Workflow in Arcmap for making spatial analyses following the methodology of the natural urban transformation process

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1. Introduction

This document describes the manual workflow that was applied to achieve the desirable results for the study case of Bergen in the form of maps. The idea is to automate this process as much as possible for future urban analysis. This will be attempted with the tools and toolboxes that are provided with Arcmap as well as the built-in Model Builder. Additional operability improvements that cannot be achieved with these tools will be worked out by building scripting modules. The last step is to enhance the possibilities to quantify and correlate the data to test the hypothesis of natural urban transformation.

2. Filename glossary (please follow)

Date notation:	YYMMDD (i.e. 180206)
AXMAP	Axial map (contains GI and LI)
SEGMAP	Segment map (contains AI, MH, ML, ASD, TSD, MSD)
GI	Global integration
LI	Local integration
AI(R0)	Angular integration (r=0)
MH	Metric step depth high radius
ML	Metric step depth low radius
ASD	Angular step depth
TSD	Topological step depth
MSD	Metric step depth
MXI	Mixed-Use Index (A=Amenities, O=Offices, H=Housing)
FSI	Floor Space Index (=Total floor space/total area)
GSI	Ground Space Index (=Building area/total area)
OSR	Open Space Ratio (=1-(GSI)/(FSI)

DO NOT FORGET TO ENTER A RETRIEVABLE FILE FOLDER AND NAME FOR EVERY SPATIAL OPERATION (BUFFER, MERGE, DISSOLVE ETC.) AND EVERY EXPORT!

See also 171108_Workflow_Toolkit_wDepthmap.PDF under Documents

3. Axial map and segment map (Step 1-3 are done)

3.1 Preparing the data

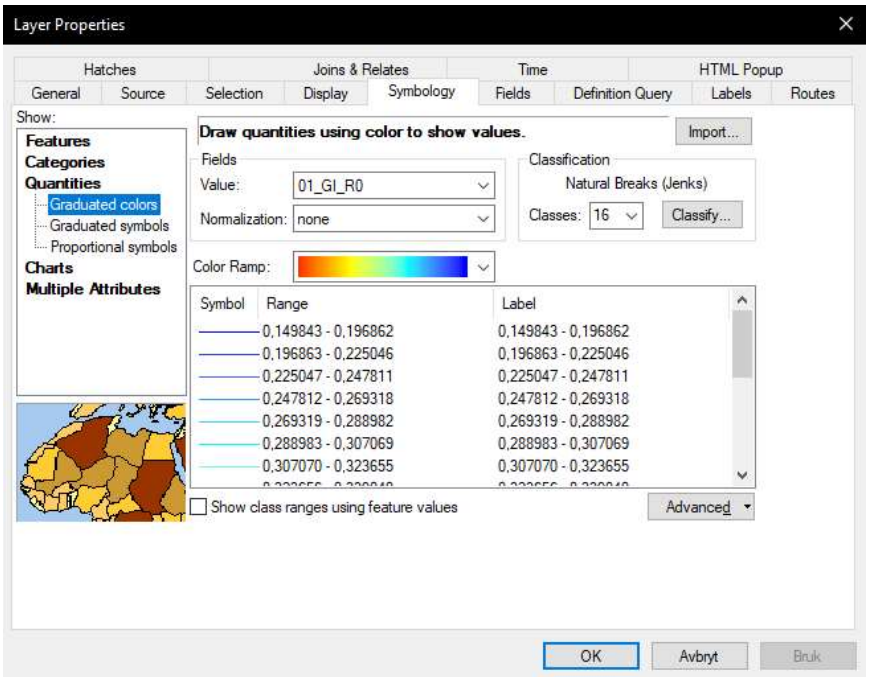
a) Draw the axial map in Arcmap and export it in *.DXF format
b) Import into Depthmap, run analyses and export as MapInfo (*.MIF) files
c) Open in QGIS and save as shapefile (*.SHP)
d) In Arcmap, add the shapefiles:

```
180202_SS_Axial_Map.shp
180202_SS_Segment_Map.shp
```

