Implementation of the 3D Cadastre in Israel

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Key words: Israel, 3D Cadaster, LADM, 3D Registration.

SUMMARY

Cadastre can be referred to as a legal frame which connects three main components of any land administration system: people, land and law. A functional and reliable cadastral system is a vital factor in proper management of land, which in turn leads to sustainable development and a strong economy of a country.
The need for a solid cadastral basis becomes more acute when land is a scarce commodity, much like in the case of Israel. Furthermore, over the past few decades due to urbanization, accelerated pace of living and rapidly emerging complex construction situations, among other factors, the necessity for utilizing the space above and below the surface and expanding the existing 2D cadastral system became more and more compelling. Consequently, this topic has been researched and investigated for quite some time. Several agencies joined forces in order to defined and implement 3D cadastre, while considering latest technological developments as well as international land administration standards such as LADM (Land Administration Domain Model).
This paper offers a conceptual as well as a technological overview of a 3D registration process, following the proposed amendments to the existing Israeli Land Law suggested and developed by the Survey of Israel 3D cadastre project team.

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1. INTRODUCTION

Israel is a small country with a constantly increasing population, hence the need for open spaces is constantly rising as well.
Planning and development needs have become more and more complex over the years from the aspect of utilizing space both above and below ground, and thus the need for an ability to administer registration of accurate multi-level and coordinate-based three-dimensional cadastre significantly becomes apparent.
The issue of 3D Cadastre has been investigated in Israel starting in the late 90s, and has been addressed by several researchers (Benhamu & Doytsher, 2001; Forrai & Kirschner, 2001; Grinstein, 2001; Sandberg, 2001, Benhamu & Doytsher, 2003; Sandberg, 2003). The work came to fruition by means of an R&D project which was carried out during 2002-2004. The conclusions the R&D research team has reached, as well as the detailed analysis of the legal and special elements of 3D cadastre, can be found in several publications (Shoshani et. Al., 2004; Shoshani et. Al., 2005, Benhamu, 2006).

Currently, one of the objectives alongside development and implementation of a 3D cadastre in Israel is the correlation between LADM ISO standard and the realization of a 3D country profile. Since more and more countries around the world adopting the principles define within the Land Administration Domain Model, which addresses both the legal and the technical/ spatial aspects and enables a mutual platform for all land authorities throughout the globe. In their paper, Felus et. al (2014) summarize previous activities in the field of 3D cadastre, offers an overview of current legislation and regulations and underlines the steps to be taken for creation of the 3D country profile.

Until now, Israeli law has not enabled registration of three-dimensional cadastre. Due to a mixture of uses in various spatial levels, registration of three-dimensional cadastre is required to enable taking a part of the realm of ownership and transferring it to others.
In the next section the main points of the law, difficulties and path to a solution: Legislation – Israel Lands Law are described.

2. 3D REGISTRATION – A NEW APPROACH

Cadastral system embodies a variety of components; the legal and the administrative components manifested in land registration, and the spatial element revealed within the cadastral mapping (Lemmen and van Oosterom, 2004). However, the registration is merely the last step in the *Registration Chain*, though the most crucial one from land rights point of few. The process starts with a planning map, depicting zoning areas and land use designations, which usually indicate changes in the current boundaries of the registered

parcels, therefore changes in land rights and ownerships. For the process to be complete, new lots need to be transformed into registration units, meaning parcels by means of a parcellation plan and finally be registered at the Ministry of Justice.
Each element of the chain is under the responsibility of a different agency and governed by particular laws: zoning plans are prepared and approved by the Israeli Planning Administration, parcellation plans are the domain of Survey of Israel, whereas the registration is performed by the registration office.
Currently the main challenges in implementing 3D cadastre in Israel stem from several definitions as they are outlined in the Land Law. Nonetheless, the planning aspect needs to be addressed as well and correlate with the other element in the registration chain.

2.1 The Israeli Land Law

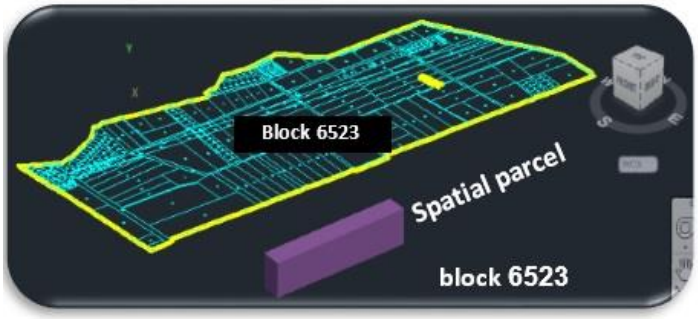
The land ownership as defined in the Israeli land law - the ownership spreads over the ground parcel in the depth below and lofty space above it - poses several difficulties, such as:

- It is not possible to carry out a land transaction and transfer of ownership of a part of the space defined as land ownership, meaning it is not possible to register a house to one person and an underground tunnel to another.
- Land registration is defined as two-dimensional
- The vertical split for various spatial levels requires 3-dimensional registration

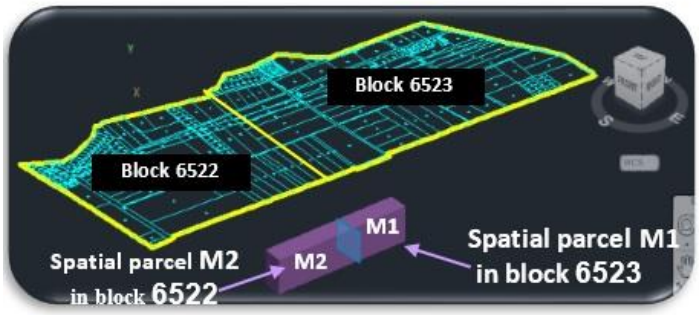
Therefore, the law needs to be amended to enable registration of vertical division of the space to various levels and designations.
The new approach as developed at the Survey of Israel, suggested several amendments to the Law. First and foremost a 3D Parcel is defined. Secondly, it enables registration of various ownerships in various levels of the space, provided it complies with the planning map and as such provides a basis for the establishment of three dimensional cadastre. The draft passed the first reading in the Knesset (Israeli Parliament) and awaits a second and a third readings to become valid.

2.2 The Principles of 3D Cadastre Registration

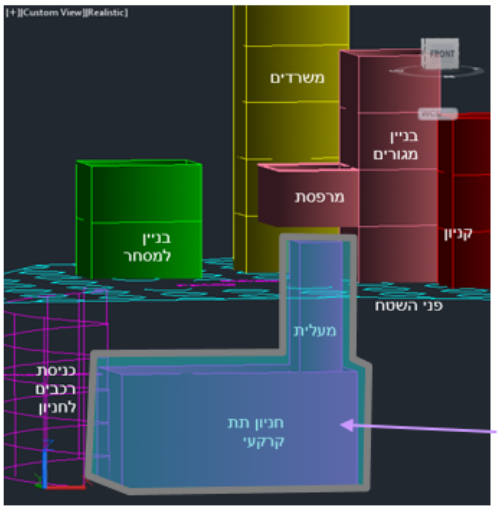
In order to enable three-dimensional cadastre in Israel as soon as the amendment to the law is ratified, a pilot program was conducted for implementation of three-dimensional cadastre at the railroad station in the city of Modi'in.
As part of the applied pilot, a market examination of technological availability that supports a process of creating three-dimensional cadastre was performed.
Hereafter, the principles of three-dimensional cadastre and all the stages undertaken for implementation of the pilot, software used and results of the pilot are presented.
In order to understand which principles and data the pilot incorporates, one must understand the principles for creating three-dimensional cadastre.



1. The first principle concerns the identification of a spatial parcel, which is to receive the block number within the borders of its location.



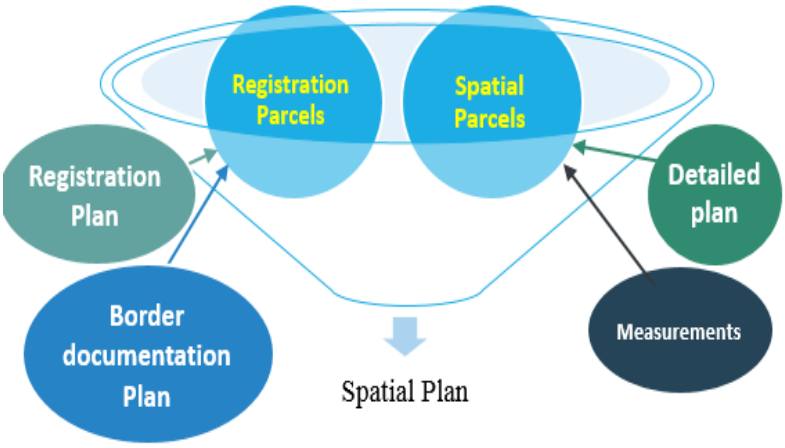
2. The second principle defines the way a special object to be divided, For example, if the spatial object, e.g. a tunnel, covers more than the borders of one block, division of the spatial parcel will be performed according to division of the blocks.



