# SIMPLIFIED MODULE DESCRIPTION IN URBANO

1   General

Urbano is modular software used for pipe design. Some modules extend Urbano functionality to the other domains, which can be very helpful in pipe design as well. Some modules are obligatory and some are optional. You can handle modules in many various ways.

We created various module packages, which contributes to better understanding of program functionality and makes selling easier. For example, we have packages like Urbano Canalis or Urbano Hydra. We usually offer packages to the customers (not modules). It is always possible to create country or region specific packages. It is possible to add some modules to basic packages when it is necessary or required.

The picture below shows module definition:
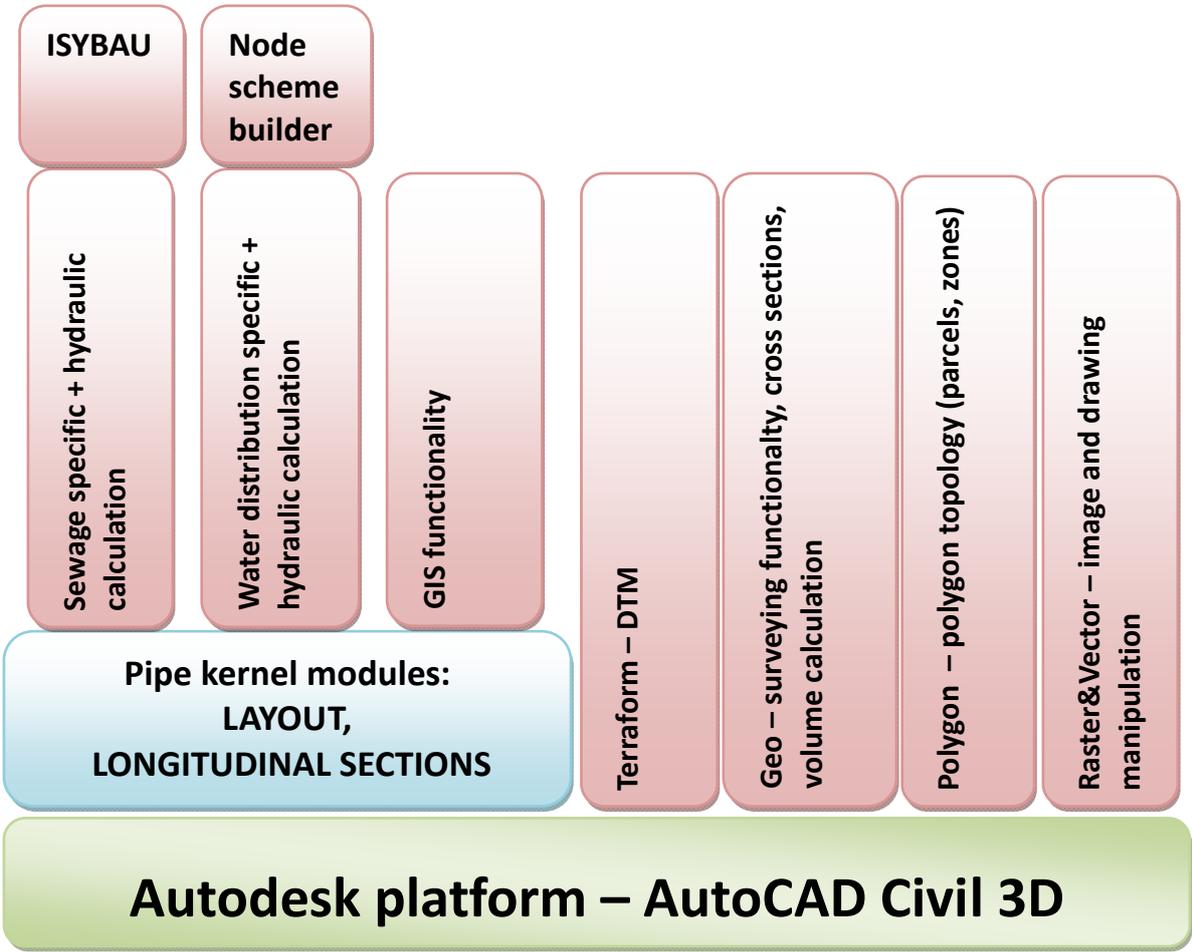
2   Platform

Urbano works on Autodesk platform. We suggest using AutoCAD Civil 3D as standard base of the program, if it is possible. It is not obligatory. Urbano has everything that is necessary to complete entire project without Civil 3D.

We support AutoCAD, AutoCAD Map and Autodesk Civil 3D, from the version 2010 to the latest one (2014), both 32 and 64 bits version. We suggest 64 bits systems (Windows 7 or 8), because of memory problems on 32 bits systems. AutoCAD LT is not supported.

Urbano manages its own pipe system, but it is possible to make bi-directional connection to Civil 3D pipe elements.