From the axial map, I usually dissolve into separate files, each with one of the following two attributes:
- Global integration (Field name: 01_GI_R0)
- Local integration (Field name: 02_LI_R3)
However, maybe we can skip this step and aggregate the data from the layer without dissolving these attributes. See more under 3.5. Aggregating the integration values.
From the segment map, we want the following attributes.
- Angular integration (Field name: 03_AI_R0 and 04_AI_R3)
- Metric step depth high and low radius (Field name: 05_MH_R558 and 06_ML_R558)
- Angular-, topological- and metric step depth from Bybanen stops (Field name: 07a_ASD_By, 07b_TSD_By and 07c_MSD_By)
I usually dissolve the axial map into two separate shapefiles.

3.2. Visualising

e) Properties>Symbology>Quantities>Graduated colors
(You can also find a layerfile in the Dropbox folder, which you can Import here (top right))
f) Fields>Value: choose the relevant layer.
g) If a warning comes up that the maximum sample has been reached, under Classification>Classify>Data Exclusion>Sampling, set Maximum Sample Size to a value higher than the total amount of elements in your layer.
h) Normalization: none
i) Classification: 16 Natural Breaks (Jenks)
j) Choose the desired colour-ramp from red on the left to blue on the right.
k) You may have to reverse colour-range: RMB on symbol lines – flip symbols.
Choose the right attribute with 16 even breaks (Jenks), and a 'spectral' colour pattern (see image below)
l) Finally, for better visual results, it is useful to double the line thickness of the two highest value categories.



3.3 Projecting Space Syntax integration values onto Street Blocks

Geoprocessing>ArcToolbox>Analysis Tools>Overlay>Spatial Join

Target Features:	Choose layer 180202_Building_Plots.shp
Join Features:	Choose relevant Space Syntax projection (GI/LI/MH/ML)
Join Operation:	JOIN_ONE_TO_MANY
Match Option:	INTERSECT
Search Radius:	Choose appropriate distance, likely 10-20m

Ill results? Check if you have not selected any lines, polygons or other objects in the workspace!

For the resulting layer, once again:
Layer properties>Symbology>Quantities>Graduated colors

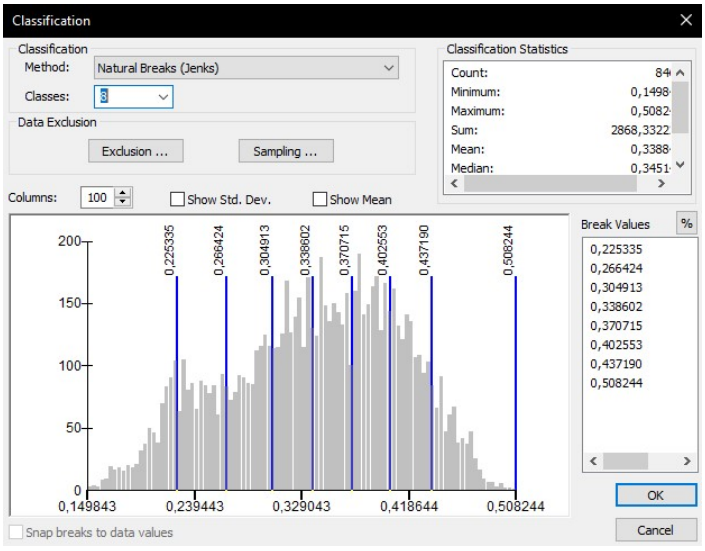
Fields>Value:	choose the relevant layer;
Normalization:	none
Classification:	16 Natural breaks (Jenks)

Choose the desired color-ramp from red on the left to blue on the right.
(Reverse color-range: right-click on symbol lines – flip symbols.)

