



**Att skapa bättre
beslutsunderlag med hjälp av
en digital tvilling – en ständigt
pågående process**

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Helena.Lager@lund.se

Lund är Sveriges tolfte största kommun



130000 invånare i kommunen
Nästan 100000 invånare i staden

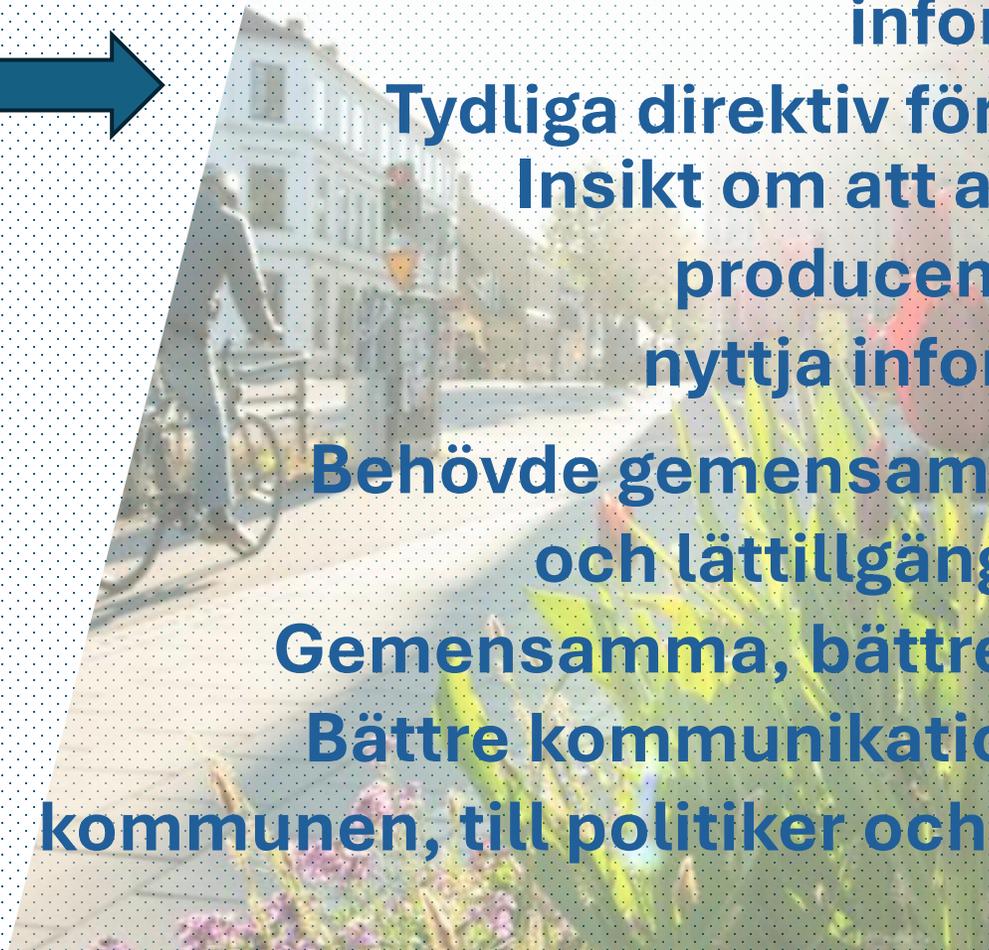
Lund C är en av Sveriges mest trafikerade
Nu 54000 resenärer/dygn
2040 74000 resenärer/dygn

Helhetsbilden/Virtuella Lund

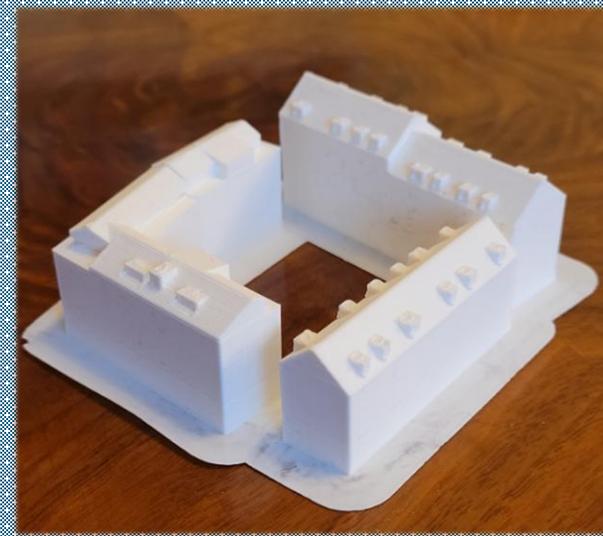
Stora mängder information
Spridda lagringsplatser
Svårt att hitta och återanvända information
Olika idéer om vad Lund är idag och planeras bli i framtiden
Motstridiga beslut
Merarbete
Missförstånd



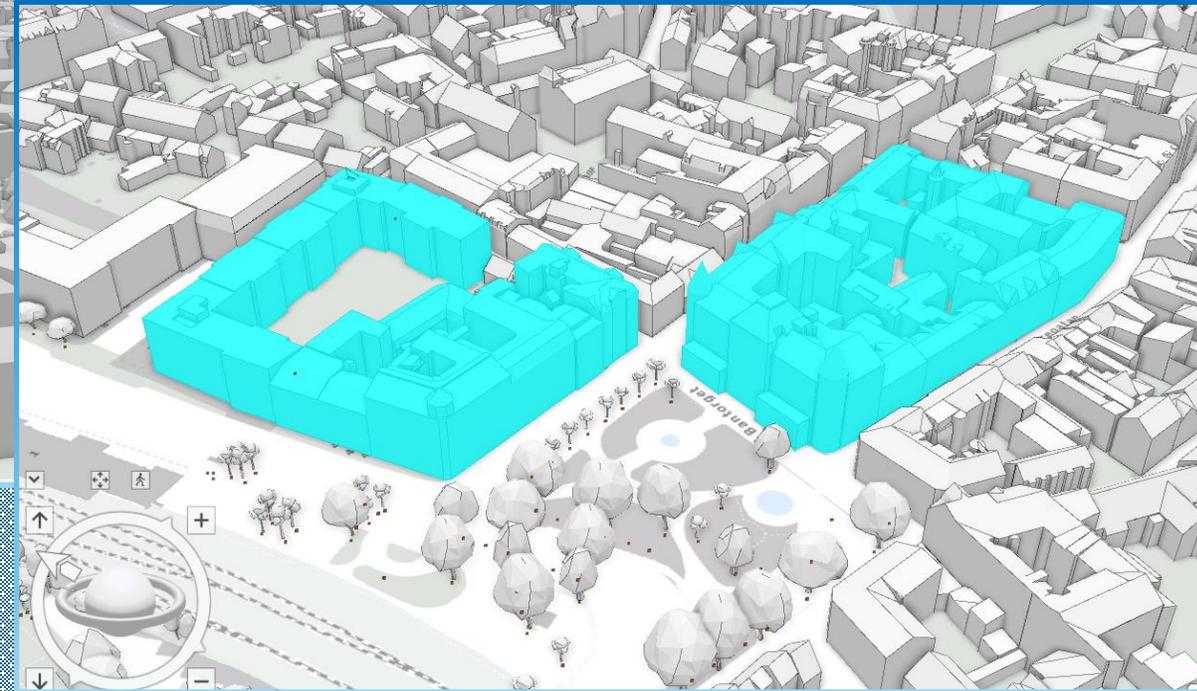
Samla och dokumentera information
Tydliga direktiv för lagring
Insikt om att andra än producenten kan nyttja information
Behövde gemensam, snabb och lättillgänglig bild
Gemensamma, bättre beslut
Bättre kommunikation inom kommunen, till politiker och externt



Prio ett: Analys
Prio två: Visualisering



Visualisering eller analys ?



Analys

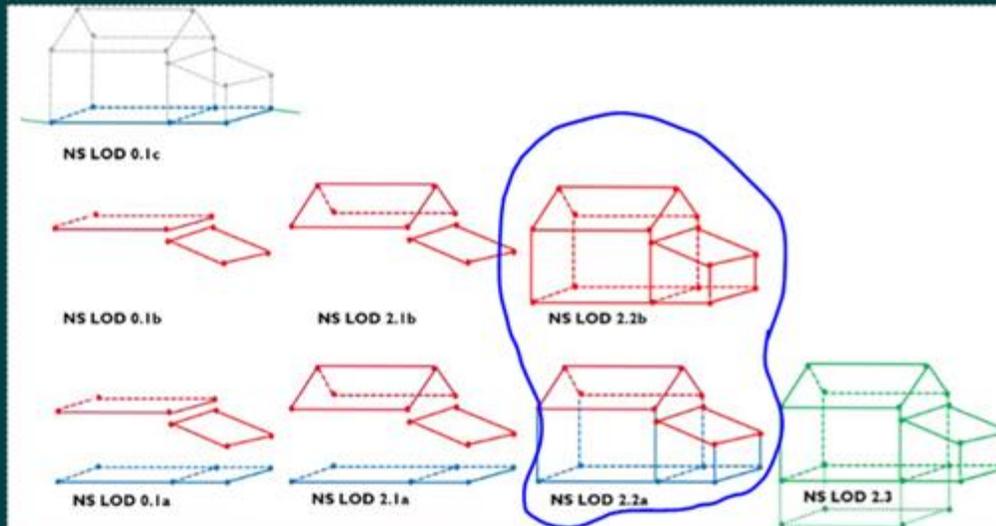
Enskilda byggnader

NS Level of Detail

- C: bottenplatta fasadliv
- 0.1b-2.2b: Inmätt takkant
- 0.1a-2.2a: bottenplatta fasad och takkant
- 2.3: Inmätt byggnad inkl. källare, vind, etc. (t.ex. från bygglov)

Förslag: 2.2a är standard i Lund om det inte finns anledning att frångå.

LOD 2.2a



CityGML



Var mäter man ett hushörn ?

Källare /2,5 m ned i mark
Specificerad lagerstruktur
Markmodell i 3D
vid större förändringar

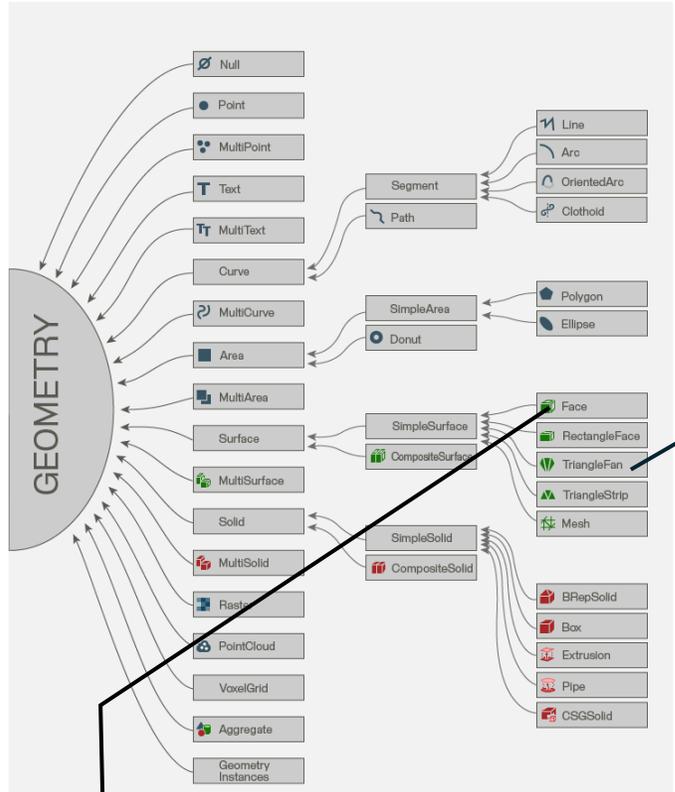


Leveransspecifikation för 3D-modeller

FME Geometry Model

FME provides a comprehensive geometry model that includes everything from the simplest geometry to the most complex.