3   Module descriptions

3.1   Pipe kernel modules – basic modules

Those modules are the heart of Urbano. The most well-known functionality comes from kernel modules. Those modules provide following functionality:

- Draw network, interactively or by conversion
- Edit network – add and remove nodes and sections, change positions or names
- Table views – any user defined table views, sort, export, select from drawing, zoom to drawing
- Labels – create any kind of label, different types (node, section, station), edit labels, automatic label reposition
- Draw longitudinal sections – lot of functionality to create specific long sections, very fast drawing (1000 profiles in less than 20 seconds), dynamic connection to layout – automatic update
- Draw and edit pipe inverts – variety of methods to create and edit pipe inverts
- Trench (ditch) definition
- Excavation calculation, rich reporting
- Manhole schemes – schematic drawing of sewage manholes
- Catalogues – manage catalogues of pipes, manholes, trenches and so on.
- Intersections (clashes) – analyse and detect crossings among several utilities, everything in table view with all associated data. Possibility to label the clashes or to show them in profiles

3.2   DTM – Terraform

DTM stands for Digital Terrain Model. The idea of using DTM is widely accepted. In some programs, it is the only option to determine terrain elevations (i.e. Civil 3D).

When we start initial pipe system design, we determine positions of sections (pipes) and nodes (manholes, structures). The very next step is to calculate or define terrain elevations in the nodes of the system. Terrain is one of the most important factors in pipe design. For example, in sewage design, we try to place pipe channels from the higher to the lower terrain point. This way the flow will be gravitational.

In Urbano we can calculate terrain elevations in several ways - direct definition (node by node), linear interpolation (using some points with elevations near the pipes), or using DTM. There are several other options that can be very useful in some specific circumstances. For example, it is possible to read terrain elevations from external sources like database or other specific files.

The basic idea of DTM is to create triangular mesh over the whole area, based on terrain elevations in available points. Pictures below show the idea:

| Some points in the area	DTM – triangular mesh created from the points
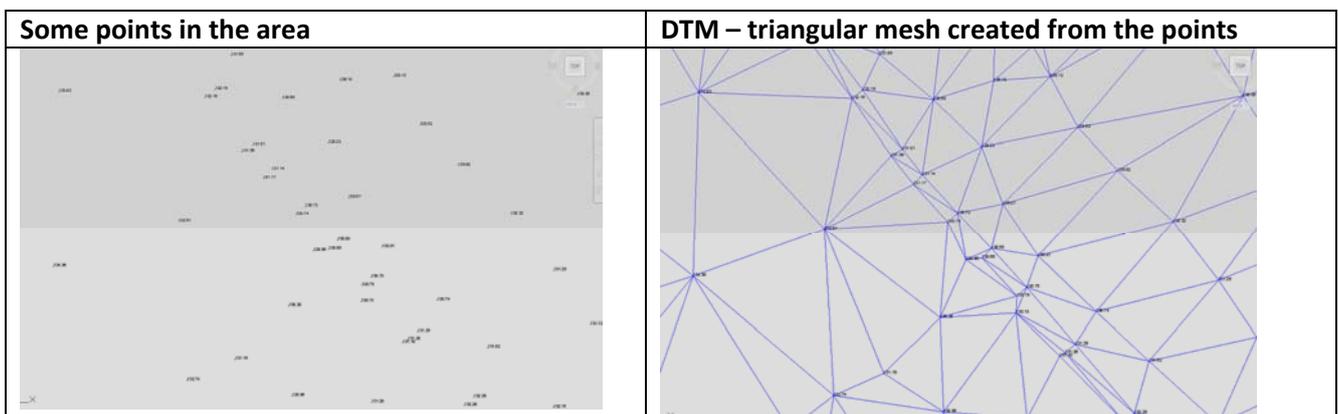
The program will create triangular mesh from the points by using some well-known mathematical methods such as Delaney's triangulation.

When we have few points in particular area, we know terrain elevations only in those points. When we create DTM, we know terrain elevations **EVERYWHERE.**

So, when we define pipe network system, with DTM we are able to calculate terrain elevation in any point. After that, it is very easy to draw profiles. When it is necessary to change the position of the node (manhole), terrain elevation of the new position of the node will be re-calculated automatically. It is very important functionality, which makes pipe design very fast, reliable and accurate.

It is always inevitable question about DTM accuracy. There are some basic requirements to satisfy. Distribution of points with elevations should be uniform over the area of interest. In case that we have enough points, but partially distributed, accuracy could be questionable. In the past, cca 20 years ago, surveyors were not familiar with DTM requirements, and DTMs were not quite accurate. However, with the technology development, with new equipment based on GPS technology, it is not problem to measure enough points according to DTM requirements.