3. A spatial parcel can outspread above and below ground at a given time.

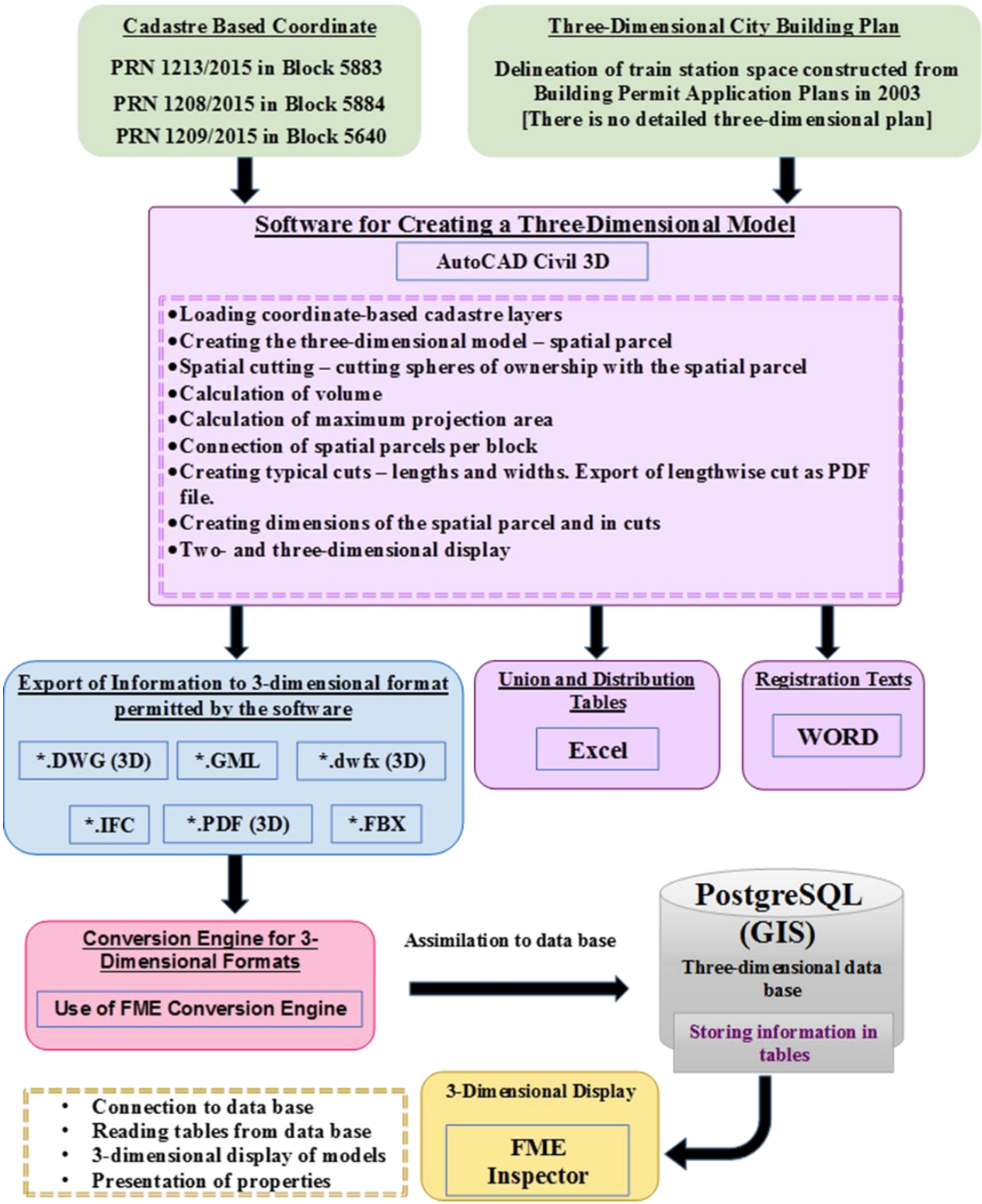
4. 3D parcellation plan – to be implemented vis-à-vis final parcels only.

One spatial parcel that is deployed above and below ground at a given time

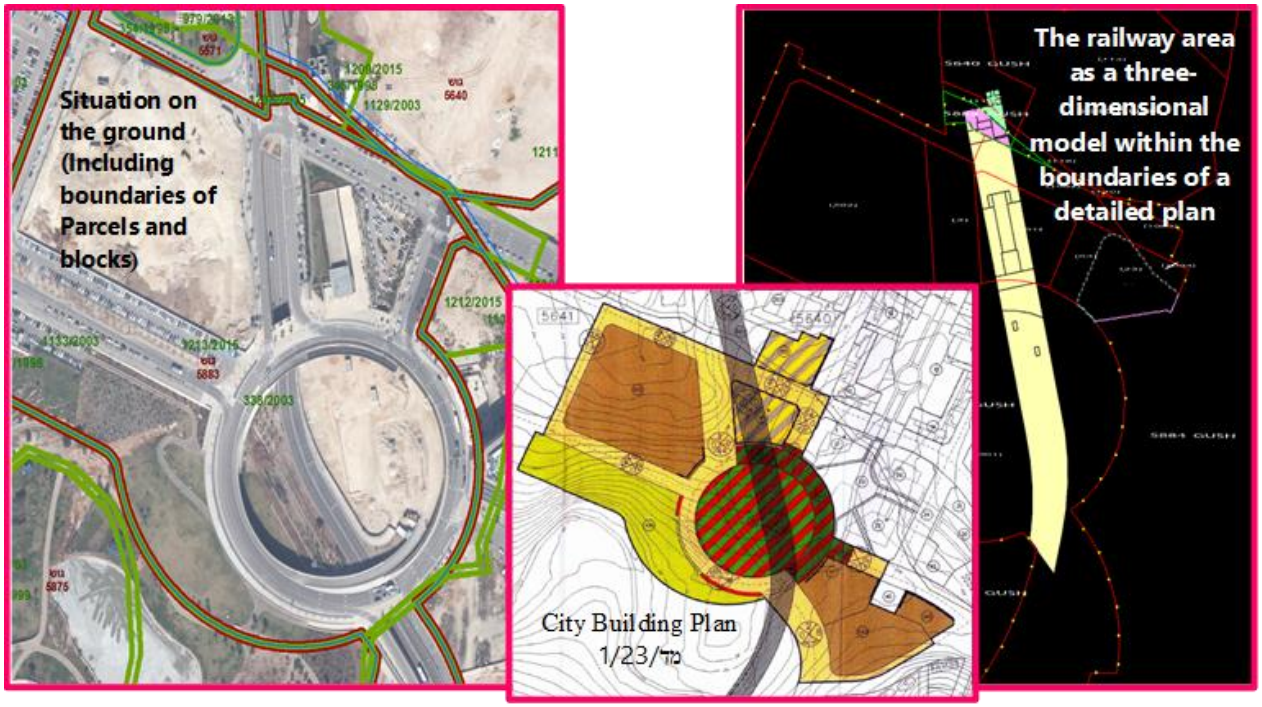


5. Prior to creation of 3D parcellation plan, a 2D plan for documenting boundaries needs to be created according to definition of final parcels

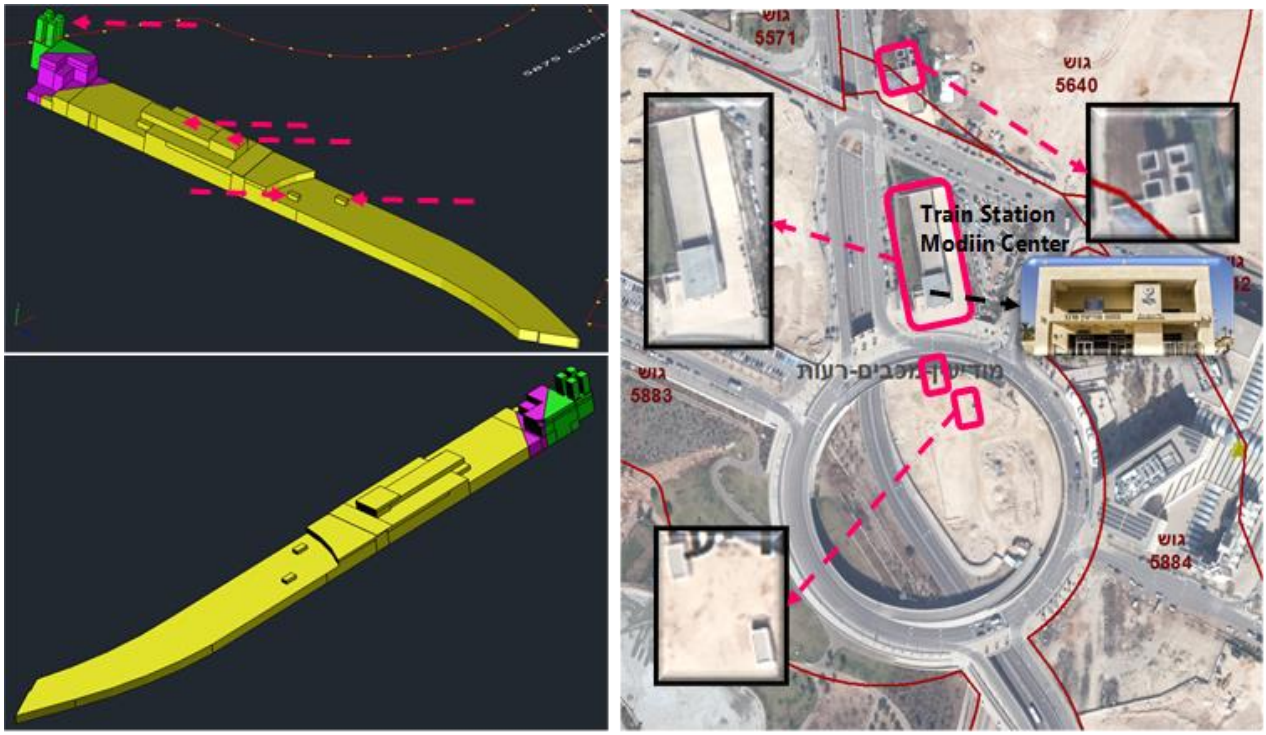
Work Process Framework



The three-dimensional model erected as part of the pilot is of the railway station in the city of Modi'in within the boundaries of CBP (city building plan) no. 1/23/MD. Below are presented the topographical features of the pilot area – the railway tunnel.



