Exercise – Geodata Transformation & Analysis

Introduction

> *Remember!*
> ***Geodata Transformation and Analysis are dealing with the fourth 'step' of the GIS definition by Burrough (1986).***
> ***The outcome of the analyses are used for Presentation (= 5th step).***
>
> ***Geodata: Capture → Storing → Retrival → Transformation & Analysis → Presentation.***

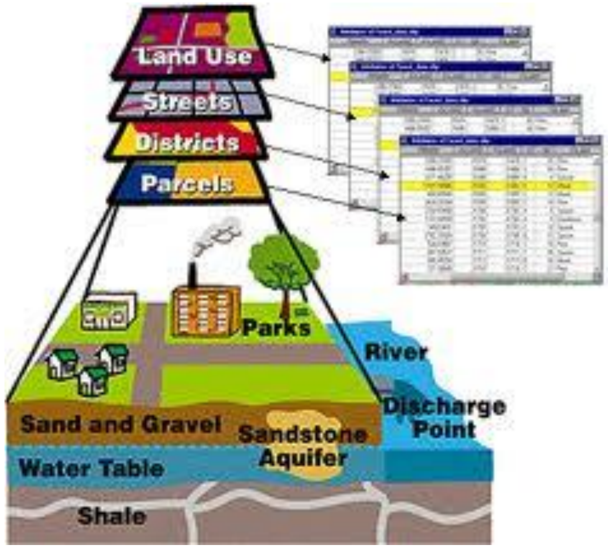
What is Geodata Transformation?

The Geodata Transformation (or Geodata Processing) functions are fundamental to GIS.
Usually these are the functions that spring to mind when you are trying to explain the use of GIS in various fields.
By transformation of geodata it is possible to answer spatial questions like:

- Which houses within a distance of 100m from the river, are situated on clay soil?

- Where is the optimal site to locate the new airport, when you consider factors like proximity to customers and infrastructure, as well as noise propagation (towards nearby residential areas and wildlife sanctuaries)?

This exercise is divided into three main tasks (Task A-C).
Each task involves one of the geodatasets (point, line and polygon), which you digitized in a previous exercise.
During each task you will conduct **Geodata Transformation** in order to answer a specific spatial question (**Analysis**).
Finally, at the end of each task you will display the result of your analysis as a Map Layout (**Presentation**).
The Map Layouts will be saved as image files.



This is yet another 'cook book style' of exercise.
However, this time <u>we expect more from you</u>.
Up till now you have literally been escorted through the basic ArcGIS Pro functionalities. Some of them several times.
In this exercise you will find more instructions like 'use your skills to…'.
Principally, you have two ways to go from there:

- Either you remember how to do it, or
- You may turn back and find the instructions in one of the earlier exercises.

As a last resort, you may always rely on the GIS exercise assistants. This is not an advisable option, though.
Not being able to solve a certain task by yourself, will leave you less well-prepared for the Project and the Exam.
Assistance will be provided for you during the Project too, by your assigned Project Advisor.
But, this support will not be as instant as during the exercises.
So, becoming more self-reliant with ArcGIS Pro and geoprocessing will be of tremendous value.

Objective

Aim:

The exercise will provide you with a useful toolset, that you may use to extract critical pieces of data to be used for analysis and decision-making.
Most importantly, this exercise serves as the first step, possibly an 'eye-opener', towards the potentials of GIS analysis.

This is a splendid opportunity for you to reflect upon the use of GIS, and to 'conjure up' brilliant ideas for your Project!

During the exercise you will be introduced to a variety of geodata transformation/processing techniques.
Most of them are available in any GIS software package, and therefore relevant to you independently of the GIS software your future employer may happen to provide.

More specifically, during this exercise you will:

- Get insight into some of the more common geodata transformation functionalities:
  - Proximity (*e.g.* Buffer, Near)
  - Overlay (*e.g.* Intersect, Identity, Union and Clip)
- Be introduced to the ArcGIS Pro toolset application – the Geoprocessing pane.
- Learn how to create summary statistics.
- Practise your skills to produce informative and nice map layouts (including more elaborate symbology).

Moreover, in a previous exercise you were introduced to four techniques to:

  - *Select* features from your geodata.
  - *Add* descriptive data to your Attribute Table/geodatabase.
- Now you will be introduced to yet another technique to select geodata and one to add data to your database.

Conclusion

To wrap up:
This exercise serves as an 'eye-opener' to you. Hopefully it will give you inspiration to your Project.
The exercise also serves as a preparation for you to be able to stand on your own two feet, in time for the Project.

- Good Luck

Exercise

Task A

Task A.

As an employee at the Municipal Traffic Administration office you will take on the task to gather data on the amount of potential customers within walking distance from a Copenhagen metro station.
The data would be of significance to a decision whether to build a new station between two existing stations.

Spatial Question: **How many people live within walking distance of a Copenhagen metro station?**

Geodata requirement:

Kvadratnettet =
National data provided by the 'Danmarks Statistik' (Statistics Denmark in English) of a maximum resolution of 100m x 100m

- The point geodata of metro stations generated by digitizing in an earlier exercise.
- A recent orthophoto or topographical map (as background).
- Geodata representing the population size in 100m x 100m squares (the so-called 'Kvadratnettet').

(If you did not digitize the metro stations, you may use whatever point geodata you digitized, to answer this question.)

1. Start a new ArcGIS Pro project.

   a) Name it and save it to a familiar location, *e.g.* your H/T drive.

   b) From the IGN Geodata Library, add a recent orthophoto or a topographic map best suited for large-scale maps (*i.e.* the *TopographicMap_25k…*).

TopographicMap_25k =
The Danish Topographical Map of '25k' is best suited at scale 1:25000

   c) Add your point feature class from the previous exercise (Fig. 1).

IMPORTANT! ➔ ➔ ➔ ➔ ➔

   Note that this feature class still is stored in the geodatabase (.gdb) of the previous exercise.
   It is a good idea to keep all the geodata to be used, inside the present project.

Export geodata

   d) Make a copy of the point feature class (store it in the .gdb of this project), and add the copy to the Map view.

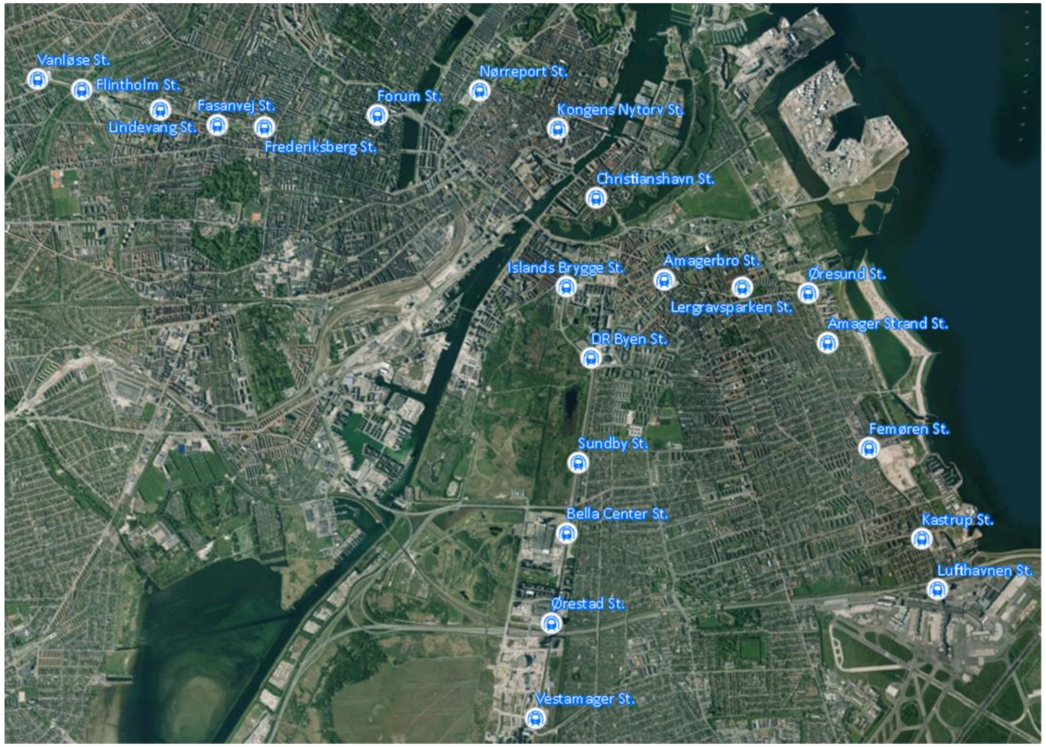


Fig. 1 The Copenhagen Line M1/M2 metro stations (point geodata) on top of a recent orthophoto.

Exercise - Task A

The Statistics Denmark is the public 'institute' in Denmark,
where much of the statistics associated with the national registries are compiled.

CPR =
The Central Citizen Registry
('Det Centrale PersonRegister')

One such registry is the CPR – the Central Citizen Registry ('Det Centrale PersonRegister' in Danish).
This registry contains data about all the citizens of Denmark, their personal ID numbers, home addresses etc.

GDPR = ***General Data Protection Regulation***

So, using address data, there is the potential to generate *point geodata* representing the location of all Danish citizens.
Although it is possible to generate such geodata, does not mean you may do so, at least *not at the level of the individual*.
According to the Danish Personal Data Protection Act and the EU GDPR (the General Data Protection Regulation)
you may *not* publish data that leads to a particular person, for reasons of integrity.

The solution to this dilemma is to aggregate the data on the individual citizens into larger geographical units or blocks.
As a result, with data on a block-level, you are not any longer able to track down data connected to a specific person.
And, with this kind of arrangement you may enjoy valuable geodata such as the population size within a certain block.

Kvadratnettet
National data provided by the 'Danmarks Statistik' (Statistics Denmark in Danish) of a maximum resolution of 100m x 100m

The geographical blocks are called the 'Kvadratnettet' (or the 'Block Grid' bluntly translated into English).
The IGN is keeping location data of the Danish citizens at the resolution of 100m x 100m blocks.
This is the best resolution of population geodata you can get in Denmark, and it means that you may find out the
population size of nearly every populated hectare of the country.

Hectare = 100m x 100m

As we told you, the original geometry of the population size geodata is *points* (representing an area of 100m x 100m).
We have transformed the point geodata for you into their correct geometry type – polygons (*i.e.* 10 000m² blocks).

2. You will have a brief look at the block population geodata representing the Copenhagen area.

a) From ***I:\SCIENCE-IGN-CGD-UVMAT/GIS_course/Exercises/ArcGIS_Pro/Exercise_GeodataTransformation_Analysis/Geodata/***:
Copy the *Kvadratnet.gdb* geodatabase and Paste it to your project folder on the H/T drive.

The population data is from the national census in 2016

b) Add the *Kvadratnet_Popsize_Cph* feature class from the *Kvadratnet.gdb* .

c) Use your skills to select one or a few of the 'blocks' in the 'Kvadratnettet' map layer.

d) Then zoom in closer to that specific neighbourhood.

e) Make the blocks transparent, and try to emphasize the outlines of the polygons (Fig. 2, next page).

Exercise- Task A

3. Next you will explore the database of the map layer you added, to see what kind of data it contains.

   a) Open the Attribute Table of the 'Kvadratnettet' layer. It contains several columns (Fig. 2). The one of most interest here is the 'Pers' column. 'Pers' is representing the number of people with a home address within a certain 100m x 100m block. ('Hustande' is the equivalent of household.)

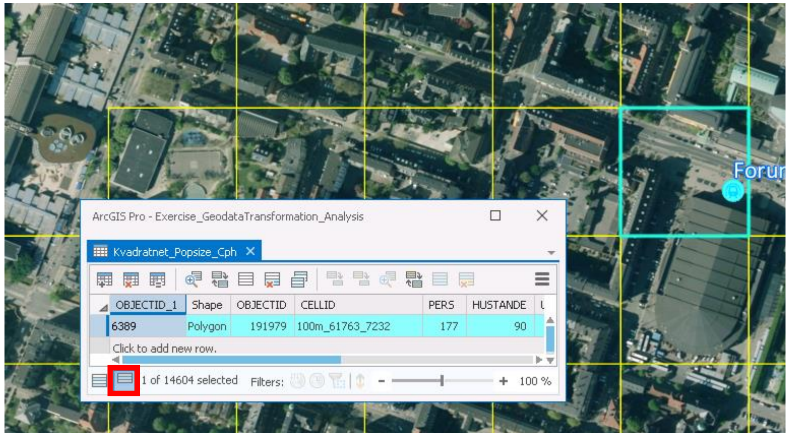


Fig. 2 The 'Kvadratnettet' geodata with its Attribute Table, presenting the population size in 100m x 100m blocks. The 'Kvadratnettet' block polygon feature located at the Forum metro station is selected.

Show selected features in the Attribute Table

   b) In the lower panel of the Attribute Table, click the Show Selected Records button (Fig. 2, red box). Now, only the block/s you selected are visible in the Attribute Table. How many people are living in the blocks you selected? How many households?

In the Introduction we announced that you would be presented to yet another technique to select geodata. This technique is called Select By Location, and it involves the use of another map layer present in the Contents pane.

[Select By Location]()

4. You will use your point map layer (*i.e.* the Metro stations) to select block/s from the 'Kvadratnettet' map layer.

   a) First, use your skills to make sure <u>no</u> features are selected.

   b) Open the Attribute Table of the point geodata layer.

   c) Select one of the rows (Metro stations) in the Attribute Table.

Intersect = cross/cut/meet

   d) Try out the functionality to select a block from the 'Kvadratnettet' geodata layer by use of the already selected feature in the Metro Station geodata layer (Fig. 3).

   The result will look something like in figure 2 (above).