You can check DTM in several ways. One of simplest methods is to check DTM in 3D, as shown on the picture below:
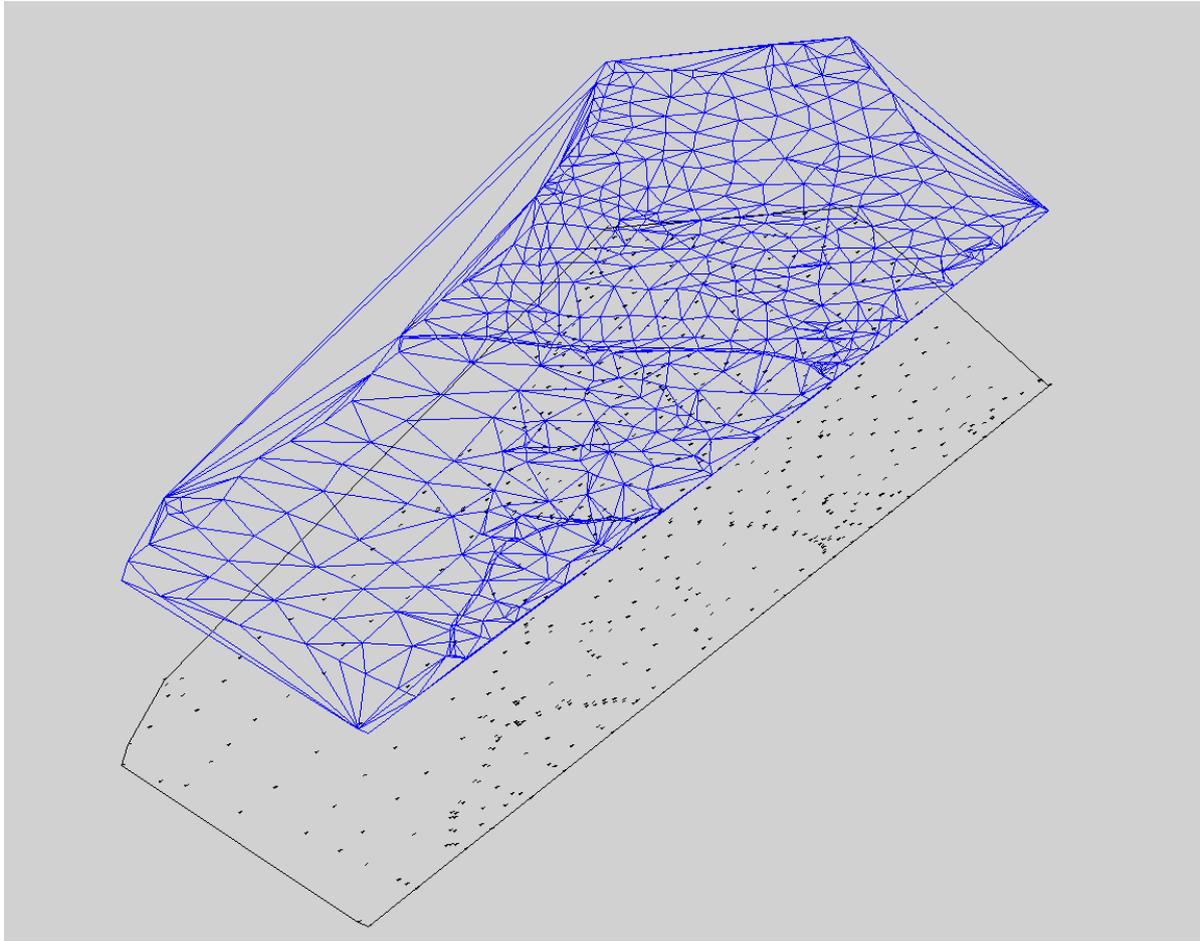
In Urbano, we have two DTM options. The first one is our own DTM program, called Terraform. The second option is to use DTM created in Civil 3D. There is no difference in program functionality – you can use both DTM created by Civil 3D or Terraform.

Civil 3D is basically more complete, better and faster solution than Terraform. But for most design tasks, Terraform functionality is more than enough.

Some users are sceptical regarding DTM, they find it complicated, they have doubts about data, think that additional DTM program is expensive and so on. In most cases, those assumptions are not right.

- Terraform DTM is very simple to use. It is necessary to start just two commands and DTM will be created.
- Source information that is necessary to create DTM (surveying points, lines…) has to satisfy some basic requirements, like uniform distribution of proper terrain elevations on specific area. If that condition is satisfied, DTM will be accurate enough for design purposes.
- Source information for DTM could be following:
    - o Real 3D elements – 3D points, contours on proper elevation (simple polyline with constant elevation), 3D lines and 3D polylines

- 2D elements such as texts and blocks. It is not necessary that elements for DTM are really positioned in 3D. DTM programs can take information about terrain elevations from the text value (elevation), from block attributes and so on.
- If design is organized over raster image, it is sufficient to vectorize content (points, contours) and to position them on 3D elevation using simple AutoCAD commands.

In pipe design, it is a big advantage to create proper DTM. If DTM exists, initial terrain values in the nodes can be defined in a second. Any further editing automatically recalculates all terrain elevations. Designer can focus to find optimal solution for the designed element, not to spend a lot of time recalculating terrain elevations manually.

3.3 Hydraulic calculation – sewage

Hydraulic calculation is very important part of sewage design. When the system has been initially defined, it is necessary to calculate or to check hydraulic parameters of the pipes. Basic parameters are following:

- *Pipe size* – diameter
- *Flow* – quantity of water which should successfully flow through pipe
- *Slope* – slope of the pipe between two nodes

In most cases, you should previously define two parameters, and the program will calculate the third one according to hydraulic parameters. In Urbano, there are two options. You can previously define slope and flow and the program will calculate required pipe diameter, or you can define pipe diameter and flow and the program will calculate the slope.