3.4 Creating Buffer lines

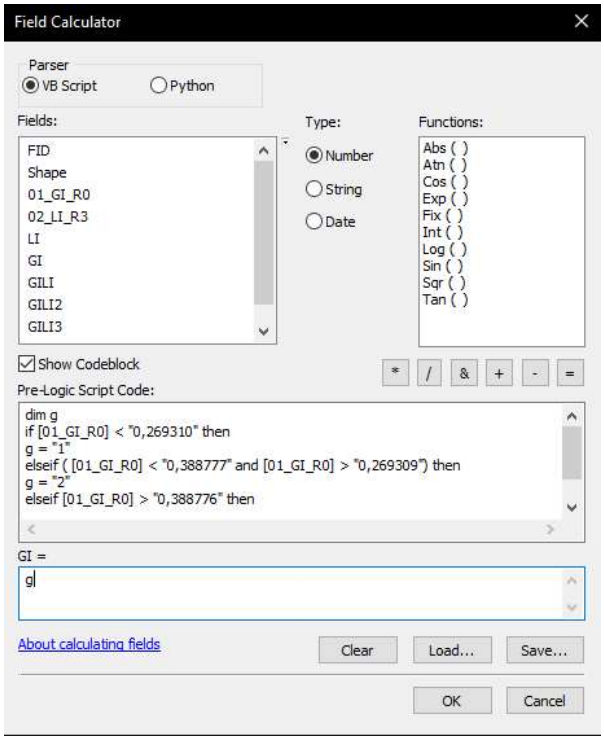
With a buffer operation, we create a polygon surface around the axial/segment lines with a set radius. To be able to merge resultant surfaces of the same value, all integration values have to be categorised. If we skip this step, we end up with numerous, unmerged buffered surfaces. It is probably easier to categorise beforehand. The integration values, therefore, have to be 'rounded off'. The way I have done this may be a bit cumbersome. Perhaps there is an easier way to do it.

First, the break values we want to use need to be found. To find those, we go to the Layer Properties>Symbology tab. Select the relevant attribute, e.g. *01_GI_Ro*. Under Classification, divide the values into categories (I have tested with 3 values), using a certain break method (Equal intervals or Natural breaks (Jenks)). The numerical break values show up on the right hand side.



Next, close the Layer Properties screen and open the attribute table. Add a new field, calling it for example 'GI_CAT' (Global Integration Categorised). Since we will reduce to whole-number categories, it can be a *short integer*.

Next, we need to derive these values from the attribute list containing the uncategorised values. This is done by opening the Field Calculator: right click on the top of the new field list and select Field Calculator.



As mentioned, a division into three categories was tested. The following script code was entered into Field Calculator:

Pre-logic script code:

```
dim g
if [01_GI_R0] < "0,269310"
then
g = "1"
elseif ( [01_GI_R0] <
"0,388777" and [01_GI_R0] >
"0,269309") then
g = "2"
elseif [01_GI_R0] >
"0,388776" then
g = "3"
end if
```

And GI = g

Geoprocessing>Buffer

Input Features:	Choose axial map layer
Output Feature Class:	Choose retrievable filename and –folder
Distance:	Linear unit, radius 35 meters
Side type:	Full
End type:	Round
Method:	Planar
Dissolve type:	List
Dissolve field(s):	Choose attribute table column in which integration values are reduced to a set amount of categories (in this example: GI_CAT)

3.5 Aggregating the integration values

With the integration values categorised, we can now easily aggregate the values. In the 3-category example, the matrix to the right was used. It shows global and local integration values were aggregated by multiplying the values with each other. The procedure is the same: add a attribute field to the list, and derive the values by the following script code (no pre-logic script code block required):

