CI322485

Maintenance of 630 rail stations: from underground utilities survey to Civil 3D model

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FS Technology

Learning Objectives

- Integrate different surveying technologies to obtain a complete 3D underground model
- Model underground utilities of a station using 3D underground model as a base for the design in Civil 3D
- Create an innovative workflow for maintenance operations of a railway Station
- Integrate BIM and GIS data: the Autodesk Civil 3D model fully integrated in Esri ArcGIS Pro

Description

In this class we'll show how to solve a critical situation that might cause a waste of money and time in the maintenance operation of underground utilities of 630 railway stations.

Major issues are caused by the lack of data. To retrieve the correct information about the underground, we've established, for each station, an innovative workflow that start from an AutoCAD file containing an old design of the utilities mainly water system and sewerage. First step of this workflow is the topographic and geophysics surveys following by a post-processing data and 3D rendering of the underground. Inside Civil 3D, the 3D model of the underground utilities can be used to optimize the design of sewerage and water system and to link them to information and documentation useful for maintenance operation.

Speaker(s)

Marcella Faraone
Marcella Faraone employed by Fs Technology. Head of Competence Center BIM GIS, She's responsible for researching new technologies and innovating workflows with BIM and GIS.

Sha has BIM management experience with a deep knowledge of BIM concepts, BIM delivery methods and BIM uses. Her work is focused mainly on the Design phase and construction follow up of the railway infrastructure projects.

She acquired this vast experience in the Red Line North Underground project in Doha, where she worked since 2014 as MEP BIM Coordinator of the Designers Joint Venture.

Before starting work with BIM, she took part in several ICT projects as a Project Manager. During these years she acquired experience in GIS platform and awareness of the great potentiality of GIS analysis.

In the last years she has focused her attention in particular on GIS and BIM data integration. During 2018 she participated as a speaker at ESRI Italia conference (where she won the “Smart Infrastructure 2018” award), Autodesk Rail summit , Esri Transportation Summit and Autodesk University.

In March 2019 she participated as a speaker at Esri Italian conference and in July at Esri Conference in San Diego. She received the Special Achievement Award 2019 in GIS for the work "Integrated ArcGIS and BIM for the entire Infrastructure Lifecycle Management"

The Project

The project started at the end of 2018 and consists of **bringing up to standard** and subsequently **maintenance** of the utilities and equipment of:

- 28 Great Stations (> 150.000mq)
- 54 Medium Stations (>100.000mq and <150.000mq)
- 548 Little Stations and Stops (<100.000mq)
- 20 Electrical Substations

Bringing up to standard

For all the stations and stops the activity consists of:

- Identification of water supply systems, sewer systems, water treatment plant, washing systems for rolling stock
- Retrieval of existent data and design of a different systems network and fire systems to bring up to standard
- Improvement of water metering and leak detection systems
- Bring up to standard of transformer trays of the electrical substations
- Check of the agreements with local providers

Maintenance

For all the stations and stops the activity consists of:

- Build up a GIS platform connected to SAP system to manage the maintenance of all assets:
  - Water supply and sewer systems
  - Water treatment plants
  - Washing system for rolling stock
  - Sanitizing devices
  - Water management (also monitoring the agreements with local providers)
- Quality and environmental monitoring with periodical surveys