The most common situation is to have slope and flow quantity. The program will perform hydraulic calculation and calculate required pipe diameters. Slopes and flows can be defined as described below:

- **Slope definition**. There are recommendations for maximum and minimum slopes, based on experience and some design regulations. It is important to respect those recommendations because of water flow velocities. When pipe slopes are higher (pipes are steeper), water can flow faster and the pipe can transfer more water volume. However, when water flows too fast, it can produce some problems (pipe damages). In the case of minimum slope values, water flow can be very slow, and as result, we can have settlement of particles from the sewage water. Shortly, designer should define pipe slopes according to regulations and experience, with respect of limit values. For example, minimum slope value could be 1‰ and maximum 60‰. In Urbano it is possible define pipe invert automatically, based on some conditions like minimum and maximum slope.
- **Flow definition**. As described earlier, quantity of flow means quantity of water which should be transferred through the pipe. In sewage systems we have basically two types of the system. The first one is sanitary and the second one is rain systems. In sanitary systems we collect waste water from houses, bigger systems (hospitals, hotels, …), industrial facilities and so on. Rain or atmospheric systems should successfully collect rain water from the streets and other areas and transfer it to the recipient (rivers, lakes, sea…). Sanitary water usually requires purification before transfer to the recipient, because it contains biological content.

In the design practice, most recently, it is intention to build so-called "separate systems". It means that we can have two systems in the same area – sanitary and rain system. Sanitary systems transfers smaller quantities of sewage water (and consequently have smaller pipe diameters), while rain systems supposed to manage higher quantities of water and consequently have bigger diameters. Some time ago, it was practice to have so called 'mixed' systems, which collect and transfer both sanitary and rain water in the one system. In Urbano, there are several methods to calculate sanitary and rain flow. Although various countries have different regulations and use various methods for water quantity calculation, in Urbano we have everything necessary to calculate all types of flow.

For the calculation of rain water, we should define so called "**catchment areas"** – areas around the pipes which collect rain water toward the pipes. There are several methods and among others there is **RATIONAL METHOD,** which is based on meteorological curves (IDF curves – rain **I**ntensity, **D**uration of rain, **F**requency of rain).

For the calculation of sanitary water, we have several algorithms based on number of inhabitants, density of inhabitants and some other parameters.

- **Calculation of pipe diameter**. If we have defined pipe slopes and calculated total flow in the pipes, we can calculate minimum diameter required to carry that flow along with all depending values. Through diameter calculation we can calculate flow velocity and fulfilment of the pipe (what is level of the water in the pipe). Calculations are based on PRANDTL-COLEBROOK's equations. User can select different diameters and the program will automatically calculate corresponding values velocities and pipe fulfilment. All the results are accurate, available and visible table views.

3.4 Hydraulic calculation – water distribution systems

Hydraulic calculation in water distribution system is different than in sewage systems. Main difference is that in water distribution systems water in the pipe is always pressurized. Water fulfils entire pipe, while in sewage systems water fulfils the pipe only partially.

The basic difference between Canalis and Hydra is hydraulic calculation. There are several other differences in the design methodology, but not so important.

Similar to sewage calculation, it is necessary to define geometry (network of nodes and pipes), calculate terrain elevations, place pipe on certain depth below terrain.

In Hydra (water distribution systems design) it is necessary to define pipe diameter before any calculation. Similar to Canalis, it is necessary to define quantity of water which system should supply. After that, in hydraulic calculation, designer CHECKS diameters and other calculated values (velocity in the pipe, pressures...). With several calculation iterations designer comes to acceptable solution (defines different diameters and check results).

Hydraulic calculation is based and performed using EPANET. EPANET is world-wide standard in hydraulic calculation of water design systems. It is product of USA's EPA (Environmental Protection Agency). Epanet is completely free of charge.

Inside of Urbano Hydra installation, there is Epanet calculation engine, so customer needs not to care about it. If it is necessary, it is possible to install Epanet as a stand-alone program.

Hydra can be treated as intelligent pre-processor of Epanet. Inside of Epanet it is very hard to manage real network, use DTM or work with the raster image. Network creation is very tedious and cumbersome.

3.5 Node scheme builder

In water systems design, sometimes it is necessary to create schemes of system nodes. In water design there are no manholes like in sewage systems. When pipe should change the direction either in vertical or horizontal direction appropriate element should be applied. The similar case is when there three or more pipes are connected in one node. Connections are managed through prefabricated elements.

There are several manufacturers in the region which are well known and recognized. Usually they offer collection of different predefined elements (change direction elements, reduction elements, T elements, X elements, different valves and so on). Some collections of the elements are already defined in the program (Hawle). It is necessary for all partners to inspect what elements are used on domestic market, and to prepare basic collection version of several equipment producers. In the program there is easy way how to create collections of different elements. StudioARS staff can help in that job.

