
    origin['lat'] = source_lat[i]


    for j in range(len(dest_lon)):

        destination['lon'] = dest_lon[j]
        destination['lat'] = dest_lat[j]
        short_route = shortest_path(origin, destination, G) ### getting the␣
 ↪shortest posssible path
        edges = get_edges(short_route) #### edges of the shortest path

        initial_route_length = int(sum(ox.utils_graph.
 ↪get_route_edge_attributes(G, short_route, "length")))
        initial_travel_time  =  int(sum(ox.utils_graph.
 ↪get_route_edge_attributes(G, short_route, "travel_time")))


        new_df = simplify_dataset(edges, short_route)


        for k in range(len(new_df)):
```

```
        source = new_df.loc[k]['u']
        dest = new_df.loc[k]['v']

        val = is_flooded(source, dest)

        if val == 1:


            select_edge = edges.loc[(new_df.loc[(k),:]['u'], new_df.
↪loc[(k),:]['v'], slice(None)),:]

            temp_df_edges = gdf_edges_copy.copy(deep = True)
            temp_df_nodes = gdf_nodes_copy.copy(deep=True)

            temp_df_edges = temp_df_edges.drop(index=(new_df.loc[(k),:
↪]['u'], new_df.loc[(k),:]['v']))

            new_G = ox.utils_graph.graph_from_gdfs(temp_df_nodes,␣
↪temp_df_edges, graph_attrs=None)

            new_G = ox.add_edge_speeds(new_G)

            new_G = ox.add_edge_travel_times(new_G)


            new_short_path = shortest_path(origin, destination, new_G) # ␣
↪new shortrest path actually represent route


            route_travel_time  =  int(sum(ox.utils_graph.
↪get_route_edge_attributes(G, new_short_path, "travel_time")))

            if ((los_df['u'] == source) & (los_df['v'] == dest)).any() ==␣
↪True:

                indx_los = los_df[(los_df['u'] == source) & (los_df['v'] ==␣
↪dest)].index

                new_travel_time = los_df.loc[indx_los[0]]['time_deference']␣
↪+ (route_travel_time - initial_travel_time)
                los_df.at[indx_los[0], 'time_deference'] = new_travel_time

                indx_affected = dataset_flooded[(dataset_flooded['u'] ==␣
↪source) & (dataset_flooded['v'] == dest)].index
```

```
                    affected_path = dataset_flooded.
↪loc[indx_affected[0]]['affected']

                    los = los_df.loc[indx_los[0]]['time_deference'] /␣
↪affected_path
                    los_df.at[indx_los[0], 'LOS'] = los
                    los_df.at[indx_los[0], 'affected_path'] = affected_path
                    #display(los_df)

                else:
                    indx  = dataset_flooded.loc[(dataset_flooded['u'] == ␣
↪source) & (dataset_flooded['v'] == dest)].index
                    name = dataset_flooded.loc[[indx[0]]]['name']

                    los_df  = los_df.append({'u' : source, 'v' : dest,'name' :␣
↪name, 'affected_path' : 1, 'time_deference': (route_travel_time -␣
↪initial_travel_time), 'LOS' : (route_travel_time - initial_travel_time)},␣
↪ignore_index=True)
                    #display(los_df)
```