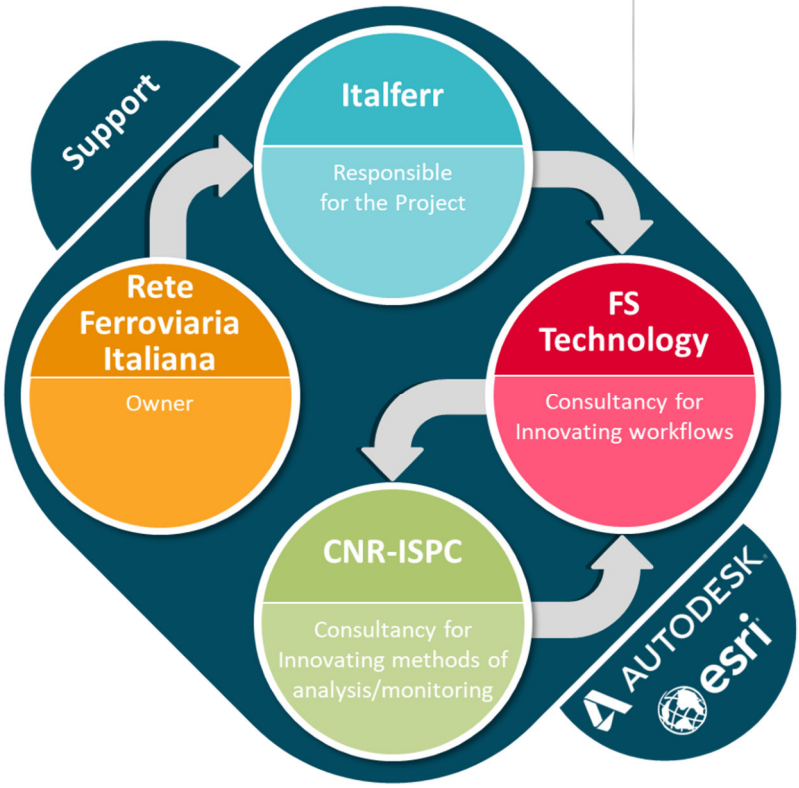
Activities in detail

For all sites one or more the following activities will be performed:

- Water supply points: wells, springs, public aqueducts, etc;
- Sewer drainage points: Imhoff tanks, losing wells, drain on surface water body, connections in public sewers...;
- Adduction and drainage networks and systems: lifting, purification, purification, washing beds, etc.;
- Census of holders of contracts and authorizations in place;
- Quantification of real incoming and outgoing volumes;
- New activations;
- Separation of utilities;
- Closures and redelivery of points;
- Control and monitoring of the parameters of interest of the hydraulic works for the quantitative and qualitative adjustment of the existing networks;
- Search for unauthorized losses and connections;

Organization

In the following picture is shown the organization of the project with the involved stakeholders.



Project Organization

Rete Ferroviaria Italiana

Rete Ferroviaria Italiana is the company of the Ferrovie dello Stato Italiane Group is the owner of entire railway infrastructure, water supplied systems, water treatment plants, well, spring, etc. It is responsible for management and for safety of the rail traffic on the whole national network, track, stations and installations.

Italferr

Italferr is the engineering company of the Ferrovie dello Stato Italiane Group. Italferr has as mission to preserve and protect the environment by making sure that their projects conform to the applicable European regulations and to sustainable development strategies.

To this end we develop ad hoc studies to assess the impact of our projects on the environment and the surrounding landscape, and, in general, to evaluate the direct and indirect effects of the infrastructure construction works

FS Technology is the hi-tech company

of the FS Italiane Group. The mission of FS Technology is to strengthen and support digital innovation in group companies, and ensure top levels of quality, efficiency and time to market in customer services. Special attention is paid to the optimisation of predictive diagnostics in industrial processes that involve the adoption of new technologies such as blockchains, Artificial Intelligence, robotics and the IoT and to the centralised management and standardisation of processes and tools.

CNR-ISPC

The National Research Council (CNR) is the largest public research institution in Italy. Founded as legal person on 18 November 1923, Cnr's mission is to perform research in its own Institutes, to promote innovation and competitiveness of the national industrial system, to promote the internationalization of the national research system, to provide technologies and solutions to emerging public and private needs, to advice Government and other public bodies, and to contribute to the qualification of human resources.

ITA BC is the department inside CNR that ITABC combines the so-called "hard sciences" with the "human sciences", with the construction and refinement of a common language in research applied to cultural heritage.Therefore the Institute defines, implements and optimizes new methodologies and technologies of investigation to study the territory and its historical artifacts. The new methods and technologies in the field of applied geophysics and the analysis/monitoring are intended to create a new knowledge, enhance and enjoy cultural, archaeological and architectural heritage in Italy and abroad.