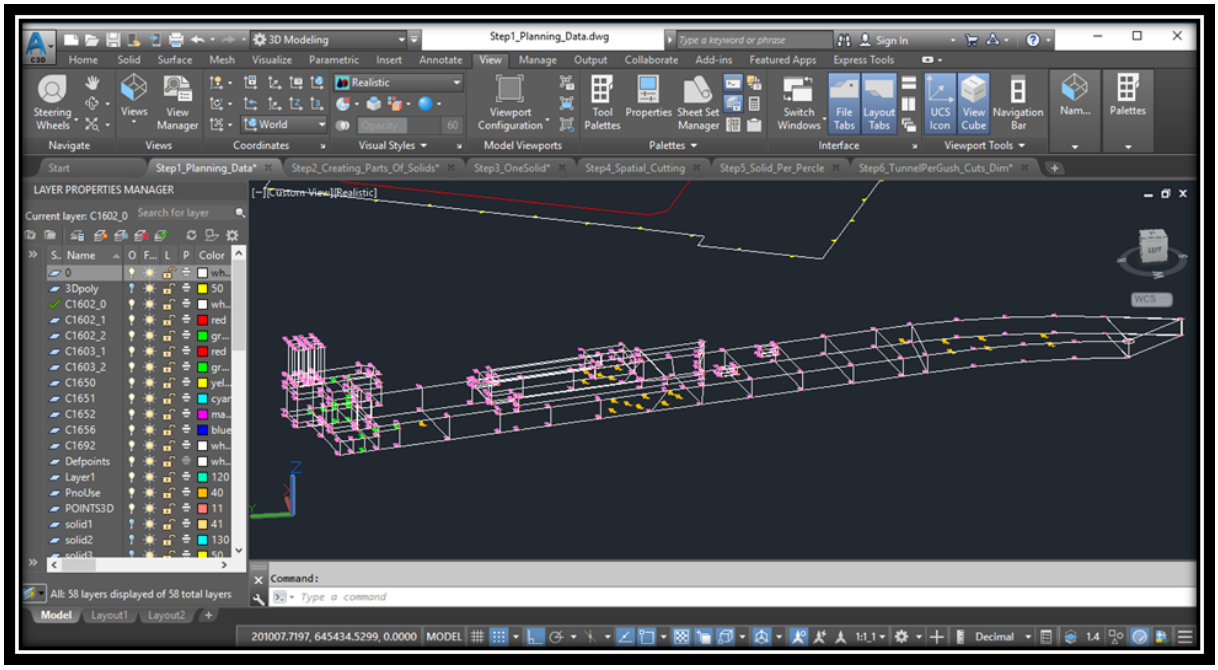
A comparison between the existing land coverage and the 3-dimensional model which was created from the planning map is shown below:



As can be seen from the images presented, that the 3-dimensional model created during the project corresponds with the elements in the area.
Once a careful examination of the 3-dimensional model is performed and it is established that the model in fact reflects the reality, a process of producing a 3D parcel begins. A review of step-by-step procedure is detailed below.

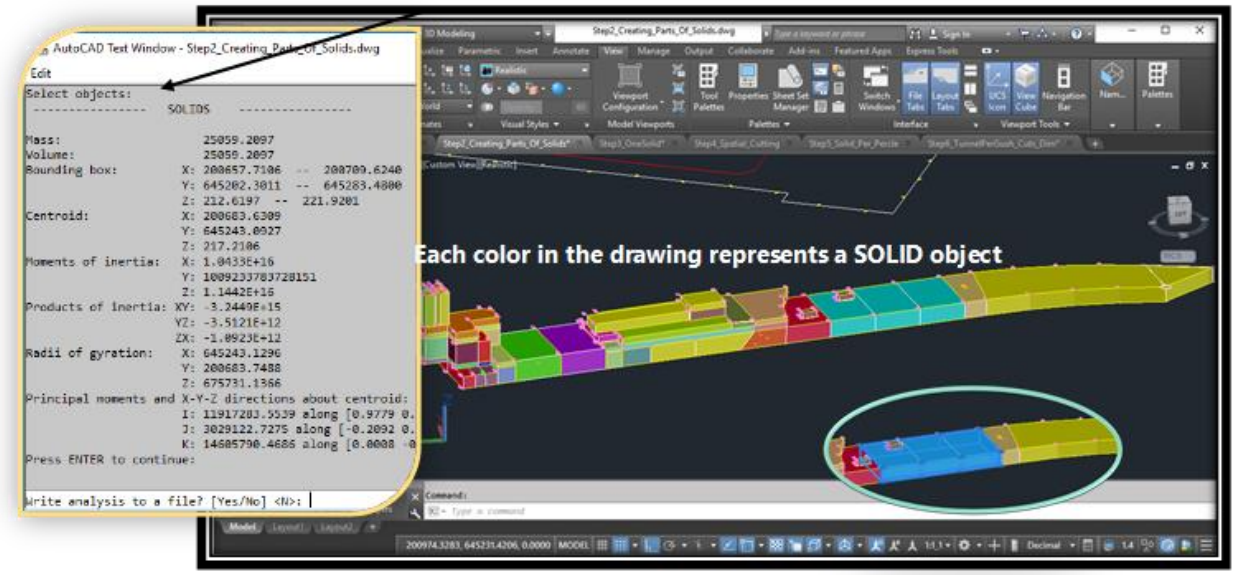
Step 1: Preparation and assimilation of planning data

- Preparing planning points file for configuration enabling assimilation in AutoCAD Civil 3D software
- Uploading the planning points and their names to the software
- Creating an outline of the three-dimensional lines (object)



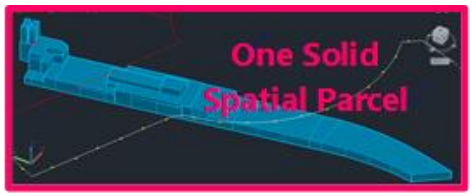
Step 2: Creating Parts of Solids

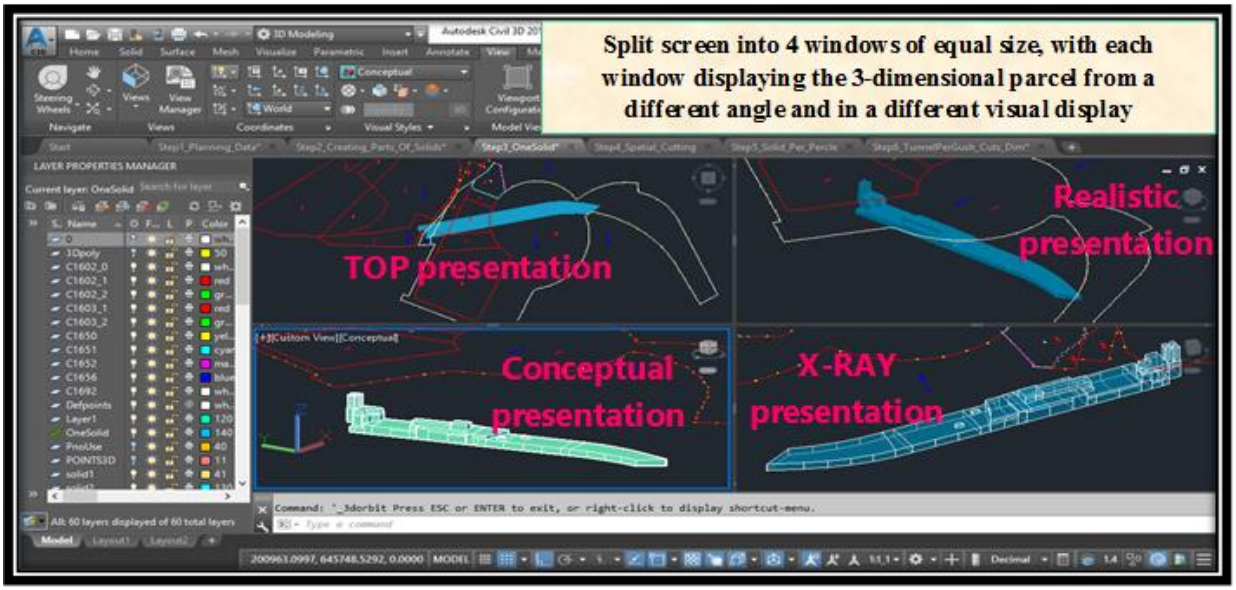
- Creating surfaces in accordance with the form of the 3-dimensional planning/object data
- Creating a solid with the help of the surfaces
- Solids produced
- For every SOLID entity one can see its properties, such as volume, bonding box and other data



Step 3: Creating One Solid Spatial Parcel (Creation of Full 3-Dimensional Model)

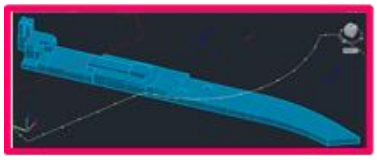
- Unification of all solid entities to one solid entity
- The solid entity created is a spatial parcel that represents the three-dimensional object