```
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\237141962.py:4: FutureWarning:
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C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: The frame.append method is deprecated and will be removed from
pandas in a future version. Use pandas.concat instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Roaming\Python\Python310\site-
packages\pandas\core\dtypes\cast.py:127: ShapelyDeprecationWarning: The array
interface is deprecated and will no longer work in Shapely 2.0. Convert the
'.coords' to a numpy array instead.
  arr = construct_1d_object_array_from_listlike(values)
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```
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C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: In a future version, object-dtype columns with all-bool values
will not be included in reductions with bool_only=True. Explicitly cast to bool
dtype instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: The frame.append method is deprecated and will be removed from
pandas in a future version. Use pandas.concat instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Roaming\Python\Python310\site-
packages\pandas\core\dtypes\cast.py:127: ShapelyDeprecationWarning: The array
interface is deprecated and will no longer work in Shapely 2.0. Convert the
'.coords' to a numpy array instead.
  arr = construct_1d_object_array_from_listlike(values)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: In a future version, object-dtype columns with all-bool values
will not be included in reductions with bool_only=True. Explicitly cast to bool
dtype instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: The frame.append method is deprecated and will be removed from
pandas in a future version. Use pandas.concat instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Roaming\Python\Python310\site-
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interface is deprecated and will no longer work in Shapely 2.0. Convert the
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  arr = construct_1d_object_array_from_listlike(values)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: In a future version, object-dtype columns with all-bool values
will not be included in reductions with bool_only=True. Explicitly cast to bool
dtype instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: The frame.append method is deprecated and will be removed from
pandas in a future version. Use pandas.concat instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Roaming\Python\Python310\site-
packages\pandas\core\dtypes\cast.py:127: ShapelyDeprecationWarning: The array
interface is deprecated and will no longer work in Shapely 2.0. Convert the
'.coords' to a numpy array instead.
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C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
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will not be included in reductions with bool_only=True. Explicitly cast to bool
dtype instead.
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one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: The frame.append method is deprecated and will be removed from
pandas in a future version. Use pandas.concat instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Roaming\Python\Python310\site-
packages\pandas\core\dtypes\cast.py:127: ShapelyDeprecationWarning: The array
interface is deprecated and will no longer work in Shapely 2.0. Convert the
'.coords' to a numpy array instead.
  arr = construct_1d_object_array_from_listlike(values)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: In a future version, object-dtype columns with all-bool values
will not be included in reductions with bool_only=True. Explicitly cast to bool
dtype instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: The frame.append method is deprecated and will be removed from
pandas in a future version. Use pandas.concat instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
C:\Users\looka\AppData\Roaming\Python\Python310\site-
packages\pandas\core\dtypes\cast.py:127: ShapelyDeprecationWarning: The array
interface is deprecated and will no longer work in Shapely 2.0. Convert the
'.coords' to a numpy array instead.
  arr = construct_1d_object_array_from_listlike(values)
C:\Users\looka\AppData\Local\Temp\ipykernel_1580\3982146179.py:24:
FutureWarning: In a future version, object-dtype columns with all-bool values
will not be included in reductions with bool_only=True. Explicitly cast to bool
dtype instead.
  new_df = new_df.append({'u' : src, 'v' : dest, 'osmid' : osmid, 'oneway':
one_way, 'lanes' : lanes, 'name' : name, 'highway' : highway, 'reversed' :
reveresed, 'length' : length,
```

[37]:
```
los_df
```

[37]:
```
            u           v                                              name  \
0  7741552929  9265904903        1    Römerbrücke
Name: name, dtype: object
1  9265904903    20834070        3    Römerbrücke
Name: name, dtype: object
2  3258357802  3258357818      151    Krahnenufer
Name: name, dtype: object
3  3258357818  3258357805    153    Katharinenufer
```

```
Name: name, dtype: object
4   3258357805  9051264526    152    Katharinenufer
Name: name, dtype: object
5   1651827294   344111833  62    Friedrich-Ebert-Allee
Name: name, dtype:…
6    344111833    20833915  50    Friedrich-Ebert-Allee
Name: name, dtype:…
7     20833915  2897253810           8    Nordallee
Name: name, dtype: object
8   2897253810  3889178192          66    Nordallee
Name: name, dtype: object
9   3889178192   247373153          72    Nordallee
Name: name, dtype: object
10   247373153    20833912          45    Nordallee
Name: name, dtype: object
11    60366894    89989804  12    Ascoli Piceno Straße
Name: name, dtype: …
12    89989804  1622444428  13    Ascoli Piceno Straße
Name: name, dtype: …
13  1622444428  1561307571  61    Ascoli Piceno Straße
Name: name, dtype: …
14  1623976380  3254826012  99    Zurmaiener Straße
Name: name, dtype: object
15  3254826012  3255219365    101    Zeughausstraße
Name: name, dtype: object
16  3255219365   246827875    107    Zeughausstraße
Name: name, dtype: object
17   246827875   281525990     80    Zeughausstraße
Name: name, dtype: object
18   281525990  3702183953  92    Kloschinskystraße
Name: name, dtype: object
19  3702183953  3702183957  115    Kloschinskystraße
Name: name, dtype: ob…
20  3702183957  9513937746  120    Benediktinerstraße
Name: name, dtype: o…
21    78273822    31942123  5    Kaiser-Wilhelm-Brücke
Name: name, dtype: …
22  3258357818  3258357826      154    Böhmerstraße
Name: name, dtype: object
23   292256500   292256497     166    Kölner Straße
Name: name, dtype: object
24   292256497   247384491     165    Kölner Straße
Name: name, dtype: object
25   247384491   247384490  160    Bitburger Straße
Name: name, dtype: object
26   247384490   259692842  159    Bitburger Straße
Name: name, dtype: object
```