The Team involved

A partnership between FS Technology, Italferr and CNR (National Research Council is the largest public research institution in Italy)

Project Organization

Workflow optimization: the case of Prenestina Electrical substation

Traditional design workflow

During the first phase of the project (still ongoing), we've been supporting Italferr in the digitalization of the first 50 sites (including stations and electrical substations).
During this first phase of the design, the workflow followed is listed below:

- Asset identification and topographic survey;
- Drainage network reconstruction with Autodesk AutoCAD:
- Bath and water services survey
- Descendants survey
- Survey of external confluence shafts
- Networks shaft survey with tracers and video inspections
- Survey of connection of the drainage network to the public sewer
- Verification of the data collected via the Excel spreadsheet
- Design new networks (AutoCAD and Excel)
- Import of the network from AutoCAD to Esri Web GIS platform trough shape files
- Integration of the information in the GIS Database trough Excel files

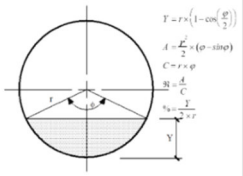
Layout of the utilities network designed with AutoCAD

Dati canale: Diametro= 0,125 metri
Area 0,0122718 mq
Pendenza canale= 0,012 m/m in % 1,2
Coeff ScabrezzaG.-Strickler= 100
Portata di progetto= 0,01 mc/s

% riempimento	gradi	rad.	Area defl.	Cont. Bagn.	R idr.	Portata (mc/s)	H riemp	Veloc m/s
5%	51,68	0,90	0,00	0,06	0,01	0,00	0,006	0,538
10%	73,74	1,29	0,00	0,08	0,02	0,00	0,013	0,674
15%	91,15	1,59	0,00	0,10	0,02	0,00	0,019	0,767
20%	106,26	1,85	0,00	0,12	0,02	0,00	0,025	0,838
25%	120,00	2,09	0,00	0,13	0,02	0,00	0,031	0,897
30%	132,84	2,32	0,00	0,14	0,03	0,00	0,038	0,947
35%	145,08	2,53	0,00	0,16	0,03	0,00	0,044	0,989
40%	156,93	2,74	0,00	0,17	0,03	0,01	0,050	1,026
45%	168,52	2,94	0,01	0,18	0,03	0,01	0,056	1,059
50%	180,00	3,14	0,01	0,20	0,03	0,01	0,063	1,087
55%	191,48	3,34	0,01	0,21	0,03	0,01	0,069	1,111
60%	203,07	3,54	0,01	0,22	0,03	0,01	0,075	1,132
65%	214,92	3,75	0,01	0,23	0,03	0,01	0,081	1,150
70%	227,16	3,96	0,01	0,25	0,03	0,01	0,088	1,165
75%	240,00	4,19	0,01	0,26	0,04	0,01	0,094	1,176
80%	253,74	4,43	0,01	0,28	0,04	0,01	0,100	1,183
85%	268,85	4,69	0,01	0,29	0,04	0,01	0,106	1,185
90%	286,26	5,00	0,01	0,31	0,04	0,01	0,113	1,180
95%	308,32	5,38	0,01	0,34	0,03	0,01	0,119	1,165
100%	360,00	6,28	0,01	0,39	0,03	0,01	0,125	1,087

La portata di progetto defluisce con i seguenti dati

75%	240,98	4,21	0,01	0,26	0,04	0,01	0,094	1,176



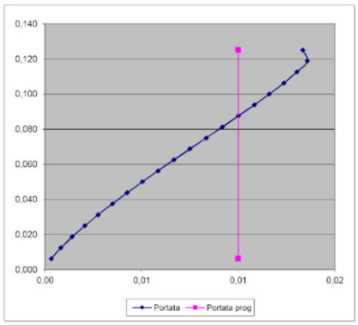
$$Y = r \times \left(1 - \cos\left(\frac{\varphi}{2}\right)\right)$$

