Vision to the Underground Utility Professional Discipline in Hong Kong

Wallace Wai-Lok Lai
Department of Land Surveying and Geo-informatics (LSGI), The Hong Kong Polytechnic University (PolyU)

Abstract: Underground utility engineering, surveying and management is an emerging professional discipline in Hong Kong and elsewhere, where the new underground utility networks are getting much complicated and the old ones are aging. It has been four years since our underground utility management and surveying specialism has been launched as one of the three streams in our BSc (Hons) in Geomatics in LSGI, PolyU, as the first such undergraduate degree program in the world. This relatively new scope extends the land surveying discipline from the scope of positioning, mapping and monitoring from above ground objects to underground objects. At present, the demand is no longer only about safety, but also extends to detail 3D underground/subsurface mapping, monitoring and method validation with precise land and underground surveying technologies, as well as customization of this information into unified database using geographical information system (GIS). Our stream strives to provide a total solution that help to solve a range of underground utility problems at different stages and provides training starting from undergraduate level. This paper attempts to answer four fundamental questions via defining our scope of training with six domains: (1) Geo-spatial positioning and mapping, (2) Condition survey, monitoring and diagnosis, (3) Coordinated and integrated system and design for new construction, (4) Trenchless construction, (5) Trenchless maintenance, and (6) Construction, operational, business, and data management.

Keywords: Underground utility engineering, surveying and management, Geomatics

1. INTRODUCTION

The unseen underground utility networks (power, water supplies, drainage, sewerage, gas, telecom, street light etc) are any city's indispensable blood vessels. But they also pose hazards and disturbance to the public, especially when these vessels are out of sight, gradually deteriorated and suddenly collapse in underground's hostile environment without notice and warning. A recent example of such fatal consequence is Kaohsiung gas explosion in 31 July 2014. In Hong Kong, MTR estimates that for 1 km long road, there are 47 km underground utility network. This ratio will certainly grow due to the ever-increasing urbanization, household demands of energy and telecommunication networks. Issues to the public like positioning and mapping of these utilities, repetitive road opening, underground water burst, lack of coordinated database exist for decades. Although underground utilities occupy the same congested underground space in Hong Kong, they are not regarded as a united body which therefore does not favour spatial integration and coordination. The underlying reason is probably because underground utility practitioners scatter in different professional disciplines and have their own definitions of utilities contributing to very distinct functions.

Since 2010, Department of Land Surveying and Geo-informatics (LSGI) implemented a BSc (Hons) curriculum of underground utility surveying and management, based on and as an extension of the well-developed curricula of land surveying and geo-information technology. In this paper, we attempt to answer five fundamental questions, defining ourselves in this evolving discipline with answers grouped in six domains taken into account in our undergraduate curriculum, namely:

- Geo-spatial positioning and mapping
- Condition survey, monitoring and diagnosis
- Coordinated and integrated system and design for new construction
- Trenchless construction
- Trenchless maintenance
- Construction, operational, business, and data management

2. QUESTIONS OF THE UNDERGROUND UTILITIES PROFESSIONAL DISCIPLINES

2.1 FIRST QUESTION: Does the new utility professional discipline covers an identifiable area that envelopes a reasonable breath of expertise?

Six domains suggested in the professional discipline are recognized and listed below:

No.	Domains	Descriptions
1	Geo-spatial positioning and mapping	This domain makes use of a combination and validation of geo-spatial underground mapping and above-ground mapping technologies. The former is a branch of engineering geophysics/nondestructive evaluation (NDE) such as quasi-static field induction (e.g. eddy current), electromagnetic wave (e.g. ground penetrating radar) and mechanical wave (e.g. leak noise). The latter includes global navigation satellite system (GNSS), total station, remote sensing, terrestrial laser scanning, etc. Processed information is integrated in geographic information system (GIS) database and form part of big data of a city.
2	Condition survey, monitoring and diagnosis	Design life of underground utilities is normally 50 years. The conditions within this life span must be surveyed, diagnosed and monitored for the sake of structural health and acceptable performance. This domain contains not only the technologies in domain 1, but also ordinary visual inspection, flow and deformation monitoring. A long term survey and monitoring strategy would provide indispensable medical records within the life cycles of any utilities.
3	Coordinated and integrated system and design for new construction	New utility construction in Hong Kong's underground shall be better coordinated and further integrated into a common duct like many other cities. For coordination, ownership and right of occupation of road's underground space is not well-defined. To date, statutory requirement is not available to regulate the use of underground space. For integration, ideas of building information modeling (BIM), common utility tunnels or ducts may be promoted in areas yet to be developed (i.e. new town), so as to reduce frequency of road opening for maintenance of utilities in the long run.
4	Trenchless construction	Trenchless technologies of utilities construction are always preferred especially in densely populated cities because of (1) its lower impact to traffic and environment compared to traditional construction making use of open trench, as well as (2) availability of significant technological advancement, (e.g. tunnel boring machine, pipe jacking) and evolution of new types of materials (e.g. polyethylene pipe) over the last decade.
5	Trenchless maintenance	The merits of trenchless technology discussed in domain 4, are also shared in this domain. Rehabilitation of existing utility (e.g. trenchless re-lining of drainage/sewer pipes) is very important to extend the service life of any utilities after positioning, mapping, monitoring, diagnosis and records in GIS. Such approach establishes medical track record from the birth to the end of service life of any utilities. A recent example is the 15-year long and 23.6 billion replacement and rehabilitation project of water mains by Water Services Department (WSD), and zoning of district metering areas (DMAs) and pressure monitoring areas (PMAs) to monitor water demand in particular areas.
6	Construction, operational, business, and data management	The above 5 domains require substantial knowledge of management, ranging from running corporate business models, project management, contract administration, procurement, database to risk management (consequences and probability of damages). Different management skills are also required from different roles in the utility industry, like clients, consultant firms, contractors and specialists.

2.2 SECOND QUESTION: Can the new discipline be perceived easily by general public?

Most people walk over the complicated matrix of underground utilities without noticing its existence and complexity. From water pipe burst happening everyday, un-coordinated and non-stop road excavation by different utility undertakers (UU) over the same area, to the recent deadly gas burst in Kaohsiung in August, 2014, countless problems seem not properly engineered and have been dragging on for decades. In Hong Kong, MTR roughly estimates that for 1 km long road, there are 47 km underground utility network, and these ratio will grow due to the ever-increasing urbanization, demands of energy and telecommunication networks. We contribute to providing solutions in a more unified approach in accordance to the clear tasks defined by the six domains listed in part 2.1. These issues of underground utilities are well recognized by general public. The table below lists the correspondence between these questions and domains suggested in Section 1.

No.	Domains	Some questions perceived and recognized by the general public
1	Geo-spatial positioning and mapping	Where are the utilities?
2	Condition survey, monitoring and diagnosis	How healthy are the utilities, and how long can and will they function? Can water burst be avoided? What if they explode like Kaosiung gas explosion?
3	Coordinated and integrated system and design for new construction	Can the utilities be put together in a common duct/tunnel? Can the road opening be less frequent?
4	Trenchless construction	Can utility construction go un-noticed without disturbance to traffic?
5	Trenchless maintenance	Can utility maintenance go un-noticed to avoid disturbance to traffic?
6	Construction, operational, business, and data management	All above

2.3 THIRD QUESTION: Is the area of the professional discipline so substantially different from existing engineering and surveying practice, that it cannot be covered within reason by extension of the scope of practice of any existing engineering and surveying disciplines?

The proposed underground utility discipline is substantially different but yet closely related to many current engineering and surveying disciplines. Although underground utilities spatially occupy the same congested underground space in Hong Kong, they are not united, which therefore does not favour integration and coordination. The most important reason is probably because underground utility practitioners scatter in different engineering/surveying disciplines and produce their own definitions of utilities contributing to very distinct functions, such as civil, electrical, gas, geotechnical, information, materials. For example, storm and foul drainage fall into the scope of civil and geotechnical engineers, and power networks is responsible by electrical engineers. To make better use of our scarce underground space, an integrated approach is very much in need but is not sufficiently or only partially embraced by current engineering or surveying disciplines. One everyday example is repetitive and not coordinated road opening over the same road section by different UU. Another example is lack of design and construction of common utility tunnels/ducts which if implemented, would substantially reduce the frequency of road opening and maintenance costs. The new discipline therefore establishes a platform for such integration and coordination amongst different utility undertakers which exists but scatters in different engineering and surveying disciplines. The table below lists the interface of this discipline with other current engineering disciplines according to the six domains.