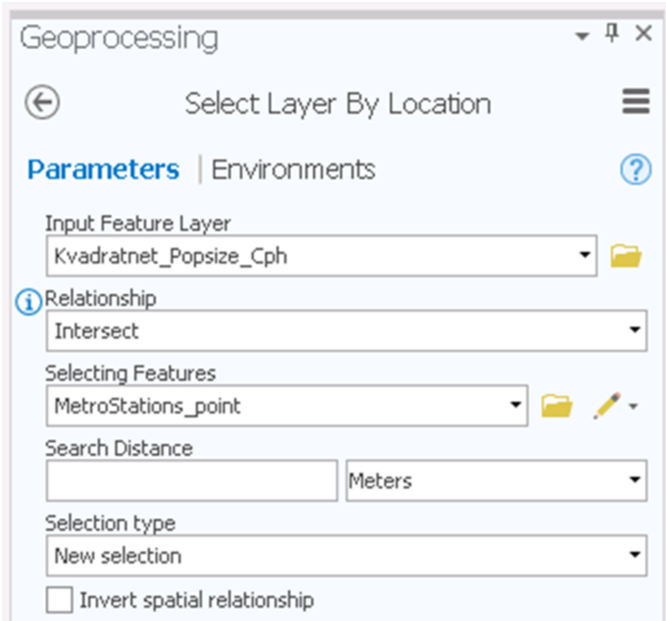


Fig. 3 The Select Layer By Location tool. The dialog enables the selection of features from one layer, using features from another layer.

Exercise - Task A

Let´s bring the focus back to the initial (spatial) question:

How many people live within walking distance of a Copenhagen metro station?

To answer this question we need to define what the ‘walking distance’ to a metro station is.

Background information: The distance from one metro station to the closest one is 500-1200m.

From this we may draw the conclusion that living along the Copenhagen Metro network, you are rarely farther away than 500m from the closest metro station.

5. Decide what you may think is a good approximation of the maximum distance a potential customers would walk to a metro station (instead of choosing another means of transportation, *e.g.* a bus or a car).

The distance you decided for is like a radius reaching out from each metro station.
Using this radius in all directions from a point will result in a circle (Fig. 4a).

Buffer =
A zone around a map feature measured in units of distance.

In GIS terms this is known as making a buffer.
You may generate a buffer around any type of feature (Fig. 4a-c, point, line and polygon, respectively).

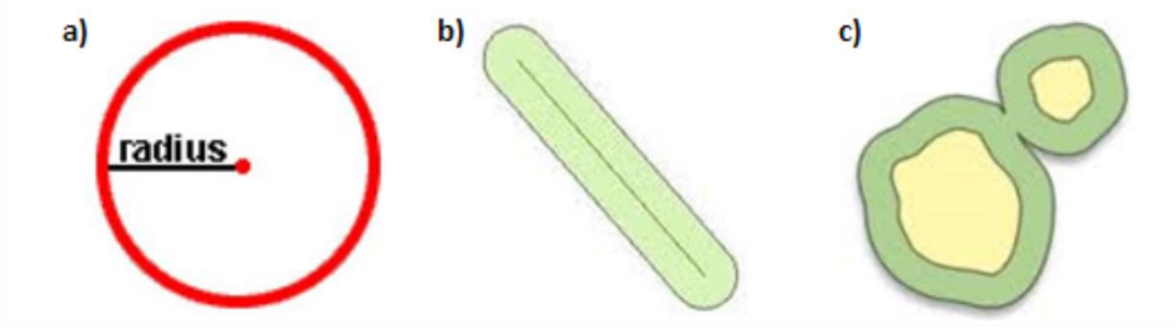


Fig. 4 The buffers surrounding a) a point feature, b) a line feature, and c) a polygon feature.

Your next job is to calculate buffers around the metro stations.
As a matter of fact, this is the first geodata transformation operation you will take on.

Exercise - Task A

Analysis ribbon

[Geoprocessing pane]

The main entrance to the geodata transformation tools is the Analysis ribbon (accessible from the Analysis tab).
However, soon you will realize that very few of the geoprocessing tools are accessible directly from the Analysis ribbon.
Instead, the majority of the geoprocessing tools are 'hidden', and you have to reveal them by opening an module called the *Geoprocessing pane*.
The Geoprocessing pane is where all the geoprocessing tools are assembled – a large box of various GIS tools.
Among them is the Buffer tool.

6. To open the Geoprocessing pane: On the Analysis ribbon, click the Tools button button 

(Fig. 5, red box).
Just like the other modules, the position of this pane may be relocated.
You may position it along any edge (*e.g.* the left side, Fig. 5),
Or just keep it free-floating.

As you may have noticed already, the Geoprocessing pane spans a whole catalogue of *toolboxes*.
There are the 3D Analyst Tools and the Analysis Tools toolboxes, just to mention a few (Fig 5, blue boxes).

Each toolbox contains several *toolsets*
(*e.g.* Extract, Overlay, Proximity, inside the Analysis Tools toolbox)
(Fig. 5, orange boxes).

And, to make things even more impenetrable,
the toolsets then contain the actual tools (Fig. 5, green box).
Like the Buffer tool you are going to use in a moment.

Luckily, there are ways to locate the tool you are looking for.
A convenient method is to use the intrinsic search function.
Using this search engine, you are searching exclusively among the tools inside the Geoprocessing pane.

7. In the Geoprocessing pane, search for and locate the Buffer tool.
There are a few variants of the tool.
Here, we are going to use the common *Buffer (Analysis Tools).*

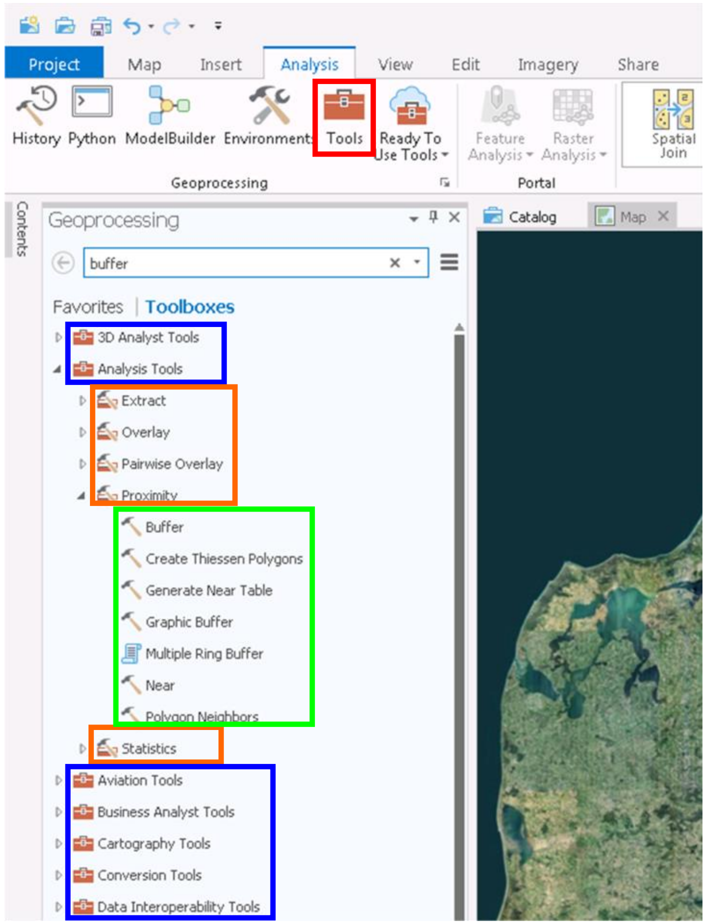


Fig. 5 The Geoprocessing pane – a comprehensive catalog of the geoprocessing tools in ArcGIS Pro.

Exercise - Task A

Create Buffer

[Buffer tool]

8. Create a buffer around the Metro Stations map layer (Fig. 6)
   (or whatever point feature class you may have digitized earlier).

The buffer map layer is generated and is added automatically to the Contents pane.

Depending on the distance you chose for the buffer, some of the buffer areas/circles may overlap (Fig. 7, below).

Geoprocessing:
- Geodata transformation
- Calculation

Geometry type shift

Geoprocessing is one of the primary objectives of this exercise.
What you have accomplished right now is the geodata transformation of the initial point feature class (*e.g.* the Metro stations) into a new polygon feature class (*i.e.* the buffers).
Thus, this kind of geoprocessing led to a shift of geometry type (points ➔ polygons).
Not all the geoprocessing tools lead to transformation, and a new geometry type.
Sometimes the geoprocessing is a calculation.
In such cases, a new vector map layer is not necessarily generated.
You will be introduced to various types of geoprocessing tools later in this exercise.

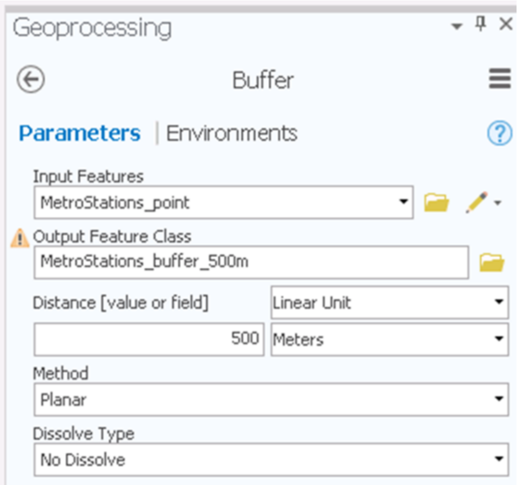


Fig. 6 The Buffer tool dialog.
Using this tool you may create a new polygon geodata containing the buffers at a predefined distance from a feature.

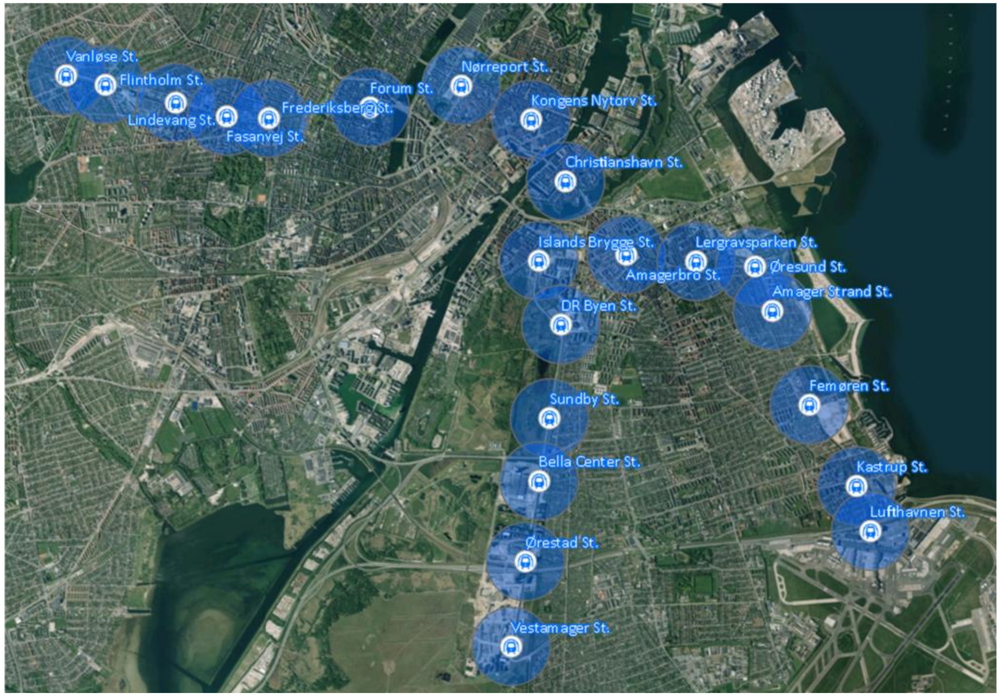


Fig. 7 Geodata Transformation. The result of the Buffer tool operation.
A new polygon map layer has been generated, representing the 500m radius distance from a Copenhagen metro station.

Exercise - Task A

The objective of Task A is to put together population data representing the walking distance to various metro stations. This far you have generated areas (buffers) representing this 'walking distance'.

You have also studied the geodata containing population size in various areas of Copenhagen (See Fig. 2, above). You will now have a closer look at this map layer containing data on population size – the 'Kvadratnettet' geodata. As we discussed earlier, the population size is presented using 100m x 100m block areas. This is a rather rough approximation of the true location of individuals.

(For example, at an extreme, assuming that all the citizens in a block area were living in one house in one corner of the block area, there would be an error of ~141m if the citizens actually all lived in the opposite corner, Fig. 8.)

It is always important to be aware of the *geodata quality*, and the *assumptions* made.

Geodata Quality

And, if there is an option to increase the quality of your analysis, then you should really consider it.

Assumptions

Accuracy

In this case, you may increase the *accuracy* of the population size geodata by one simple assumption – *people are living in houses.*

Fig. 8 The building polygons (pink) inside each 'Kvadratnet' block area (yellow). Every building part (blue) inside one 'Kvadratnet' block area is belonging to the same multi-part building polygon in that 100m-by-100m block. Here, one such multi-part building polygon is highlighted/selected in blue. The population data from a 'Kvadratnet' block area has been 'superimposed' onto the multi-part building polygons, so as to resemble that people are living in the houses (and not all over the 'Kvadratnet' block area).

Thus, by obtaining the buildings within each block area, we are actually getting a more accurate spatial estimate of where people are located.

This will still be an approximation of the true 'position' of individuals within a block.

However, the accuracy is better than before, simply because the population of a 'Kvadratnettet' block is not spread across the whole square surface any longer, but instead to all the building polygons.

Multi-part polygon

To increase the accuracy of your analysis, we have prepared such polygon geodata (Fig. 8).

9. From the *Kvadratnet.gdb*:
 Add the *Buildings_Popsize_Cph* feature class.

Exercise - Task A

The buffer polygons you have created may be used to gather data about the population size within each circular buffer.
But, how are you going to accomplish this?

Spatial Join
- Add data to a database based on mutual spatial extent

As always, when it comes to GIS, there are several methods.
To solve this specific task you will be presented to one very useful geoprocessing technique – a ***Spatial Join***.