$$A = \frac{r^2}{2} \times (\varphi - \sin\varphi)$$

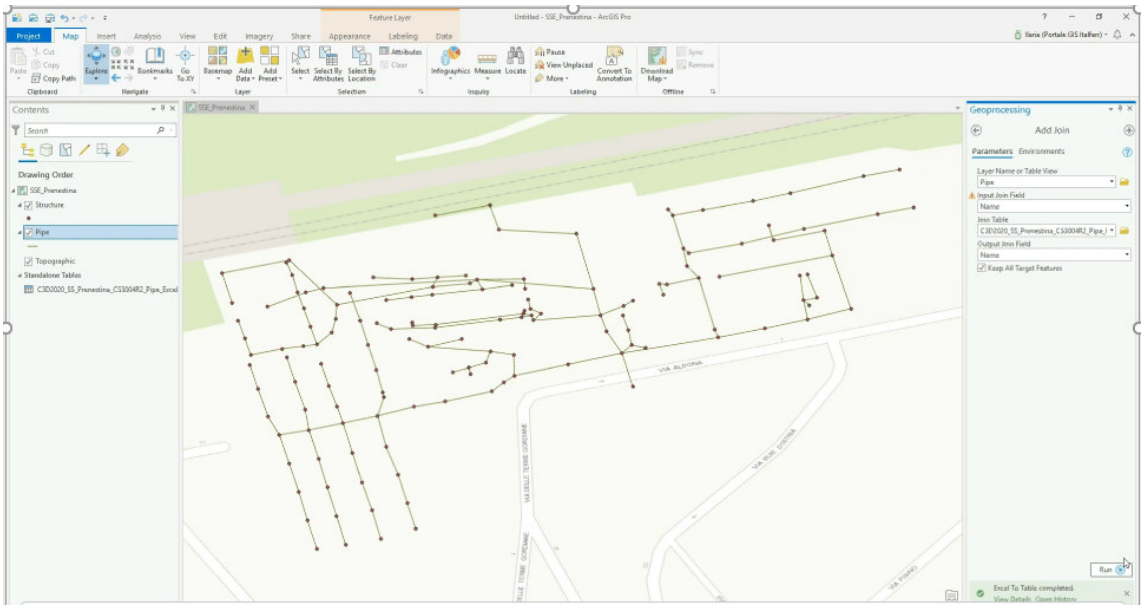
$$C = r \times \varphi$$

$$\Re = \frac{A}{C}$$

$$\varepsilon_0 = \frac{Y}{2 \times r}$$



Verification of the data collected via the Excel spreadsheet



Web GIS Database

Meanwhile we decided, to propose to Italferr new technologies to improve and simplify the workflow both during survey and design phases.

We choose as site to experiment the new technologies and the new workflow the Prenestina Electrical Substation in Rome which is one of the sites to bring up to standard.
The activities to be done in this case are:

- Sewer drainage points: Imhoff tanks, losing wells, drain on surface water body, connections in public sewers.
- Adduction and drainage networks and systems: lifting, purification, purification, washing beds.
- Control and monitoring of the parameters of interest of the hydraulic works for the quantitative and qualitative adjustment of the existing networks.

We choose this site because of the complexity of the area.

Workflow optimization

Below we can see the optimization proposed with the software used:

01 **Geophysical survey**

With the use of a Georadar

02 **Digitalization of the network model**

Civil 3D and Storm and Sanitary Analysis

03 **Import of all data In GIS Platform**

Esri ArcGIS Pro Network Utility and Civil 3D

04 **Connection with ERP system**

Esri ArcGIS Pro and SAP

We choose BIM 360 as a Common Data Environment.

Geophysical survey – Collaboration with ISPC - CNR

The issues given by the traditional topographic survey are the following:

- Manhole covered and not viewable;
- Complexity of reconstruction areas that are difficult to understand;
- Impossibility of identifying impediments in the underground;
- Impossibility of detecting water leakage along the networks;
- Inability to identify voids or cavities that could be dangerous for the subsequent activity.