Click on a geometry class for more information.



Triangle Fan

A triangle fan is a series of connected triangle faces. The first three vertices (denoted below by v_1 , v_2 , and v_3), define the first triangular face. A new triangle is formed by connecting the next point with its immediate predecessor and the first point of the triangle fan. That is, every additional point v_i defines a new triangular face with vertices v_1 , v_{i-1} , and v_i .

For example, the second triangle is defined by v_1 , v_3 , v_4 , the third by v_1 , v_4 , v_5 , and so on. The following diagram illustrates a typical triangle fan.

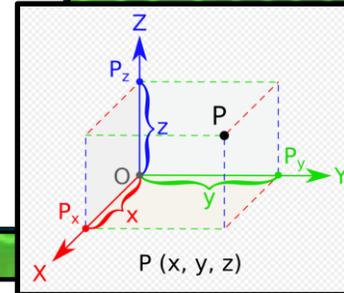
The orientation of the triangle fan is determined by the order of vertices of any triangle within the fan. For more information on how vertex order affects surface normal and front/back surface determination, see [Faces](#).

Triangle fans may store [measures](#) on their nodes.

Triangle fans may possess optional front or back [appearances](#), and may be single or double [sided](#).

3D-grafik

Objektsmodell Multipatch/polygon



Face

A face is a planar area in 3D space. The planar structure can be a [polygon](#) or a [donut](#).

The orientation of a face is determined by using the following rule: If the fingers of your right hand curl along the order of the vertices, the direction that the thumb points to is the front of the face. This thumb direction also describes the surface normal of the face, a vector that points outwards perpendicular from the area.

While a face is often expected to be planar, FME does not enforce planar restrictions in the storage of faces. If required, transformers may be used to force faces into more strict adherence of planar constraints.

Optionally, faces may possess a [transformation matrix](#). Faces may also possess front or back [appearances](#), and may be single or double [sided](#).

Polygonal Modeling

Polygons consist of geometry based on vertices, edges, and faces that you can use to create three-dimensional models in Maya.

Polygons are useful for constructing many types of 3D models and are widely used in the development of 3D content for animated effects in film, interactive video games, and the internet.

Polygon terminology

Polygons are straight-sided shapes (3 or more sides), defined by three-dimensional points (vertices) and the straight lines that connect them (edges). The interior region of the polygon is called the face. Vertices, edges, and faces are the basic components of polygons. You select and modify polygons using these basic components.

When you model with polygons you usually use three-sided polygons called triangles or four-sided polygons called quadrilaterals (quads). Maya also supports the creation of polygons with more than four sides (n-gons) but they are not as commonly used for modeling.

An individual polygon is commonly called a face, and is defined as the area bounded by three or more vertices and their associated edges. When many faces are connected together they create a network of faces called a *polygon mesh* (also referred to as a *polysurf* or a *polygonal object*). You create your 3D polygonal models using polygon meshes. Polygon meshes can be created using a variety of techniques. For more information on these techniques see [Polygon modeling overview](#).

Polygonal models are composed of many separate polygons combined into a polygon mesh.

Polygon meshes normally share the vertices and edges that are common between the individual faces. These are referred to as *shared vertices* or *shared edges*.

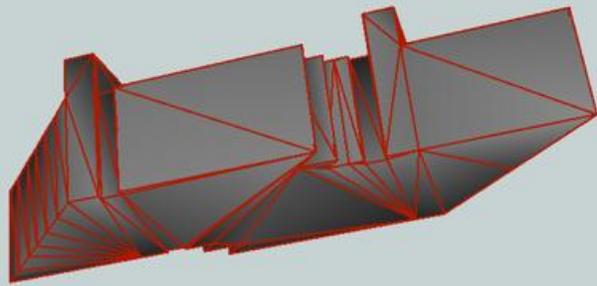
A polygon mesh can also be composed of several disjointed sets of connected polygons called shells. The outside edges of a mesh or shell are referred to as *border edges*.

Texture mapping polygonal models

Polygon models are texture mapped using UV texture coordinates. For more information on texturing polygonal models see [Mapping UVs](#).

3D-grafik

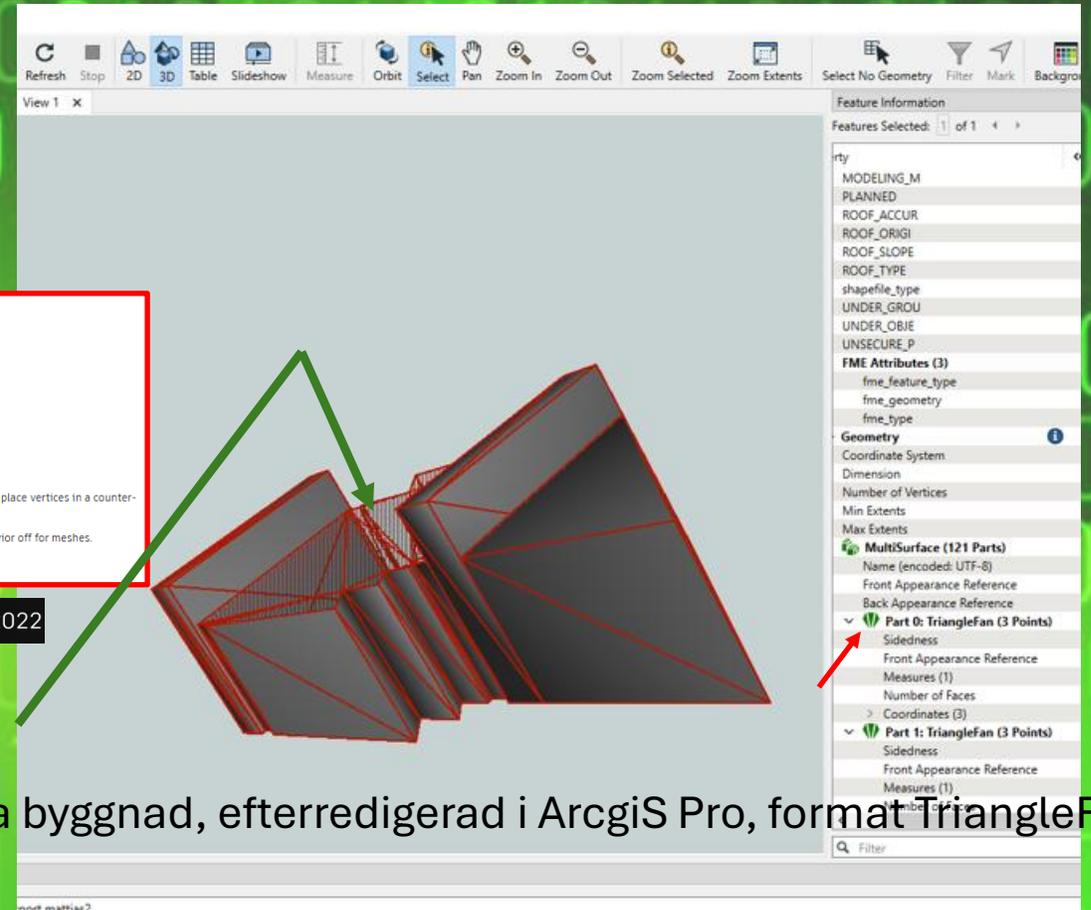
Normaler



Inköpt byggnad, format Face

Property	Value
Exposed Attributes (0)	
Inexposed Attributes (7)	
BID	9921
GlobalID	{E026459C-894...}
Origin	Photogrammet...
shapefile_type	shapefile_multi...
FME Attributes (3)	
fme_feature_type	exempel export
fme_geometry	fme_aggregate
fme_type	fme_surface
Geometry	
Coordinate System	_SWEREF-99-13
Dimension	3D
Number of Vertices	764
Min Extents	132726.416400
Max Extents	132875.103299
MultiSurface (71 Parts)	
Name (encoded: UTF-8)	shapefile
Front Appearance...	<inherited_or_d...
Back Appearance...	<inherited_or_d...
Part 0: Face	
Sidedness	1-sided (front)
Front Appearance...	<inherited_or_d...
Area: Polygon	
Linear Boundary	Yes
Convex	No
Orientation	Right Hand Rule
Boundary: ...	(132732.437599
Closed	Closed In 3D
Measures (1)	<default_meas...
Coordinate...	Coordinate Dim...
0	132732.437599
1	132726.416400
2	132762.820899

Normalen åt fel håll gör att ytan inte syns, blir felaktigt skuggad och solcellerna hamnar i fel väderstreck



Face normals

The front of a polygon's face is graphically represented using a vector called the polygon's normal.

The order of vertices around the face determine the direction of the face (whether a side of the polygon is the front or the back). For example, if you place vertices in a clockwise direction, the face normal points downward. If you place vertices in a counter-clockwise direction, the face normal points upward. See [Create a polygon mesh](#).

This can be important because technically polygons are only visible from the front, though by default Maya automatically makes all polygons double-sided so you can see them from the back. You can turn this double-sided behavior off for meshes.

When you shade or render polygons, the normals determine how light reflects from the surface and the shading that results.



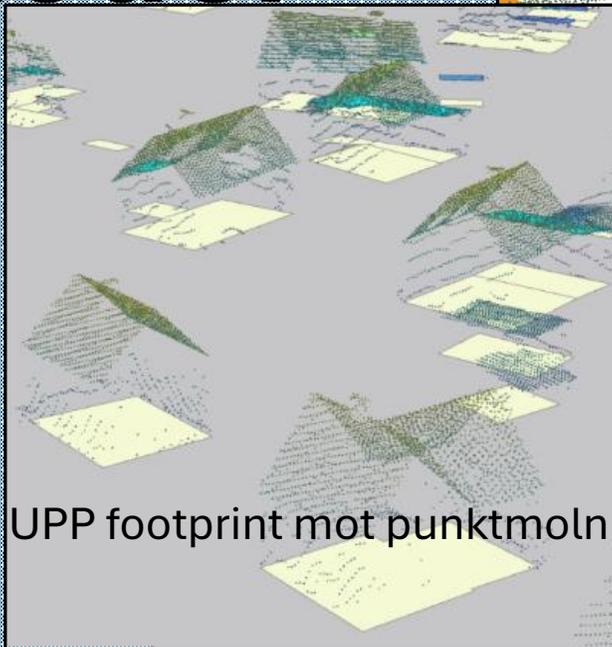
Vertex/brytpunkter i oväntad ordning!