Earlier, we informed you that we were going to teach you yet another technique to add data to your database.
Actually, Spatial Join is the fifth technique to add data to a database (including the ones in a previous exercise).

Once again you will consult the Geoprocessing pane.

10. Use your skills to search and locate the Spatial Join tool.

Spatial Join tool

11. Conduct a Spatial Join (Fig. 9).

a) Target Features: The buffer polygons.
   - This map layer is the receiver of data to its Attribute Table.

b) Join Features: The building 'block areas' with the population size data.
   - This map layer is the contributor of data to the Target map layer.

c) Output Feature Class: A new feature class will be generated.
   - The buffer polygons + the database from the 'building block' areas.

Join: One-to-Many

d) Join Operation: **JOIN ONE TO MANY**
   - The population size data from several ‘block areas’ of buildings will be added to each large circular buffer area.

e) Output Fields: Select the fields to be added/joined (**Optional**).

Intersect = cross/cut/meet

f) Match Option: **INTERSECT**
   - The population size data from all those ‘block areas’ of buildings intersecting with a 500m buffer, will be added to the Attribute Table.
   (Recall: The 500m buffer represents the ‘walking distance’ to a Metro).

g) Click Run.

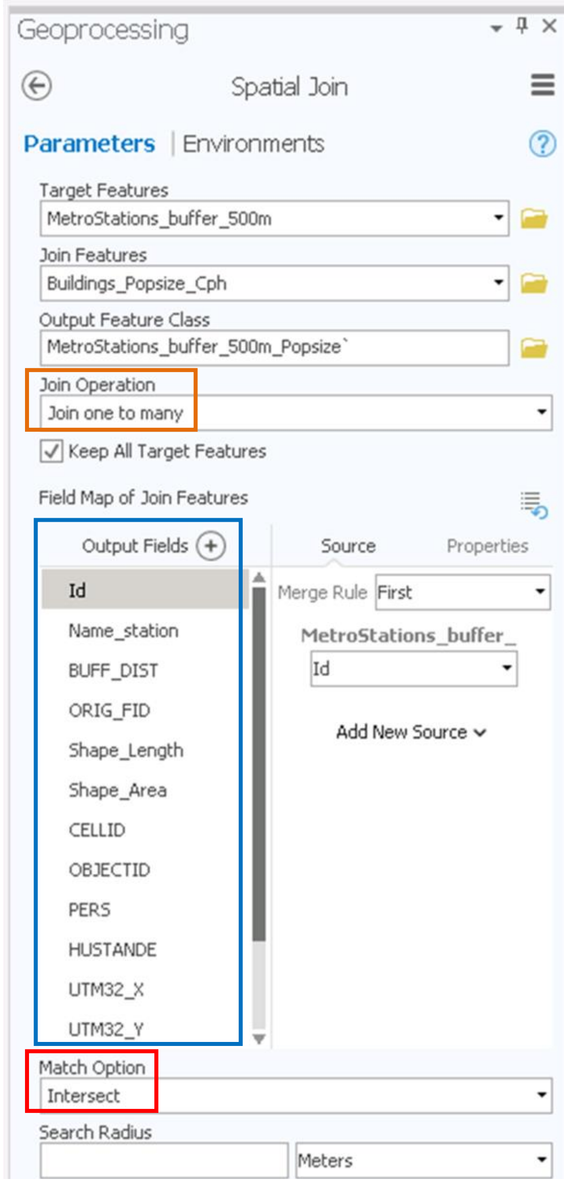


Fig. 9 The Spatial Join tool dialog.
By a Spatial Join you may attach data from the Attribute Table of one map layer to another map layer, based on their spatial extents.

Exercise - Task A

As you realize, the Spatial Join operation generated a new feature class, which was automatically added as a map layer (just like the previous Geodata Transformation operation above, *i.e.* the Buffer tool operation).

The newly-created polygon geodata:

- Has the same type of features as the input Metro station 500m buffer map layer (*i.e.* polygons).
- Also contain tabular data on the population sizes inside the buffers (from the building 'block areas').

Hence, you have combined (joined) data from one geodata to another, based on their mutual spatial extent. Quite neat.

You will now have a look at this outcome in the geodatabase.

12. Open the Attribute Table of the newly-generated polygon map layer (*i.e.* the *MetroStation_buffer_500m_Popsize*).

OBJECTID	Shape	Join_Count	TARGET_FID	JOIN_FID	Id	Name_station	BUFF_DIST	ORIG_FID	CELLID	OBJECTID	PERS	HUSTANDE	UTM32_X	UTM32_Y	Col_Row	Shape_Length	Shape_Area
1	Polygon	1	1	5969	0	Vanløse St.	500	1	100m_61762_7192	1	110	77	719250	6176250	3 - 5	3141.592654	785398.163397
2	Polygon	1	1	5970	0	Vanløse St.	500	1	100m_61762_7193	1	257	175	719350	6176250	4 - 5	3141.592654	785398.163397
3	Polygon	1	1	5971	0	Vanløse St.	500	1	100m_61762_7194	1	178	124	719450	6176250	4 - 5	3141.592654	785398.163397
4	Polygon	1	1	6055	0	Vanløse St.	500	1	100m_61763_7190	1	229	176	719050	6176350	3 - 5	3141.592654	785398.163397
5	Polygon	1	1	6056	0	Vanløse St.	500	1	100m_61763_7191	1	182	126	719150	6176350	3 - 5	3141.592654	785398.163397

Fig. 10 The Attribute Table of the geodata layer generated by a spatial join operation.
The original fields in the Metro station map layer (green), and the attached fields from the Buildings map layer (red).

We already mentioned that there were new fields/columns/attributes added to the Attribute Table (Fig. 10).
However, there are now many more *rows* in this Attribute Table too, than in the original input map layer.

Join: One-to-Many

Each row is representing one station buffer feature, and has one unique pop.size number attached.
This is a result of the spatial join One-to-Many; *one* station buffer has turned into *many* station buffer features, which are joined to a unique population data within its area (Fig. 10).

Overlapping features

That is, there are now completely *overlapping* buffer polygon features at each metro station location – just like a pile of pancakes.

Much data is nice.
But, in the present format it is difficult to get the whole picture.
Is there a way we can summarize the data and present them in a clear and comprehensible manner?
The question is rhetoric.
Most commercial GIS software cover the whole suite of functions from geodata capture to presentation.
(The freedom to present your data exactly as you wish can be rather limited in a GIS software, though. Then, there is always the option to export the unfinished map layout to a professional layout software.)

Next you will learn how to summarize the data.

Exercise - Task A

The goal of this task is to present a summary of potential customers within walking distance of a Metro station.
Those data are in fact available in the newly-created geodata layer (Fig. 10, previous page).
Thus, the Attribute Table of this layer may serve as an appropriate starting point for the summary statistics.

Create Summary Statistics

Return to this Attribute Table.
A good approach will be to use the names of the Metro stations as the least denominator for the summary statistics.

Use your skills

13. a) Use your skills to generate descriptive statistics (the sum of pop.size), based on the Metro station names (Fig. 11).

Notice that a new table will be generated, and added to the Contents pane.

b) Open the generated table and study the output (Fig. 12a).

This is exactly what you want:
The summed population size based on the name of a Metro station.
That is, the total number of potential customers within a walking distance of 500m from each Metro station.

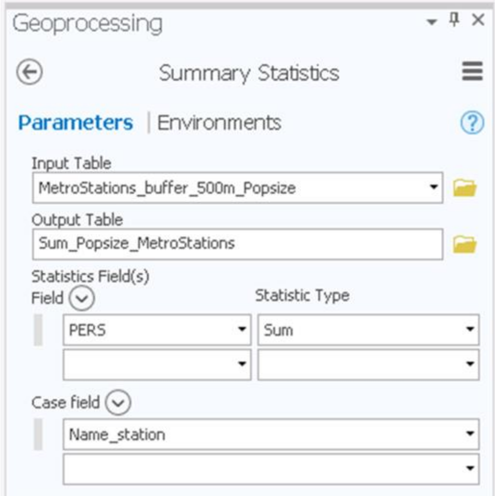


Fig. 11 The Summary Statistics dialog.
Using this dialog you may create simple summary statistics from the data in an Attribute Table.

a)

OBJECTID	Name_station	FREQUENCY	SUM_PERS
1	Amager Strand St.	78	3329
2	Amagerbro St.	93	22351
3	Bella Center St.	34	2037
4	Christianshavn St.	50	6344
5	DR Byen St.	27	3463
6	Fasanvej St.	81	11656
7	Femøren St.	49	3278
8	Flintholm St.	77	5883
9	Forum St.	82	14146
10	Frederiksberg St.	81	13755
11	Islands Brygge St.	33	6558
12	Kastrup St.	72	4553
13	Kongens Nytorv St.	74	5501
14	Lergravsparken St.	87	16418
15	Lindevang St.	84	11160
16	Lufthavnen St.	26	922
17	Nørreport St.	68	8796
18	Ørestad St.	12	696
19	Øresund St.	51	5040
20	Sundby St.	27	801
21	Vanløse St.	91	8020
22	Vestamager St.	13	229

b)

OBJECTID	Shape	Ic	Name_station	BUFF_DIST	ORIG_FID	OBJECTID	Name_station	FREQUENCY	SUM_PERS
1	Polygon	0	Vanløse St.	500	1	21	Vanløse St.	91	8020
2	Polygon	0	Flintholm St.	500	2	8	Flintholm St.	77	5883
3	Polygon	0	Lindevang St.	500	3	15	Lindevang St.	84	11160
4	Polygon	0	Fasanvej St.	500	4	6	Fasanvej St.	81	11656
5	Polygon	0	Frederiksberg St.	500	5	10	Frederiksberg St.	81	13755
6	Polygon	0	Forum St.	500	6	9	Forum St.	82	14146
7	Polygon	0	Nørreport St.	500	7	17	Nørreport St.	68	8796
8	Polygon	0	Kongens Nytorv...	500	8	13	Kongens Nytorv St.	74	5501
9	Polygon	0	Christianshavn St.	500	9	4	Christianshavn St.	50	6344
10	Polygon	0	Islands Brygge St.	500	10	11	Islands Brygge St.	33	6558
11	Polygon	0	DR Byen St.	500	11	5	DR Byen St.	27	3463
12	Polygon	0	Sundby St.	500	12	20	Sundby St.	27	801
13	Polygon	0	Bella Center St.	500	13	3	Bella Center St.	34	2037
14	Polygon	0	Ørestad St.	500	14	18	Ørestad St.	12	696
15	Polygon	0	Vestamager St.	500	15	22	Vestamager St.	13	229
16	Polygon	0	Amagerbro St.	500	16	2	Amagerbro St.	93	22351
17	Polygon	0	Lergravsparken St.	500	17	14	Lergravsparken St.	87	16418
18	Polygon	0	Øresund St.	500	18	19	Øresund St.	51	5040
19	Polygon	0	Amager Strand St.	500	19	1	Amager Strand St.	78	3329
20	Polygon	0	Femøren St.	500	20	7	Femøren St.	49	3278
21	Polygon	0	Kastrup St.	500	21	12	Kastrup St.	72	4553
22	Polygon	0	Lufthavnen St.	500	22	16	Lufthavnen St.	26	922

Fig. 12 a) The Summary table of the number of potential customers within walking distance of a Metro station.
b) The data of the Summary table in a), incorporated into the Attribute Table of another map layer.

Exercise - Task A

Table 12a nicely sums up the data you are looking for.
You may for example pinpoint the Metro stations, which are situated in the more densely populated areas.
In the 'Frequency' column you may also find out how many 'block areas' of buildings that were found within a buffer.

A table is nice and informative. But, it is not very GIS…
The whole point of GIS is to be able to present extensive and quite complex spatial data in a comprehensible manner.
This is preferably done using a map layout.

The table you just generated (Fig. 12a), however, is a simple table. It is not proper *geodata*.
As a consequence, you cannot really use it to present its content as a map.

Hints!
'Geodatabases & AttributeTables'. In addition, figure 12b shows the result of such a 'link' operation.

A natural next step would be to link the data in the summary table with some true geodata, so as to use them in a map.
How can we do that? Well, this time you are on your own.
The techniques to add data from a table to a map layer were introduced to you in a previous exercise.

With the summarized population data incorporated into one of the geodata, you may start to consider how those data are best presented in a map layout.

Symbology - classes

Class Boundary

Label

14. Try to generate a meaningful symbology for your features (Fig. 13a-c, below is a suggestion):

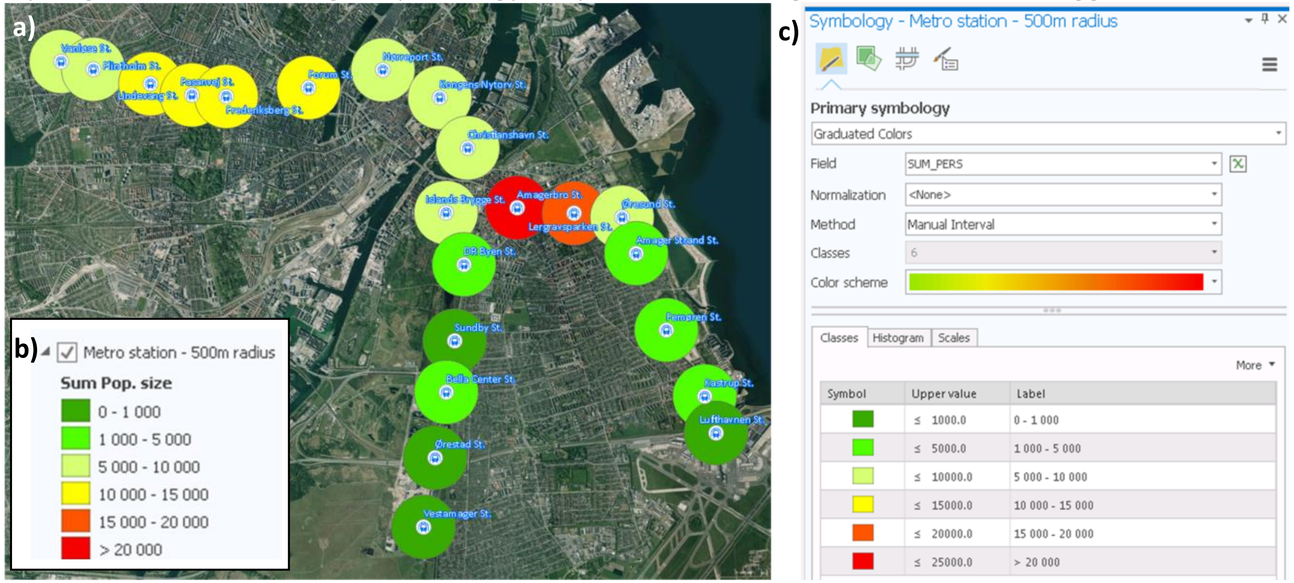


Fig. 13 Symbolization of the metro station 'walking distance' buffers.
a) The Map view: The colouration is based on the population size of potential customers within those buffer areas.
b) The Contents pane: The legend representing the class boundaries of the population size in the buffer areas.
c) The Symbology dialog: Use various colours, sizes or symbols to the features in your map layout.
The symbology is based on the data in columns of the Attribute Table.