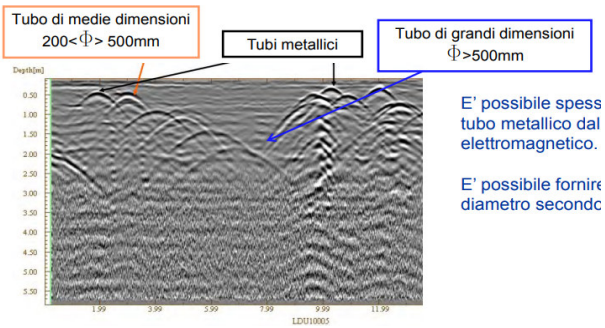
We choose to investigate a new way to detect the underground utilities together with the department ISPC of CNR. ISPC – CNR have a great experience in use technologies and instrumentations that regards the geophysical surveys.

This Method is fast and not invasive

- It allows to produce a detail image or map of an area
- We can better plan the construction and obtain an effective maintenance project

  The best geophysical method to survey the utility is G.P.R. - Ground Penetrating Radar
- The radar signal is an electromagnetic pulse that is directed into the ground

- When the pulse meets an object, the waves are reflected identifying the shape of its
- The travel time of pulse indicates the depth of the object

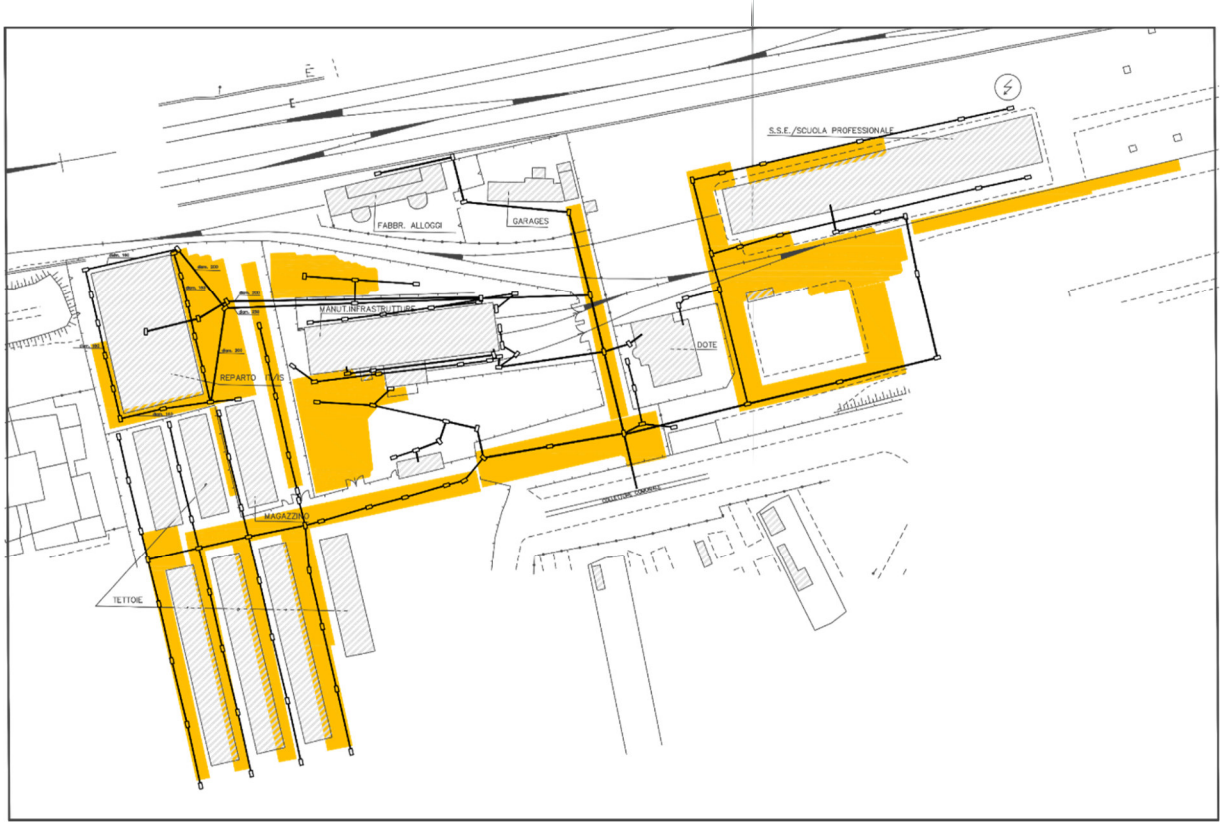


The ground penetrating radar (G.P.R.) method is useful

- to have an accurate knowledge of the underground utilities
- to prevent potential danger for the people or the interruption of services
- to work in compliance with the design phase
- to avoid wrong estimates of costs