GI/LI	LOW	MID	HIGH
LOW	1	2	3
MID	2	4	6
HIGH	3	6	9

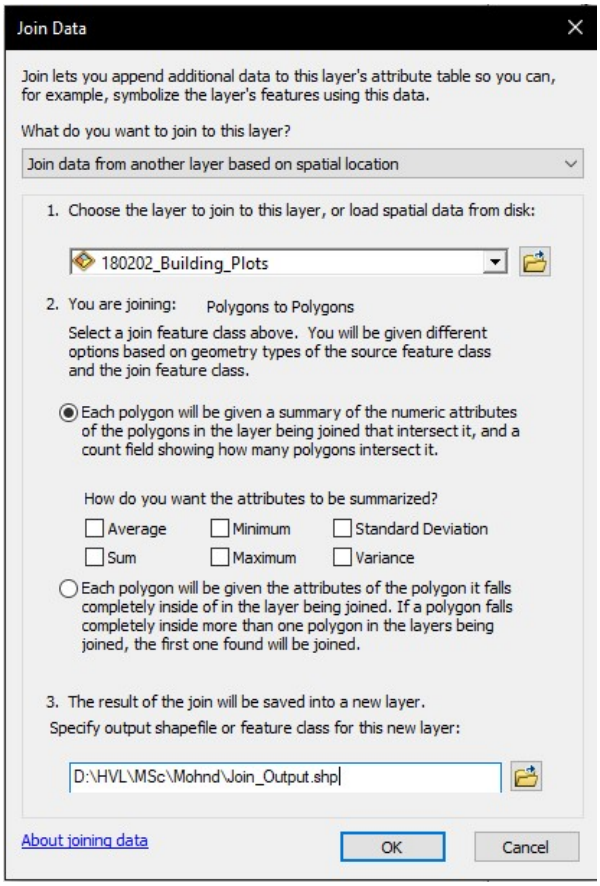
```
[GI] * [LI]
```

3.6. Combining attribute data from two different layers

We have now aggregated Global and Local integration values into one buffer layer. We also have aggregated the Metric step depth high radius with Metric step depth low radius into one buffer layer. The last step is to join the data. To combine data from layers with the same polygons (i.e. both buffer layers, but containing different attribute data), we use a join operation:

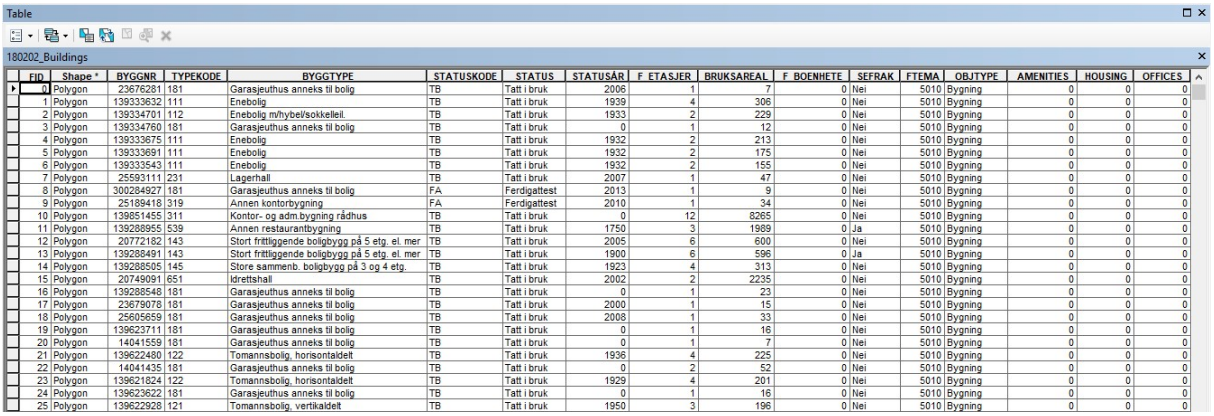
Table of Contents>Right Mouse Button on the layer you wish to join to

Join Data menu:
Choose *"Join data from another layer based on spatial location"*



1. Choose the layer to join to this layer;
2. Make sure it says: *"You are joining: Polygons to Polygons"*
   Choose second option *"Each polygon will be given the attributes of the polygon it falls completely inside of…"*
3. Results are saved into a new layer; choose a retrievable filename and folder.