When the whole water network system is defined, designer can choose some (or all nodes) and draw elements connected in that node. Program automatically creates labels, reports and bill of material.

| Layout of water distribution network	Node scheme for two nodes of the system
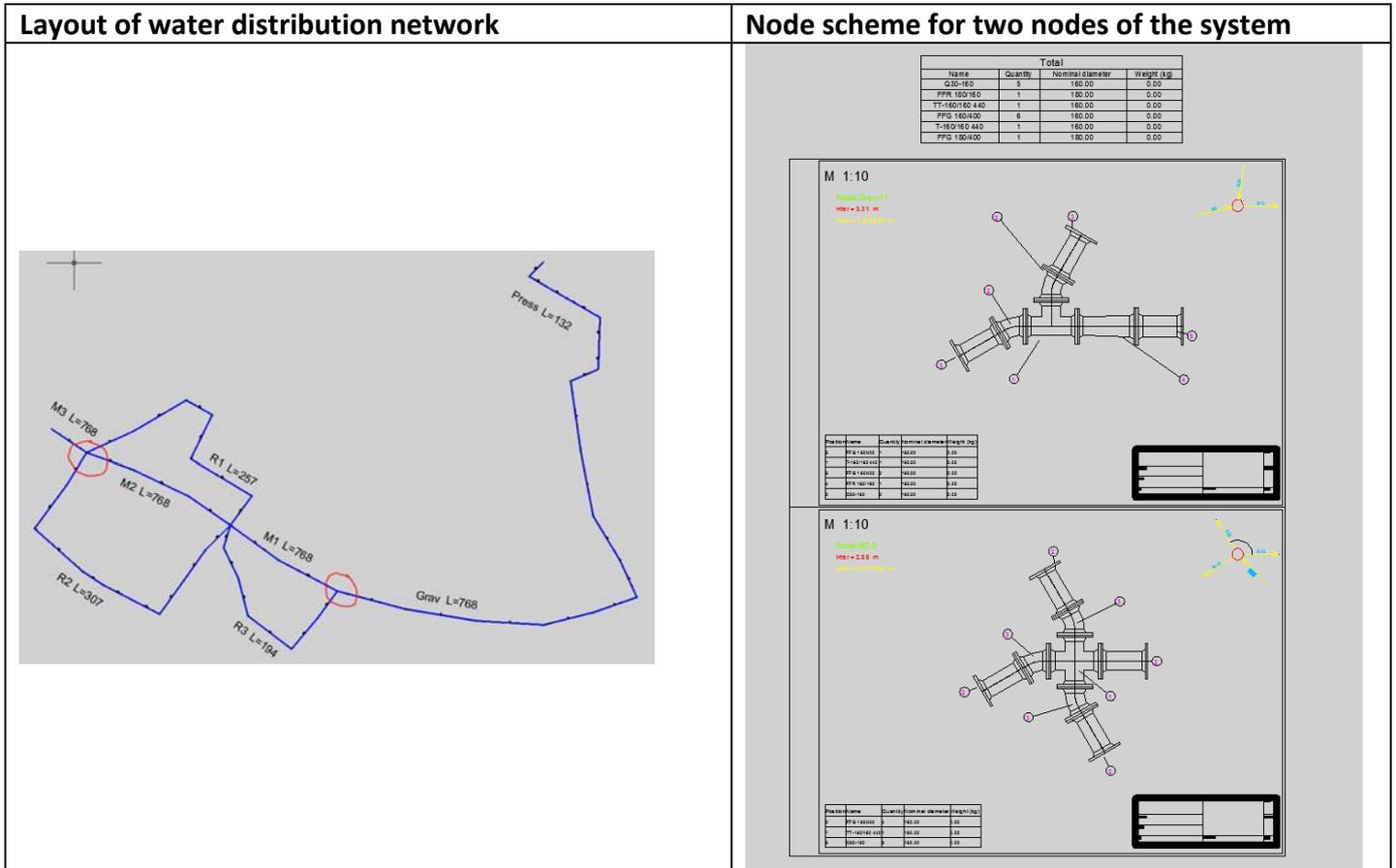
3.6 GEO module

In pipe design, it is very common for surveyors to prepare initial underlay. Pipe designers usually don't deal with surveying data. GEO module is primarily intended for surveyors in Croatia.

However, this module contains various very useful functionalities for pipe design in general. It contains function for drawing cross sections and it is possible to shop pipes and trenches in those cross sections.

In pipe design, usually it is necessary to create layout drawing and longitudinal profiles. They include all necessary information for building of pipe design. In some special cases, it is very useful to show pipes in cross section view, for example when there are several pipe systems really close to each other. In situations like that, it is necessary to check pipe positions regarding each other to avoid damages.

Cross sections creation is available only if we have DTM of the area. Cross sections can be drawn quickly and easily. Cross sections are dynamic - any change in geometry (position or diameters) will be updated in cross sections automatically.

Other functionality of GEO module is not important for pipe designer. When we analyse usability of that module, we use it to strengthen and emphasize the power of the whole package.