Samma byggnad, efterredigerad i Arcgis Pro, format TriangleFan

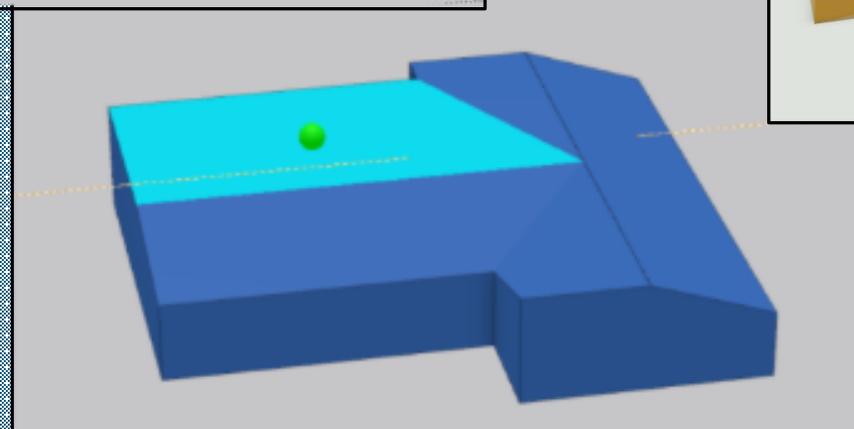
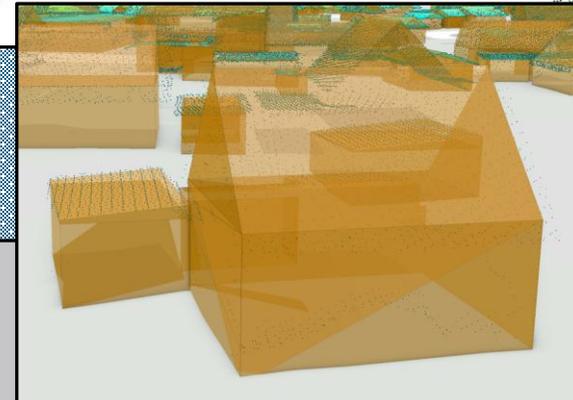
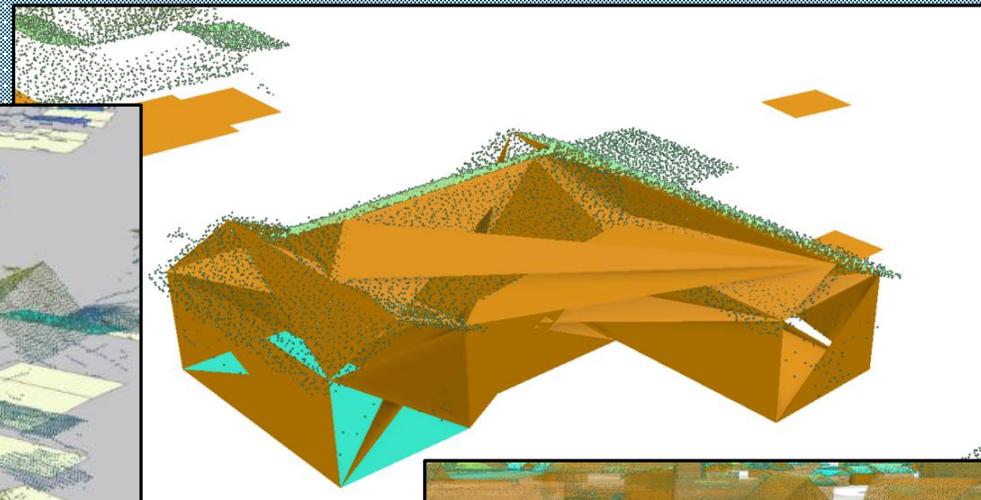
Byggnadsmetoder

Manuellt byggande i ArcGIS Pro

Klassificerat punktmoln+footprints



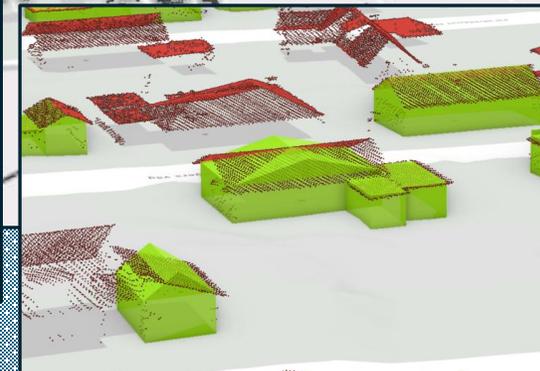
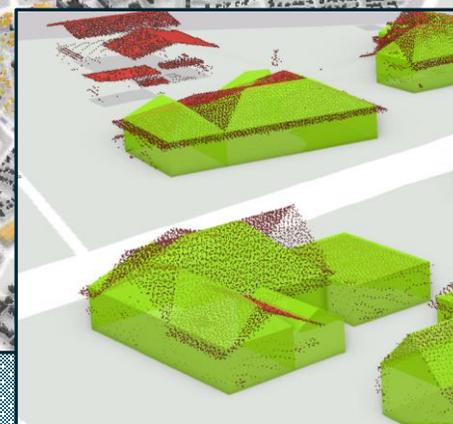
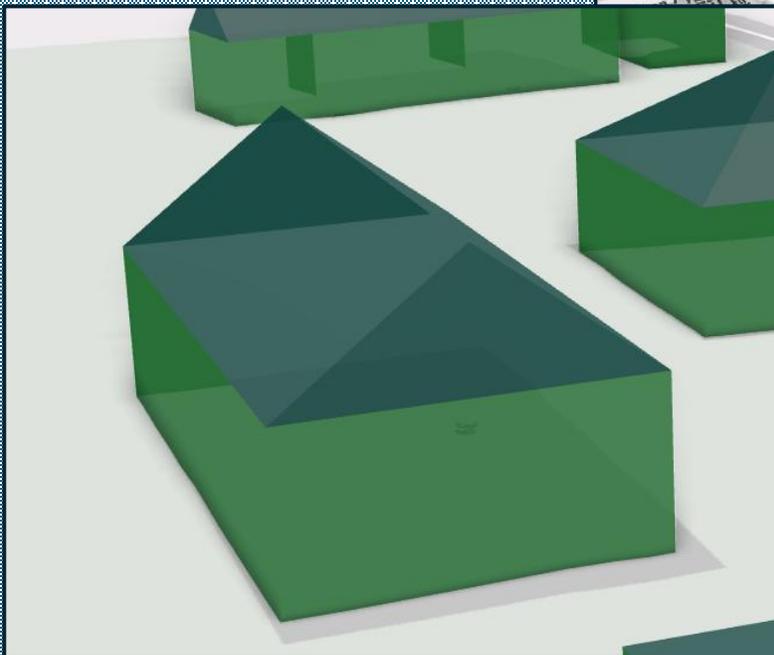
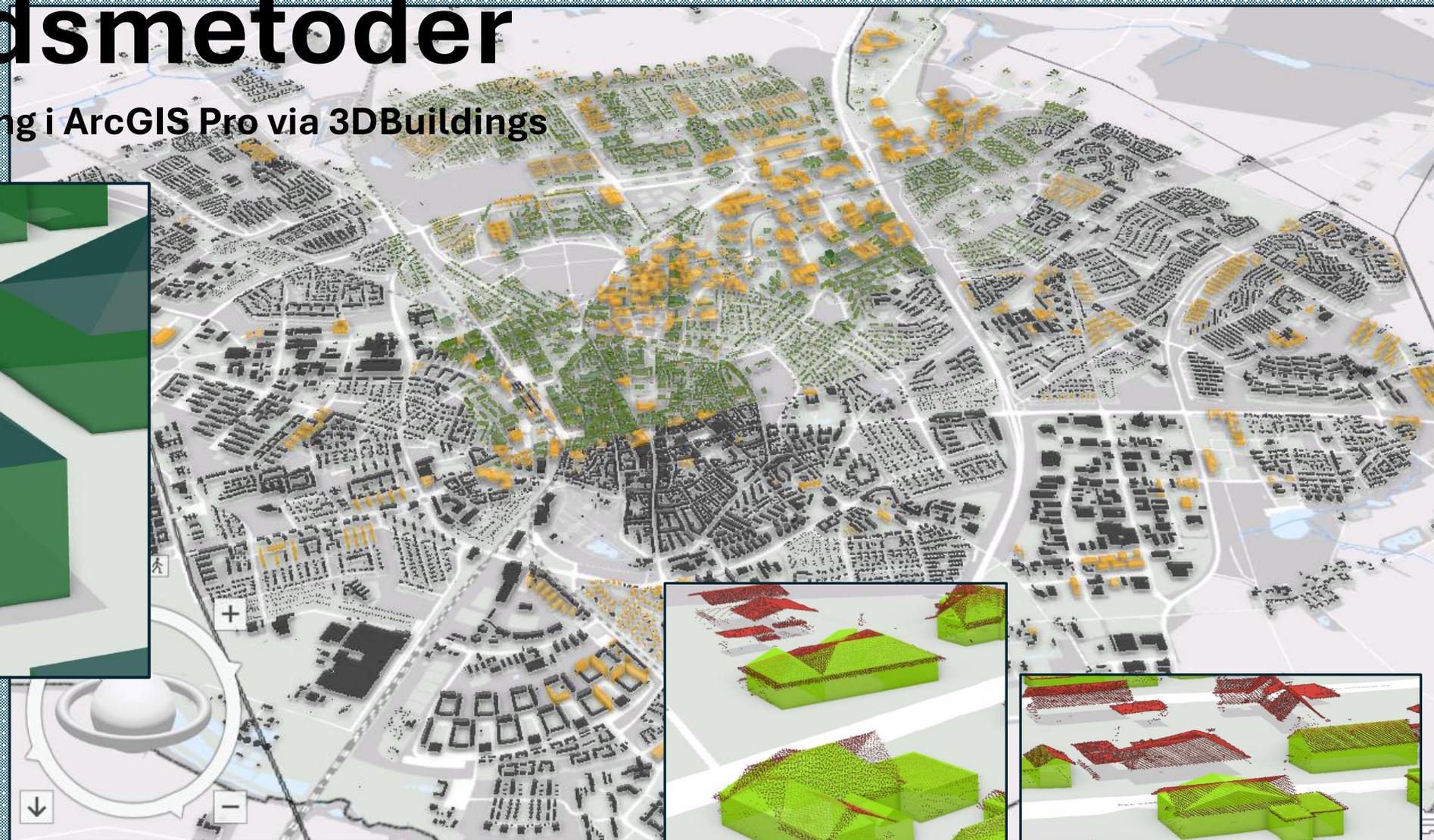
Dra UPP footprint mot punktmoln