The geophysical survey for the Prenestina Electrical substation

We realized a survey of all the areas by moving the GPR antenna through a mesh of equidistant lines (see the pictures below).

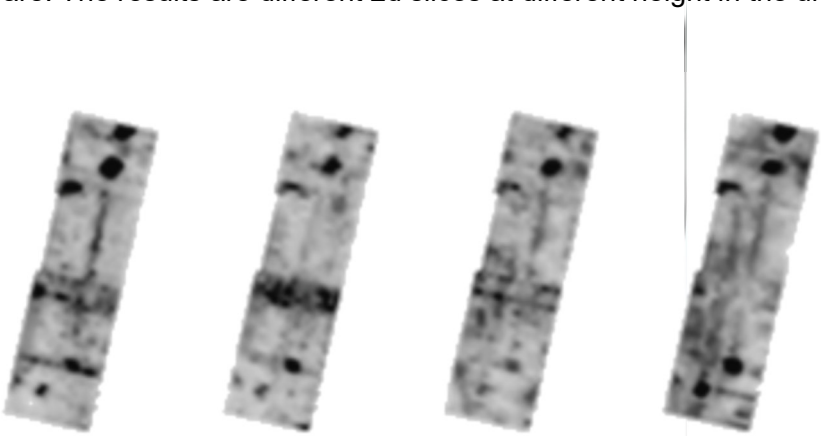


Prenestina Electrical substation – area surveyed (highlighted in yellow)