4 Buildings



Table

180202_Buildings

FID	Shape *	BYGGNR	TYPEKODE	BYGGTYPE	STATUSKODE	STATUS	STATUSÅR	F_ETASJER	BRUKSAREAL	F_BOENHETE	SEFRAK	FTEMA	OBJTYPE	AMENITIES	HOUSING	OFFICES
0	Polygon	23676281	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	2006	1	7	0	Nei	5010	Bygning	0	0	0
1	Polygon	139333632	111	Enebolig	TB	Tatt i bruk	1939	4	306	0	Nei	5010	Bygning	0	0	0
2	Polygon	139334701	112	Enebolig m/hybel/sokkelleil.	TB	Tatt i bruk	1933	2	229	0	Nei	5010	Bygning	0	0	0
3	Polygon	139334760	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	0	1	12	0	Nei	5010	Bygning	0	0	0
4	Polygon	139333675	111	Enebolig	TB	Tatt i bruk	1932	2	213	0	Nei	5010	Bygning	0	0	0
5	Polygon	139333691	111	Enebolig	TB	Tatt i bruk	1932	2	175	0	Nei	5010	Bygning	0	0	0
6	Polygon	139333543	111	Enebolig	TB	Tatt i bruk	1932	2	155	0	Nei	5010	Bygning	0	0	0
7	Polygon	25593111	231	Lagerhall	TB	Tatt i bruk	2007	1	47	0	Nei	5010	Bygning	0	0	0
8	Polygon	300284927	181	Garasjeuthus anneks til bolig	FA	Ferdigattest	2013	1	9	0	Nei	5010	Bygning	0	0	0
9	Polygon	25189418	319	Annen kontorbygning	FA	Ferdigattest	2010	1	34	0	Nei	5010	Bygning	0	0	0
10	Polygon	139851455	311	Kontor- og adm.bygning rådhus	TB	Tatt i bruk	0	12	8265	0	Nei	5010	Bygning	0	0	0
11	Polygon	139288955	539	Annen restaurantbygning	TB	Tatt i bruk	1750	3	1989	0	Ja	5010	Bygning	0	0	0
12	Polygon	20772182	143	Stort fritliggende boligbygg på 5 etg. el. mer	TB	Tatt i bruk	2005	6	600	0	Nei	5010	Bygning	0	0	0
13	Polygon	139288491	143	Stort fritliggende boligbygg på 5 etg. el. mer	TB	Tatt i bruk	1900	6	596	0	Ja	5010	Bygning	0	0	0
14	Polygon	139288505	145	Store sammenb. boligbygg på 3 og 4 etg.	TB	Tatt i bruk	1923	4	313	0	Nei	5010	Bygning	0	0	0
15	Polygon	20749091	651	Idrettshall	TB	Tatt i bruk	2002	2	2235	0	Nei	5010	Bygning	0	0	0
16	Polygon	139288548	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	0	1	23	0	Nei	5010	Bygning	0	0	0
17	Polygon	23679078	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	2000	1	15	0	Nei	5010	Bygning	0	0	0
18	Polygon	25605659	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	2008	1	33	0	Nei	5010	Bygning	0	0	0
19	Polygon	139623711	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	0	1	16	0	Nei	5010	Bygning	0	0	0
20	Polygon	14041559	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	0	1	7	0	Nei	5010	Bygning	0	0	0
21	Polygon	139622480	122	Tomannsbolig, horisontaldelt	TB	Tatt i bruk	1936	4	225	0	Nei	5010	Bygning	0	0	0
22	Polygon	14041435	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	0	2	52	0	Nei	5010	Bygning	0	0	0
23	Polygon	139621824	122	Tomannsbolig, horisontaldelt	TB	Tatt i bruk	1929	4	201	0	Nei	5010	Bygning	0	0	0
24	Polygon	139623622	181	Garasjeuthus anneks til bolig	TB	Tatt i bruk	0	1	16	0	Nei	5010	Bygning	0	0	0
25	Polygon	139622928	121	Tomannsbolig, vertikaldelt	TB	Tatt i bruk	1950	3	196	0	Nei	5010	Bygning	0	0	0