Eller upp till högsta punkt och vik NED taket

Byggnadsmetoder

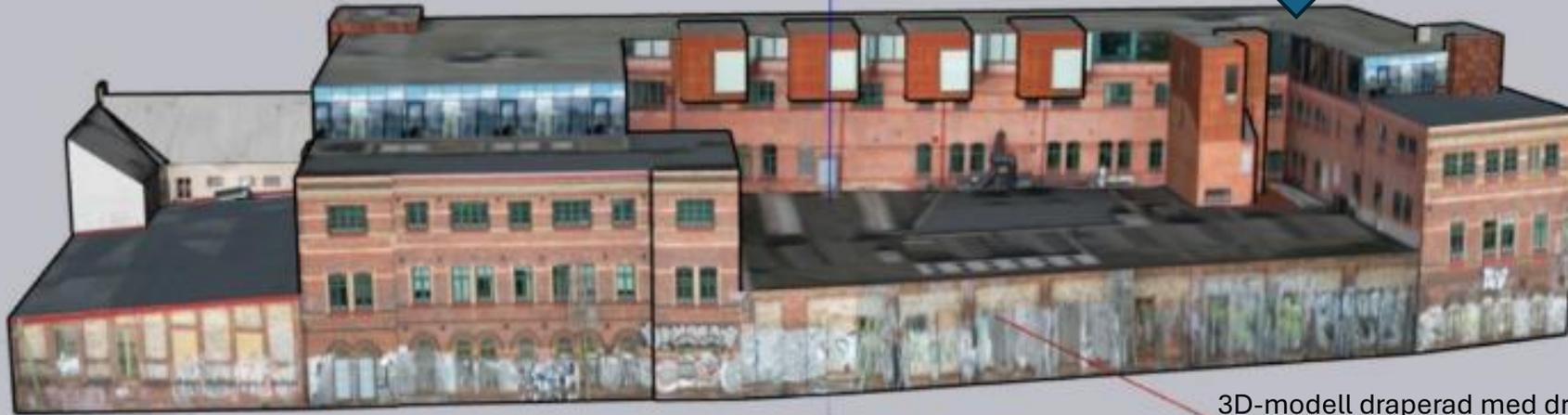
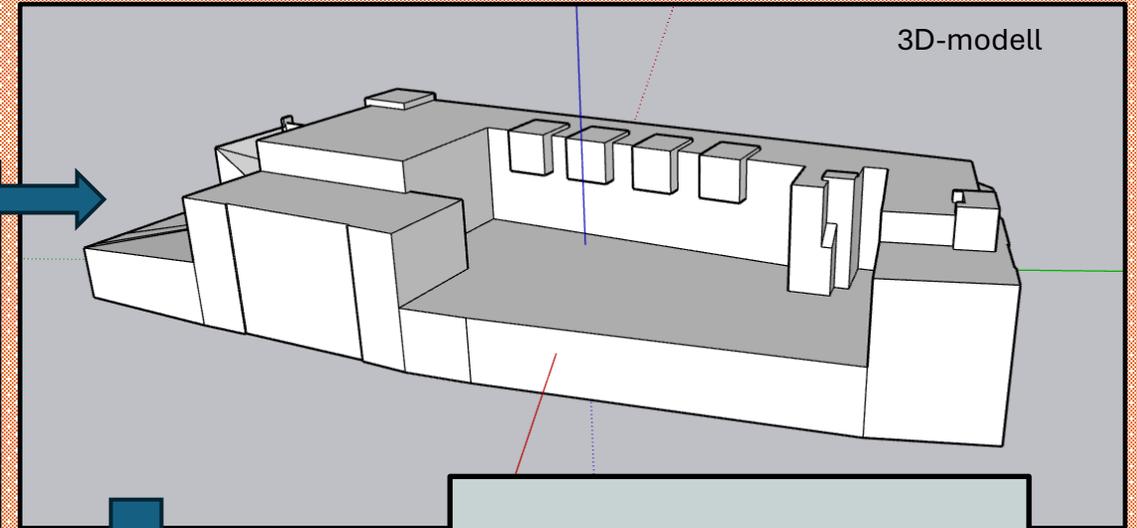
Automatisk generering i ArcGIS Pro via 3DBuildings



Byggnadsmetoder

Manuell konstruktion i Sketchup

Mark- och drönarskanning



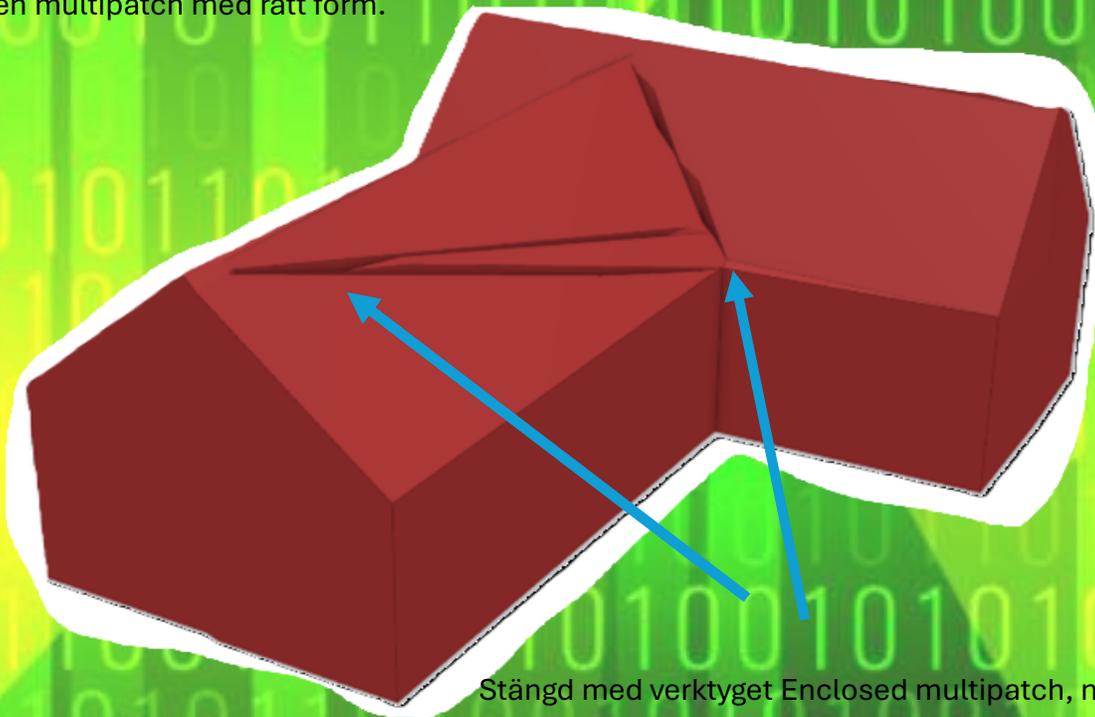
3D-modell draperad med drönarfoto

Stängda volymer + mängdlära=CSG

(Constructive Solid
Geometry)



Öppen multipatch med rätt form.



Stängd med verktyget Enclosed multipatch, nu förvrängd.

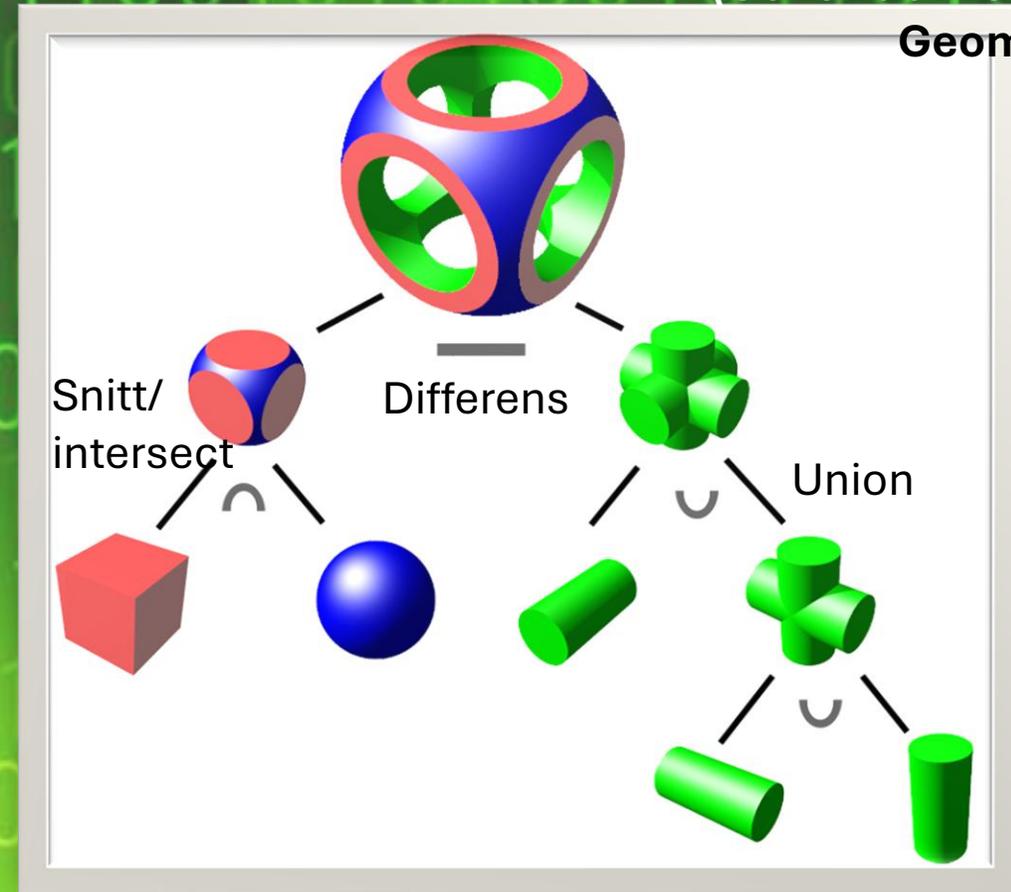
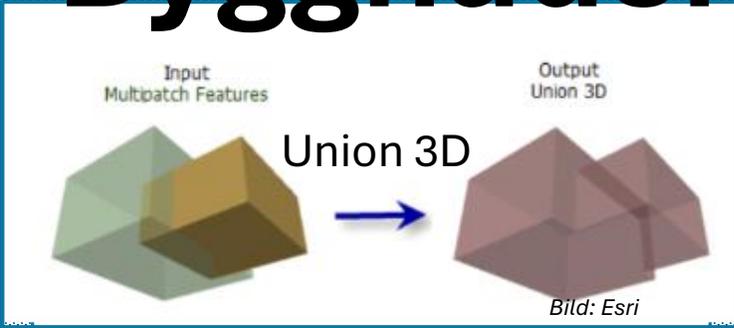


Bild: User:Zottie, CC BY-SA 3.0 <<http://creativecommons.org/licenses/by-sa/3.0/>>, via Wikimedia Commons

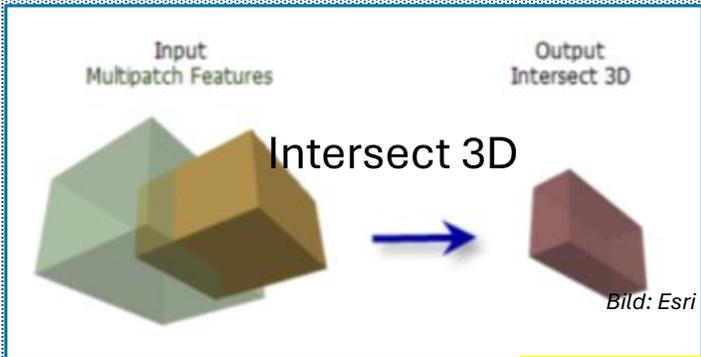
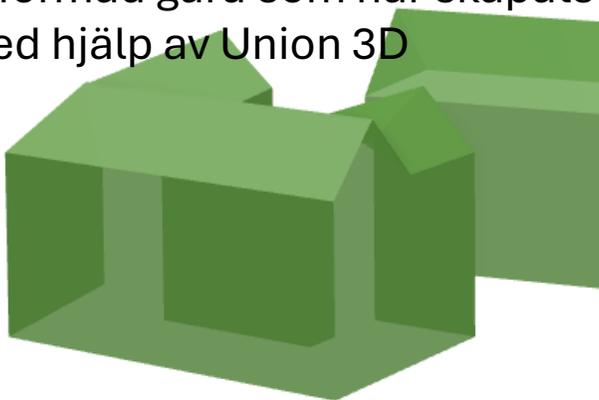
3D-grafik

Byggnadsmetoder

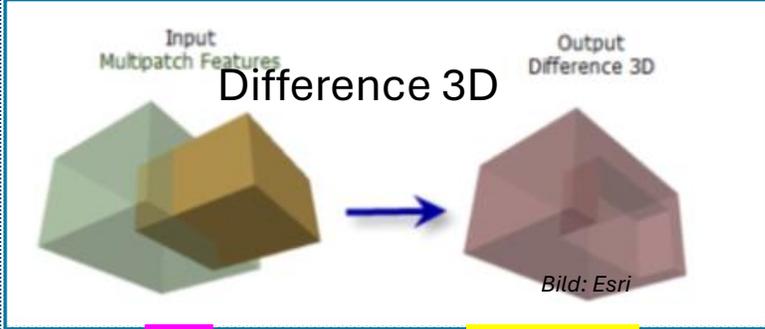
3D-analyst/ArcGIS Pro (Union 3D, Intersect 3D, Difference 3D)