```
27   344115654   344114270        52    Oerenstraße
Name: name, dtype: object
28   344114270   247367976  51    Bruchhausenstraße
Name: name, dtype: object
29   247367976  2897253810  42    Bruchhausenstraße
Name: name, dtype: object
30   247367976    20833915  43    Bruchhausenstraße
Name: name, dtype: object
31    20833915  3307821765        7    Lindenstraße
Name: name, dtype: object
32  3307821765   247367269       67    Lindenstraße
Name: name, dtype: object
33   247367269   246824042       41    Lindenstraße
Name: name, dtype: object
34   246824042    20833916       39    Lindenstraße
Name: name, dtype: object
35    20833916  3310626162        9    Lindenstraße
Name: name, dtype: object
36  3310626162   295985903  68    Zurmaiener Straße
Name: name, dtype: object
37   295985903   246824016  48    Zurmaiener Straße
Name: name, dtype: object
38   246824016   246824017  17    Zurmaiener Straße
Name: name, dtype: object
39   246824017   246824018  19    Zurmaiener Straße
Name: name, dtype: object
40   246824018   246824024         21    Maarstraße
Name: name, dtype: object
41   246824024   246824025         27    Maarstraße
Name: name, dtype: object
42   246824025   246824026         29    Maarstraße
Name: name, dtype: object
43  3702183950   246828507  114    Kloschinskystraße
Name: name, dtype: ob…
44   246828507  4060225101  83    Kloschinskystraße
Name: name, dtype: object
45  4060225101  9513937760        126    Bachstraße
Name: name, dtype: object
46  9513937760  9513937746        147    Bachstraße
Name: name, dtype: object
47  9051264525  3258357805      155    Böhmerstraße
Name: name, dtype: object

   affected_path time_deference         LOS
0             42           3339        79.5
1             42           3339        79.5
2             19            103    5.421053
```

| | | | |
|---|---|---|---|
| 3 | 19 | 103 | 5.421053 |
| 4 | 19 | 103 | 5.421053 |
| 5 | 46 | 1519 | 33.021739 |
| 6 | 46 | 1519 | 33.021739 |
| 7 | 46 | 1519 | 33.021739 |
| 8 | 63 | 5446 | 86.444444 |
| 9 | 63 | 5446 | 86.444444 |
| 10 | 51 | 3753 | 73.588235 |
| 11 | 9 | 107 | 11.888889 |
| 12 | 9 | 107 | 11.888889 |
| 13 | 9 | 107 | 11.888889 |
| 14 | 9 | 107 | 11.888889 |
| 15 | 9 | 8 | 0.888889 |
| 16 | 9 | 107 | 11.888889 |
| 17 | 9 | 4 | 0.444444 |
| 18 | 9 | 4 | 0.444444 |
| 19 | 9 | 107 | 11.888889 |
| 20 | 9 | 107 | 11.888889 |
| 21 | 18 | 1929 | 107.166667 |
| 22 | 4 | 196 | 49.0 |
| 23 | 6 | 127 | 21.166667 |
| 24 | 6 | 181 | 30.166667 |
| 25 | 6 | 24 | 4.0 |
| 26 | 6 | 24 | 4.0 |
| 27 | 20 | 700 | 35.0 |
| 28 | 20 | 700 | 35.0 |
| 29 | 17 | 30 | 1.764706 |
| 30 | 3 | 7 | 2.333333 |
| 31 | 3 | 7 | 2.333333 |
| 32 | 3 | 7 | 2.333333 |
| 33 | 3 | 78 | 26.0 |
| 34 | 3 | 78 | 26.0 |
| 35 | 3 | 78 | 26.0 |
| 36 | 3 | 48 | 16.0 |
| 37 | 3 | 48 | 16.0 |
| 38 | 3 | 3 | 1.0 |
| 39 | 3 | 3 | 1.0 |
| 40 | 3 | 3 | 1.0 |
| 41 | 3 | 3 | 1.0 |
| 42 | 3 | 3 | 1.0 |
| 43 | 3 | 48 | 16.0 |
| 44 | 3 | 48 | 16.0 |
| 45 | 3 | 43 | 14.333333 |
| 46 | 6 | 86 | 14.333333 |
| 47 | 5 | 247 | 49.4 |

[38]:

```
los_df = los_df.rename(columns={'time_deference' : 'time_difference'})
los_df
```

[38]:

```
             u           v                                               name  \
0   7741552929  9265904903         1    Römerbrücke
Name: name, dtype: object
1   9265904903    20834070         3    Römerbrücke
Name: name, dtype: object
2   3258357802  3258357818       151    Krahnenufer
Name: name, dtype: object
3   3258357818  3258357805    153    Katharinenufer
Name: name, dtype: object
4   3258357805  9051264526    152    Katharinenufer
Name: name, dtype: object
5   1651827294   344111833  62    Friedrich-Ebert-Allee
Name: name, dtype:…
6    344111833    20833915  50    Friedrich-Ebert-Allee
Name: name, dtype:…
7     20833915  2897253810           8    Nordallee
Name: name, dtype: object
8   2897253810  3889178192          66    Nordallee
Name: name, dtype: object
9   3889178192   247373153          72    Nordallee
Name: name, dtype: object
10   247373153    20833912          45    Nordallee
Name: name, dtype: object
11    60366894    89989804  12    Ascoli Piceno Straße
Name: name, dtype: …
12    89989804  1622444428  13    Ascoli Piceno Straße
Name: name, dtype: …
13  1622444428  1561307571  61    Ascoli Piceno Straße
Name: name, dtype: …
14  1623976380  3254826012  99    Zurmaiener Straße
Name: name, dtype: object
15  3254826012  3255219365    101    Zeughausstraße
Name: name, dtype: object
16  3255219365   246827875    107    Zeughausstraße
Name: name, dtype: object
17   246827875   281525990     80    Zeughausstraße
Name: name, dtype: object
18   281525990  3702183953  92    Kloschinskystraße
Name: name, dtype: object
19  3702183953  3702183957  115    Kloschinskystraße
Name: name, dtype: ob…
20  3702183957  9513937746  120    Benediktinerstraße
Name: name, dtype: o…
21    78273822    31942123  5    Kaiser-Wilhelm-Brücke
```

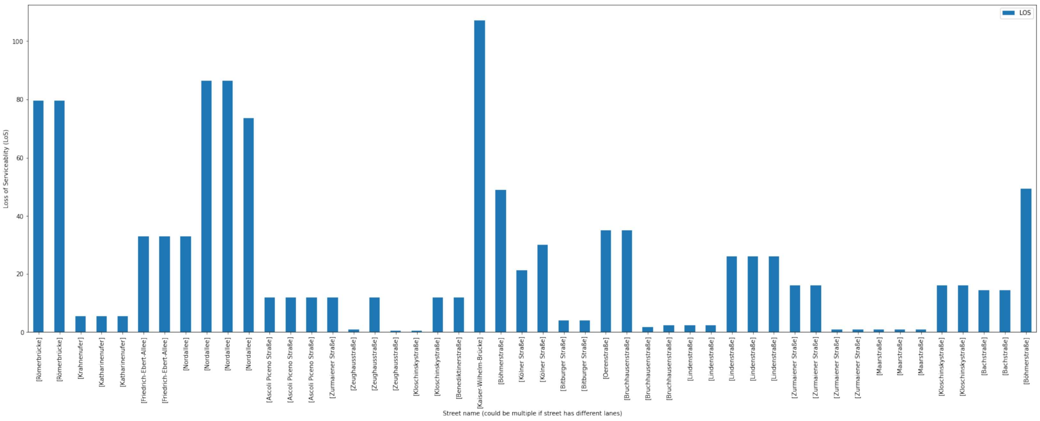
```
Name: name, dtype: …
22  3258357818  3258357826      154    Böhmerstraße
Name: name, dtype: object
23   292256500   292256497     166    Kölner Straße
Name: name, dtype: object
24   292256497   247384491     165    Kölner Straße
Name: name, dtype: object
25   247384491   247384490  160    Bitburger Straße
Name: name, dtype: object
26   247384490   259692842  159    Bitburger Straße
Name: name, dtype: object
27   344115654   344114270        52    Oerenstraße
Name: name, dtype: object
28   344114270   247367976  51    Bruchhausenstraße
Name: name, dtype: object
29   247367976  2897253810  42    Bruchhausenstraße
Name: name, dtype: object
30   247367976    20833915  43    Bruchhausenstraße
Name: name, dtype: object
31    20833915  3307821765        7    Lindenstraße
Name: name, dtype: object
32  3307821765   247367269       67    Lindenstraße
Name: name, dtype: object
33   247367269   246824042       41    Lindenstraße
Name: name, dtype: object
34   246824042    20833916       39    Lindenstraße
Name: name, dtype: object
35    20833916  3310626162        9    Lindenstraße
Name: name, dtype: object
36  3310626162   295985903  68    Zurmaiener Straße
Name: name, dtype: object
37   295985903   246824016  48    Zurmaiener Straße
Name: name, dtype: object
38   246824016   246824017  17    Zurmaiener Straße
Name: name, dtype: object
39   246824017   246824018  19    Zurmaiener Straße
Name: name, dtype: object
40   246824018   246824024         21    Maarstraße
Name: name, dtype: object
41   246824024   246824025         27    Maarstraße
Name: name, dtype: object
42   246824025   246824026         29    Maarstraße
Name: name, dtype: object
43  3702183950   246828507  114    Kloschinskystraße
Name: name, dtype: ob…
44   246828507  4060225101  83    Kloschinskystraße
Name: name, dtype: object
```