Exercise - Task A

Map layout

15. Use your skills to produce a map layout for Task A.
    The procedure and the prerequisites of a proper map layout (including all the necessary map elements) are described in a previous exercise (See example in figure 14).

Remember! A map layout should always be intuitive. You could ask a person without prior knowledge of your project. If she/he is able to understand the map without further questions, then you have really succeeded.

Notice!
There are two new elements along the right edge of the map layout:
- an Extent Indicator
- a Table
Those have not been presented before in a video.
Please feel free to try to develop them by yourself.
Hint!
In Layout view, the tools are available on the Insert ribbon

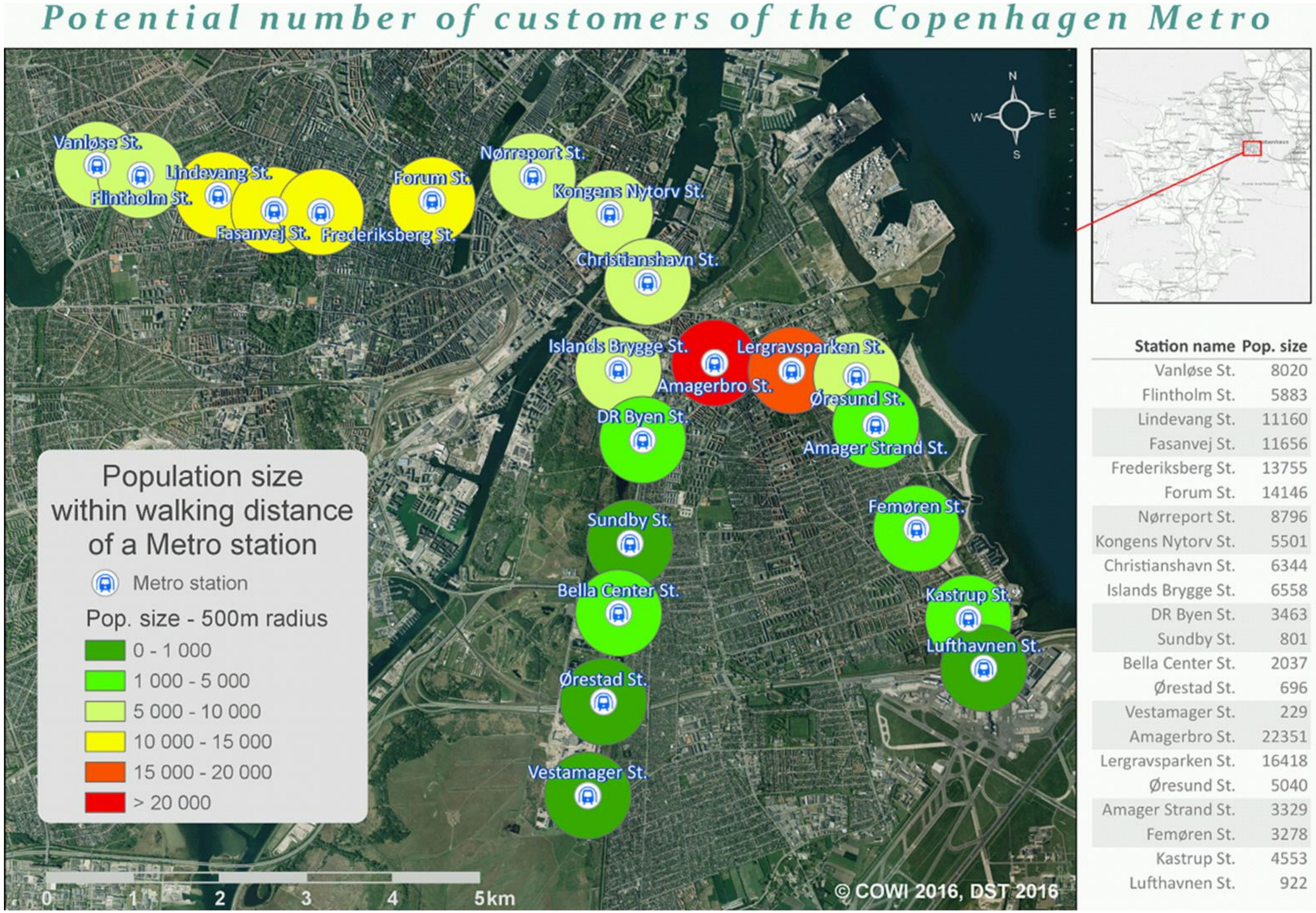


Fig. 14 A suggestion of a map layout serving to answer the spatial question of Task A.

Exercise - Task B

Task B

In the Task B you will be using the *line* geodata,
Which you digitized in a previous exercise.

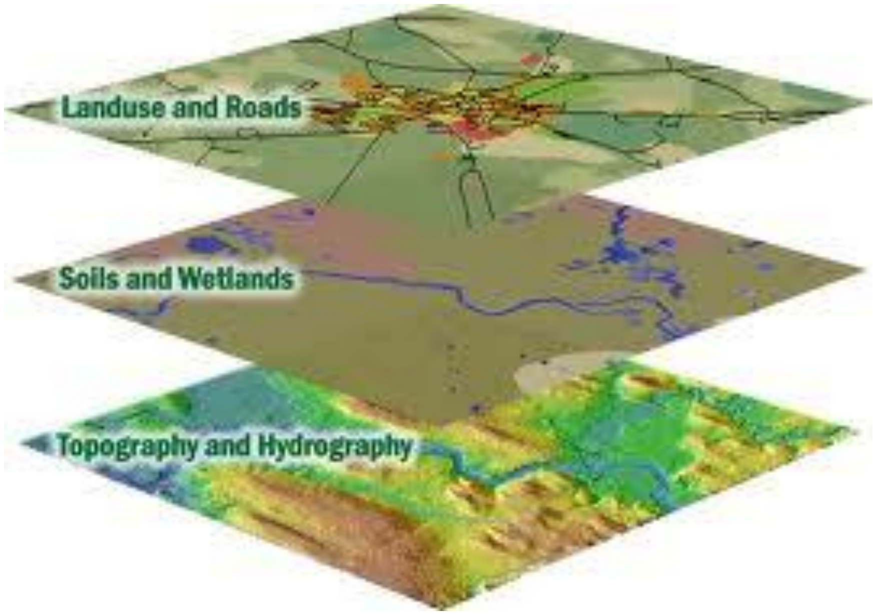
Those of you who have followed the standard procedure of the exercise series will have digitized roads as line features.

If you chose to digitize any other type of line feature (*e.g.* rivers, railroads), or in a different area, there should be no problem.

The methods and tools you are going to use here during the tasks are applicable for any area and any object type represented by lines.

You will just have to use your ingenuity to adapt your lines to the specific spatial questions asked.

If in doubt, do not hesitate to ask the assistants.



The Task B is divided into two sub-tasks – Task B_1 and Task B_2 .

Map Layouts

Both the sub-tasks shall end up as separate map layouts (image files) including the necessary map elements.
How to generate a map layout is described in a previous exercise.

Good saving procedures

Create a layer file (.lyrx)
- stores the symbology you have created.

Before you get started with the Task B, we would like to remind you about some very important instructions and tips.

We have mentioned them before, however, stressing them once again will make your workflow much easier.

And, you may avoid some common pitfalls, so that your Project and geodata do not get lost or end up corrupt.

Exercise - Task B

Sub-Task B_1

Task B_1

A global hotel chain is planning for a new hotel in the Frederiksberg area of Copenhagen.
Your GIS business analyst company has been assigned to identify an optimal location for the new hotel.

Spatial Question: **Where is the optimal location for the new hotel?**

Overlay Analysis

As the skilled GIS analyst you are, with years of experience of similar spatial questions, you immediately identify the method to find an answer to this question – a classic ***overlay analysis***.

An overlay analysis operation combines relevant data from several geodata, like one layer on top of another layer.

This combination of map layers helps you to retrieve valuable information, which you otherwise may not have revealed by looking at the maps side-by-side.

Visual

At its simplest, overlay analysis can be a *visual* operation with semi-transparent layers.

Analytical

True *analytical* overlay operations, however, require one or more data layers to be 'amalgamated' (blended) physically, in an overlapping manner.

Since you are eager to provide a quality product to your customer you will conduct an *analytical* overlay operation, with pieces of advice based on numerical calculations rather than visual considerations.

Obviously, the challenge seems not to be the method, but instead what geodata to use, and to find out if those geodata are available.

Geodata requirement:

- The line geodata of roads generated by digitizing in an earlier exercise.
- A recent orthophoto or topographical map (as background).
- Geodata of relevance to find out the optimal location of the new hotel.

(If you did not digitize roads, you may use whatever line geodata you produced to answer the spatial question.)

Exercise - Task B

Sub-Task B_1

For this Task (and the subsequent ones) you may of course start up a whole new ArcGIS Pro project.
However, you may as well just add another Map view to the current project.
That is, you may have several Maps and create several Layouts in the same ArcGIS Pro project (Fig. 15).

Map view

Layout view

16. Insert a new Map (view)
    (or start a whole new ArcGIS Pro project.)
    a) From the IGN Geodata Library, add a recent orthophoto and/or a topographic map best suited for large-scale.
    b) Add your line feature class (Fig. 15).
    c) Zoom in to area of your line features.

As mentioned before, the toughest challenge of this task seems to be to pin down what geodata may be relevant to use
(and if those geodata are available).

This is a very important step and involves the question about geodata quality.

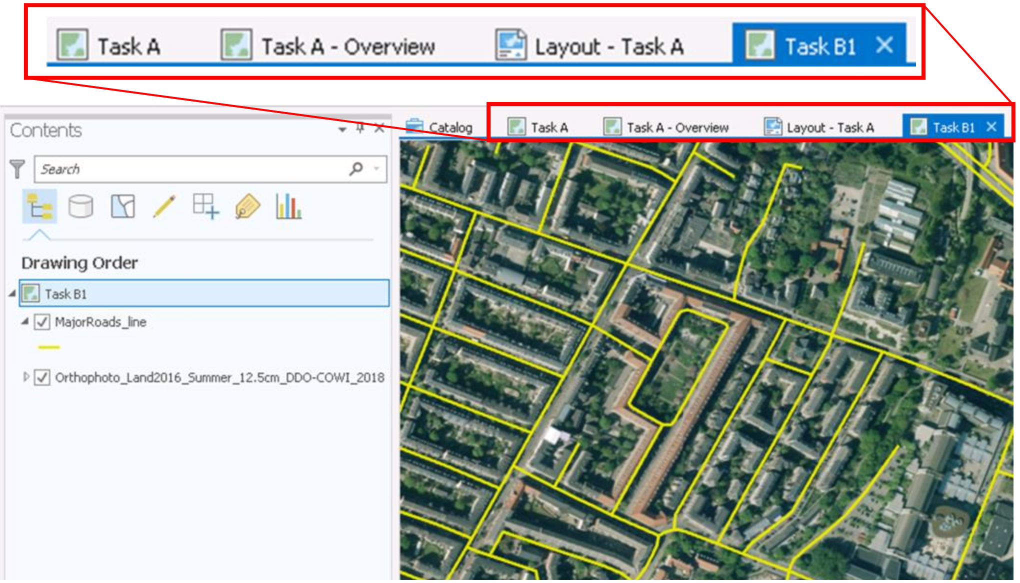


Fig. 15 The line feature class of Task B_1, represented by the major road network in the Frederiksberg area of Copenhagen.
Notice! It is possible to have several Map views and Layout views in the same project.

Below, you will be thoroughly introduced to the necessary steps of an overlay analysis.
You will, for example, learn how to combine data in order to extract information, which may help you solving the task.
After this introduction you are expected to use the skills you acquired to incorporate more geodata to the final output.

Recreational Areas

For example, for this particular task you may have concluded that recreational areas could be of relevance for a hotel.
You may find it relevant, that the closeness to a recreational area, or even better, the view over a green area would be attractive for a hotel customer.
Consequently, you will need geodata on the recreational/green areas.

Tip! ➔ ➔ ➔ ➔ ➔ ➔ ➔ ➔
Use the one from year 2005

17. Use your skills to find and add geodata representing the recreational/green areas from the IGN Geodata Library.

    A recreational area layer appears in the Contents pane, and as polygons in the Map view.

Exercise - Task B

Sub-Task B_1

Like most geodata in the IGN Geodata Library, this layer is nationwide, covering the recreational areas of Denmark.
You are soon going to let this map layer undergo some geodata transformation.
But first, there is one thing you will have to realize.
Conducting geodata transformation on such a large geodataset will take unnecessary long time.
Here, you are only interested in utilizing a small portion of this map layer.
A good working practice is therefore to extract only those features of interest for your further analysis.