Layout with several networks	Defined cross lines	Cross sections with shown pipes
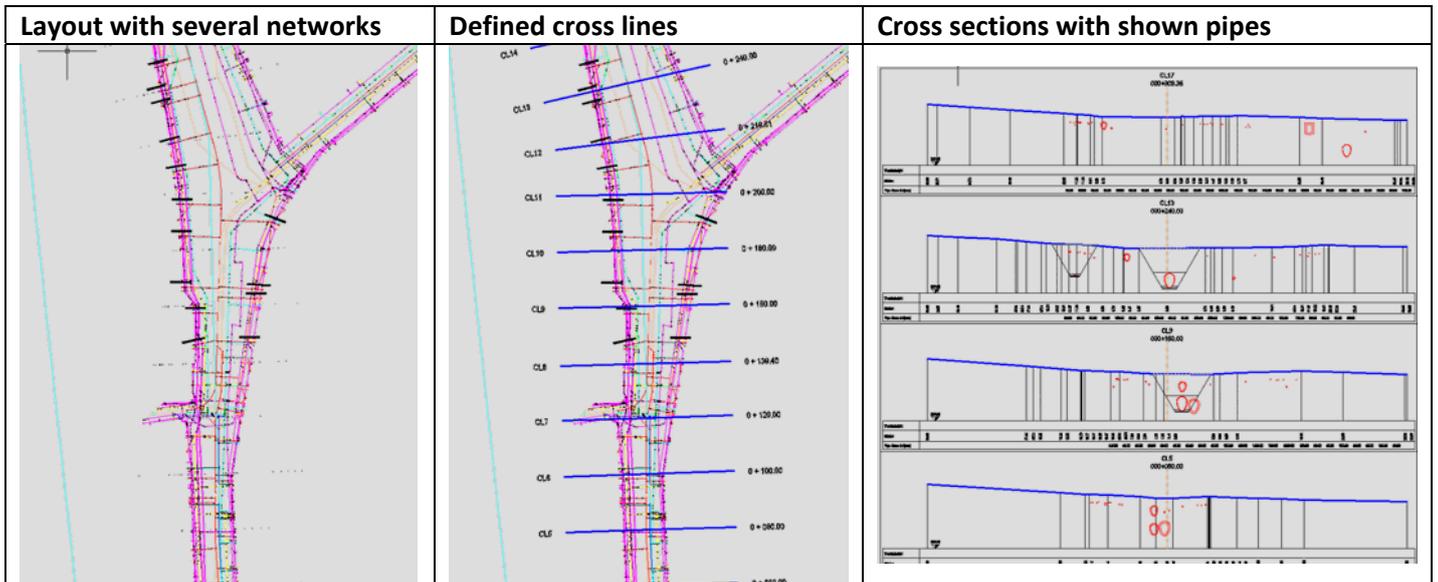
3.7 Polygon manager

Polygon manager is one module of Urbano family which operates with polygon topology. That means that can operate with closed polylines which represent parcels, zones and similar. The user interface is very similar to the other Urbano modules.

Module is oriented to users who operate with parcels like surveyors or similar. Additional functionality is connection to linear topology (sewage and water distribution systems). In that way, if parcels are managed through Polygon manager, it is possible to show how pipes intersect the parcels.

Whenever some pipe design should be made, on one certain area, the whole area is covered by parcels of different owners. Owners could be public (municipality, state, ..) or private. If infrastructure (sewage, water or gas) should pass the private parcels, it should be analysed, how pipes will pass them. Mostly, parcels should be bought from private owners, what increases the price of the whole design (and time necessary to build the system). Sometimes, condition not to pass over private parcels is stronger than some technical conditions.

The similar functionality regarding managing parcels and infrastructure exists in AutoCAD MAP and Civil 3D. But, functionality is somehow divided between those two products. And because products do not communicate to each other, it is hard to make everything what is necessary. For example, MAP has quite good functionality for managing parcels, but without clear connection to infrastructure. On the other hand Civil 3D does have connection with infrastructure, but does not have a lot functionality regarding parcels itself (connection to databases, additional data, and so on).

Polygon manager has, in one module, the both. It is possible to make polygon topology, inspect parcels through tables, label parcels, connect them to database (owners and other parcel data),
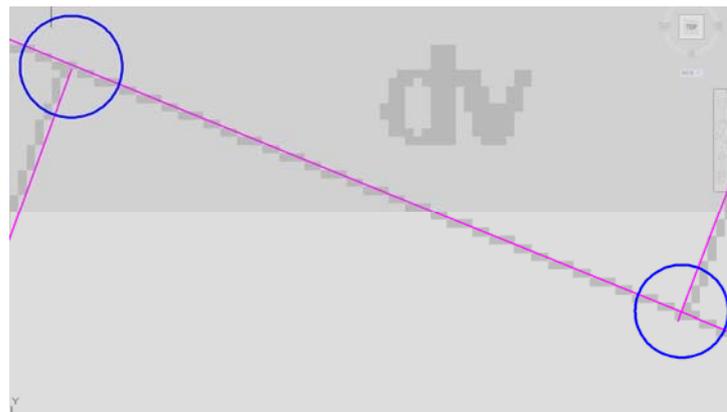
analyse crossings with sewage or water pipes, make buffer and overlay analysis (necessary for buying part of parcel because of passing infrastructure) and so on.