Georadar survey – mesh of equidistant lines

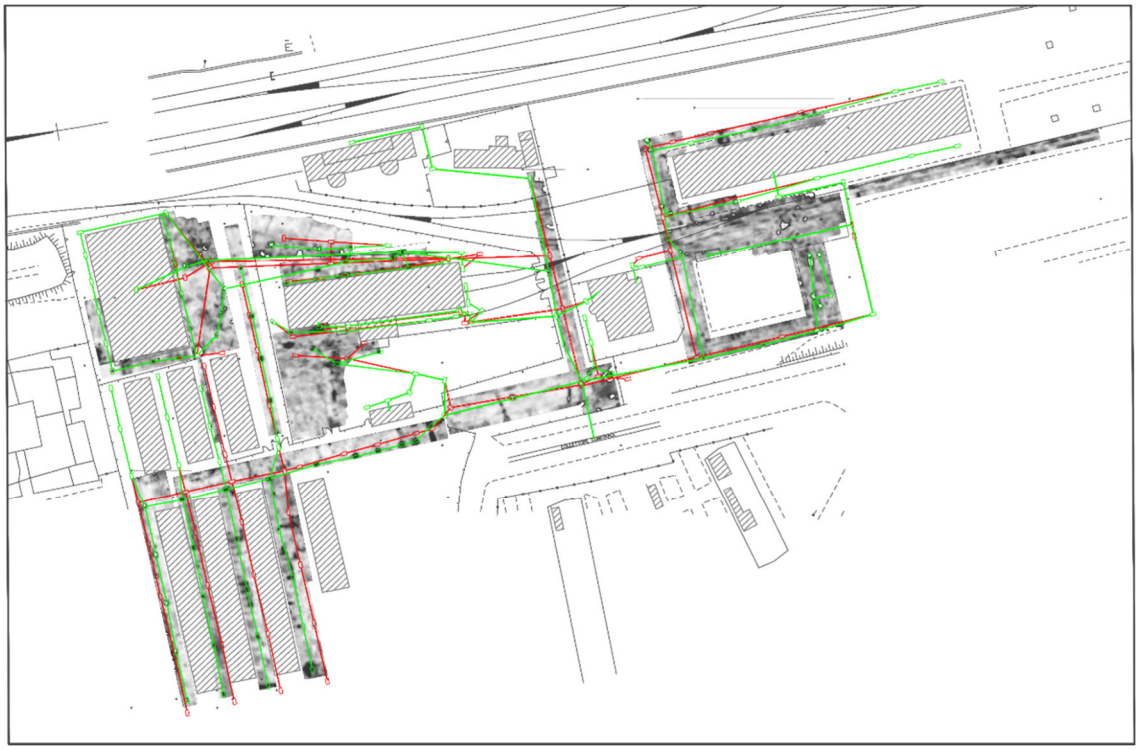
The real utilities network

The elaboration of data coming from the survey have been done with GPR-Slice software. The results are different 2d slices at different height in the underground.

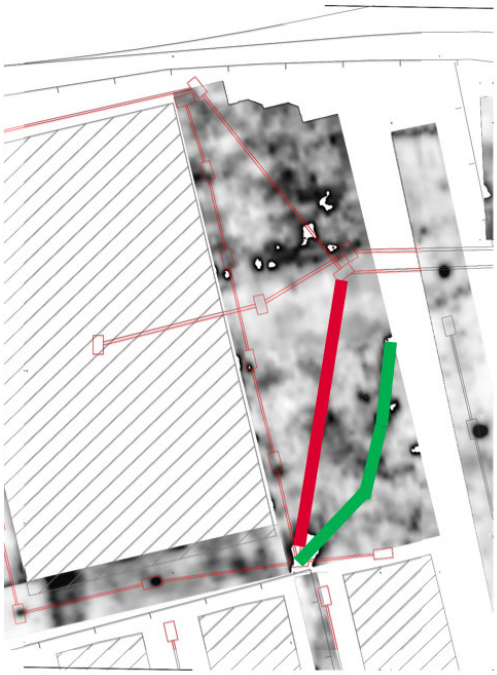


Slices resulting from elaboration of GPR–Slice software

These files have been elaborated inside Civil 3D and compared with the model coming from the old project and traditional survey. The result is shown in the picture below where in red is visible the old project and in green the resulting network coming from the geophysical survey.