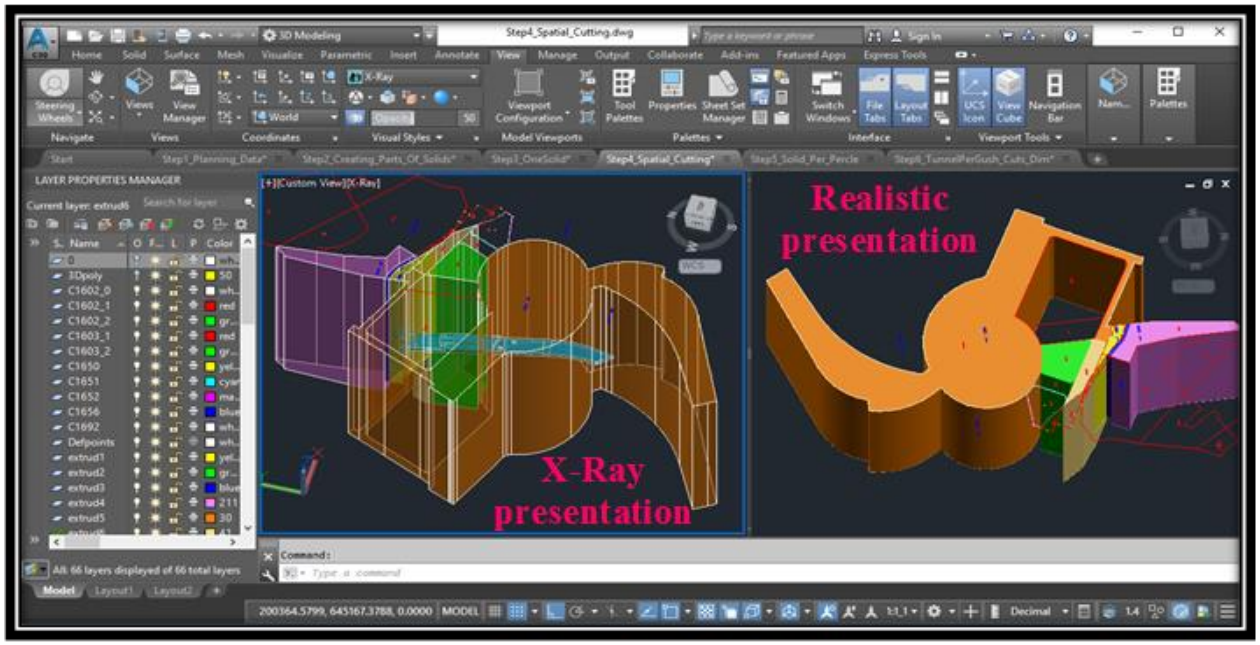


Step 4: Spatial Cutting

- Creating volume for each ordinary parcel representing the sphere of ownership of the parcel's owner(s)
- Creating volume in this case was done by using the "Extrude" command
- In this case I created volume representing the parcel's sphere of ownership only for parcels in which I saw that the spatial parcel spans their vertical boundaries



One Solid
Spatial Parcel



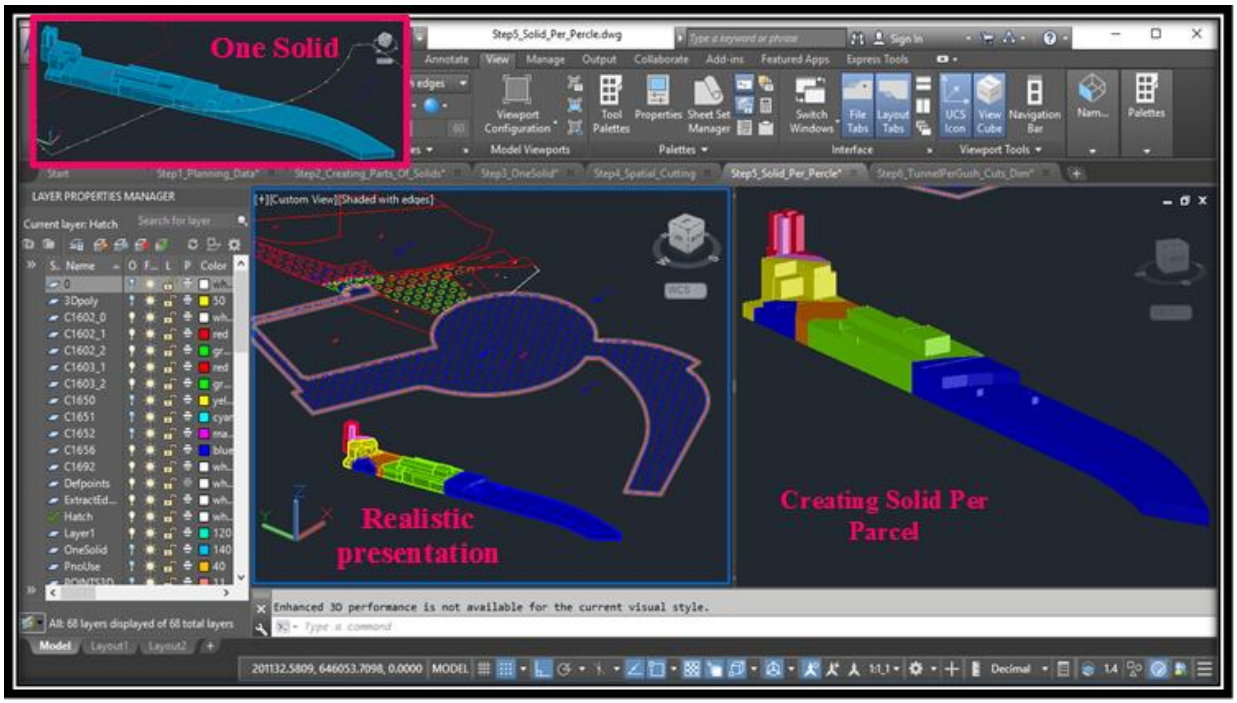
Note:

- Split screen into 2 windows of equal size.
- In the right window one can clearly see for which parcels the volume was created representing the sphere of ownership.
- In the left window one can see that the spatial parcel spreads out over these parcels.

Step 5: Creating Spatial Parcels

- Splitting the spatial parcel representing the spatial object into spatial parcels per boundaries of each of the ordinary parcels
- Creating separate solid entities per each ordinary parcel boundary done in this case by use of the "Intersect" command
- The command enables production of a solid that is a part shared between sphere of ownership space of the ordinary parcel and the spatial object

- Calculating volume of each of the spatial parcels created was via use of the “MassPro” command.

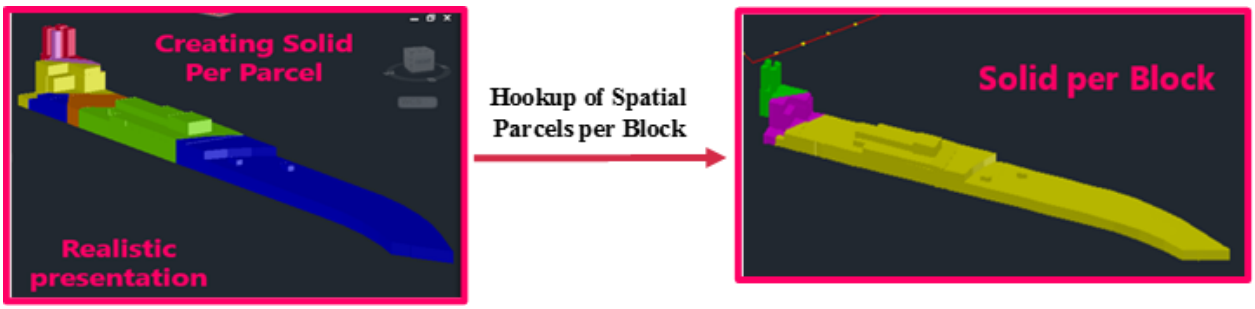


Note:

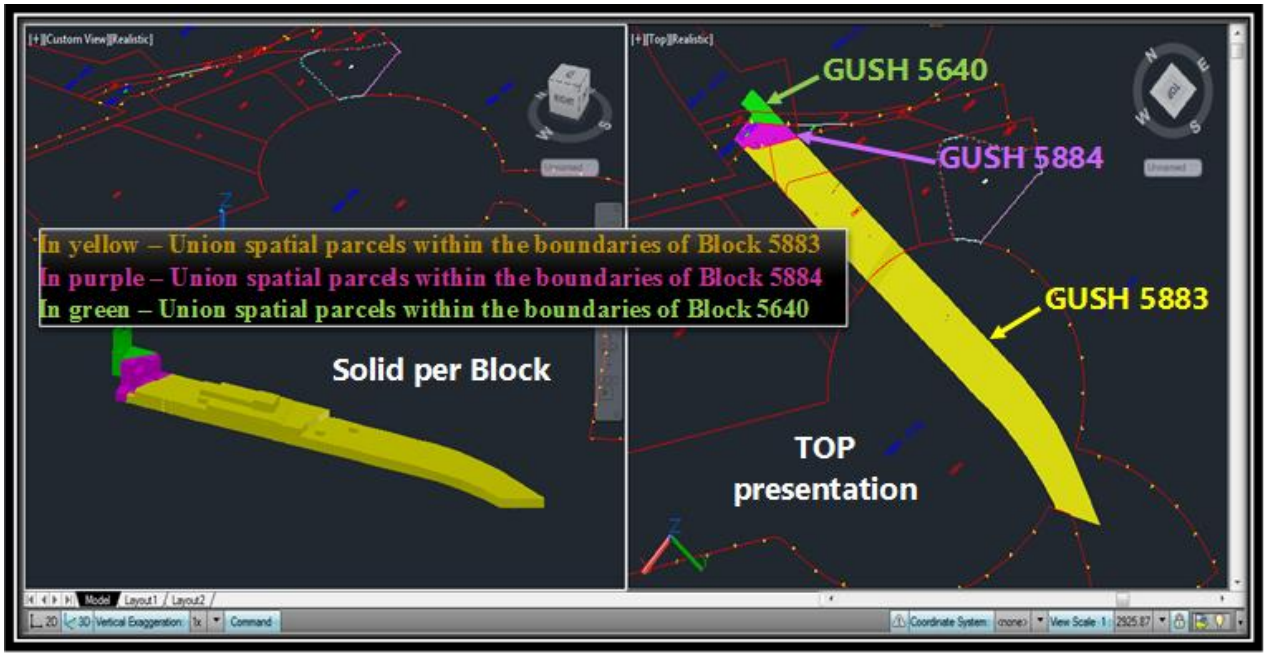
- Split screen into 2 windows of equal size.
- In the right window the 3-dimensional parcels created in accordance with the ordinary parcels are displayed.
- In the left window we can see the hatch filling the ordinary parcel with the same color as the spatial parcel spreading over its borders.