Data source for Polygon manager is AutoCAD drawing with parcel boundaries (lines, polylines). Even if parcel boundaries are not 100% correct (do not make closed area), program can automatically correct that. Besides that, it is possible to import parcel geometry and associated data from external files like Esri SHP or external databases.

|	
Initial drawing in AutoCAD. All magenta lines represent parcel boundaries. Every magenta line is separate polyline (or line).	
Parcel boundaries are not completely correct. In blue circles there are inconsistencies. Parcel is not 100% closed. During the automatic polygonization – conversion of lines to closed polylines it is possible to define degree of error. Program will automatically correct errors.	
Created polygon topology using Polygon manager. It is possible to use table views, labels and other Urbano functionality	
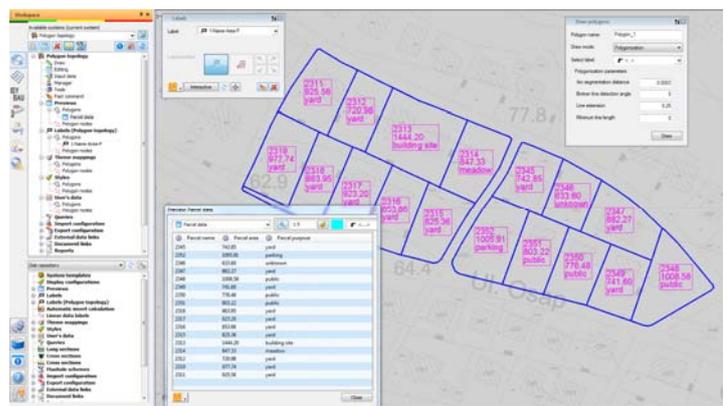
Showing of crossings between sewage pipe and parcels in longitudinal sections view. Connection is dynamic, so every change of geometry will be automatically updated in profile view.	
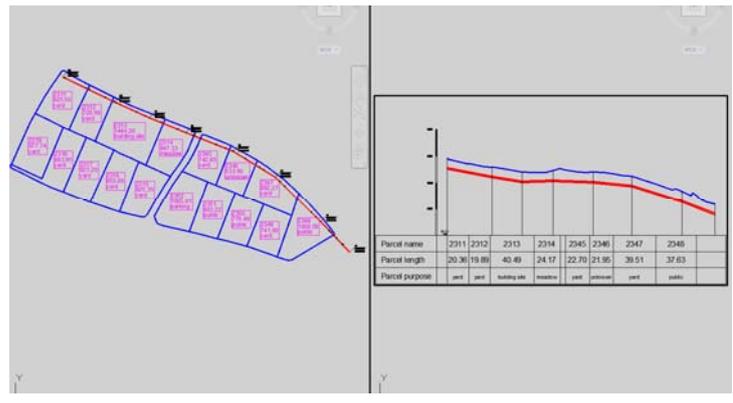
3.8 Raster & Vector

In real design very often designers use raster images or drawings as kind of background and source of spatial information.

Raster images should be placed correctly in the drawing, which means that should be inserted to proper coordinate and their size (length and width) should be proper. All information about specific raster image are stored, most often, in associated file (for TIF image we have additional TFW file). AutoCAD LT or pure Autocad cannot interpret information from TFW file, means cannot place and show raster image correctly. AutoCAD MAP or Civil can do that. If somebody initially insert raster image with correct information from TFW file, save the drawing, it is possible to open DWG with correct image even in AutoCAD LT or plain AutoCAD.
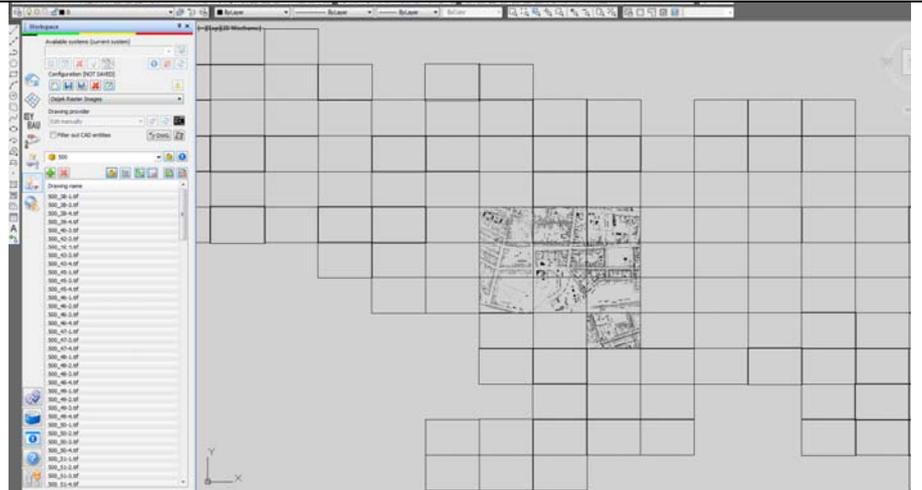
Raster & Vector module can interpret additional information about raster image coming from associated TFW (or other type) file.

Additional problem, when raster images are issue, is managing raster images if there are lot of them. Raster & Vector has nice functionality to group raster images (according to scale, source, space covered, type). It is very easy to manage hundreds of raster images, to partially show or switch off certain images and so on.
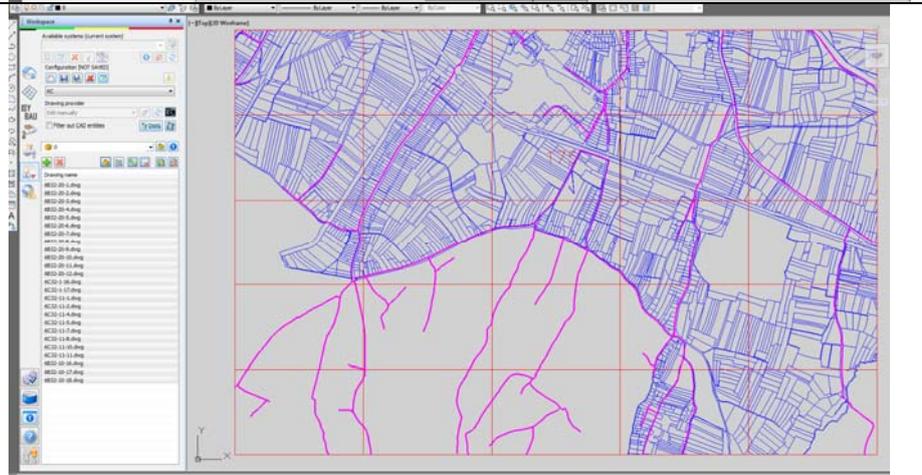
Raster & Vector module cannot calibrate raster image, scale or stretch it non-uniformly. For those purposes AutoCAD Raster Design software (or some other packages like ViseImage) should be used.