```
45  4060225101  9513937760        126    Bachstraße
Name: name, dtype: object
46  9513937760  9513937746        147    Bachstraße
Name: name, dtype: object
47  9051264525  3258357805      155    Böhmerstraße
Name: name, dtype: object

   affected_path time_difference         LOS
0             42            3339        79.5
1             42            3339        79.5
2             19             103    5.421053
3             19             103    5.421053
4             19             103    5.421053
5             46            1519   33.021739
6             46            1519   33.021739
7             46            1519   33.021739
8             63            5446   86.444444
9             63            5446   86.444444
10            51            3753   73.588235
11             9             107   11.888889
12             9             107   11.888889
13             9             107   11.888889
14             9             107   11.888889
15             9               8    0.888889
16             9             107   11.888889
17             9               4    0.444444
18             9               4    0.444444
19             9             107   11.888889
20             9             107   11.888889
21            18            1929  107.166667
22             4             196        49.0
23             6             127   21.166667
24             6             181   30.166667
25             6              24         4.0
26             6              24         4.0
27            20             700        35.0
28            20             700        35.0
29            17              30    1.764706
30             3               7    2.333333
31             3               7    2.333333
32             3               7    2.333333
33             3              78        26.0
34             3              78        26.0
35             3              78        26.0
36             3              48        16.0
37             3              48        16.0
38             3               3         1.0
```