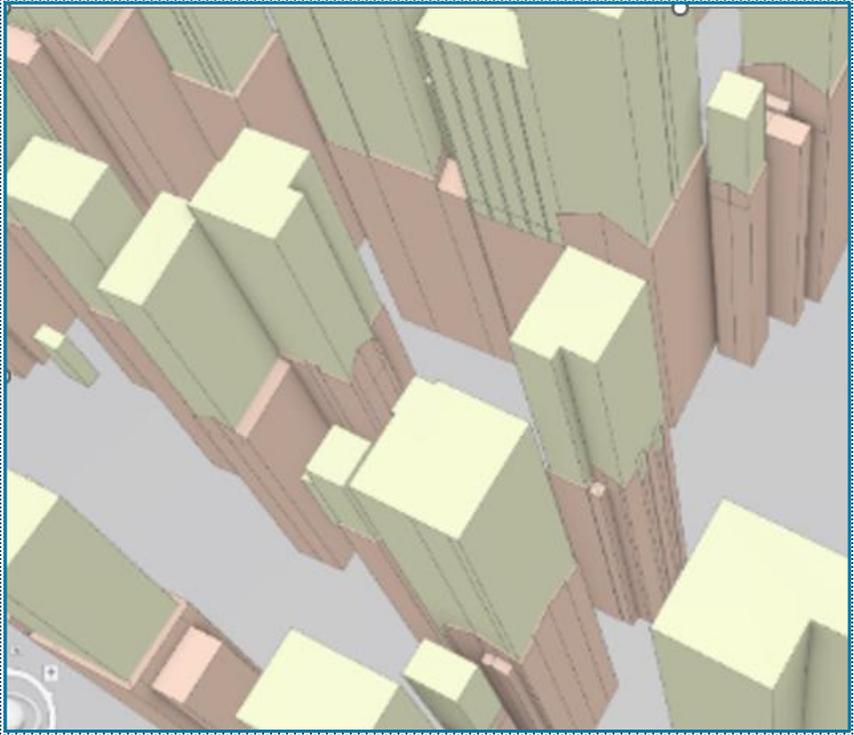
U-formad gård som har skapats med hjälp av Union 3D



Förberett för Intersect 3D: Inköpta hus och inmätta byggnadsfotavtryck i LOD1, över högsta nockhöjd.



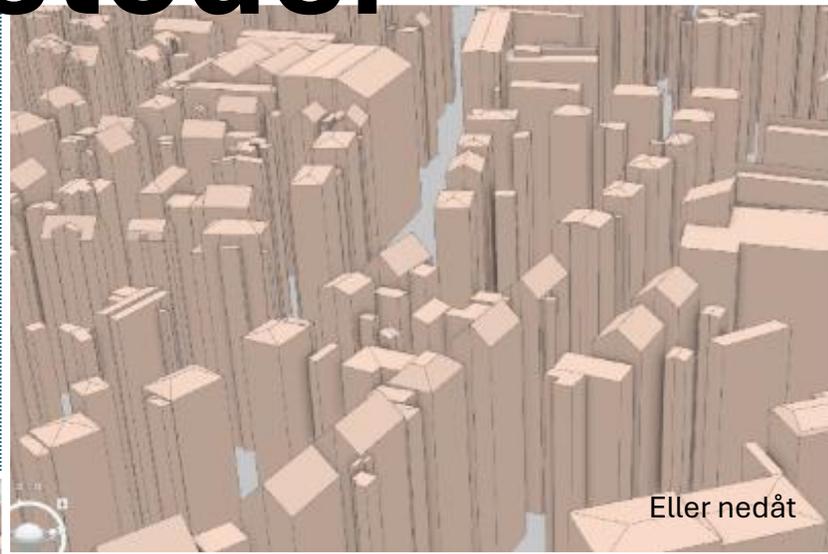
Difference 3D: Tak neddragna, byggnad uppdragen



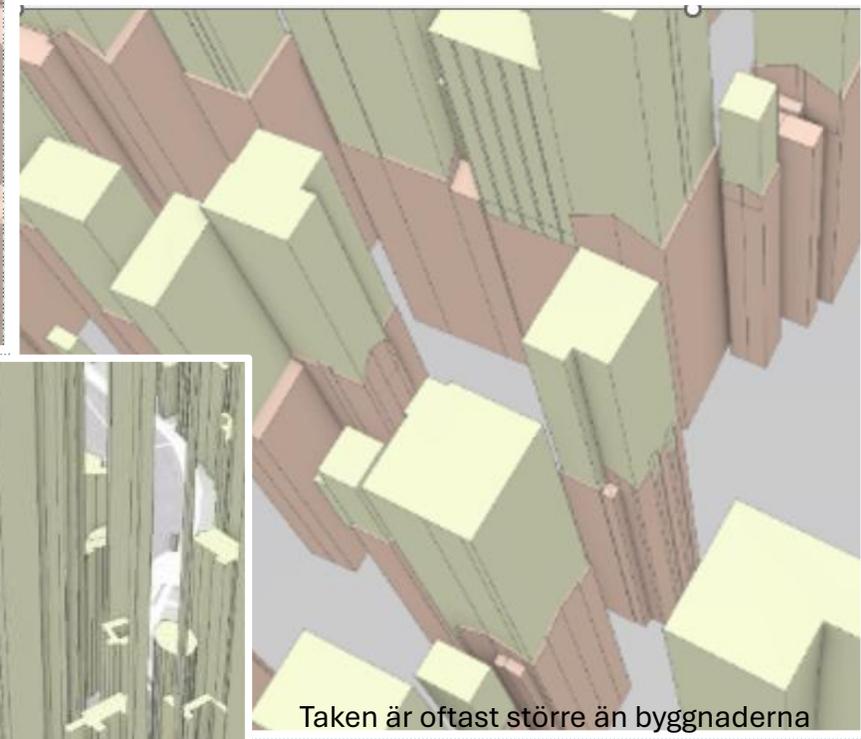
Byggnadsmetoder



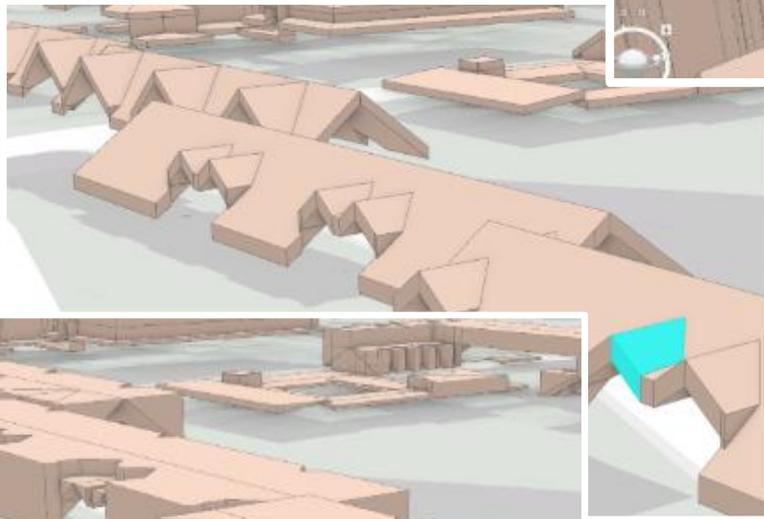
Inköpt tak har individuella polygoner



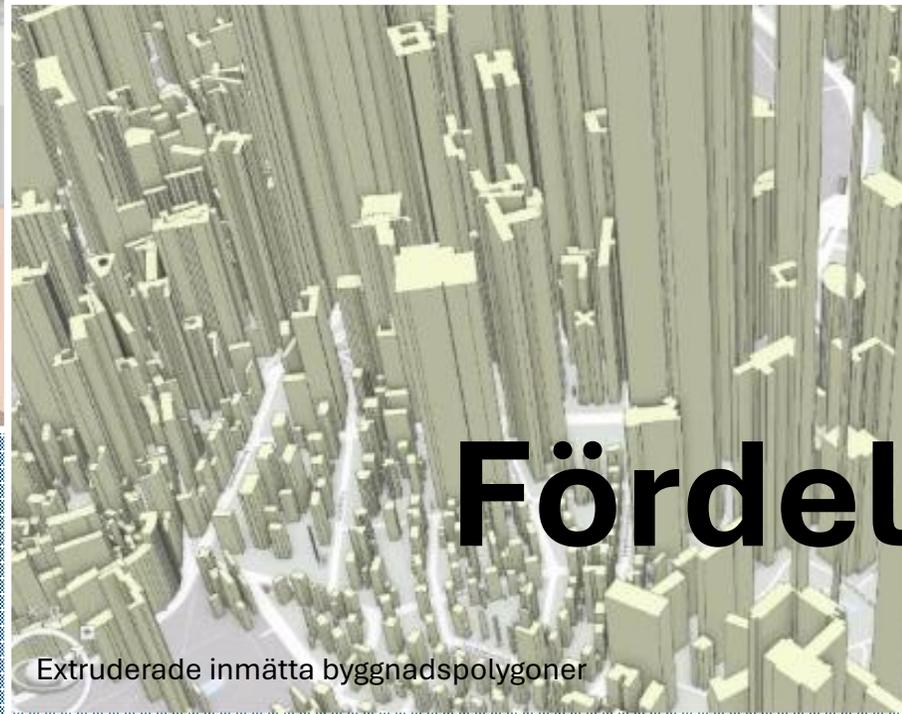
Eller nedåt



Taken är oftast större än byggnaderna



Kan extruderas uppåt på olika sätt



Extruderade inmätta byggnadspolygoner

Fördel polygon

Träd (som finns på riktigt)

Symbologi - Träd

Variera symbologi efter attribut

▼ Transparens

Fält <Inga> [X]

▼ Rotation

Lutning (X) <Inga> [X]

Roll (Y) <Inga> [X]

Riktning (Z) <slumpmässig> [X]

Minsta värde 0°

Högsta värde 360°

Rotationsstil

Geografiskt Aritmetiskt

0° 90° 180° 270°

▼ Färg

Fält Kronutbred

Normalisering Tr?dh?jd

Färgschema

0,133427098 0,133427098

4,70833998 4,70833998

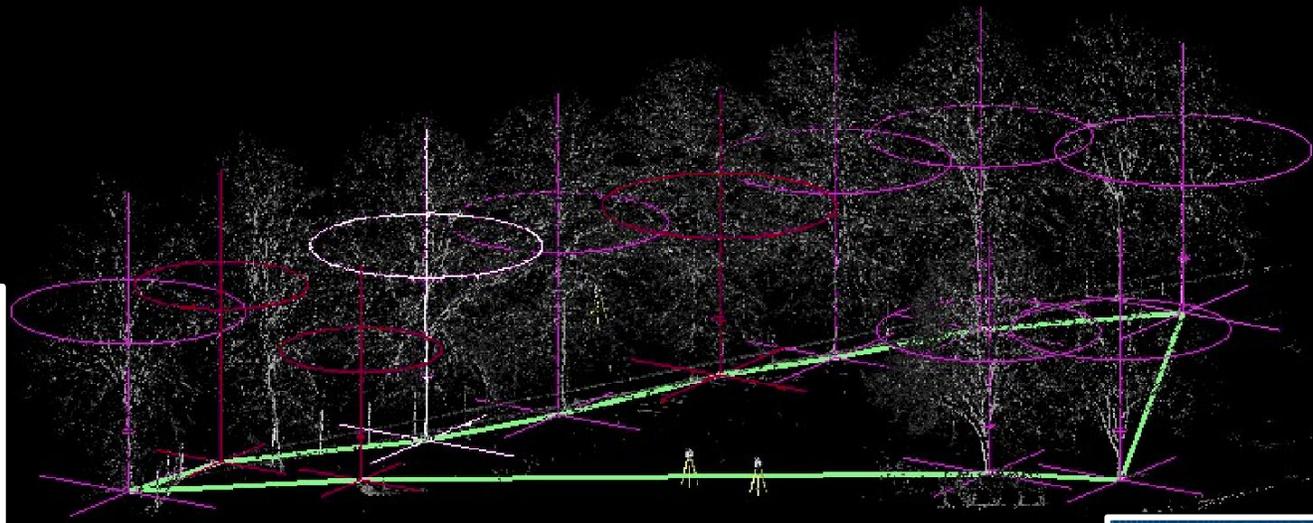
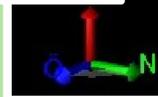
Uppdatera värden