Area Of Interest (AOI)

This is preferably done by creating a new map layer (a polygon), delineating your 'Area Of Interest' (AOI).

Use your skills

18. a) Generate a new (empty) polygon feature class to your geodatabase (.gdb).

Make sure the Spatial Reference is set to: *ETRS 1989 UTM Zone 32N* (Projected Coordinate System).

b) Add the new (empty) polygon map layer to the Contents pane.

19. Digitize your area of interest (Fig. 16).

Guidelines:

- The area could have any shape (*e.g.* rectangle, irregular polygon).
- It should be at least 1km x 1km (but not too large, like 10km x 10km).
- Preferably, it should cover the extent of the line features you digitized earlier (in case you would like to use those line features as input to your analysis).

Fig. 16 The Area Of Interest (AOI) represented by a rectangular polygon feature, outlined in red. Roads (yellow) and Recreational Areas (green) are shown.

'Cookie-cutter' & 'Dough'

[Clip tool]

With your newly-created AOI polygon feature class you may proceed to 'extract' the recreational area features relevant to this task.
To extract exactly those park areas you will be introduced to another geoprocessing tool – the ***Clip tool***.

The Clip tool is available from the Geoprocessing pane.

The Clip tool functions much like a 'cookie-cutter' on a 'dough':
You are using one feature map layer as a 'cookie-cutter' to clip out *a sample of* features from another map layer – the 'dough'.

20. Use the Clip tool to extract only the recreational area features inside your AOI polygon feature map layer (Fig. 17).

A new feature map layer with the 'clipped' recreational areas is added to the Contents pane and the Map view.

21. You may now remove the nationwide map layer of recreational areas.

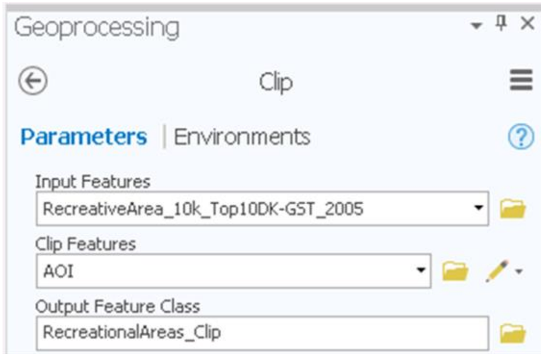


Fig. 17 The Clip tool dialog

Exercise - Task B

Sub-Task B₁

Now is the question*: How can we use the geodata (to find the optimal location of a new hotel)?*

How to use geodata?

Obviously, you cannot build a hotel inside a park area. So what is really interesting is the area *surrounding* each polygon.

Value assessment

Next consideration may be how to evaluate the surroundings of a park polygon.

For example, *a view* over a park from a hotel window would probably be very attractive.

A park *in the close vicinity*, within walking distance, is also good, but perhaps not as valuable as the view from a window.

The park area itself would then get a highly negative value (since you cannot allocate a new hotel inside there).

These kinds of considerations may come into use for your overlay analysis. How come?

Cost/Benefit Surface

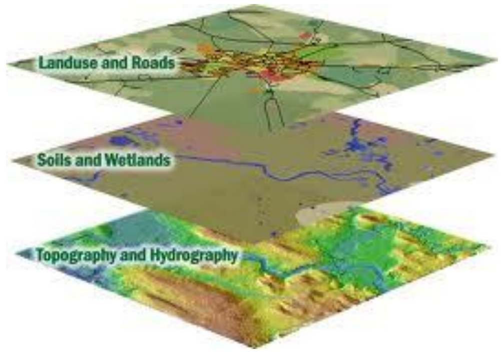
Because, by setting values to spatial locations, you may actually establish a *cost/benefit surface* for the whole AOI, where some locations of the AOI will be more or less beneficial for a new hotel.

Overlay analysis

In the end you are going to put together several different types of cost/benefit surfaces in an overlay analysis.
Each surface, or map layer, will cover the same area and will represent some sort of variable with varying attractiveness to place a new hotel.

Combination

By using the combination of the *cost/benefit surfaces,* you may add up the values from the various layers into one single layer.
Such a procedure makes it considerably easier to pinpoint the optimal area/s for the new hotel – those with the highest aggregated values.
It is appealing to use this approach by its pedagogic merits – your choice of an optimal location is easily comprehendible to any layman and needs very little further explanation.



Exercise - Task B

Sub-Task B_1

Let´s put the considerations above into concrete numbers.

We had 3 considerations for a value assessment of the area close to a park:

(i) Window view of a park was extremely valuable.

(ii) Walking distance was valuable, but not nearly as good.

(iii) The park areas themselves could not be used to set up a hotel, hence they were useless.

Value Estimation

Value estimation
How do we set points to these 'values'? That is, exactly how good is a view of the park?
Obviously, there is no correct answer to this question.
Actually this is a quite tricky part of the process.
It does not always have to be so, but here you will have to rely on *subjective estimates*.

Subjective estimates vs. (objective) measurements

Spatial Assumptions

Spatial assumptions
Next you will need to put figures to the spatial extent of the values.
Also, this step of the process can sometimes be subjective.
For example, how long is a 'walking distance' to a park from a hotel?
It is important to reflect over the spatial assumptions.
A window view distance set too far, may result in areas that actually are blocked to a park view, will receive high values.

The assumptions and suggestions of estimated values are summarized in the table:

Aspect	Spatial extent (Buffer distance)	Value
Window view	0 – 30 m	25
Walking distance	30 – 200 m	5
Park itself	0 m	- 1000

As you see from the table, also the *value range* is subjective.
For example, instead of 25, 5 and -1000, we could have chosen to set the values to 2, 1 and 0, respectively.
What is important to realize is that the value range in this example is not necessarily proportional.
That is, window view does not have to be 5 times better than walking distance.
It is merely a way to single out that window view is far better.

A value for the restricted access area (*i.e.* the park itself) is far easier to conjure up – it just have to be so low, that such an area never would be considered as an option, when all the various layers have been aggregated into one.

Exercise - Task B

Sub-Task B₁

Now, let's put the spatial assumptions and value estimations into GIS practice.

You will use a Buffer tool to create the various spatial extents.
Since you are interested in creating buffers at *various distances* the Multiple Ring Buffer tool comes into play this time.

Multiple Ring Buffer tool

- a tool to generate buffers around a feature, like the 'rings of an onion'.

22. Use your skills to find this tool in the Geoprocessing pane, and then use it (Fig. 18).

The '30' and '200' represents the 30m and the 200m buffers.

But what is the 0 (zero) m buffer?

The Multiple Ring Buffer tool is normally creating a new layer with only the areas *surrounding* your input features.
But, in this case you are actually interested in keeping the *original* (input) area too, together with the buffer rings.
(Remember, the actual park areas are going to receive a -1000 value.)
What the '0' is doing here, is to keep the 'core', that is the area pointing *inwards* from the park boundary.

A new polygon map layer is added to the Contents pane and thus, may be displayed in the Map view (Fig. 19).

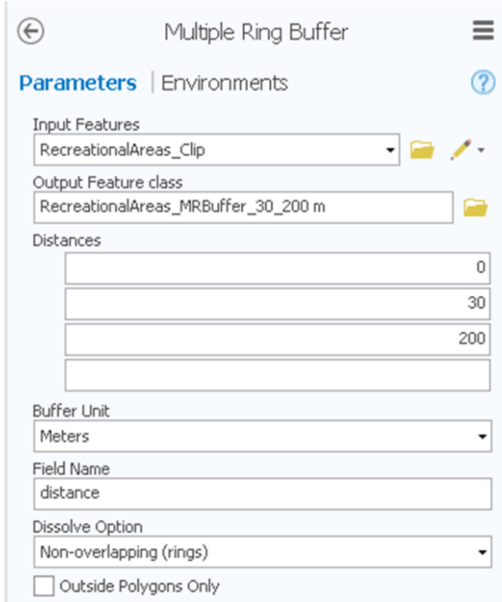
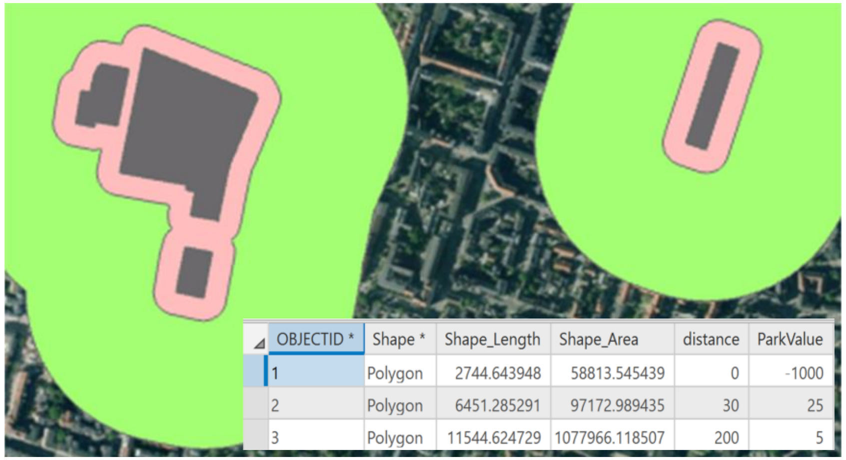


Fig. 18 The Multiple Ring Buffer tool dialog.

The image in figure 19 shows the three buffer areas:

- The original park area (gray)
- The 0-30m buffer (pink)
- The 30-200m buffer (green)



OBJECTID *	Shape *	Shape_Length	Shape_Area	distance	ParkValue
1	Polygon	2744.643948	58813.545439	0	-1000
2	Polygon	6451.285291	97172.989435	30	25
3	Polygon	11544.624729	1077966.118507	200	5

Fig. 19 One Cost/Benefit Surface represented by the multiple ring buffers surrounding the recreational areas.
The Attribute Table shows a field 'ParkValue' with the estimated values of the various buffer areas.

Now, the estimated 'location' values need to be entered into the geodatabase of the newly-created buffer layer.

Use your skills

23. Use your skills to enter the data into a new column in the Attribute Table (Fig. 19).
(Hint! Use the Short Integer data type.)

If you disagree with the estimated 'location' values you may of course invent your own.

Exercise - Task B

Sub-Task B_1

24. Next, you may use your digitized line feature class to generate a similar cost/benefit surface.
(If your line features are not covering the whole AOI, you should really consider supplementing with more lines.)

Again, the spatial extent and value estimates are exposed to subjective considerations.
If you digitized road lines, they may be considered beneficial to the accessibility to the hotel.
But, traffic also produces noise and fumes, which are negative.

How far are the positive/negative effects protruding beyond the actual road lines?

In this example we consider nearness to roads as beneficial.
After all, a hotel situated in a backyard or along an alley may be harder to access or discover.
The spatial extent of a first line buffer should be wide enough to cover the buildings facing the street.

a) Consider what spatial extent and 'location' value/s are appropriate.

b) Use your skill to generate one or multiple road buffers.

c) Then enter the 'location' value/s into the Attribute Table.

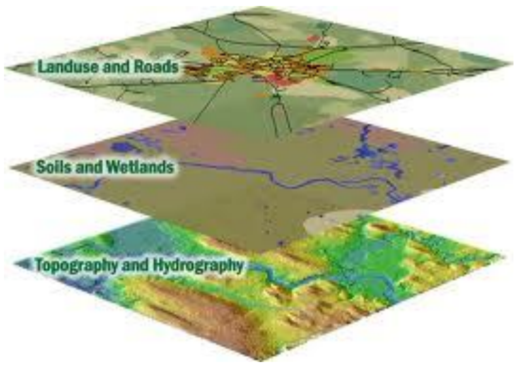
Now you are on your own for a moment.
Take some time to consider other factors of importance to the establishment of a new hotel in an area.
A topographic map may help you to detect some other spatial entities that you can add to your cost/benefit surface.
What about the metro stations? Railroads? Or closeness to competitors (other hotels/hostels)?
Only your imagination and the availability of geodata, are setting the limits.

Tip!
The IGN Geodata Library may give some inspiration.
-Take another look inside.

Besides your digitized line geodata, you are expected to generate cost/benefit surfaces from at least **three more** entities (*e.g.* hotels and hostels are considered one entity – tourist accommodation).

Overlay Analysis

When you have accomplished *at least five* cost/benefit surface layers, it is time to sum up.
That is, you are going to combine the layers into one, new layer with the data from all the separate layers.
This will be the so-called ***overlay analysis***.



Exercise - Task B

Sub-Task B_1

As a matter of fact, there is no *one* Overlay Analysis tool – there are many operations/tools (Fig. 24).

The difference between them is principally the output layer:

- The outcome of an ***intersect*** overlay is just the area of overlap, nothing more.
- The outcome of a ***union*** overlay is the total extent of all the input areas.

Overlay Analyses
- ***Intersect***
- ***Identity***
- ***Union***
- ***etc***

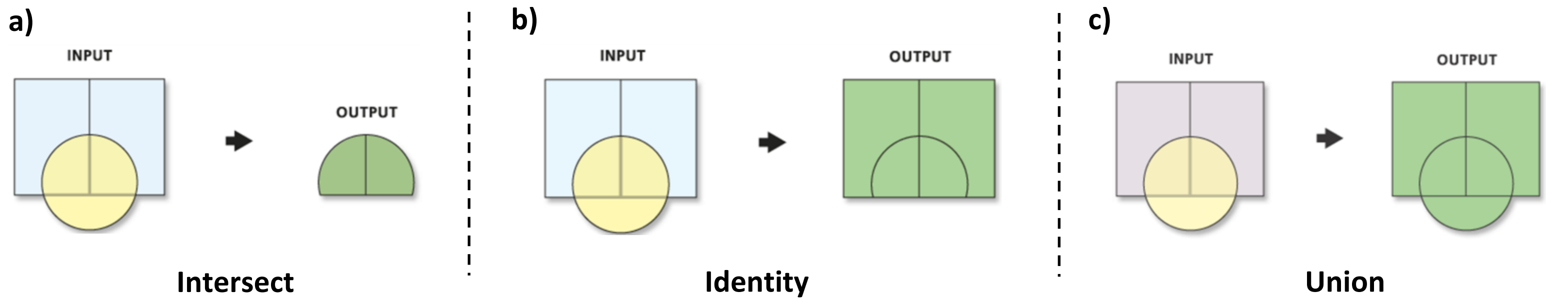


Fig. 20 Overlay operations: a) Intersect, b) Identity, and c) Union.