```
39             3              3         1.0
40             3              3         1.0
41             3              3         1.0
42             3              3         1.0
43             3             48        16.0
44             3             48        16.0
45             3             43   14.333333
46             6             86   14.333333
47             5            247        49.4
```

[42]:
```
ax = los_df.plot.bar(x='name', y='LOS',figsize = [30,10])
plot.xlabel('Street name (could be multiple if street has different lanes)')
plot.ylabel('Loss of Serviceablity (LoS)')
plot.show(block=True)
```



[47]:
```
los_df['name']=los_df['name'].astype(str)
los_df['affected_path']=los_df['affected_path'].astype(int)
los_df['time_difference']=los_df['time_difference'].astype(int)
los_df['LOS']=los_df['LOS'].astype(float)
```

[59]:
```
final_df = los_df
final_df = final_df.sort_values(by = ['LOS'], ascending= False)
final_df
most_los = final_df.head(10)
less_los = final_df.tail(10)
```

[65]:
```
final_df
```

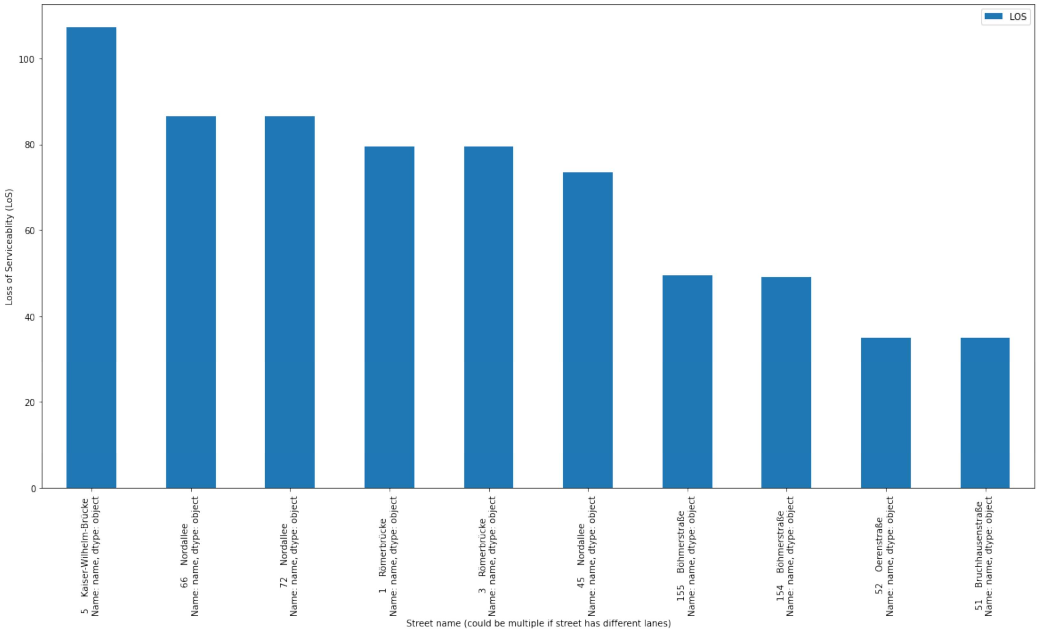
[65]:
```
              u           v                                          name  \
21     78273822    31942123  5    Kaiser-Wilhelm-Brücke\nName: name, dtype:…
8    2897253810  3889178192         66     Nordallee\nName: name, dtype: object
```