No.	Domains	Current engineering disciplines	Current surveying disciplines
1	Geo-spatial positioning and mapping	Civil, electrical, gas, information	Land
2	Condition survey, monitoring and diagnosis	Civil, electrical, gas, geotechnical, materials	Land, building

3	Coordinated and integrated system and design for new construction	Building services, Civil, electrical, gas, geotechnical, materials	-
4	Trenchless construction	Civil, electrical, gas, geotechnical, materials	-
5	Trenchless maintenance	Civil, electrical, gas, geotechnical, materials	-
6	Construction, operational, business, and data management	Building services, civil, electrical, gas, geotechnical, materials	-

2.4 FOURTH QUESTION: Do statutory requirement exist and are there conceivable statutory needs?

It is of utmost importance that statutory requirements of underground utilities are established, implemented and abided by different Government departments, practitioners and general public. As listed in the table below, there are three existing statutory requirements about underground utilities in Hong Kong, and further statutory needs are conceived as well.

No.	**Domains**	**Existing statutory requirements**	**Conceivable statutory needs**
1	Geo-spatial positioning and mapping	- The Electricity Supply Lines (Protection) Regulations and The Gas Safety (gas supply) Regulations made under the Electricity Ordinance, Cap. 406 and Gas Safety Ordinance CAP 51B (1997) respectively, enforce the requirements of safety of underground electricity cables and gas pipes before road opening. These regulations do not allow any road opening of the vicinity of an underground electricity cable or overhead electricity line unless all reasonable steps have been taken to ascertain the existence of such cable or line. Licensed competent persons recognized by Electrical and Mechanical Services Department (EMSD) are required to carry out such reasonable steps. -	- The current legislations are only about electricity supply and gas lines. The scope of which is conceived to extend to all types of underground utilities.
2	Condition survey, monitoring and diagnosis	- A code of practice (COP) on Monitoring and Maintenance of Water Carrying Services Affecting Slopes by the Works Bureau was enacted on 1996 and revised on 2006, after the disaster of Kwun Lung Lau's landside on 1994 which killed five people. One of the important reasons of the landslide was constant water leak of a storm and sewerage water pipes buried in the slope (Morgenstern N.R., 1994).	- Current COP relies on visual inspection of pipe's internal conditions, but the damages within the pipes are not known, which is too late when disasters like landslide and road collapse happen. These surveys shall be extended to in-depth inspection by nondestructive testing methods which enable engineers and surveyors to see through the unseen. An analogy of such statutory requirement is mandatory building inspection scheme (MBIS) implemented in buildings.

3	Coordinated and integrated system and design for new construction	- Currently there is no statutory requirement.	Construction of common utility tunnel in new town rather than dig-lay-backfill approach.
4-6	Trenchless construction, maintenance, construction, operational, business, and data management	- Currently there is no statutory requirement.	Submission and maintenance of GIS database containing the most updated utility records like other statutory requirements in construction (e.g. building and framing plans).

3. CONCLUSION

Hong Kong, and elsewhere in the world, is very much in shortage of properly trained utility engineers, surveyors and managers that can integrate this spatial above-ground and underground information. It is anticipated that qualified utility professionals are in large demand due to persistent urbanization, underground utility projects and increasing demand of energy. In this paper, we envisaged and made use of six domains to address four common questions perceived during the development of such discipline. We look forward to the healthy development of the professional discipline under the suggested domains in this paper.

References

[1] Morgenstern N.R. "Report on the Kwun Lung Lau Landslide of 23 July 1994", 1994.
[2] The Electricity Supply Lines (Protection) Regulations, Electricity Ordinance, Cap. 406.
[3] The Gas Safety (gas supply) Regulations, Gas Safety Ordinance CAP 51B, 1997.