Step 6: Create a spatial parcel within a block

- Union of spatial parcels located in same block in order to create one spatial parcel per block
- Union of spatial parcels effected via use of “Union” command

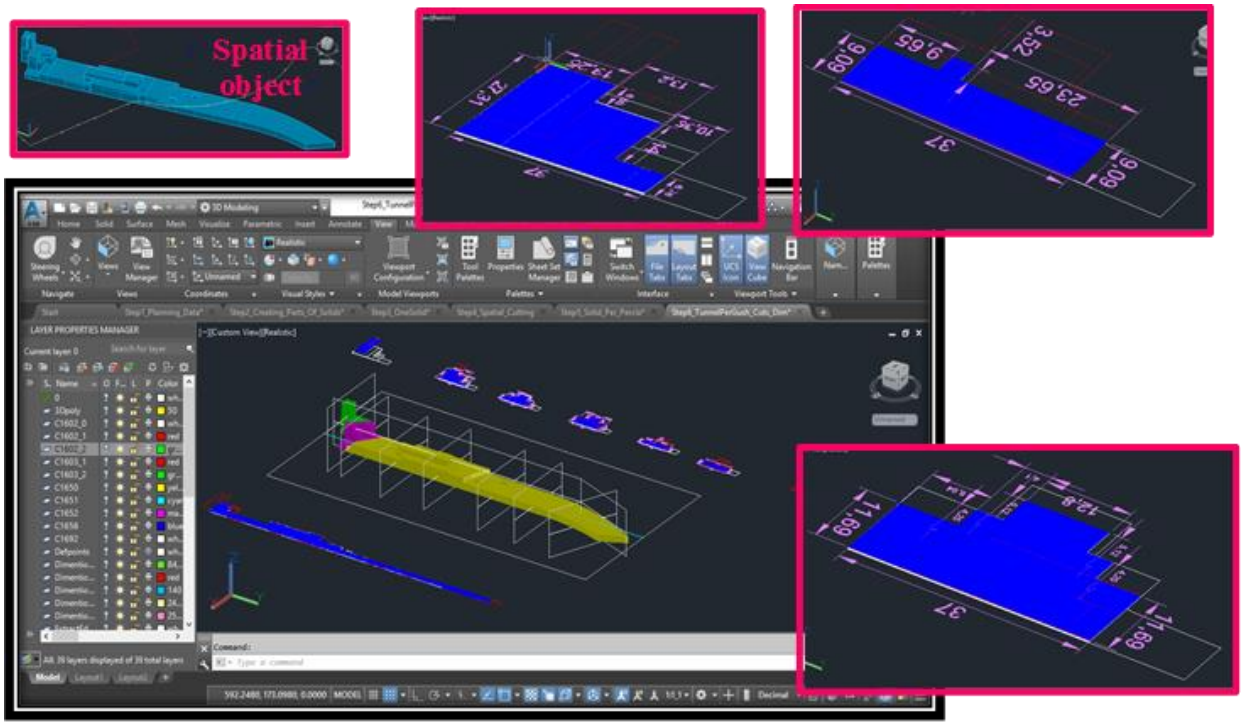


- We see that the spatial object has spread out over three different blocks
- Each color represents a spatial parcel in another block



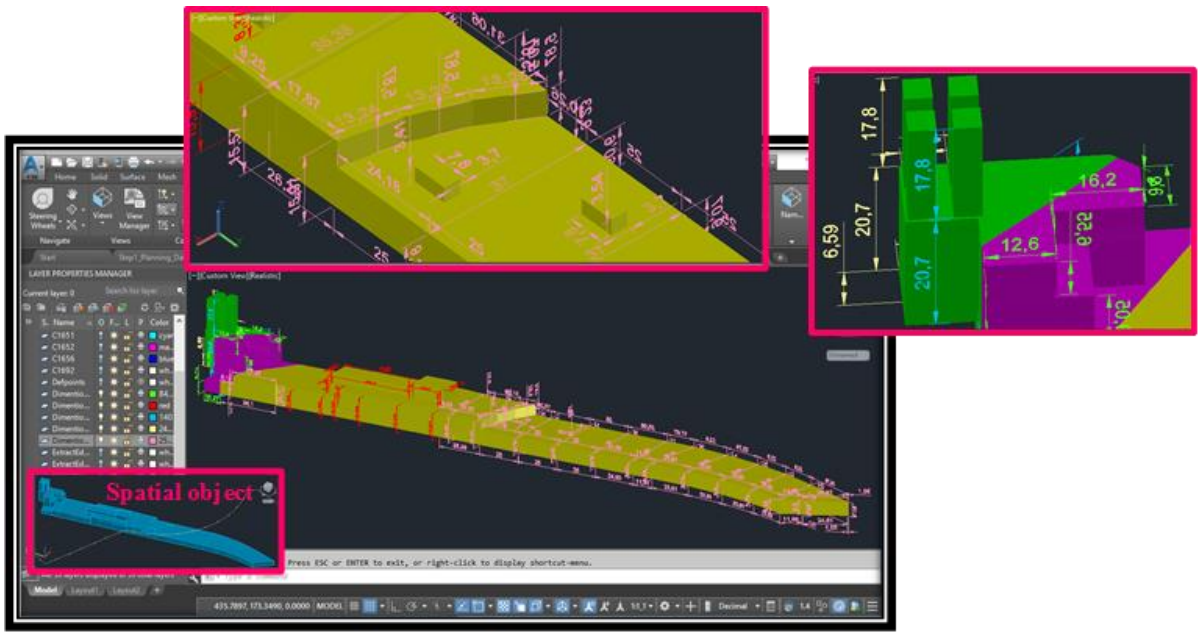
Step 7: Creating Property (Characteristics) Cuts

- Creating a planning plane in any direction desired and placing it in the desired location within the spatial parcel
- The diagram contains three types of cuts: Length, width and position
- In each cut we can see the cut section itself in the color blue.

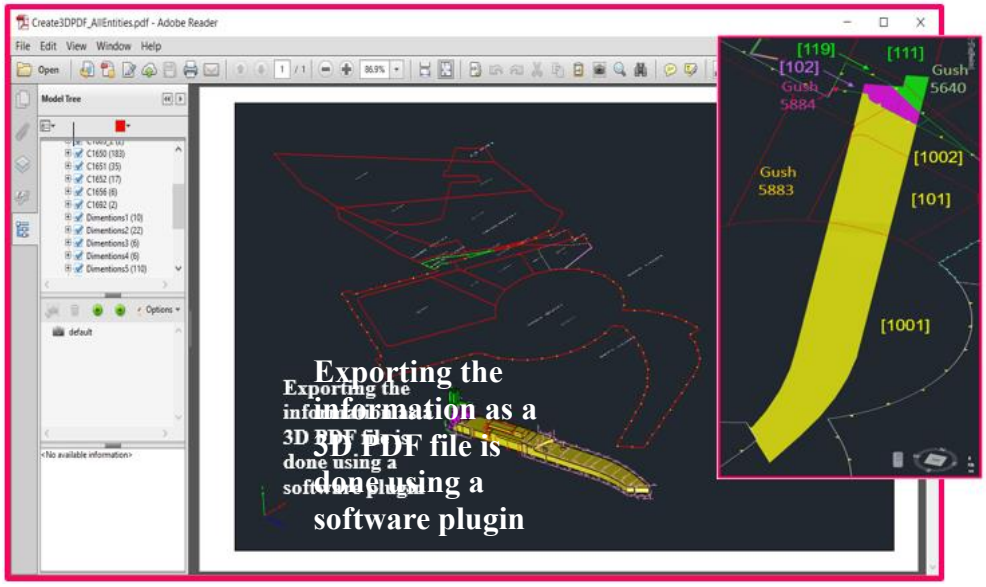


- In the cut, the colors read and white represent the projection of the 3-dimensional parcel over the cut section
- The cuts can be exported to a separate *.dwg file in addition to a PDF file

Step 8: Creating dimensions for the spatial Parcels
Creation of dimensions by setting a temporary coordinate system in the relevant directions and utilization of the DimAligned command to draw the scale on the screen or another option is to use the plugin.



Step 9: Exporting Information Entities to 3D PDF Fil
In this picture we can see the numbers of the parcels and their blocks Unified and Divided.



Step 10: Creating Union and Distribution Tables and Producing Registration Texts

Spatial Plan 12345/2018 – Report on Union and Distribution Tables

Distribution Table – Calculation of Reductions (Volumes) from Each Parcel

Block	Creative Parcel	Random Spatial Parcel Created	Calculated Volume [m3]	Maximum Projection on XY Plane [m2]	Continuity Status of Creative Parcel
5883	101	M101-1	57928.890	3445.5573	Continuous
	1001	M1001-1	86917.583	9004.111	Continuous
	1002	M1002-1	12538.510	1079.245	Continuous

Union Table – Definition of 3-Dimensional Parcel (Within the Block)

Block	Random Spatial Parcel Created	Final Spatial Parcel	Calculated Volume [m3]	Maximum Projection on XY Plane [m2]	Designation/Type of Spatial Object
5883	M101-1		57928.890	3445.5573	Tunnel
	M1001-1		86917.583	9004.111	Tunnel
	M1002-1		12538.510	1079.245	Tunnel
	M1		157384.983	13528.9129	Railway Station in City of Modi'in

Block	Creative Parcel	Random Spatial Parcel Created	Calculated Volume [m3]	Maximum Projection on XY Plane [m2]	Continuity Status of Creative Parcel
5884	102	M102-1	12293.730	701.5236	Continuous

Union Table – Definition of 3-Dimensional Parcel (Within the Block)

Block	Random Spatial Parcel Created	Final Spatial Parcel	Calculated Volume [m3]	Maximum Projection on XY Plane [m2]	Designation/Type of Spatial Object
5884	M102-1		12293.730	701.524	Tunnel
	M1		12293.730	701.5236	Railway Station in City of Modi'in