Union Tool

25. You are going to use a union overlay, because you are interested in the whole area, not just where they overlap.

    a) Use your skills to find the Union tool. Open the Union tool dialog (Fig. 20).

    b) Input Features: Add all the buffer layers you have created. (Make sure they all have received 'location' values.)

    c) Output Feature Class: Navigate to the folder where you would like to store the new (output) geodata. Name it (*e.g. Overlay_Union*).

    d) Click OK. The union map layer is added to the Contents pane and the Map view.

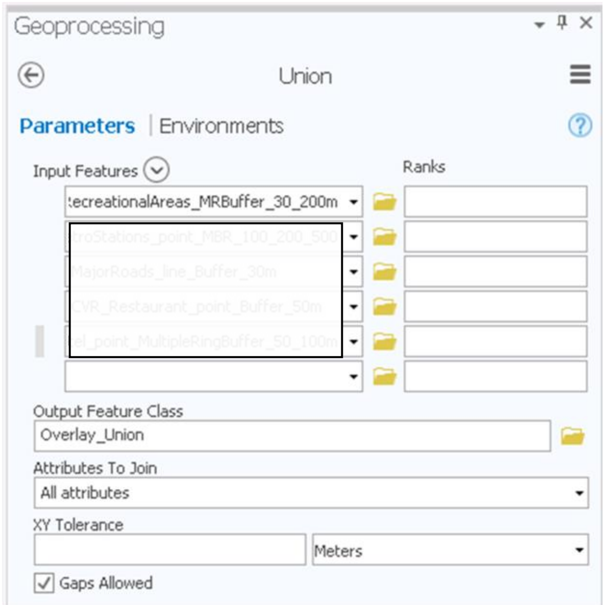


Fig. 20 The Union tool dialog.
Map layers representing five different entities have been added (four of them are blurred).

Exercise - Task B

Sub-Task B_1

The outcome of the union overlay may look like in figure 21.
This is an interesting image, but it is difficult to make something out of it.
One reason is that the various 'location' values still are split into separate columns in the Attribute Table (Fig. 21).

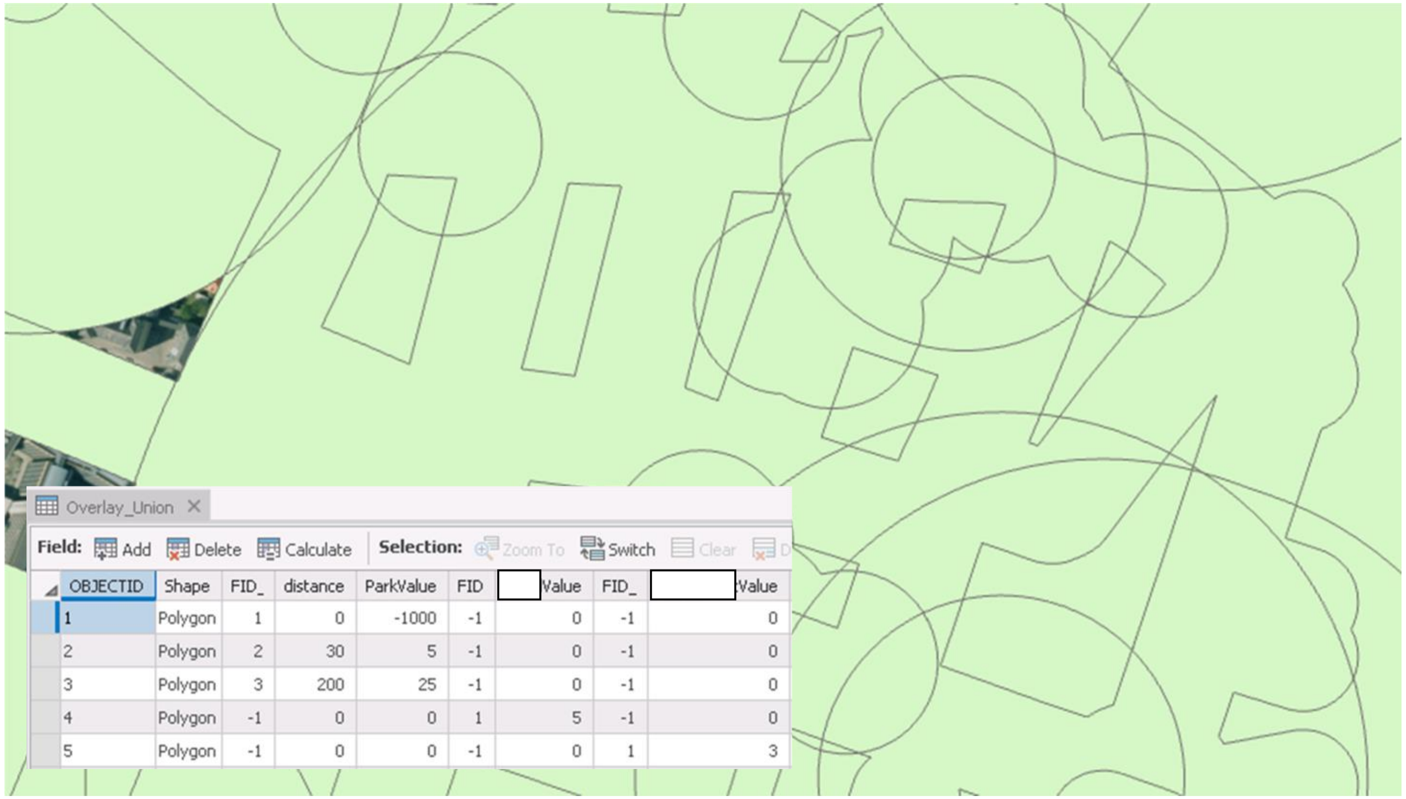
26. Consequently, it is a good idea to combine (sum up) the 'location' values into one new column.

a) Use your skills to create a new numeric column in the Attribute Table.

Calculate Field

b) Right-click the header of the new column ➔ Calculate Field.

c) Use your skills to add (+) the values of all the 'location' value columns into this new column.
(Hint! The technique was described in the Geodatabases & Attribute Tables exercise)



OBJECTID	Shape	FID_	distance	ParkValue	FID	Value	FID_	Value
1	Polygon	1	0	-1000	-1	0	-1	0
2	Polygon	2	30	5	-1	0	-1	0
3	Polygon	3	200	25	-1	0	-1	0
4	Polygon	-1	0	0	1	5	-1	0
5	Polygon	-1	0	0	-1	0	1	3

Fig. 21 An example of the output map layer of a union overlay operation, zoomed in to a smaller section of the AOI. An extract of the Attribute Table is shown in the lower left corner.

Exercise - Task B

Sub-Task B_1

The new column with the ‘location’ values summed up may be used to generate some informative symbolization. Using an appropriate symbology will help you enormously to visually isolate the ‘hot spots’ for the new hotel.

27. Use your skills to symbolize the union map layer, based on the column with the sum of ‘location’ values (Fig. 22). The colouration gives you a very helpful overview of the optimal spots to allocate the new hotel.

Select By Attribute

However, it would be valuable to high-light the true ‘hot spot’ areas.
Remember, you may use the Select By Attribute function to select the features belonging to a specific class or range.

28. Use your skills to select the ***top*** ‘location’ ***values*** from the column containing the summed values.
(Hint! The technique was described in Geodatabases & Attribute Tables exercise.)
The selected features are high-lighted with a blue outline in the Map view and in the Attribute Table (Fig. 22).

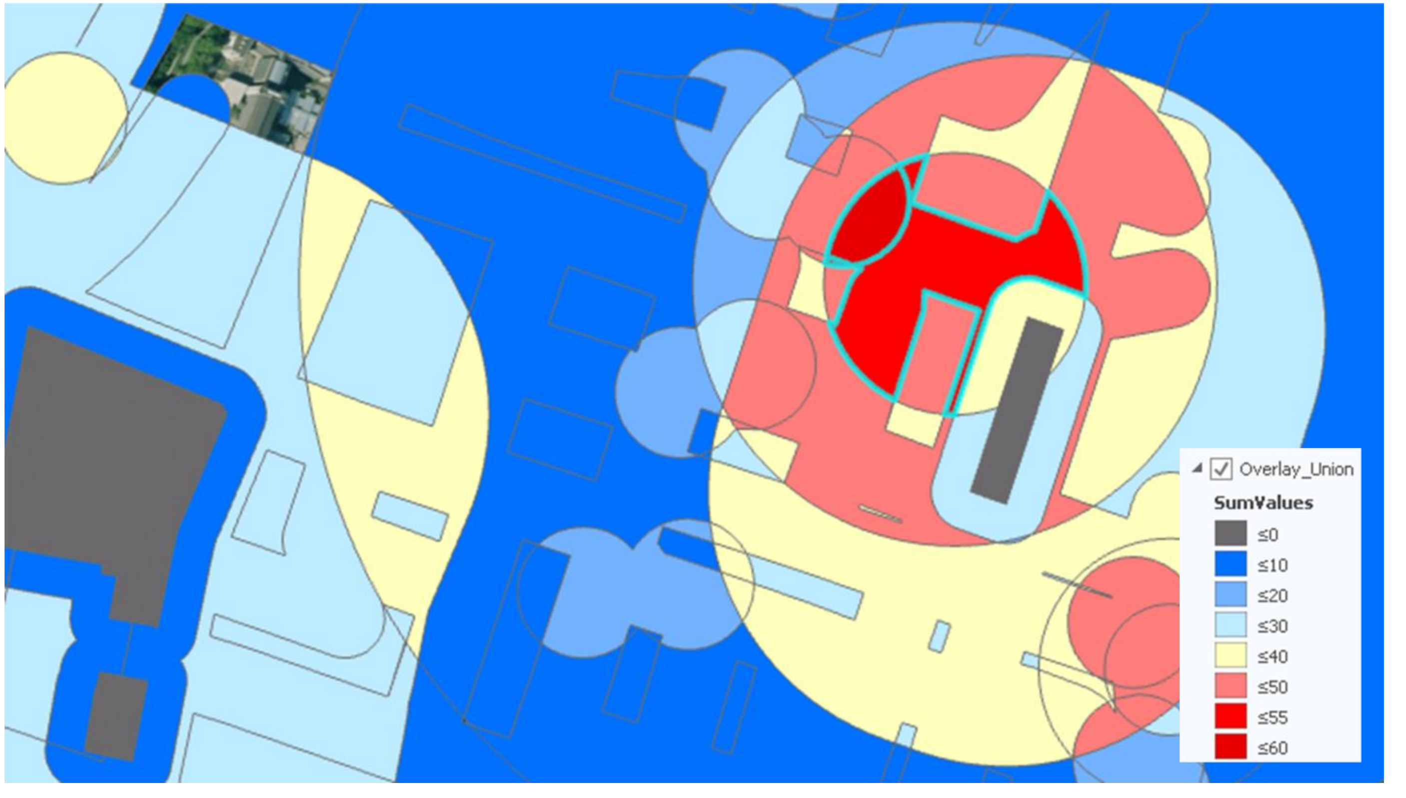


Fig. 22 The symbolized union overlay map layer, indicating the ‘hot-spots’ for allocation of a new hotel (red nuances). And the not-so-hot-spots (blue nuances). The symbolization is shown by the legend (bottom right corner). The absolutely top-ranked allocation areas were selected, and are high-lighted in with lightblue outline.

Exercise - Task B

Sub-Task B_1

You have reached a point where your analysis efforts will bring your customer some quality results – the guidelines to a location of the new hotel.

But, as the professional GIS analyst you are, you are concerned with providing your customer an even better product.

You may actually help her/him to identify the very buildings where the new hotel could be located.
With this information, your customer may have a look to see if the buildings are suitable for the business, and perhaps contact the proprietor of the building to check if it is for sale.

Hint:
Select By Location
(Intersect = cross/cut/meet)

Map Layout

29. From the I:/SCIENCE-IGN-CGD-UVMAT/GIS/Geodata/English/2. Building, Plant & Cadastre/ folder:
    Add the *Bygning_10k_GeoDanmark-SDFE_2021.lyr* geodata.
    This is a nationwide geodataset with the buildings in Denmark.

    a) Make sure that the 'hot spot' features still are selected.
    You are now going to select the buildings based on the selected 'hot spot' features.

    b) Save the selected building features as a separate geodata.

30. Task B_1 is going to be presented as a proper map layout (including all the necessary map elements).

Study carefully!! ➔ ➔ ➔ ➔
This is a valuable exercise in Map Layout-making.
By including these elements, you are providing a Viewer with information both of your results and your methodology.

It should contain:

- The hot spot buildings feature map layer (Fig. 23) on top of a background (*e.g.* a recent orthophoto).
- The whole extent of the union map layer (Fig. 22).
- A legend describing the union overlay classes.
- A summary of the various layers that were used to generate the union overlay map layer.
- A text describing your considerations for each input entity - **which values the entity classes received and why**.
- References (or copyrights) to ALL input geodata.

Fig. 23 The 'hot spot' buildings (brown) for allocating a new hotel. Bottom right corner: The Building map layer (brown) shown on top of the symbolized union overlay map layer.

Before entering the Sub-task B_2, you are advised to consult the '[Good Saving Procedures]' above.

Exercise - Task B

Sub-Task B_2

Task B_2

Let´s say the global hotel chain from Task B_1 decided to establish a new hotel in the Frederiksberg area of Copenhagen.
As manager of the new hotel you would like to advertise the opening of this branch as well as possible.
You assume that one of the strongest customer groups are business people on a short visit to the capital.
Most of them arrive by car. However, the hotel parking facilities are limited. The parking lots are likely to fill up quickly.
Moreover, you know that quite a few of the customers are not so digitally-capable, so as to handle a navigation app.