Comparison between the old and the new design

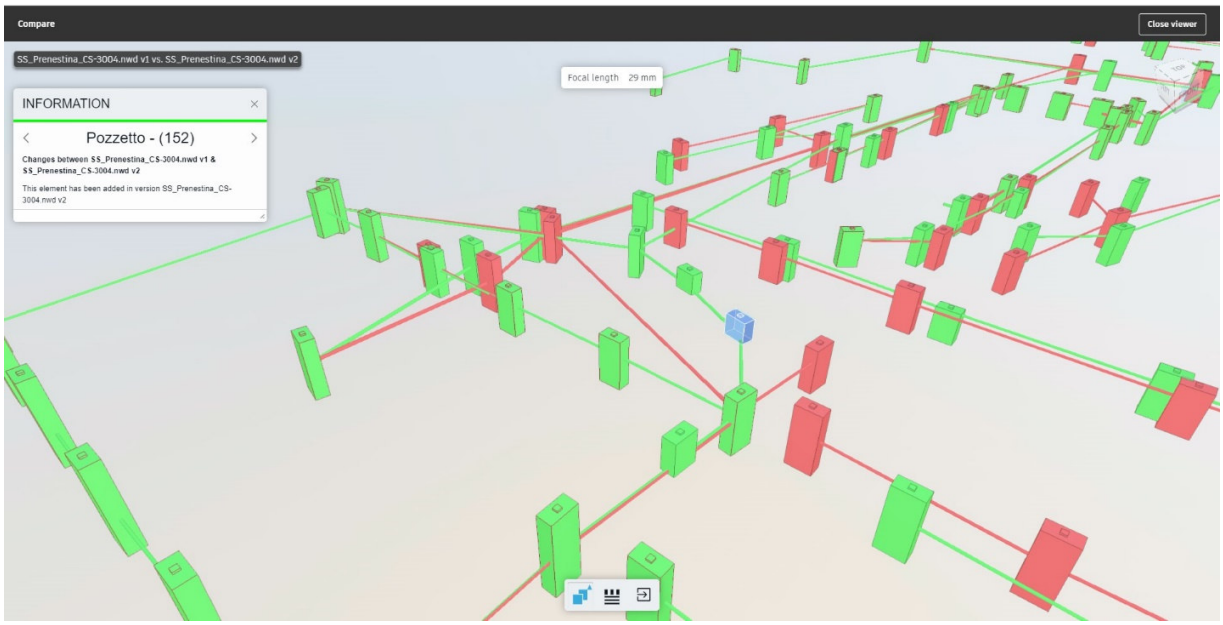


Detail of the comparison

Digitalization of the utilities network

Starting from the survey results, the entire network of utilities has been modelled with Civil 3D.
With Autodesk Storm and Sanitary Analysis, we have checked the drainage system, the storm and sanitary sewer and designed the necessary changes.

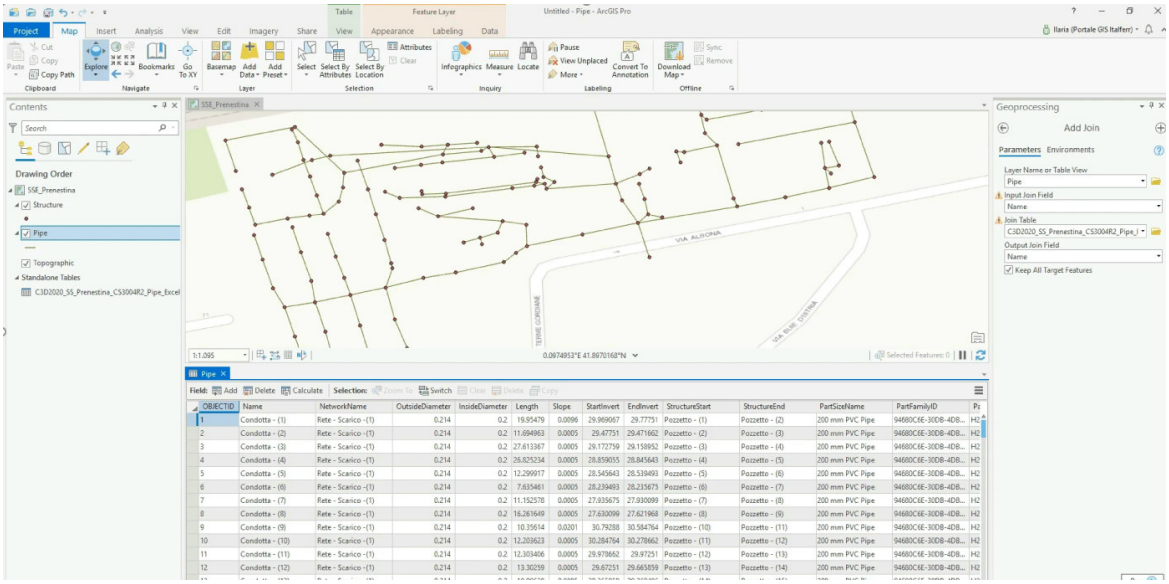
The comparison of the models highlights more effectively the differences between the old and the new design (see the picture below).



Comparison between the models (Compare functionality inside BIM 360)

Esri ArcGIS Pro Network utility tool: BIM and GIS integration

Considerable progress has been achieved in terms of interoperability between Esri and Autodesk platform since 2017. One of this progress regards the integration between Civil 3D and ArcGIS Pro. The interoperability between these 2 software allow us to recreate the entire network, designed within Civil 3D, inside ArcGIS Pro with all attributes and elements. No further elaborations are required.



Connection with SAP Hana

Finally the connection with the ERP system lead to an effective maintenance of the Utilities for all the 630 sites involved in the project.
In the following picture has shown the workflow used for the Prenestina Electrical Substation and that we are going to apply starting from the beginning of 2020.