4.1 Introduction

The building data was taken from Bergen Kommune's database and contains different data attributes including building number, building type, function type, protective status etc. For the Spacematrix calculations, we use the attributes from the buildings layer:
BRUKSAREAL (floor space in m²) and
F_ETASJER (number of floors).
To make the Spacematrix calculations, we need the plot sizes. These are found in the building plots layer, attributes AREAL or Shape_Area.

a) Geoprocessing>ArcToolbox>
b) Analysis Tools>Overlay>Spatial Join
c) Target Features: Choose Building layer
d) Join Features: Choose Building Plots layer
e) Output Feature Class: Choose retrievable filename and –folder
f) Join Operation: JOIN_ONE_TO_ONE
g) Match Option: HAVE_THEIR_CENTER_IN
h) Search Radius: Choose slight overlap of 1m
i) Keep All Target Features: Untick
j) Field Map of Join Features: Here you can delete all but AREAL or Shape_Area.

4.2 FSI (Floor Space Index)

The tested VB Script in Field Calculator:

```
dim f
if [BRUKSAREAL] > "0" then
f = [BRUKSAREAL] / [AREAL]
else f = "X"
end if
```

With FSI = f

4.3 GSI (Ground Space Index)

The tested VB Script in Field Calculator:

```
dim g
if [BRUKSAREAL] / [AREAL] > "50" then
g = "X"
elseif [BRUKSAREAL] > "0" then
g = [BRUKSAREAL] / [AREAL]
elseif [AREAL] < "25" then
g = "X"
end if
```

With GSI = g

4.4 OSR (Open Space Ratio)

Field Calculator script code:

```
(1- [GSI]) / [FSI]
```

4.5 MXI (Mixed-Use Index)

The attribute TYPEKODE was used for the function mix calculations. Under Documents in the Dropbox folder, the files:
9_2_Bygningstyper_basert_pa_NS_3457_kortversjon_.pdf and
9_3_Bygningstyper_basert_pa_NS_3457_fullversjon_.pdf
describe the types of functions behind each code in the case of Bergen. Using these, we can arrange them into the three desired categories: amenities, housing and offices. Note that in the buildings layer, there have already been added the columns AMENITIES, HOUSING and OFFICES.
To generate the attribute data, the scripts below are used.

Note that the Housing attributes are dependent on the values from Amenities and Offices. Run this field calculation operation last.

Amenities:

```
dim a
if ((( [TYPEKODE] > "200") and ( [TYPEKODE] < "300") and ( [F_BOENHETE] = "0"))
or (( [TYPEKODE] > "320") and ( [F_BOENHETE] = "0"))) then
a = [F_ETASJER]
elseif ((( [TYPEKODE] > "200") and ( [TYPEKODE] < "300") and ( [F_BOENHETE] >
"0")) or (( [TYPEKODE] > "320") and ( [F_BOENHETE] > "0"))) then
a = "1"
else a = "0"
end if
```

With AMENITIES = a

Offices:

```
dim o
if (([TYPEKODE] < "320") and ([TYPEKODE] > "300" and ([F_BOENHETE] = "0")))
then
o = [F_ETASJER]
elseif (([TYPEKODE] < "320") and ([TYPEKODE] > "300") and ([F_BOENHETE] > "0"))
then
o = "1"
else o = "0"
end if
```

With OFFICES = o

Housing (Run this operation last):

```
dim h
if [TYPEKODE] < "200" and [F_BOENHETE] > "0" then
h = [F_ETASJER]
elseif [TYPEKODE] > "200" and [F_BOENHETE] > "0" then
h = ([F_ETASJER] - ( [AMENITIES] + [OFFICES]))
else h = "0"
end if
```

With HOUSING = h