As a service to your business customers you consider producing a map guiding a customer to a nearby parking area.

Spatial Question: **Where are the parking areas located?**

This is a very unspecific question. At its simplest, you could just create a map showing the location of the parking areas.
Nevertheless, by using some nice symbology you may 'spice up' the map layout, and make it clearer at the same time.

Geodata requirement:

- The line geodata of roads generated by digitizing in an earlier exercise.
  Make sure you have at least 20 line features stretching a kilometer, or so.
- A recent orthophoto or topographical map (as background).
- Geodata of the parking areas.

(If you did not digitize roads, you may use whatever line geodata you produced to answer a similar spatial question.)

Exercise - Task B

Sub-Task B_2

31. Start a new ArcGIS Pro Map view and add the relevant map layers:

a) Main menu: Insert tab ➔ New Map.

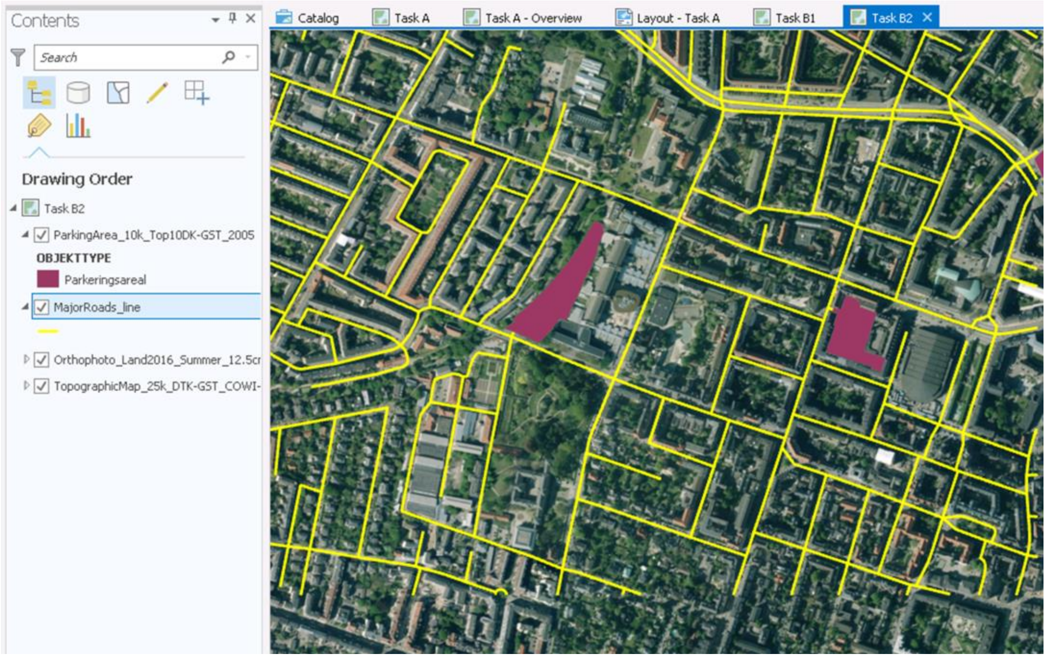
b) From I:/SCIENCE-IGN-CGD-UVMAT/..
../GIS/Geodata/English/..
../6. Aerial & Orthophoto/
add a recent orthophoto image
(*i.e.* the *Orthophoto_Landyyyy_..*),
and/or a topographic map
best suited for large-scale maps
(*i.e.* a *TopographicMap_25k_..*).

Tip! ➔ ➔ ➔ ➔ ➔ ➔ ➔ ➔
Use the one from year 2005

c) Use your skills to find and add a parking area polygon feature class.

d) Add your line feature class (Fig. 24).

e) Zoom in to your area of interest.



The parking area geodata you have added cover the whole country.

Fig. 24 The line feature geodata of Task B_2, represented by the major road network in the Frederiksberg area of Copenhagen. Purple areas represent parking area polygons.

32. Extract the parking areas in your AOI and locate the output feature class preferably inside your project geodatabase. (The extracted parking areas are not necessarily public, but we may pretend that they are…)

One way to use the geodata is to write driving instructions as text.
Driving and reading small text simultaneously is not a good combination, though.

Proximity

What if you could give some kind of driving directions using a map layout instead?
For example, by colouration of your road segments, you could indicate their proximity to a parking area.
In figure 26 below is the proximity of road segments to a parking area indicated by a colour interval from green to red.

Exercise - Task B

Sub-Task B₂

To accomplish such graduated colouration, you will need data on the *closeness* from a road segment to a parking area. But first, you may need to shorten your road *segments*.
Because, if the road segments are too long, pretty much all the segments will be close to a parking area.
And, then the graduated colouration of the roads will say nothing.

Splitting line features

Splitting longer line features into shorter segments is an easy operation.

Split Line At Vertices tool

33. Use the Split Line At Vertices tool to make longer road segments into shorter (Fig 25).

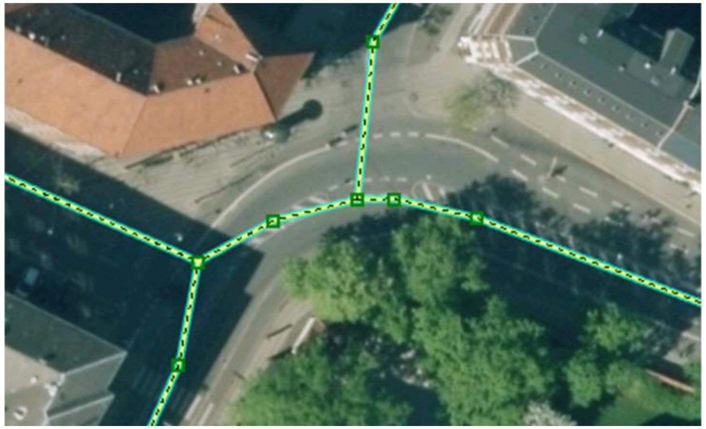


Fig. 25 During digitizing nodes/vertices typically appear at curves and intersections between lines (see green squares).

Split tool (manually) Split

(alt. the Divide tool) Divide

With the line geodata layer split up into shorter segments, you are ready to take on the task to measure the distance from each segment to the nearest parking area.

Near Tool

34. This operation calls for the Near tool.

Calculation vs. Geodata Transformation

The Near tool operation results in new columns in the Attribute Table. Thus, nothing happens to the geometry (shapes) of the features (*i.e.* the line features look the same as before the operation).
Consequently, the Near tool is considered more like a calculation, than a geodata transformation operation.

35. Using the data in the NEAR_DIST column you may symbolize the line map layer (Fig. 26).

Map Layout

Task B₂ is going to be presented as a map layout, including all the necessary map elements, and:

- The line feature map layer.
- The parking areas layer (or equivalent).
- A legend describing the symbolized line feature map layer.
- A background map (*e.g.* a recent orthophoto).
- References to ALL input geodata.

Fig. 26 Road segments in the Frederiksberg area symbolized by their proximity to a parking area. The legend of the road features is shown.

Before leaving the Sub-task B₂ you are advised to consult the 'Good Saving Procedures' above.

Task C

In the Task C you will be using the *polygon* feature class you digitized in a previous exercise.

Those of you who have followed the standard procedure of the exercise series will have digitized recreational areas as polygon features.

If you chose to digitize another type of polygon feature, or in a different area, there should be no problem.

The methods and tools you are going to use here during the tasks are applicable for any area and any object type represented by the polygons.

You will just have to use your ingenuity to adapt your polygons to the specific spatial questions asked.

If in doubt, do not hesitate to ask the assistants.

Background

It has become increasingly difficult to find calm areas in the city centres.

‘Urban lungs’ like parks are visually and audially encroached by an ever increasing intensity of traffic.

The chance of getting a moment of peace and quiet in the urban environment is getting slimmer and slimmer.

The problem is well-known and is taken seriously by the local authorities and the city planners.

Exercise - Task C

As an employee at the Municipal Urban Planning office your task is to put numbers to the noise problem.
More specifically, you will investigate the proportion of the recreational areas that escape severe traffic noise, if any.
The investigated area, shown in the figures, is the larger parks in the northern part of the Frederiksberg Municipality.

Spatial Question: **What proportion of the recreational areas is 'unaffected' by traffic noise?**

Geodata requirement:

- The polygon feature class of recreational areas generated by digitizing in an earlier exercise.
- A recent orthophoto or topographical map (as background).
- Geodata representing the noise propagation over space.

If you did not digitize the recreational areas, you may most likely use your own polygon features anyway.
Else, you may extract some recreational areas from another geodata source, for example the IGN Geodata Library.

31. Start a new ArcGIS Pro Map view and add the relevant map layers:

a) Main menu: Insert tab ➔ New Map.

b) From I:/SCIENCE-IGN-CGD-UVMAT./GIS/Geodata/English/..
../6. Aerial & Orthophoto/
add a recent orthophoto image
(*i.e.* the *Orthophoto_Landyyyy_..*),
and/or a topographic map best suited for large-scale maps
(*i.e.* a *TopographicMap_25k_..*).

c) Add your polygon feature class (Fig. 27).

d) Zoom in to your area of interest.

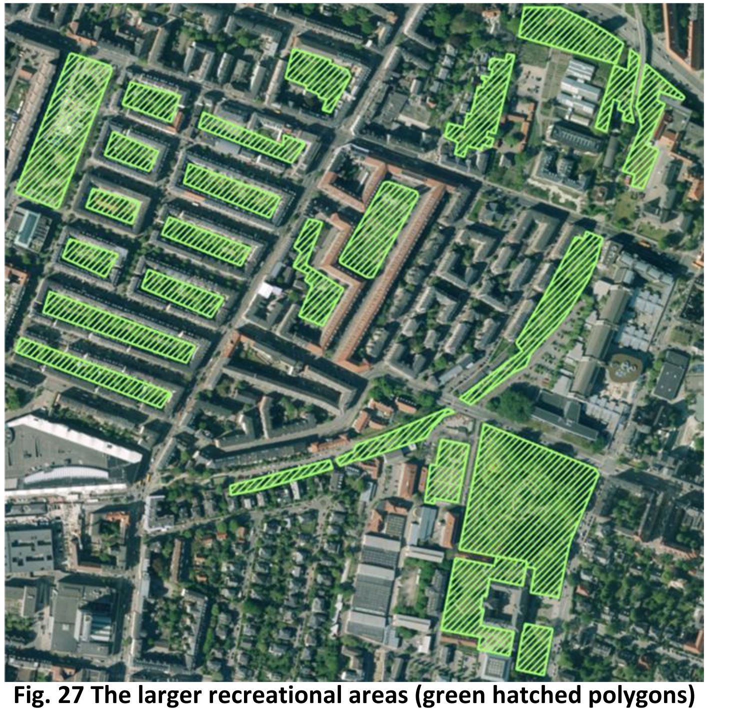


Fig. 27 The larger recreational areas (green hatched polygons) in the Northern Frederiksberg Municipality.

Exercise - Task C

Important! ➔ ➔ ➔ ➔ ➔ ➔
Use Windows Explorer

(You will NOT be able to see zip-files using ArcGIS Pro)

32. In ***I:\SCIENCE-IGN-CGD-UVMAT\GIS_course\Exercises\ArcGIS_Pro\Exercise_GeodataTransformation_Analysis\Geodata***

    a) Using Windows File Explorer: Copy the TrafficNoise .zip file over to your H/T drive.

    b) Using Windows File Explorer: Unzip the copy of the TrafficNoise .zip file. Inside there will be a shapefile.

    c) Then, in ArcGIS Pro: Add the *Traffic_noise_Cph* shapefile.

    The noise propagation from infrastructure is shown as polygon buffers reaching out from /rail/roads etc (Fig. 28).

Noise mapping

Miljøstyrelsen
(Environmental Protection Agency)

These geodata are an extract from the national mapping of noise at roads, railroads, airports and industries in cities.
The geodataset was provided by the Miljøstyrelsen in 2011 (Environmental Protection Agency, in English).

33. Open the Attribute Table of the *Traffic_noise_Cph* layer.
    In the table are two columns of special interest to your study - ‘noise_cl’ (noise *class*) and ‘noise_in’ (noise *intensity*):

- Class
  The noise *class* column, represented by a alphanumerical code, is describing:

  - The source of the noise:

  A and B = road
  C and D = railroad
  E and F = airport
  G = industry

  - The height/time at which the noise was recorded:

  1 = 1,5m (day)
  2 = 4m (day)
  3 = 1,5m (night)
  4 = 4m (night)

- Intensity

  1 - 6 = >75 - 50 dB

dB = decibel

Fig. 28 Noise geodata provided by the Environmental Protection Agency (2011).
The image shows noise from road traffic in the Northern part of the Frederiksbergs Municipality.
Noise levels are symbolized by the noise level 50 dB (light green) to >75 dB (red).

Exercise - Task C

"Never process larger geodata extents than you need"

A good rule-of-thumb when working with geodata is: "Never process larger geodata extents than you need".
In this case you have access to the noise geodata for the whole Copenhagen area.
Conducting geodata transformation on this entire area is a terrible waste of time (and of disc memory), especially when your area of interest constitutes only a minimal fraction of this area.

Overlay Analyses
- ***Intersect***
- ***Identity***
- ***Union***
- ***etc***

34. The next step will be to extract only the noise geodata overlapping the recreational areas.
    This calls for an overlay operation. But which type (Fig. 29)?