In addition Raster & Vector can manage external DWG files (vector files). If there are lot DWG-s connected to specific project, it is possible to filter connected DWG-s, based to spatial, entity or layer filter. In that way it is possible, from hundreds of source DWG-s, to filter and show on certain area just element coming from certain layer(s). For example, if we have parcel boundaries drawn on one layers, it is possible to show all parcels inside of defined polygon area (which extend over more drawings).
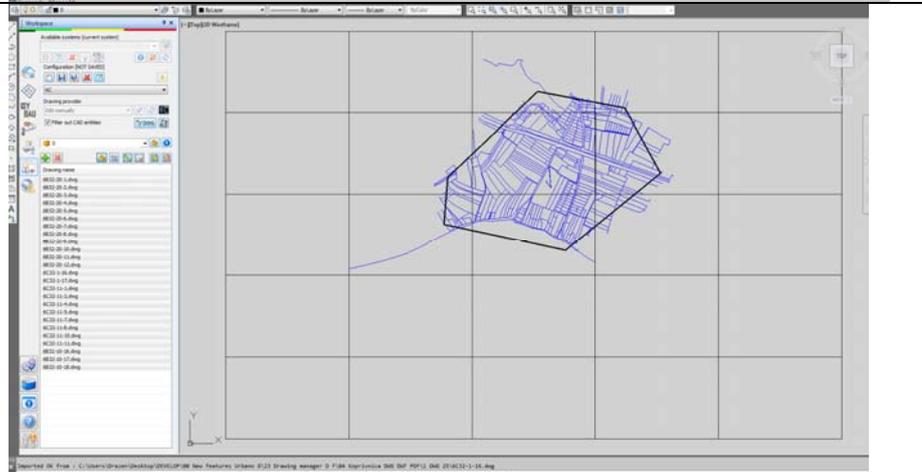
Many raster images connected to the project. Boundaries of all the raster images drawn. Some raster images inserted, based on spatial filter.	
Many drawings connected to the project. Complete content of all connected drawings are shown.	
Many drawings connected to the project. Only entities on the layer "Parcels" shown inside of defined boundary.	

3.9 Urbano GIS

The characteristic of pipe design (sewage, water distribution) is that complete design of isolated system which will function completely independent is quite rare. In almost all cases we design part of the system which should be connected to some existing system.

In addition, the new system usually shares the same space with the other infrastructure of various types (existing sewage or water distribution system, gas, electricity, …).

When the new system is designed and built, it is necessary to include it in kind of existing GIS system.

From the facts listed above, it is obvious that certain GIS functionality is inevitable in every software that deals with the pipe design. To have proper information about existing utilities it is necessary to have possibility to show utilities with all necessary information (exact position, utility depth/elevation, diameter, and other data). Mostly, all those information are stored in some GIS systems, which are database oriented.

We defined Urbano as "**bridge to GIS systems**". Urbano can read and show all utilities whose data are stored in different systems. Urbano has possibility to read data from various external sources such as any Windows based database (Access, SQL Server, Oracle, …). In addition it is supported reading from specific files like ESRI SHP, MapInfo TAB, IsyBAU and so on. According to specific circumstances, thanks to open Urbano architecture, we can quickly add some new data sources.

When some pipe system is designed, in addition to standard design data (diameter, pipe depth/elevation, slope, flow velocity, fulfilment, …) we can manage any other attribute data. We call it "User data". User data is a part of all Urbano functionality, so it is possible to use it in table views, labels, queries, thematic mapping and so on. User can define arbitrary number of user data.

In Urbano it is possible to use some functionality which fits well to GIS tasks:

- Query – it is possible to search the project according to any condition. For example: "*Show me all pipes with the diameter bigger than 400, which material is AC and which are inside of defined polygon*" – mixed attribute and spatial conditions.
- Thematic mapping – well-known GIS functionality which enables showing of system elements in different colour, based on some characteristics. For example: "*Show me pipes which are older than 30 years with red colour, 10-30 years blue colour and less than 10 years in green colour*".
- Connection to databases – it is possible to connect to databases in two ways. The first one is to connect, and read in all data into drawing. Later on it is possible to export all data back to source. The other way is to have dynamic connection to database. In that case data are not part of drawing/project, but always visible and usable in the project.
- Document view – it is possible to attach external documents (photos, videos, other documents) to elements of the system. Urbano has intelligent procedure to automatically connect documents according to rules (names).