City Information Modeling (CIM) concepts applied to the management of the sewage network

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Abstract. To solve challenges in management of sewage infrastructure in cities with the same features of Piumhi, Brazil, this research seeks to study a method of work for the management sewage system that aims, based on accurate information, to act in a preventive way and increase the quality of the decision making as the city grows and new projects areas are occupied and to prioritize investments. Strategies for the field survey for the diagnosis of the collectors and interceptors and for wells' information collect were established through meetings with the local autarchy SAAE (Water and Sewage Public Provider). A computational tool, based on Python codes, was developed to facilitate the input of georeferenced data into the QGis software. Tutorials of preventive management and contracting and supervision of future projects to the sewage network were also developed. The information obtained from the survey of the wells showed several barriers arising from the corrective management model adopted previously by SAAE and from ignorance of the population about the operation of the sewage network. During the network mapping, several stretches missing were found, some of them were corrected based on the analysis of the topography and of the wells upstream and downstream. The tool developed allows that any server of the autarchy gets access to the information about the operation of the system. Besides it allows the identification of problems and compares them to the conditions and features of the existing network, enables the definition of strategies of preventive actions and improvement of infrastructure from a historical assessment. The registration of the sewage network allowed match GIS tools and the BIM concepts, innovating the management process, improving the attendance to the population, increasing the quality of life and seeking a sustainable model that might be used by other public managers, walking towards the concept City Information Modeling.

1. Introduction
Brazil contains low rates of collected sewage (Instituto Trata Brasil, 2014). Actions to combat this important social issue are associated to implementing efficient solutions and technologies to improve the quality of the projects, maintenance and operation of these systems. The City Information Modeling (CIM), according to Amorim (2015), is a way to improve the urban management efficiency.

Several problems can be observed in the sewage network management, such as illegal connections of rain waters in a system not prepared for, overloading the treatment station. Also, in cases of obstructed stretches of the network, the sewage or its odor use to return into the houses, what can cause different diseases or complications. The actions conducted by local autarchy, after the problem identification, signify high costs of maintaining the system and, once no one knows the network, any planning of expanding the city will be made without projects with high levels of maturity.
The implementation of CIM concepts presents several challenges like internet availability, generation and data feed by the different operators using specialized tools like GIS software or simple apps like Google Maps or WhatsApp.

A case study was conducted for applying a workflow including solutions for the urban transition, from the current state to a future state, what includes optimization of the system and of its operations and maintenance.

2. Materials and Methods
For the development of this work, the first step was the literature review to acquire knowledge related to the existing process of sewage management around the world and in Brazil, about City Information Modeling (CIM), Building Information Modeling (BIM) and Geographic Information System (GIS). After that, many meetings were held with the local autarchy SAAE’s team. It was important to understand their level of compliance and knowledge about the infrastructure and the needs to improve its management process.

Thereafter the sewage network was surveyed, using Global Positioning System (GPS) and Real Time Kinematic (RTK) systems to acquire geodetic coordinates for each well, which were classified in (1) Wells in sewage interceptor and (2) Wells in sewage network, which concerns to the wells surveyed with high precision coordinates; (3) Unseen wells in sewage interceptors and (4) Unseen wells in sewage network, which concerns to assumed wells that were covered by something like asphalt, concrete or others; (5) Non-precision wells in the sewage network, which concerns to visible wells with low precision coordinates due to the field limitations.

The classified wells were mapped using the software QGis by the Engineering team. The process was discussed and presented to the IT team, so they could develop the solution to facilitate and to automate the process of insertion or actualization of the network by the autarchy SAAE’s team. Then, the operation of this system was designed using free tools as Google Maps and the communication trough conventional apps available in any smartphone, as for example, the app WhatsApp.

To facilitate the use of the solution by the lay people, some tutorials were recorded, avoiding printing. It will also be available for anyone who start working in the team, making possible to them to learn quickly and to provide data.

3. Results
The total of 1956 wells were surveyed. 1.400 (71,6%) were localized and had their interior observed; 368 (18,8%) were not localized (unseen wells); 71 (3,6%) had low quality of GPS signal (non precision wells); 62 (3,2%) belongs to the sewage interceptor, instead the sewage network; 55 (2,8%) belongs to the interceptor and were unseen. It’s important to highlight that, representing 22,4% of the surveyed points, the unseen and no precision wells in sewage network limited the model developed, due to the lack of information.

The plug-in is a complement for the QGis and is still under development using Python. This provides a way that lay people can insert the information provided from the field survey into the GIS software to evaluate technical issues related to the information modeled.

There is only one initial option for the operator which is “Load file” as showed in the Figure 1. After loading the file, the operator can visualize the data into the map and if it is correct, just click on “Load data”, what will make the data appear in the QGis. The information from the wells will then, be available with georeferenced information, combining parametric and georeferenced data for the wells and for the sewage network.
Figure 1. Interface of the plug-in.

The data available in QGis can be seen in the Figure 2. It is possible to see green, yellow and red dots related to the wells. Also, colored arrows show the sewage network with the information of the initial and final wells for each stretch, its materials, diameters, length and slope.

Figure 2. Wells and Sewage Network in the software QGis.

In the Figure 2 is also possible to see an area without arrows, but with some dots. It shows new data obtained recently from the urban expansion, what proves the need of keeping updating the data.

Then this data is uploaded to the Google Maps and become available to anyone who has a smartphone and has access to the link of the map, avoiding plotting. The Figure 3 shows how to use these tools, and how the operators are able to identify the wells or stretches to be maintained, define the best routes to drive to the area and also to update the data sending information to the Engineering team through apps for communication as, for example, the WhatsApp.

The data of the sewage network was collected initially using the GNSS/RTK system as described before. From now on, the workers must collect new data using their own devices, during the activities of maintenance, to guarantee the model updated. This process must be as simple as possible, once the workers are not prepared to use complex applications or devices and it would signify high costs and a lot of time of training. For that, the process determined is that new localizations must be generated
using the Google Maps and sent throw WhatsApp with the detailed description of the wells observed. The engineers are in charge of updating the sheet and the maps shared with the teams. It is simple and has showed high level of acceptance by the workers.

Figure 3. Example of locating and identifying a well using a smartphone.

4. Conclusions
This paper presents a solution tested to keep the data of the sewage network updated for cities with low economic resources. The tools and tutorials developed provide a cheap and simple workflow, enabling any operator without specific skills to work with it.

The programming using Python showed feasible, but with some challenges that require experts. Providing simple ways for inserting information by lay people is an important way of designing.

The parametric information as the diameter, materials, length and slope of the stretches, together the parametric information of the wells as diameter and depth, together the georeferenced location of them, allows to develop further information with objects associated to quantities and costs, what proves that is important to survey with high quality and to keep the survey updated for developing and keeping good models of information of the cities.

However, the lack of information can decrease the quality of the data, implicating low quality of the model, but it can be healed over time, during the maintenance and operation of the network.

The tutorials in video shows a better and sustainable way of providing information to the people who need to be trained, and also allows that the trainings occur in the field in an easier way. A limitation of it would be were you don’t have internet access, what can be minimized by saving the maps to be used offline, only with the GPS of the smartphone.

It is recommended further jobs to develop parameterized objects that provides information related to quantity and costs, what could be used for projects, maintenance and operation.

The solutions tested in real environment shows that it is possible to provide low costs, simple and high precision tools to be used by any operator in any urban system, making possible the urban transition from the current state to a future state, even for cities in developing countries.

References
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