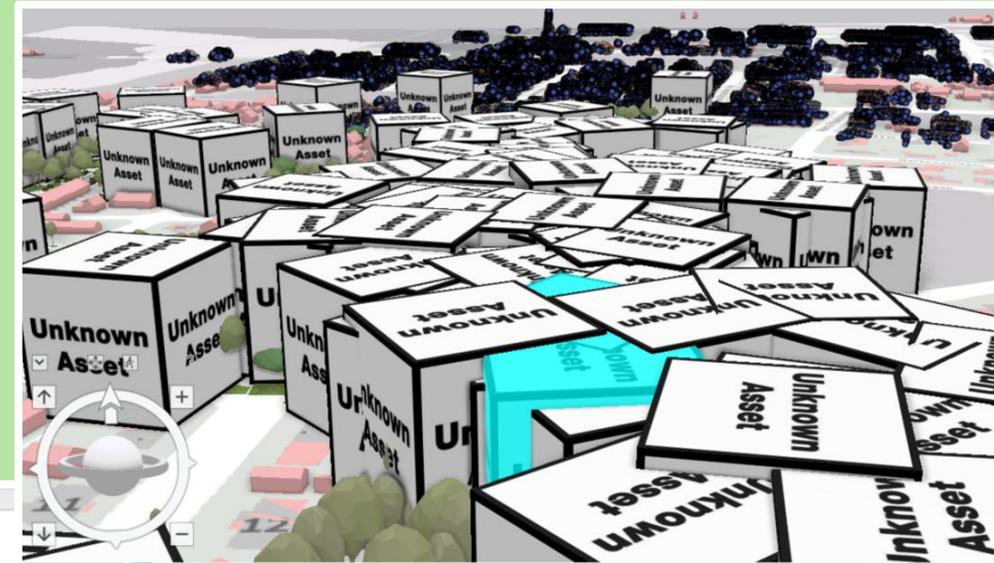
Visa teckenförklaring

▼ Storlek

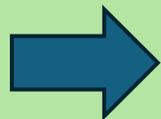
Behåll proportioner

Fält <Inga> m [X]





Jag skulle ju bara göra lite gräsmatta...



Trädindividens
attribut

3D Buildings | Karta

Popupfönster

Lövträd (1)

52

Lövträd - 52

egenTr	FID	52
egenTr	Kronubred	15
egenTr	Arter_jvt	
egenTr	Stamdiamet	0.65
41125	Tröshjd	18.23
L_24112	PointID	120
L_24112	Descriptio	

neType

24112

M:24;Continuous

fra värden-

L_241125_Träd_symboler-Polygon

L_241125_Träd_symboler-MultiPatch

ILLERADE Framtida potentiell byggn...

gnader Lunds tätort

odeller för framtida byggnader

GGNADER

ich

skan Mark 2

dsdelar 3D Smörlyckan

kan

und-ging-existerande byggnader



Planerade Nya sjukhuset bland
verifierade träd och befintlig bebyggelse

Träd

som symbol

Träd

som
multipatch

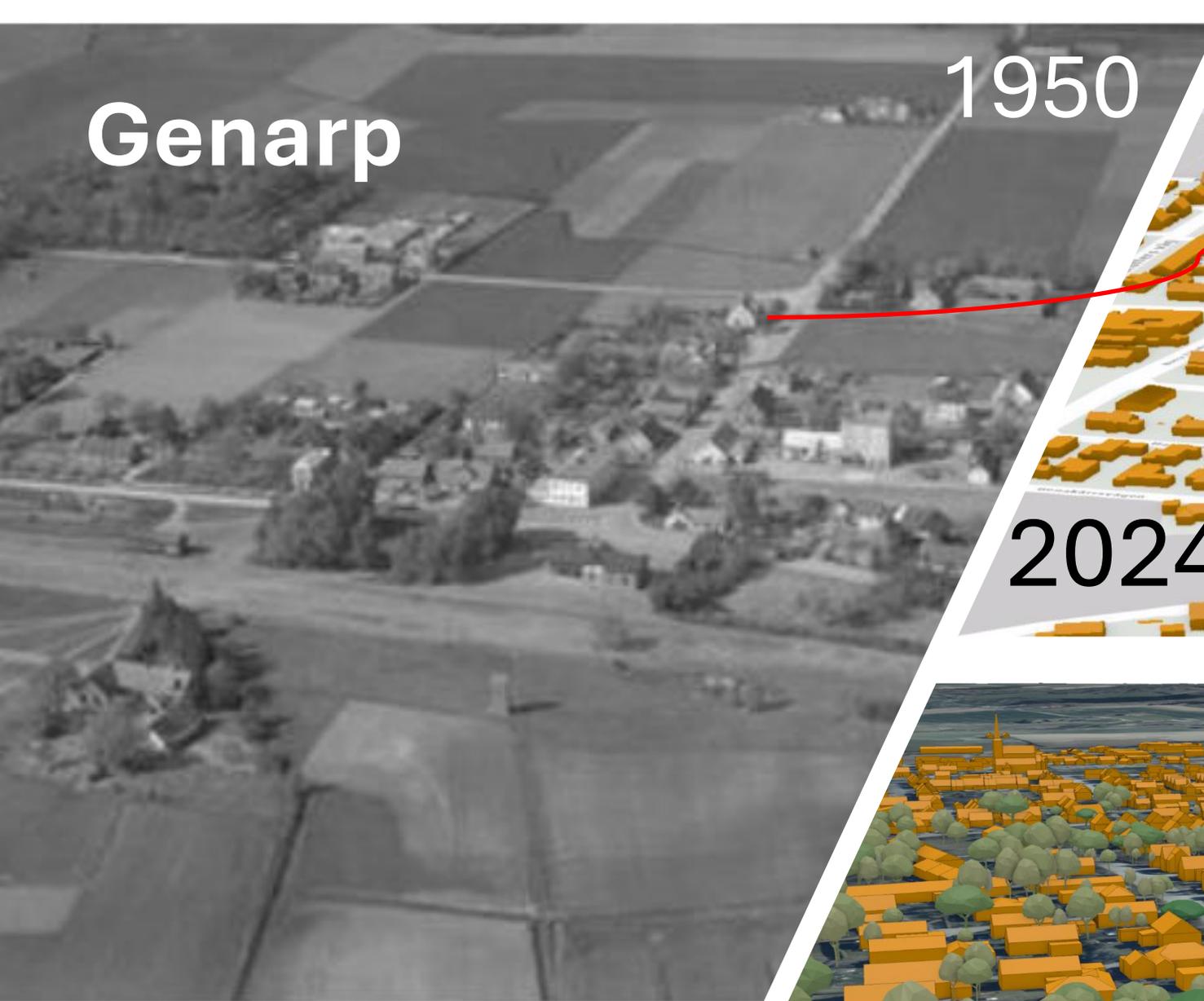
Planerade nya sjukhusområdet i Lund samt träd från LIDAR och TBC

Reell höjd och storlek att jämföra med



Genarp

1950



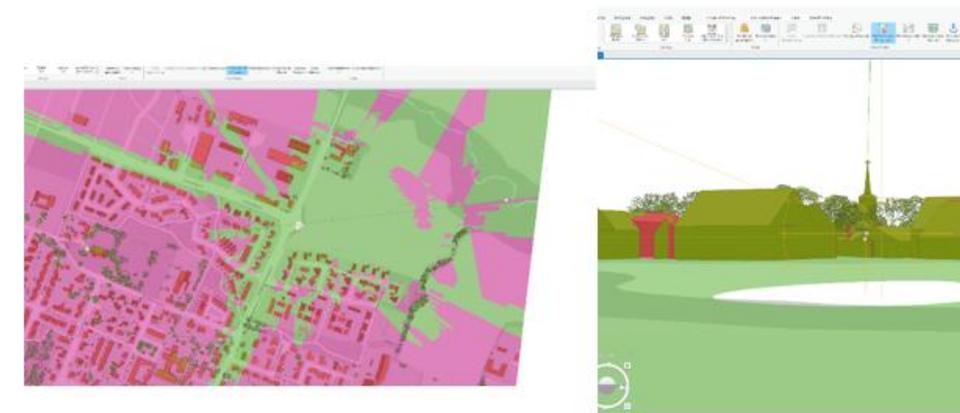
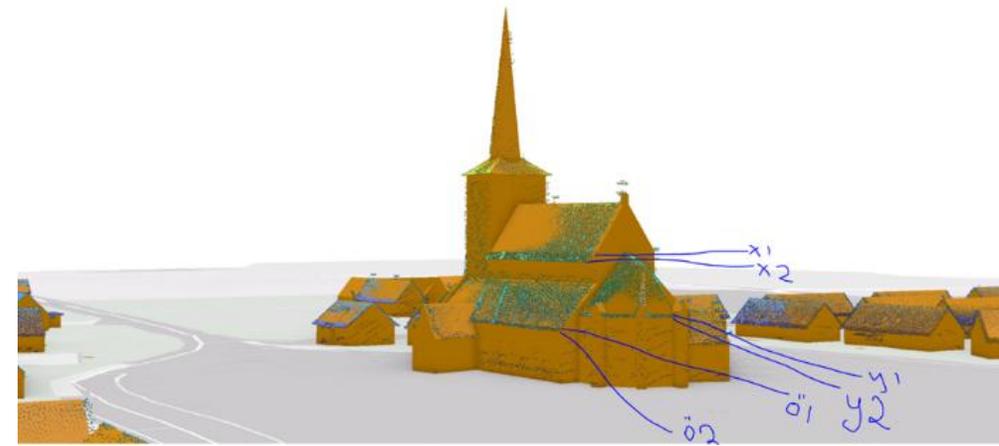
2024