```
9   3889178192   247373153         72    Nordallee\nName: name, dtype: object
0   7741552929  9265904903        1    Römerbrücke\nName: name, dtype: object
1   9265904903    20834070        3    Römerbrücke\nName: name, dtype: object
10   247373153    20833912         45    Nordallee\nName: name, dtype: object
47  9051264525  3258357805     155    Böhmerstraße\nName: name, dtype: object
22  3258357818  3258357826     154    Böhmerstraße\nName: name, dtype: object
27   344115654   344114270       52    Oerenstraße\nName: name, dtype: object
28   344114270   247367976  51    Bruchhausenstraße\nName: name, dtype: ob…
6    344111833    20833915  50    Friedrich-Ebert-Allee\nName: name, dtype…
7     20833915  2897253810          8    Nordallee\nName: name, dtype: object
5   1651827294   344111833  62    Friedrich-Ebert-Allee\nName: name, dtype…
24   292256497   247384491    165    Kölner Straße\nName: name, dtype: object
35    20833916  3310626162       9    Lindenstraße\nName: name, dtype: object
34   246824042    20833916      39    Lindenstraße\nName: name, dtype: object
33   247367269   246824042      41    Lindenstraße\nName: name, dtype: object
23   292256500   292256497    166    Kölner Straße\nName: name, dtype: object
44   246828507  4060225101  83    Kloschinskystraße\nName: name, dtype: ob…
43  3702183950   246828507  114    Kloschinskystraße\nName: name, dtype: o…
37   295985903   246824016  48    Zurmaiener Straße\nName: name, dtype: ob…
36  3310626162   295985903  68    Zurmaiener Straße\nName: name, dtype: ob…
46  9513937760  9513937746       147    Bachstraße\nName: name, dtype: object
45  4060225101  9513937760       126    Bachstraße\nName: name, dtype: object
16  3255219365   246827875   107    Zeughausstraße\nName: name, dtype: object
20  3702183957  9513937746  120    Benediktinerstraße\nName: name, dtype: …
11    60366894    89989804  12    Ascoli Piceno Straße\nName: name, dtype:…
13  1622444428  1561307571  61    Ascoli Piceno Straße\nName: name, dtype:…
14  1623976380  3254826012  99    Zurmaiener Straße\nName: name, dtype: ob…
12    89989804  1622444428  13    Ascoli Piceno Straße\nName: name, dtype:…
19  3702183953  3702183957  115    Kloschinskystraße\nName: name, dtype: o…
2   3258357802  3258357818      151    Krahnenufer\nName: name, dtype: object
4   3258357805  9051264526   152    Katharinenufer\nName: name, dtype: object
3   3258357818  3258357805   153    Katharinenufer\nName: name, dtype: object
26   247384490   259692842  159    Bitburger Straße\nName: name, dtype: ob…
25   247384491   247384490  160    Bitburger Straße\nName: name, dtype: ob…
32  3307821765   247367269      67    Lindenstraße\nName: name, dtype: object
31    20833915  3307821765       7    Lindenstraße\nName: name, dtype: object
30   247367976    20833915  43    Bruchhausenstraße\nName: name, dtype: ob…
29   247367976  2897253810  42    Bruchhausenstraße\nName: name, dtype: ob…
38   246824016   246824017  17    Zurmaiener Straße\nName: name, dtype: ob…
39   246824017   246824018  19    Zurmaiener Straße\nName: name, dtype: ob…
40   246824018   246824024        21    Maarstraße\nName: name, dtype: object
41   246824024   246824025        27    Maarstraße\nName: name, dtype: object
42   246824025   246824026        29    Maarstraße\nName: name, dtype: object
15  3254826012  3255219365   101    Zeughausstraße\nName: name, dtype: object
17   246827875   281525990    80    Zeughausstraße\nName: name, dtype: object
18   281525990  3702183953  92    Kloschinskystraße\nName: name, dtype: ob…
```

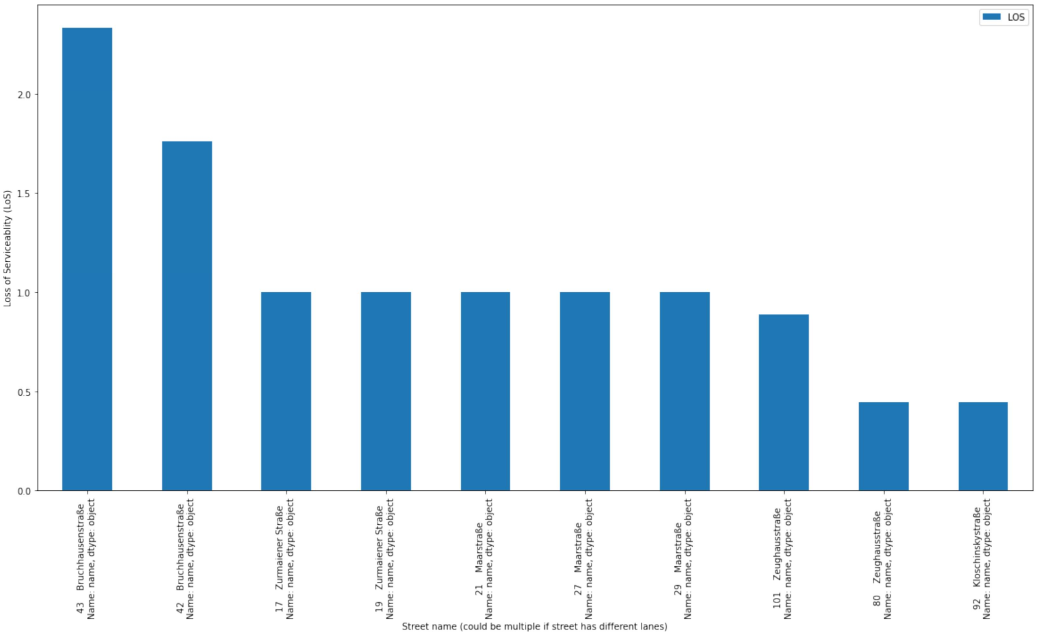
```
    affected_path  time_difference         LOS
21             18             1929  107.166667
8              63             5446   86.444444
9              63             5446   86.444444
0              42             3339   79.500000
1              42             3339   79.500000
10             51             3753   73.588235
47              5              247   49.400000
22              4              196   49.000000
27             20              700   35.000000
28             20              700   35.000000
6              46             1519   33.021739
7              46             1519   33.021739
5              46             1519   33.021739
24              6              181   30.166667
35              3               78   26.000000
34              3               78   26.000000
33              3               78   26.000000
23              6              127   21.166667
44              3               48   16.000000
43              3               48   16.000000
37              3               48   16.000000
36              3               48   16.000000
46              6               86   14.333333
45              3               43   14.333333
16              9              107   11.888889
20              9              107   11.888889
11              9              107   11.888889
13              9              107   11.888889
14              9              107   11.888889
12              9              107   11.888889
19              9              107   11.888889
2              19              103    5.421053
4              19              103    5.421053
3              19              103    5.421053
26              6               24    4.000000
25              6               24    4.000000
32              3                7    2.333333
31              3                7    2.333333
30              3                7    2.333333
29             17               30    1.764706
38              3                3    1.000000
39              3                3    1.000000
40              3                3    1.000000
41              3                3    1.000000
42              3                3    1.000000
15              9                8    0.888889
```