Distribution Table – Calculation of Reductions (Volumes) from Each Parcel

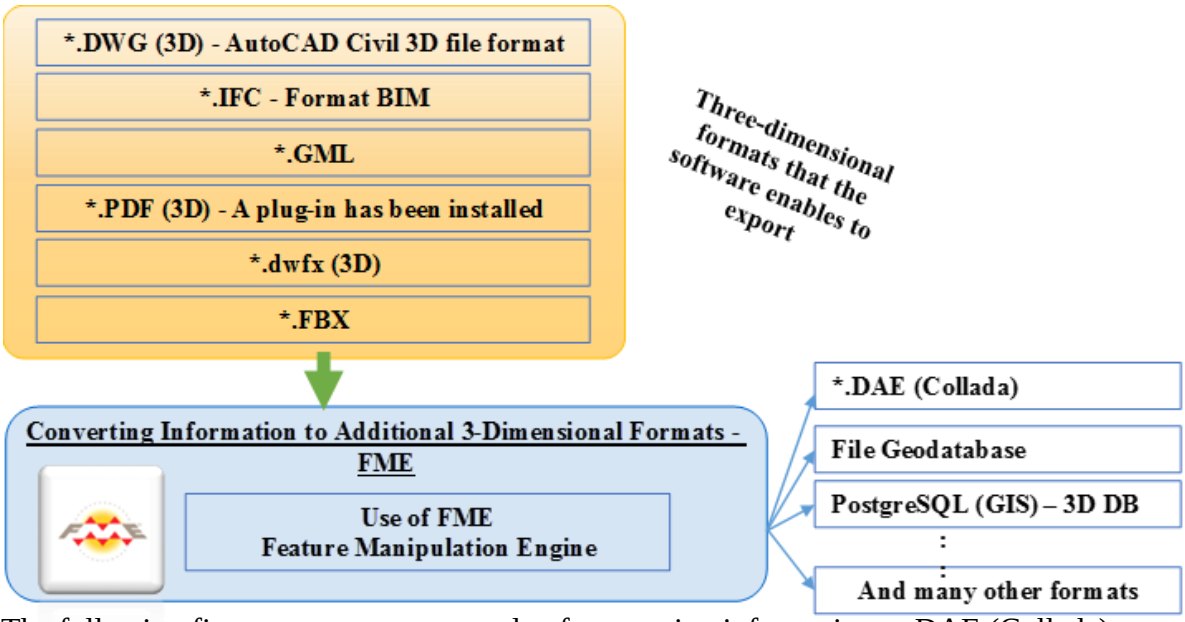
Block	Creative Parcel	Random Spatial Parcel Created	Calculated Volume [m3]	Maximum Projection on XY Plane [m2]	Continuity Status of Creative Parcel
5640	111	M111-1	7139.998	243.2787	Continuous
	119	M119-1	5839.552	211.172	Continuous

Union Table – Definition of 3-Dimensional Parcel (Within the Block)

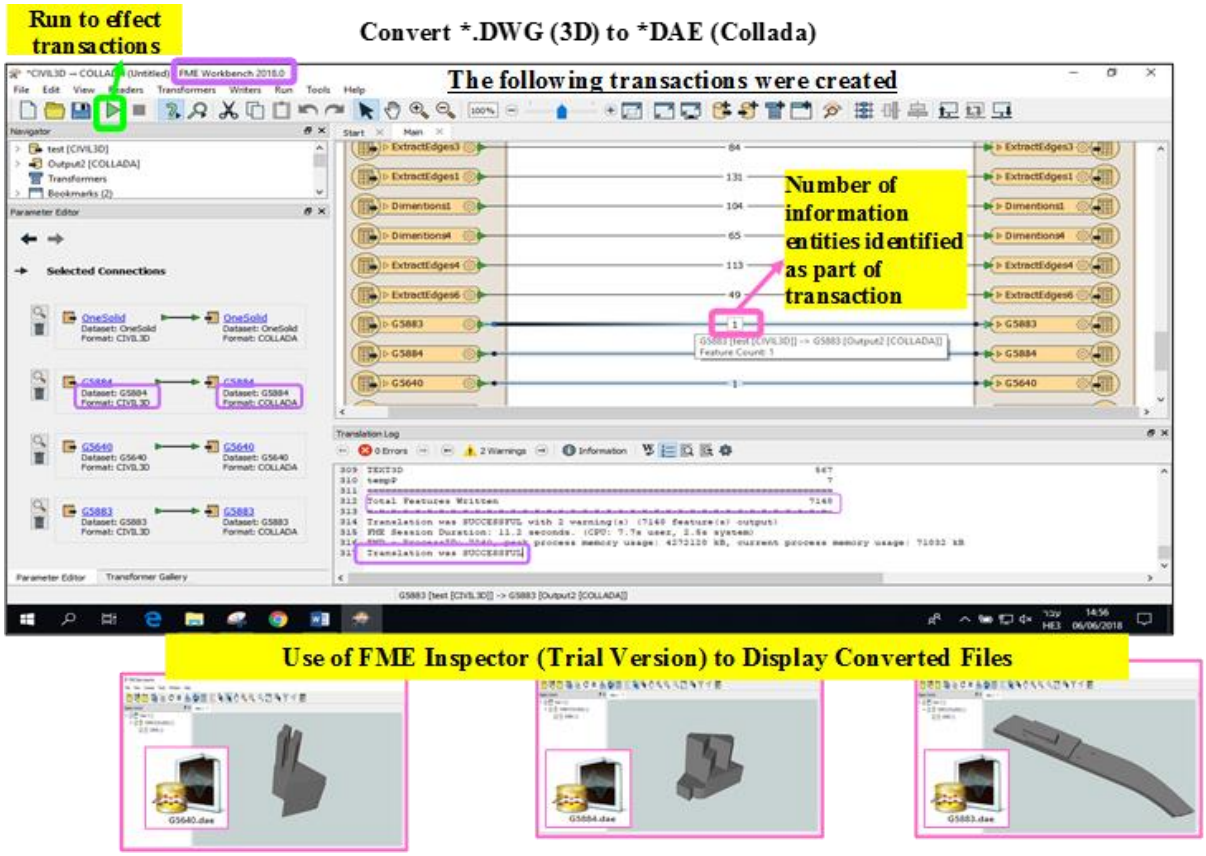
Block	Random Spatial Parcel Created	Final Spatial Parcel	Calculated Volume [m3]	Maximum Projection on XY Plane [m2]	Designation/Type of Spatial Object
5640	M111-1		7139.998	243.2787	Tunnel
	M119-1		5839.552	211.172	Tunnel
	M1		12979.549	454.4508	Railway Station in City of Modi'in

Union and distribution effected according to blocks over which the spatial parcels are spread out (the 3-dimensional model).

Step 11: Exporting the Information to Three-Dimensional Formats

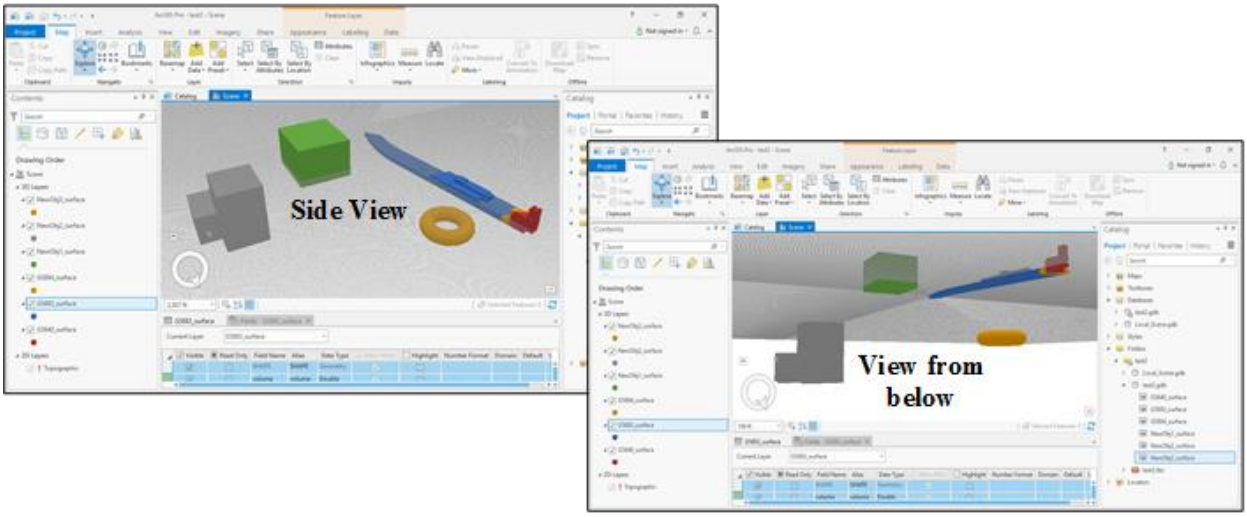


The following figure portrays an example of converting information to DAE (Collada) Format via FME:

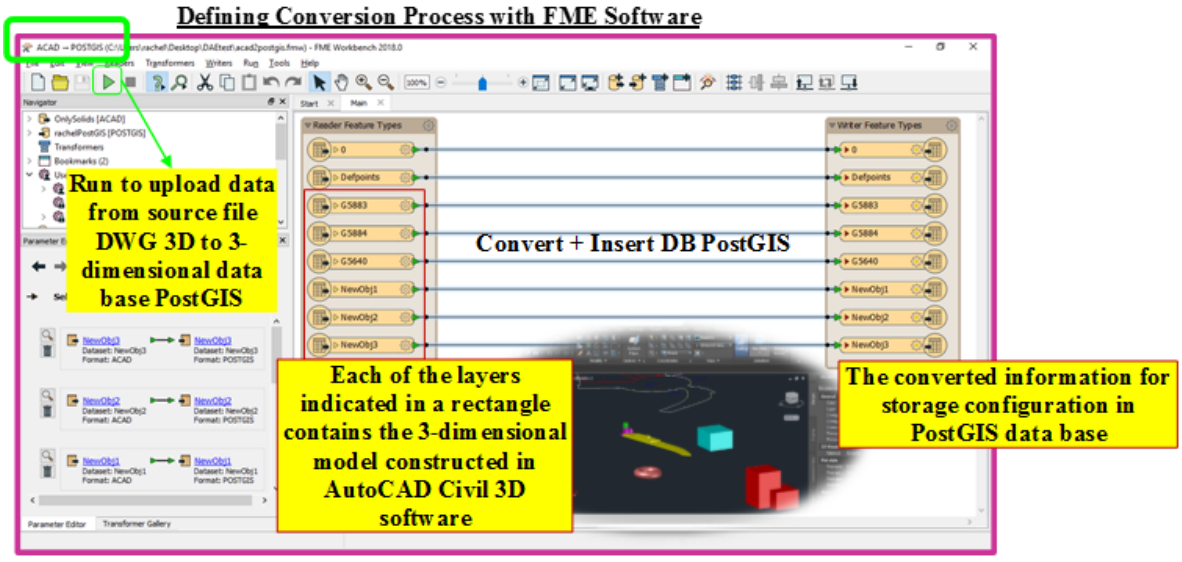


Step 12: Uploading Model to 3-Dimensional Data Base and Displaying Model from Data Base