er Genarp 1950, mot norr



Ortofoto, höjdmödel, 3D-hus och TBC-träd

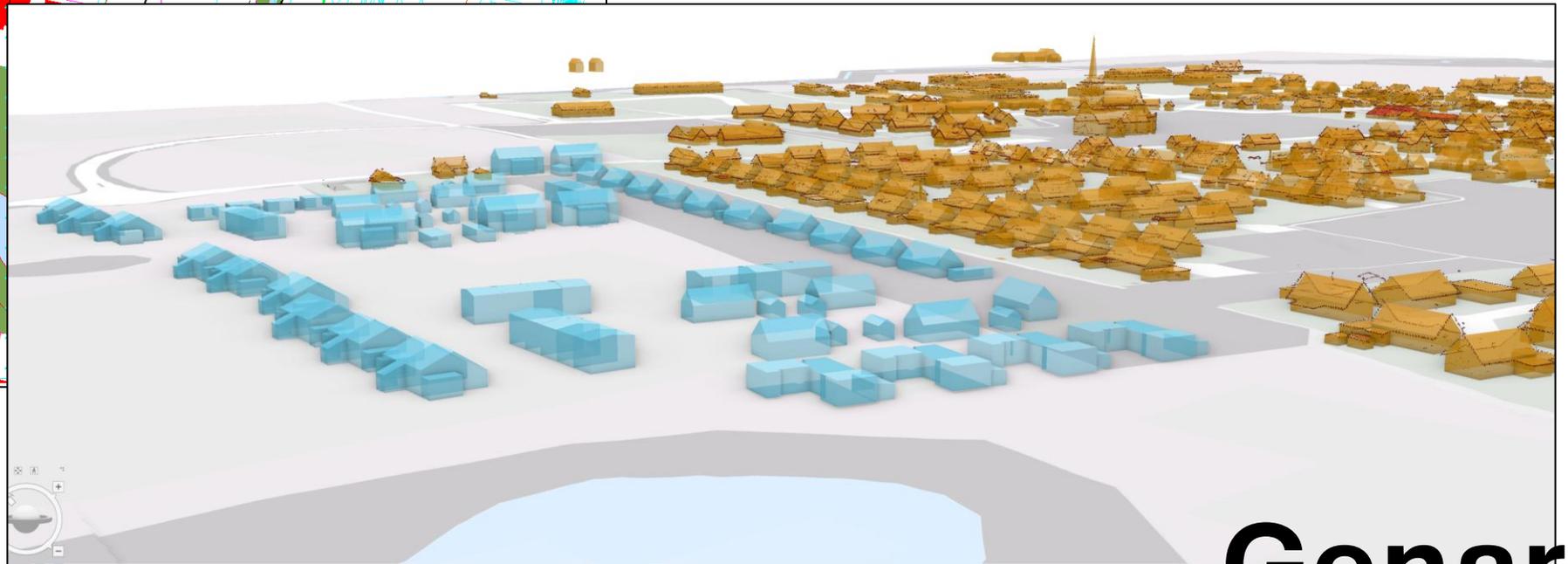


Genarp



Planerad byggnation

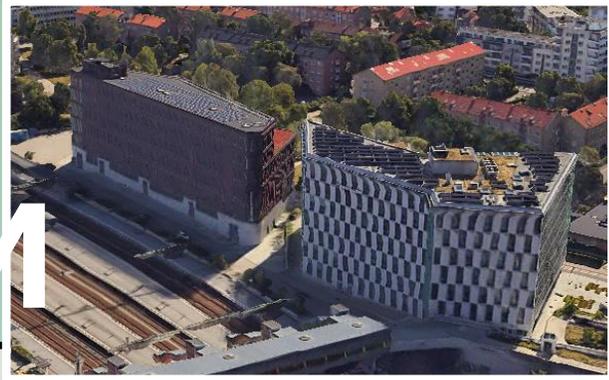
2D-CAD till 3D-GIS eller ritning till tvilling



Genarp

Planerad byggnation

IFC, BIM





Visionen om den smarta
snebildsoperationen

Snebild
+
DSM
=
3D-stadsmodell

2004

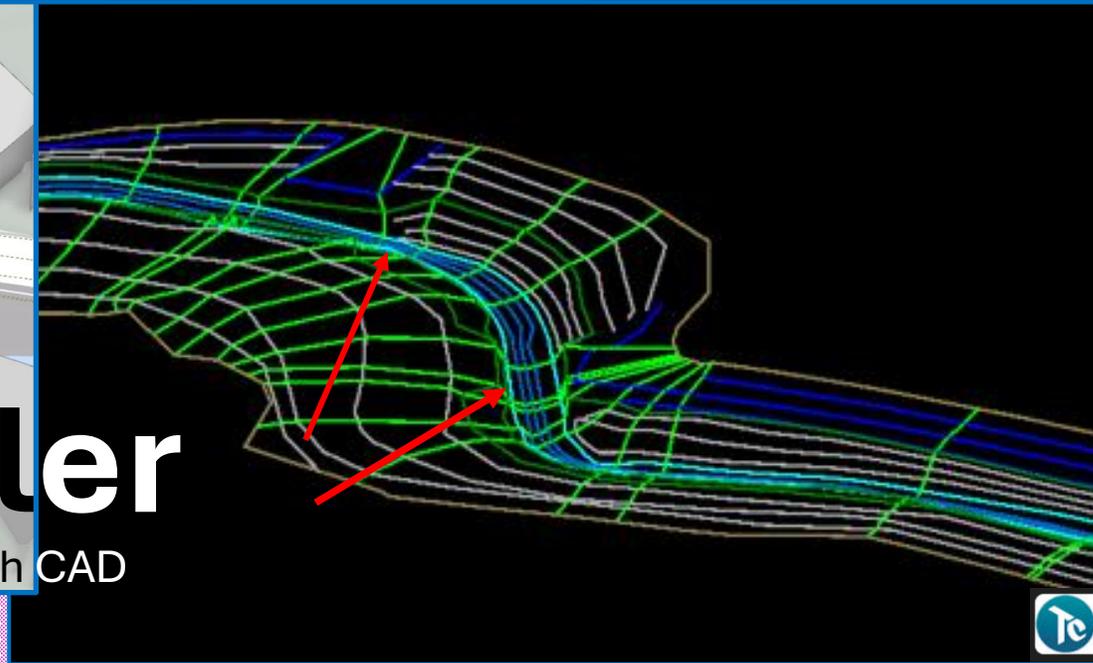
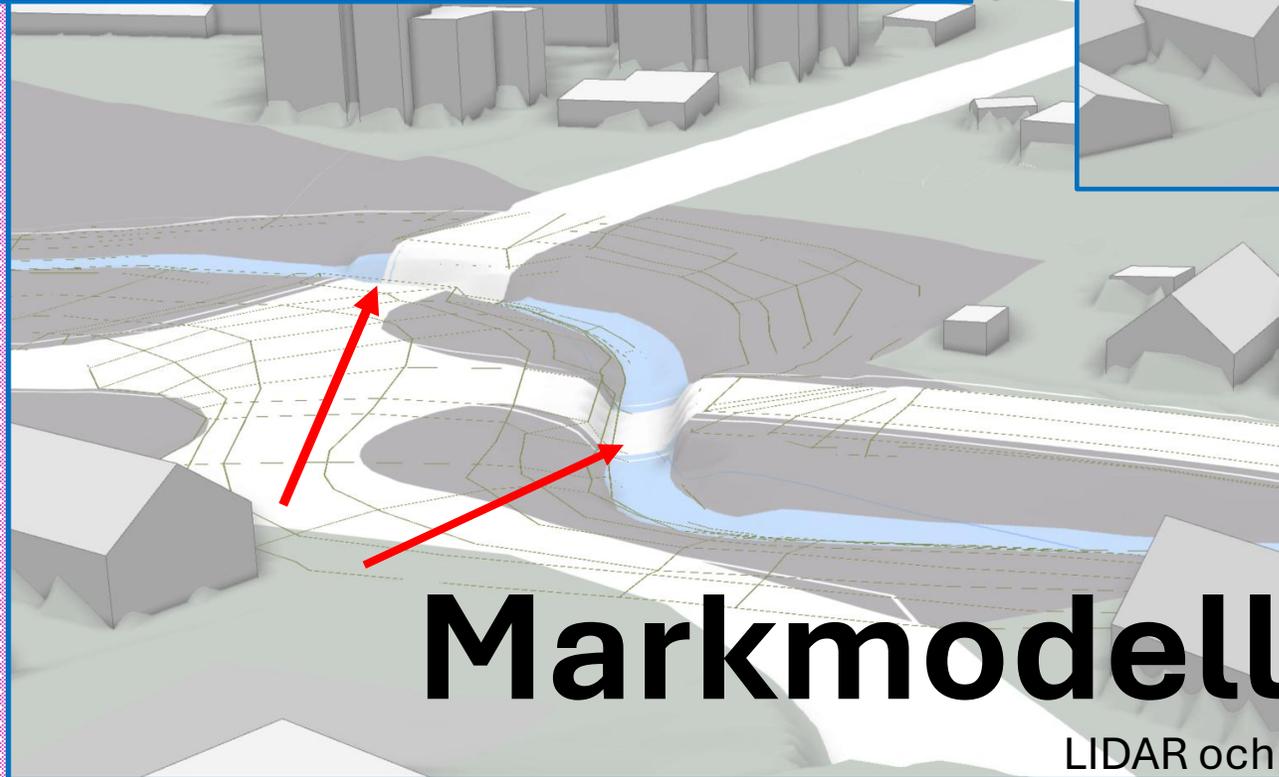