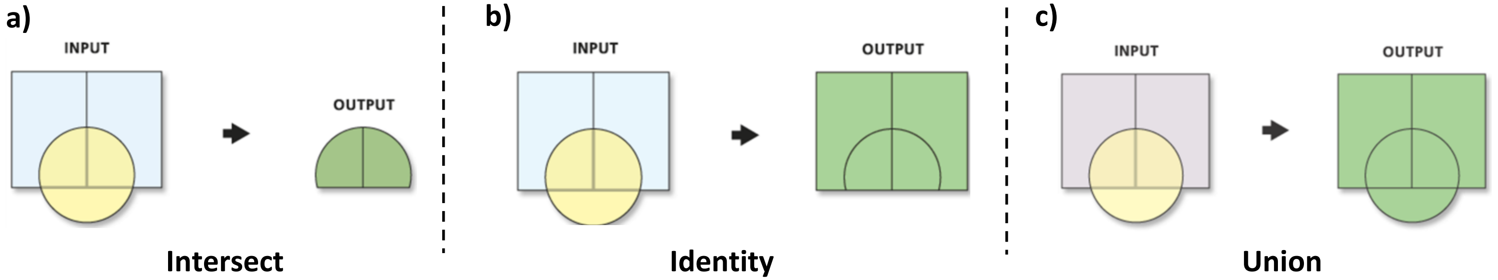


Fig. 29 Overlay operations: a) Intersect, b) Identity, and c) Union.

Use your skills

a) Find the preferred tool in the Geoprocessing pane.

b) Use your skills to complete the overlay tool dialog.

As always, you are supposed to:
- Add the map layers used for the overlay operation (*i.e.* the Input Features).
- Save and name the resulting feature layer (*i.e.* the Output Feature Classs).

Notice! ➔ ➔ ➔ ➔ ➔ ➔ ➔
This transformation may take some time depending on the size and number of polygons and the current network traffic in the Student Computer Lab.

c) Check that the resulting feature layer is what you intended – the noise geodata *inside* the recreational areas.

d) If not, try one of the other overlay techniques.

The result may be presented like something in figure 30, noise geodata only within the recreational area.

Fig. 30 Noise geodata (green/red transparent polygons) inside one of the recreational areas of the Frederiksberg Municipality. Note: Red/Green symbology has been added manually.

In the Attribute Table, note that the IDnr of the recreational area is added to each of the 'noise polygons'.

Exercise - Task C

However, the extraction of the geodata of interest does not end here.
From the description of the noise geodata table (above) you can tell that noise was recorded at two different heights.
Your study principally concerns park visitors standing on the ground.
Consequently, you will need to extract the geodata representing the recordings at 1,5m height (*i.e.* classes 1 and 3).
The classes 1 and 3 are representing noise recordings at day-time and night-time, respectively.

35. You will select and generate two separate geodata:

- First one with only the *day-time* recordings at 1,5m height (*i.e.* class A1 and B1), and
- Then one with the *night-time* recordings at 1,5m height (*i.e.* class A3 and B3).

Select By Attributes

To select the *day-time* road noise recordings *at 1,5m*, you will use the Select By Attributes function:

a) Open the Attribute Table of the newly-created layer with the noise geodata inside recreational areas.
The noise recording height and recording time are noted in the 'noise_cl' column.

Use your skills

b) Open the Select By Attributes dialog.
The classes of interest to you are the A1 and B1.

c) Therefore, your SQL query should say something like:

SQL =
Structured Query Language

(From the map layer) [your map layer name]
(make a) New Selection
(of all the records/rows)(where the field)
noise_cl = A1 OR noise_cl = B1

(Hint! Consult the Geodatabases & Attribute Tables exercise if you are uncertain about the technique)

OBJECTID	Shape	FID_RecreationalAreas_Task_C	FID_Traffic_noise_Cph	noise_cl	noise_in	org
853	Polygon	2	42689	B2	2	Frederiksberg Kommune
854	Polygon	2	43262	B1	3	Frederiksberg Kommune
855	Polygon	2	45667	A1	3	Frederiksberg Kommune
856	Polygon	2	45670	A4	4	Frederiksberg Kommune
857	Polygon	2	38514	A2	2	Frederiksberg Kommune
858	Polygon	2	38535	A3	4	Frederiksberg Kommune
859	Polygon	2	39721	B4	3	Frederiksberg Kommune
860	Polygon	2	41508	B3	4	Frederiksberg Kommune
861	Polygon	2	42689	B2	2	Frederiksberg Kommune
862	Polygon	2	45667	A1	3	Frederiksberg Kommune
863	Polygon	2	45670	A4	4	Frederiksberg Kommune
864	Polygon	2	46508	B1	2	Frederiksberg Kommune
865	Polygon	2	38514	A2	2	Frederiksberg Kommune

Fig. 31 The Attribute Table of the noise geodata in the recreational areas. Only those rows representing the day-time noise recordings at 1,5 m height are selected (Classes: A1 and B1).

d) Click Run.
The day-time 1,5m-recordings are high-lighted in the Attribute Table and the Map view (Fig. 31).

You may construct a new feature class with only the selected polygons.

e) In the Contents pane: Right-click the map layer with the selected polygons ➔ Data ➔ Export Features.

f) Navigate to the folder where you would like to save the selected polygons ➔ Name the new geodata ➔ OK.
The new geodata layer representing the polygons you selected will turn up in the Contents pane.

Exercise - Task C

36. Repeat the step 35 to generate the geodata for *night-time* recordings at 1,5m height (*i.e.* class A3 and B3).

But, are the night-time noise recordings really relevant here?
Not many people are using the parks during the night, so should we not dispose of those recordings too?
Actually, the night-time noise recordings *are* of value. They are indicating noise levels at *lower* traffic intensity.
Thus, they can serve as reference to the noise levels at higher traffic loads.
They could also give a hint to what the noise situation may turn towards if the politicians were to consider traffic control measures, like car tolls or speed humps and bumps.

Know your data!

When you are receiving geodata from an external partner it is always a good idea to 'play around' with them.
The purpose is to find out about inconsistencies, errors and peculiarities in the data.
'Playing' could be to test geodata transformation operations, or just to investigate the geodatabase.

37. Open the Attribute Table of either the day-time or the night-time noise map layer.

a) Let´s have a look at the far end of the table, at the column with polygon area measurements.
(If there is no such column: Use your skill to create a new column, and then generate the area calculations.)

Perhaps it is not easy to spot, but there are actually rows with exactly the same area measurement.
This should be an alarm clock. What are the chances that two polygons are equally large, down to decimal level?
It actually turns out there are overlapping polygons in both the day-time and night-time map layers.
There could be several reasons for this, for example, that noise has been recorded many times in the same area.
Anyway, for our calculations we are only interested in counting the area once. We need to dispose of all duplicates.

Dissolve Tool

38. The Dissolve tool will help us out (Fig. 32).
It turns the (overlapping) polygons <u>with a common ID</u> into <u>one</u> polygon.

Use your skills

a) Open the Dissolve tool dialog in the Geoprocessing pane.

b) Input Feature: Select the day-time recordings layer.

c) Output Feature Class: Navigate to where you would like to save the dissolved feature class ➔ Name it.

d) Dissolve Field: Check the 'FID_RecreationalArea…'
This is the ID of the recreational area a noise polygon belongs to.
(Note! The column name may differ.)

39. Repeat the step 38, for the night-time recordings layer.

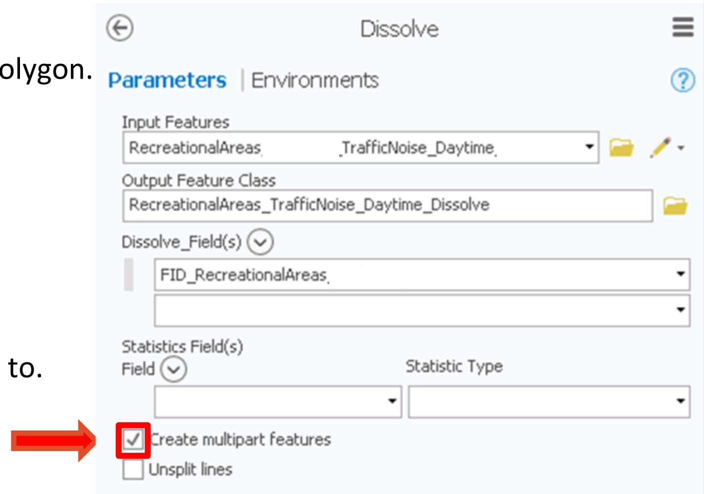


Fig. 32 The Dissolve tool dialog.

Exercise - Task C

At last, you have 'distilled' the geodata (*i.e.* disposed of all the irrelevant geodata and duplications).

You have got three pieces of geodata (Fig. 33):

i) The polygons of the recreational areas.
ii) Polygons representing the noise propagation in each of the recreational areas at *day*-time.
iii) Polygons representing the noise propagation in each of the recreational areas at *night*-time.

You can now proceed with the area calculations you need in order to solve the task – to answer the spatial question:

What proportion of the recreational areas is 'unaffected' by traffic noise?

To answer the spatial question you will need the area measurements of the polygons in all the three map layers.

40. Open the Attribute Tables of all three polygon map layers.
Is there a column with the area measurements in each of them?
There ought to be (*e.g.* Shape_Area).

Use your skills

a) For the two noise map layers, create a new column anyway:
- Name it something different, *e.g.* NoiseArea_Day
- Use the same data type as the Shape_Area field.

Hints!
Calculate Geometry
and/or
Calculate Field

b) Calculate the polygon areas once again.

41. Next, to calculate the proportions you will need to 'combine' the area measurements from all of the map layers, so that all necessary data are located within one of the Attribute Tables (preferably the recreational areas map layer).

a) Use your skills to 'combine' the area data into one geodatabase.
(Hint! The Geodatabases & Attribute Tables exercise)

b) Conduct the necessary calculations of proportions in the Attribute Table.

Fig. 33 Noise propagation from roads into recreational areas. Day-time noise (yellow) and night-time (gray).

Exercise - Task C

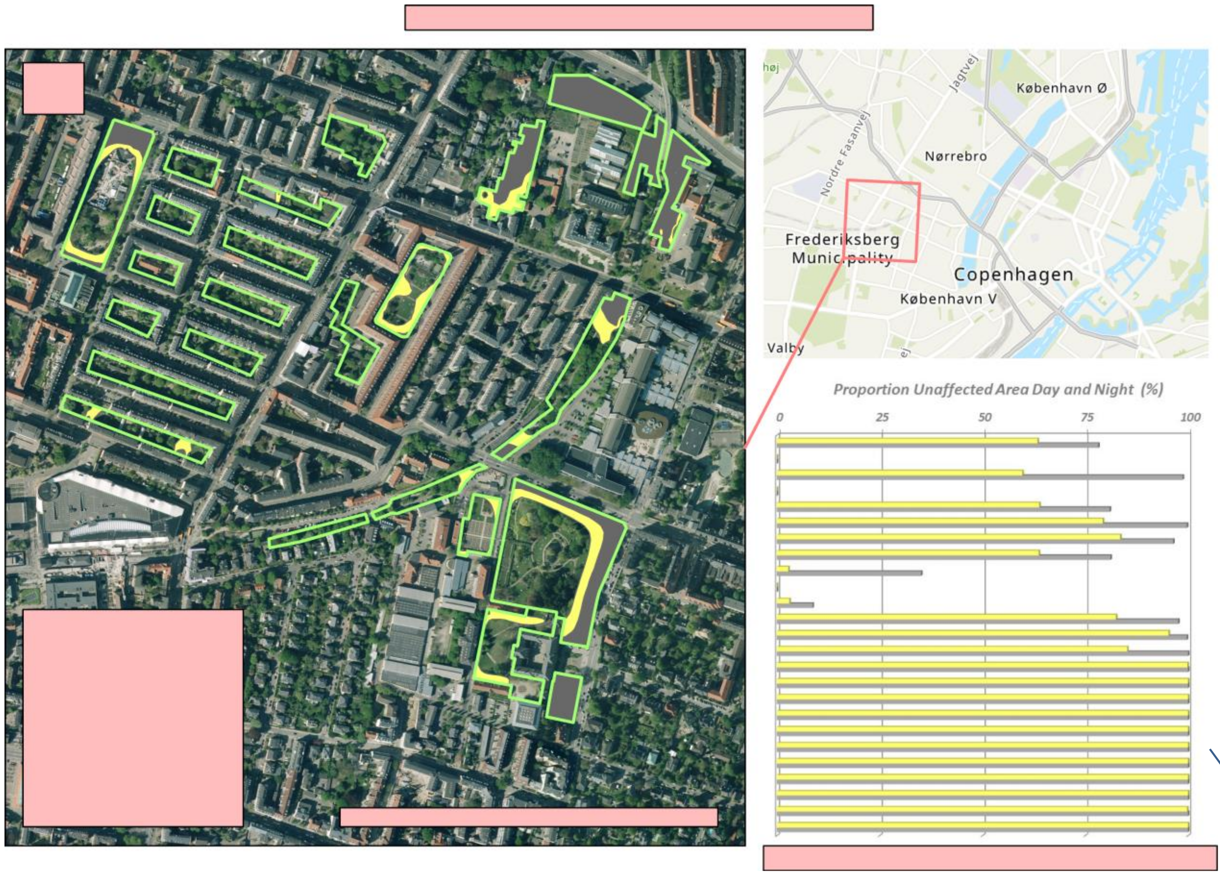
42. Task C is going to be presented as a map layout (including all the necessary map elements).

It must contain:

Map layout

- The recreational areas polygon map layer.
- The two noise propagation polygon map layers (day-time and night-time).
- Graphs or Tables summarizing the **proportion (%)** of the areas which are '**un**affected' by traffic noise in each recreational area (day-time and night-time).
- References to ALL input geodata layers.

Please note! ➔ ➔ ➔ ➔
All the pink boxes in the map layout to the right are indicating essential elements of a map.
- Do not forget about them!



This bar graph was generated in Excel.

Tips!
If you feel more comfortable you may create components of the map layout in another software (e.g. Adobe, Excel).

You may always import those to ArcGIS Pro as picture.

Before you finish you are advised to consult the 'Good Saving Procedures' above.

Thanks for your attention!