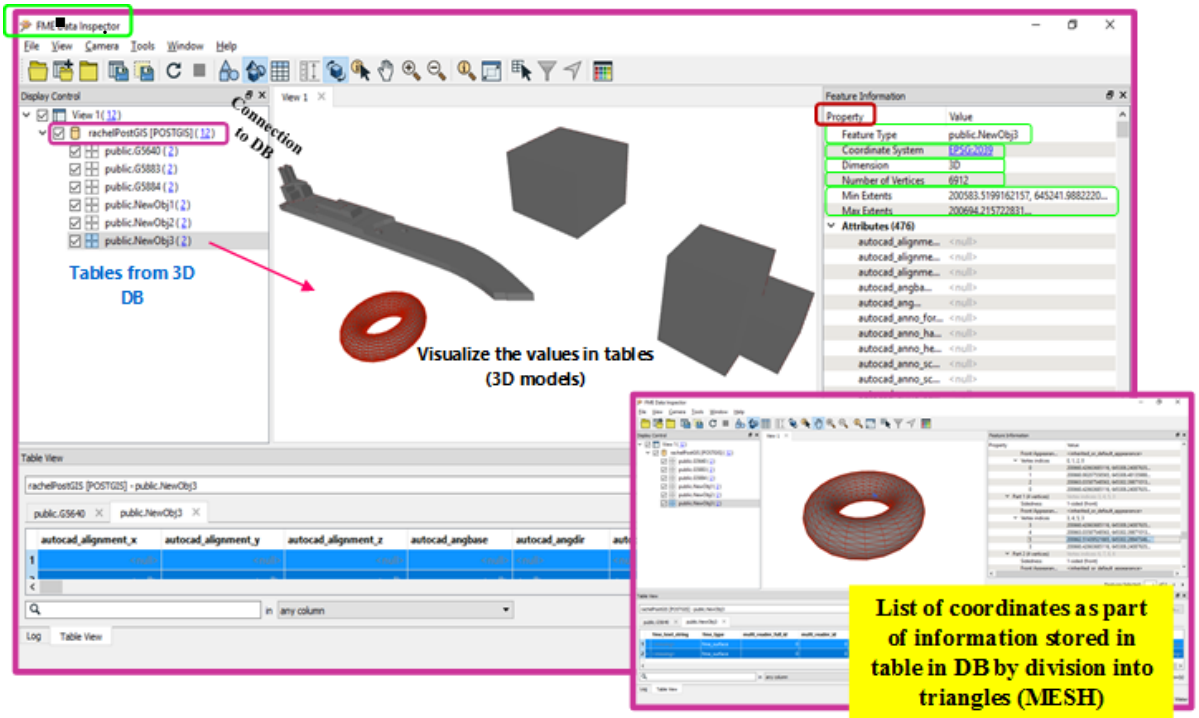
- One option that was examined – use of ESRI tool.



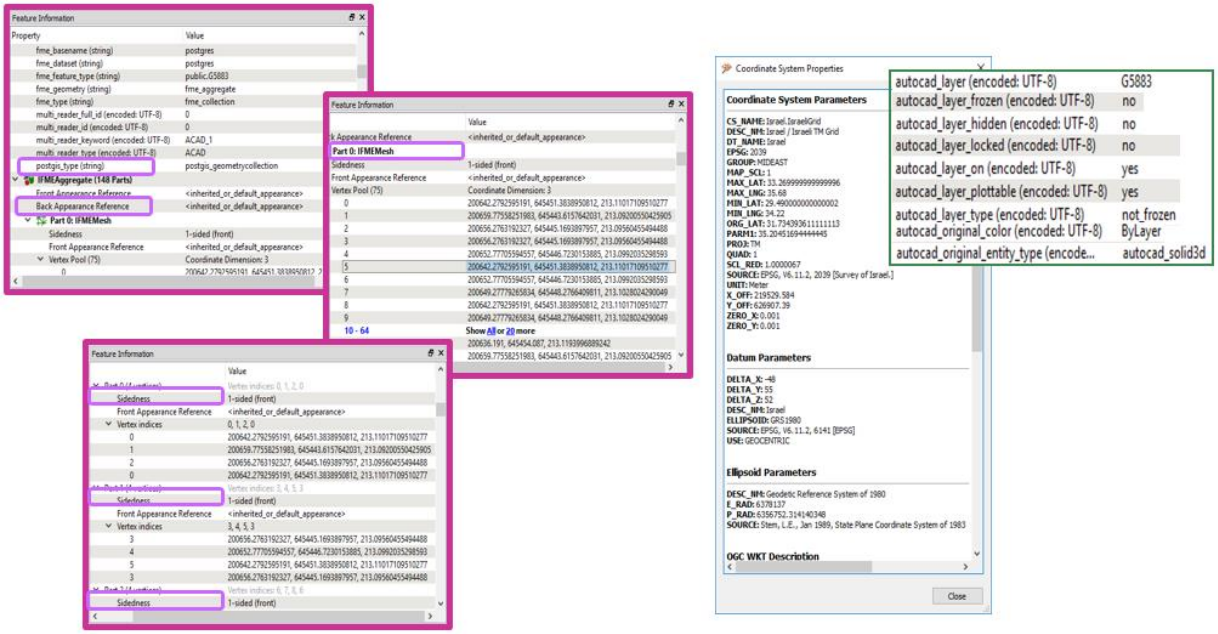
- Additional option examined – use of PostgreSQL data base with PostGIS spatial additive. This product is Open Source



- Connecting to PostGIS data base and displaying information stored there via use of the FME Data Inspector tool.



- Additional Properties stored in DB and brought up and displayed by FME Inspector