Planerad byggnation inlagd i Google Earth Pro



Fotorealistisk mesh med snebilder
2026

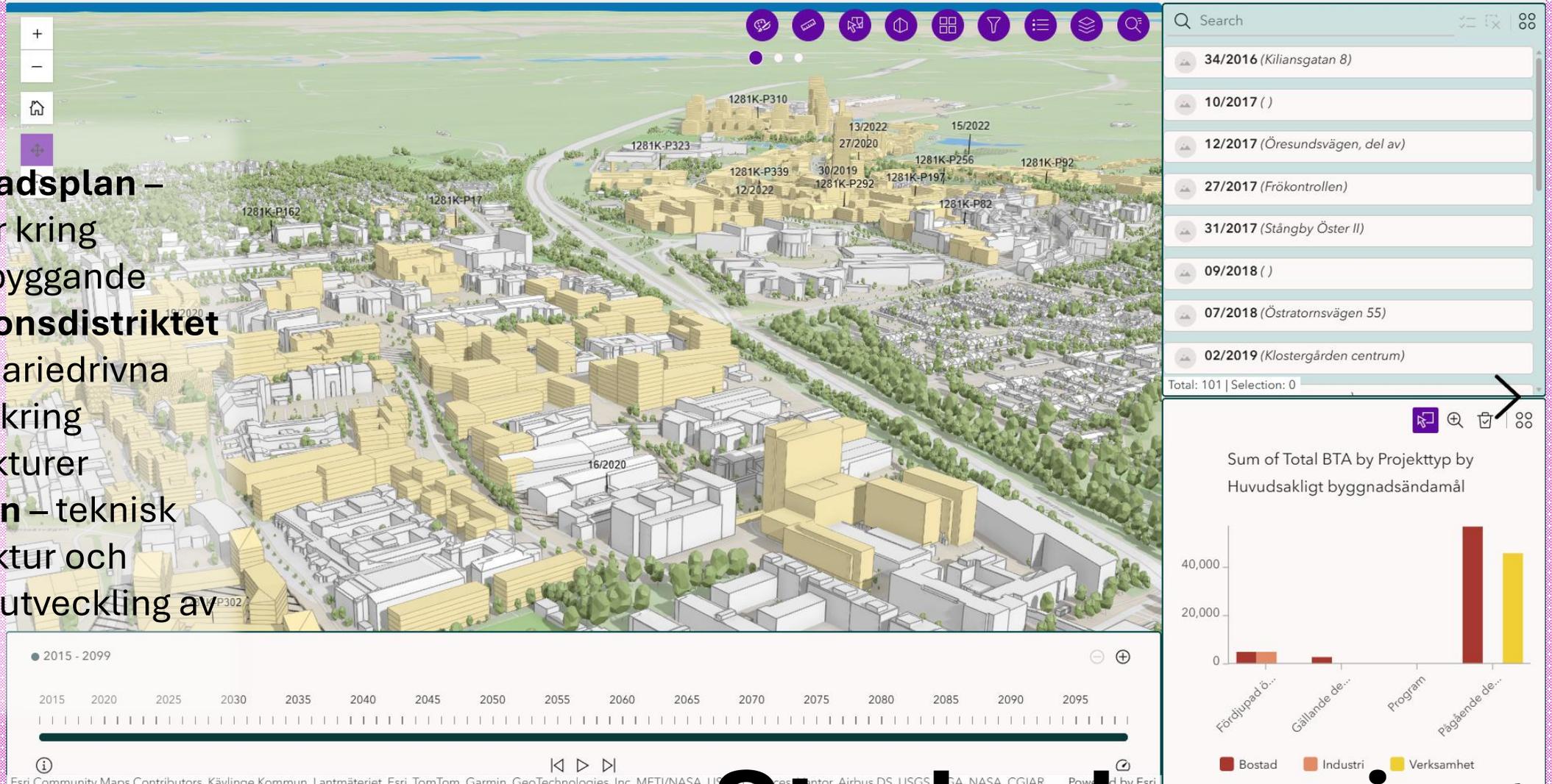
Analys



Analys

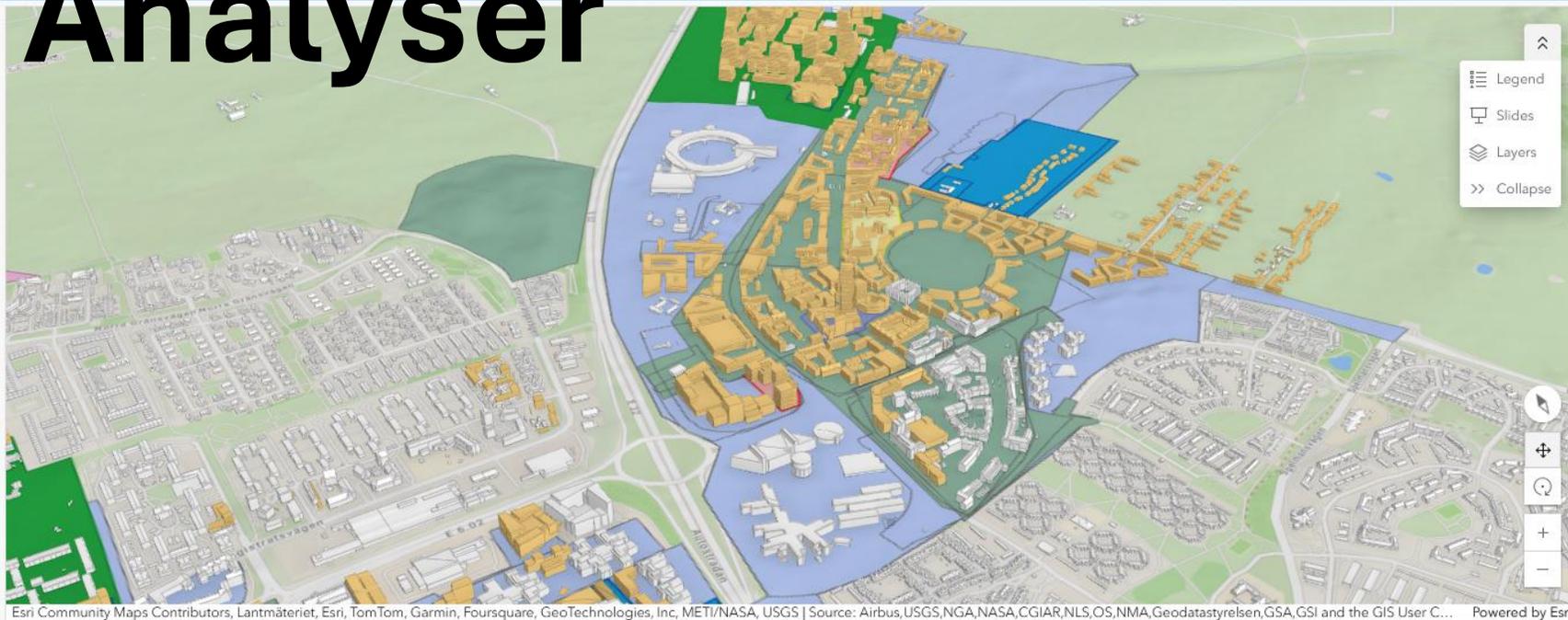
Virtuella Lund - scenariovyer

- **Utbyggnadsplan** – scenarier kring bostadsbyggande
- **Innovationsdistriktet** – ex scenariodrivna analyser kring grönstrukturer
- **Co Action** – teknisk infrastruktur och framtida utveckling av denna



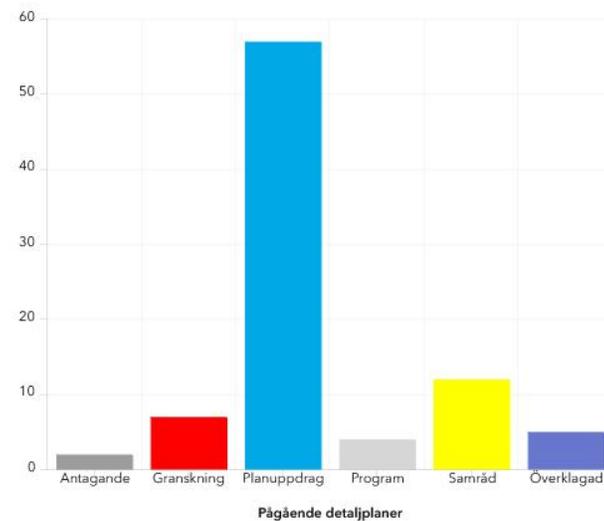
Stadsplanering

Analys



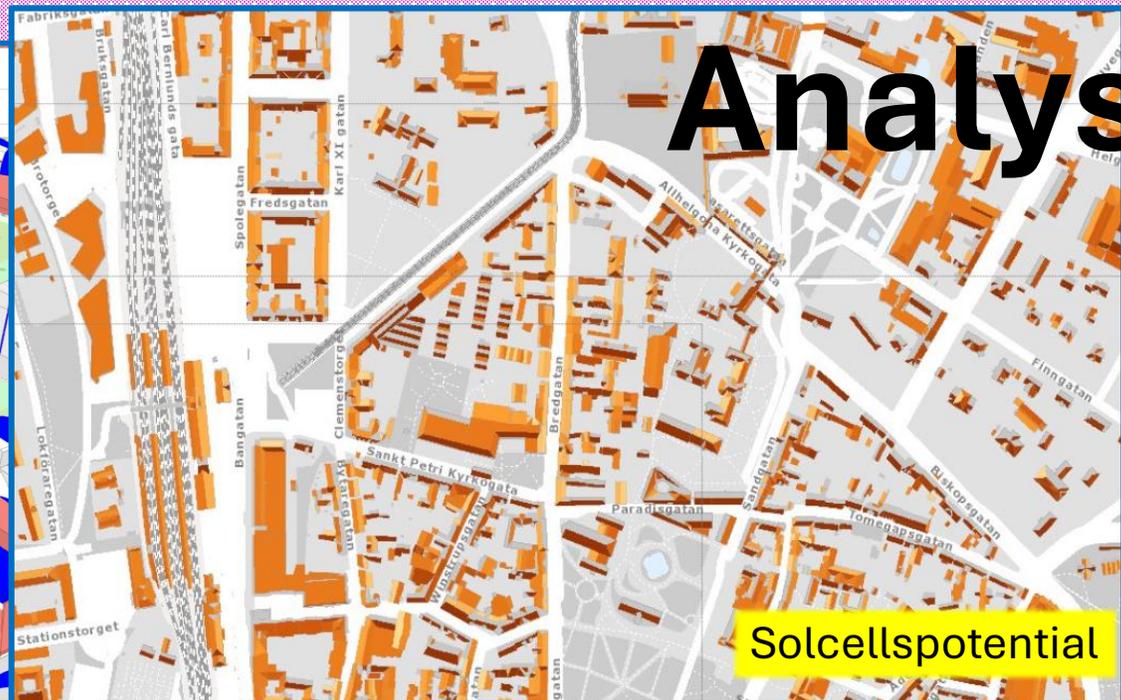
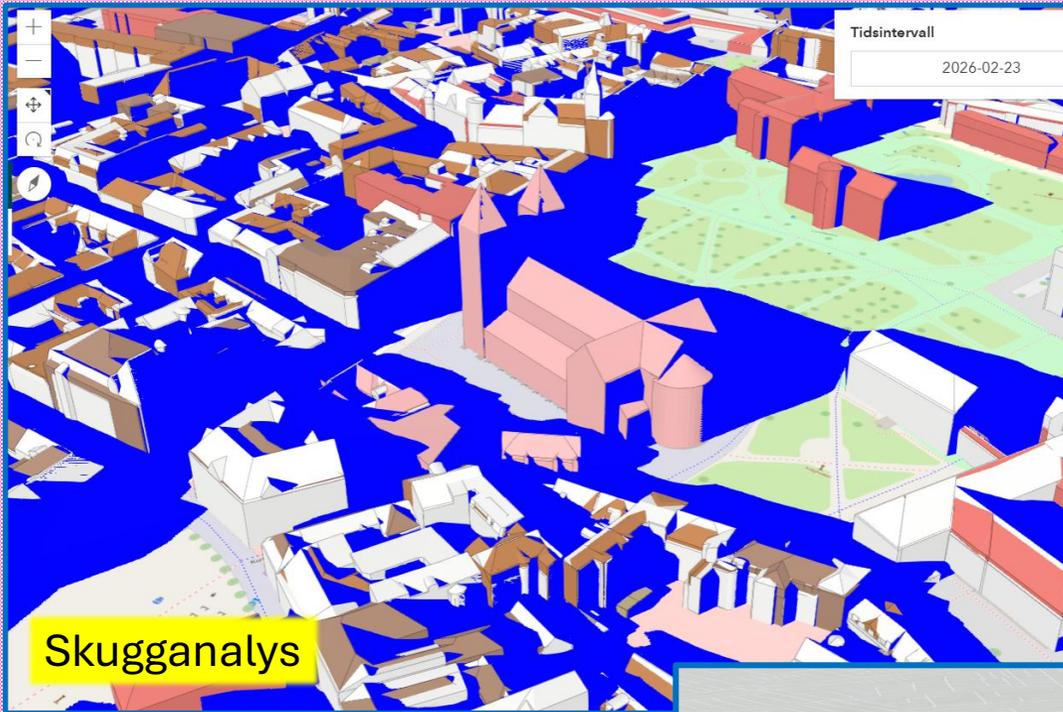
Just nu visas
831732 kvm
planerad BTA i kommunen

Total BTA BTA per huvudändamål



Projektkartan

Analys



Trädrötter i mark
Föroreningar i mark
Trafik, gata
Vind och träd i stadsmiljö



Arbete på väg mot mot 3CIM

Och sedan?

Kameror som mäter antalet personer som passerar

IoT och sensordata, tex sopbilar utrustade med kameror för att filma vägbelägningens slitage

Samarbete med DTCC

Pågående projektansökan Urban Transitions Lab (Shift Sweden)

steg mot en digital tvilling som kan uppdateras i realtid

Modell som håller ihop undersökningar, data och analyser