```
17              9                 4    0.444444
18              9                 4    0.444444
```

[62]:
```
ax = most_los.plot.bar(x='name', y='LOS',figsize = [20,10])
plot.xlabel('Street name (could be multiple if street has different lanes)')
plot.ylabel('Loss of Serviceablity (LoS)')
plot.show(block=True)
```



[64]:
```
ax = less_los.plot.bar(x='name', y='LOS',figsize = [20,10])
plot.xlabel('Street name (could be multiple if street has different lanes)')
plot.ylabel('Loss of Serviceablity (LoS)')
plot.show(block=True)
```


LOS
2.0
1.5
1.0
0.5
0.0
Loss of Serviceablity (LoS)
43 Bruchhausenstraße
Name: name, dtype: object
42 Bruchhausenstraße
Name: name, dtype: object
17 Zurmaiener Straße
Name: name, dtype: object
19 Zurmaiener Straße
Name: name, dtype: object
21 Maarstraße
Name: name, dtype: object
27 Maarstraße
Name: name, dtype: object
29 Maarstraße
Name: name, dtype: object
101 Zeughausstraße
Name: name, dtype: object
80 Zeughausstraße
Name: name, dtype: object
92 Kloschinskystraße
Name: name, dtype: object
Street name (could be multiple if street has different lanes)