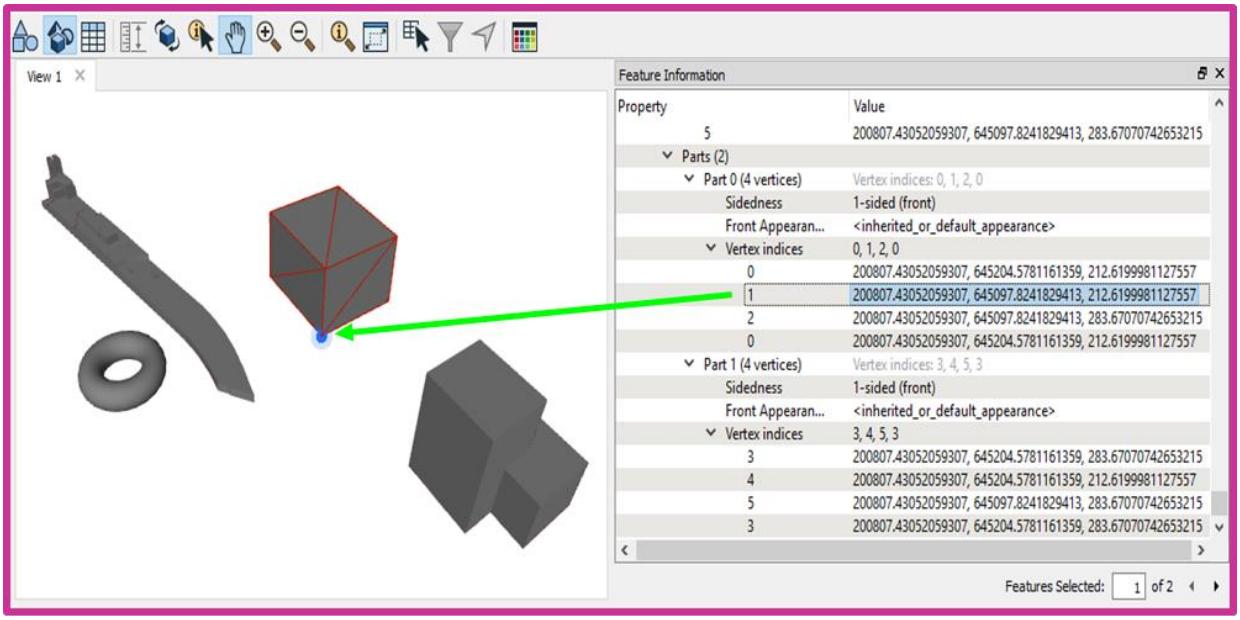


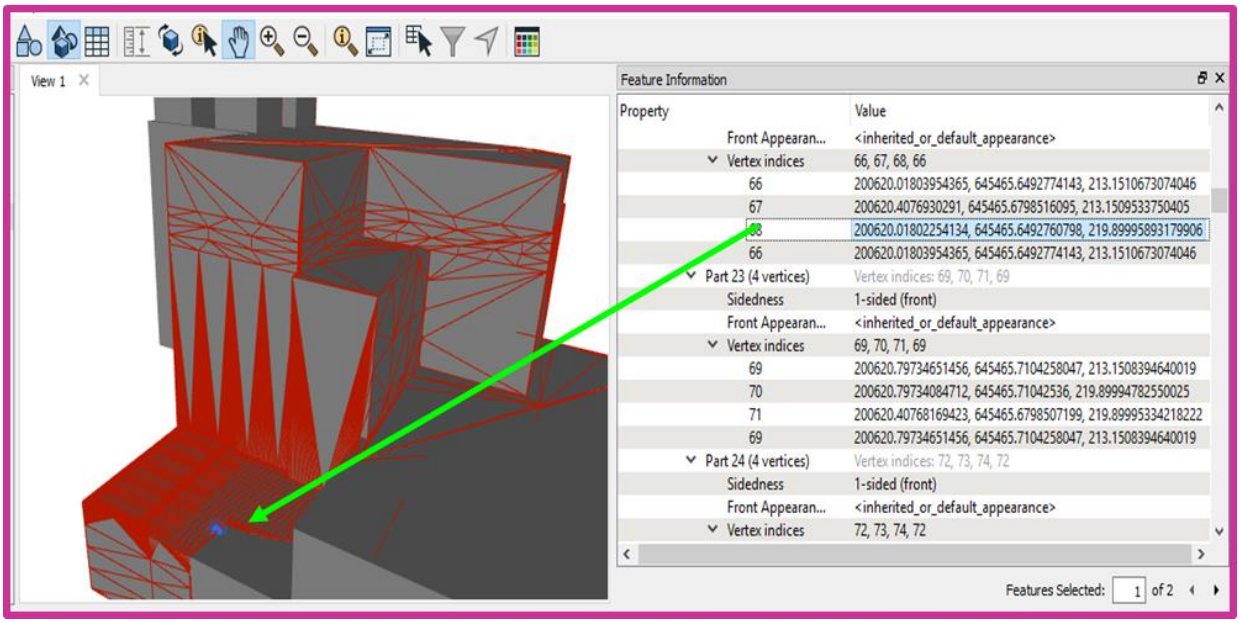
2.3 3D models in VIEWER called FME INSPECTOR

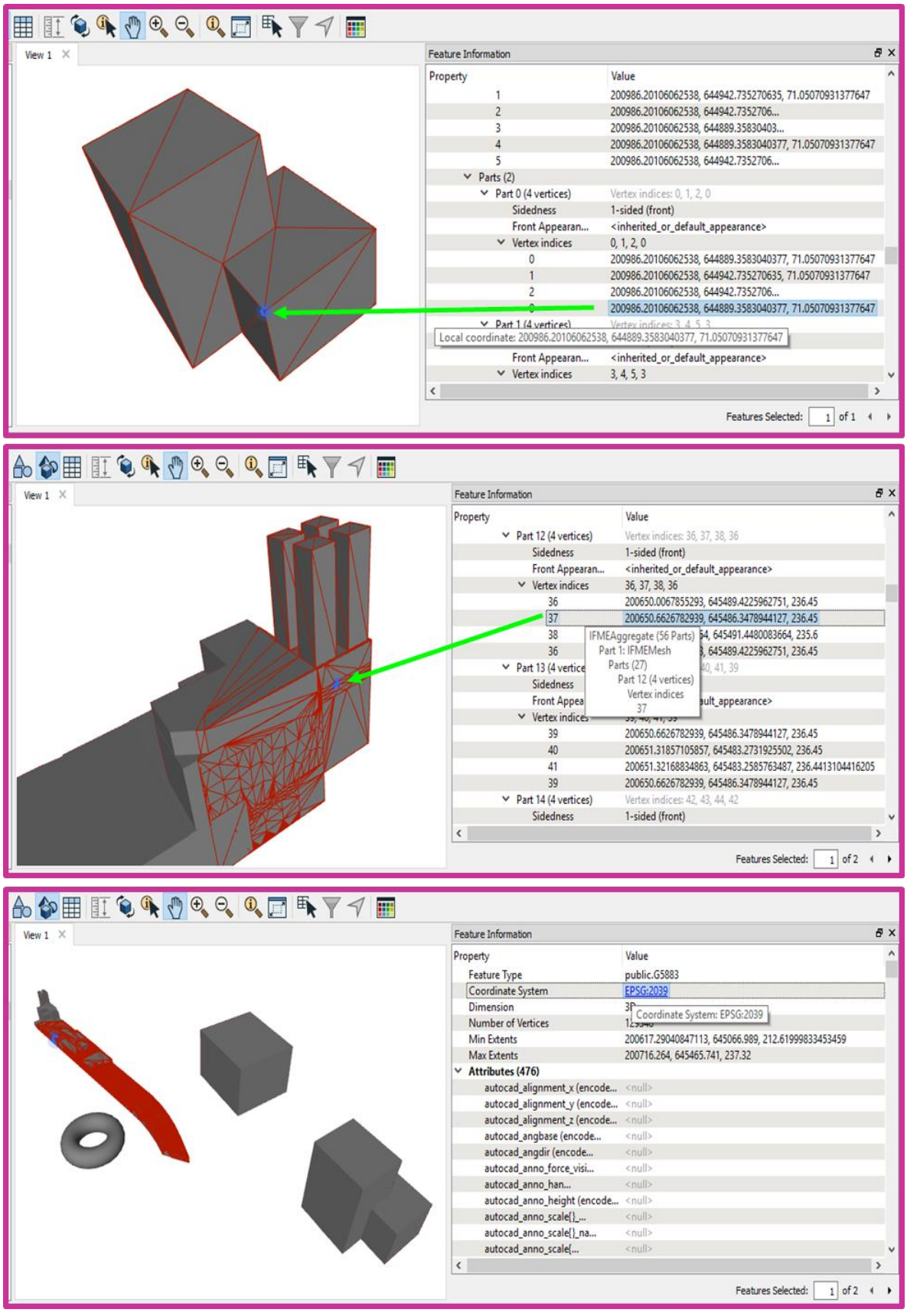
- On the right side are all the properties stored in the data base for each of the models.
- As part of the properties there is also a list of turning point coordinates for the models. By pressing any one of the coordinates, we can see the placement of the point in the diagram on the screen, the point selected appears as a blue circle in the diagram itself.

- When we press on the model that we want to examine more in depth or on the name of its table, we see how the model is divided into triangles (MESH) in the same manner in which the model is stored in the data base, and in the properties we can see which triangles were stored in each of the model's planes and what the coordinates are of each point.

If we wish to download some of the models from the VIEWER, we can download the checkmark beside the tables representing each of them, and thus the display of that model will be removed.



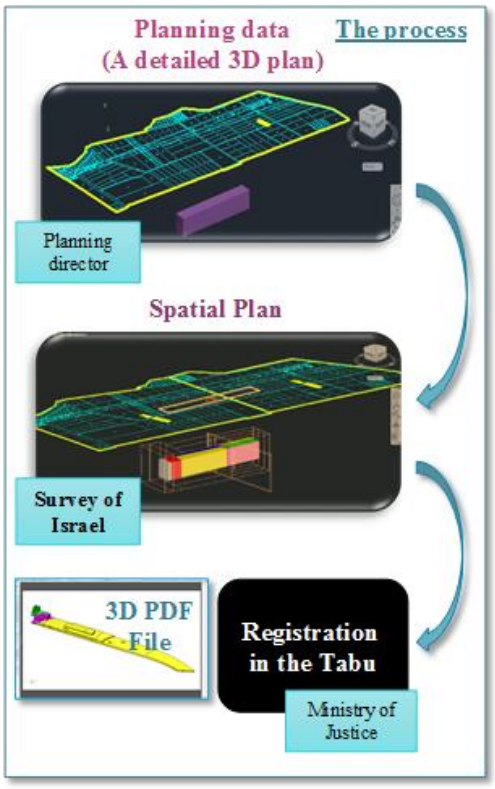


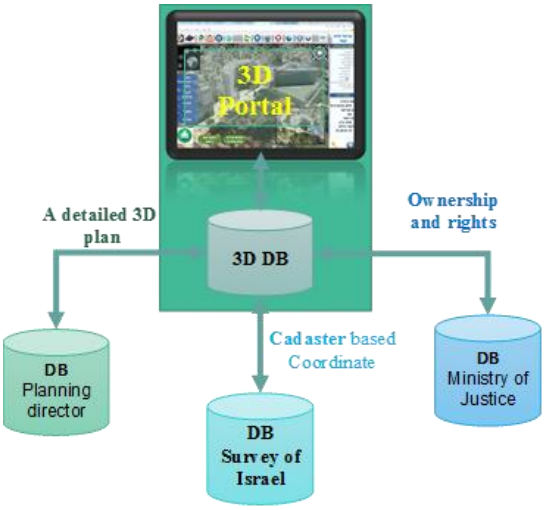

View 1
Feature Information
Property
Value
Features Selected: 1 of 1
Features Selected: 1 of 2
Feature Type
public.G5883
Coordinate System
EPSG:2039
Min Extents
200617.29040847113, 645066.989, 212.61999833453459
Max Extents
200716.264, 645465.741, 237.32
Attributes (476)

3. SUMMARY AND FUTURE WORK

The technology existing in today's market enables creation of 3-dimensional cadastre.

Several authorities take part in creating three-dimensional cadastre (planning director, Survey of Israel and Ministry of Justice - "Tabo"); in order to enable an automated process with a minimum of manual input, adjustments need to be made to the shelf products used to facilitate a quick process with minimum human error.
Each authority participating in the process has systems conforming to their own needs. These systems currently allow only a 2-dimensional capability.
In order to enable these three authorities to continue their daily and orderly work, as well as to enable a process of 3-dimensional cadastre registration, the 3-dimensional capability must be added without creating numerous changes in existing systems and without imposing developments and tests on these systems.
The solution is creating a shared 3-dimensional data base and "3-dimensional" portal that meets the demands of the three authorities involved. The portal will display information that each authority needs (sub-folders, links between data bases etc.); its visual display will be 3-dimensional, and 3-dimensional services will also be provided to various entities and citizens. Authorizations will be allocated according to need. In this manner, minimal changes will be required in the current systems as well as coordination of development/adaptation of current products in one project that meets the needs of all the entities. In this manner, there will be no duplicate development of the same capabilities, and each entity also works with its current system with the addition of the three-dimensional capability.





Unified Platform for Use by All Entities
1) Three-dimensional data base
2) Three-dimensional portal

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