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A LADM-based 3D underground utility data model: a case study of Singapore

LADM Workshop 2019

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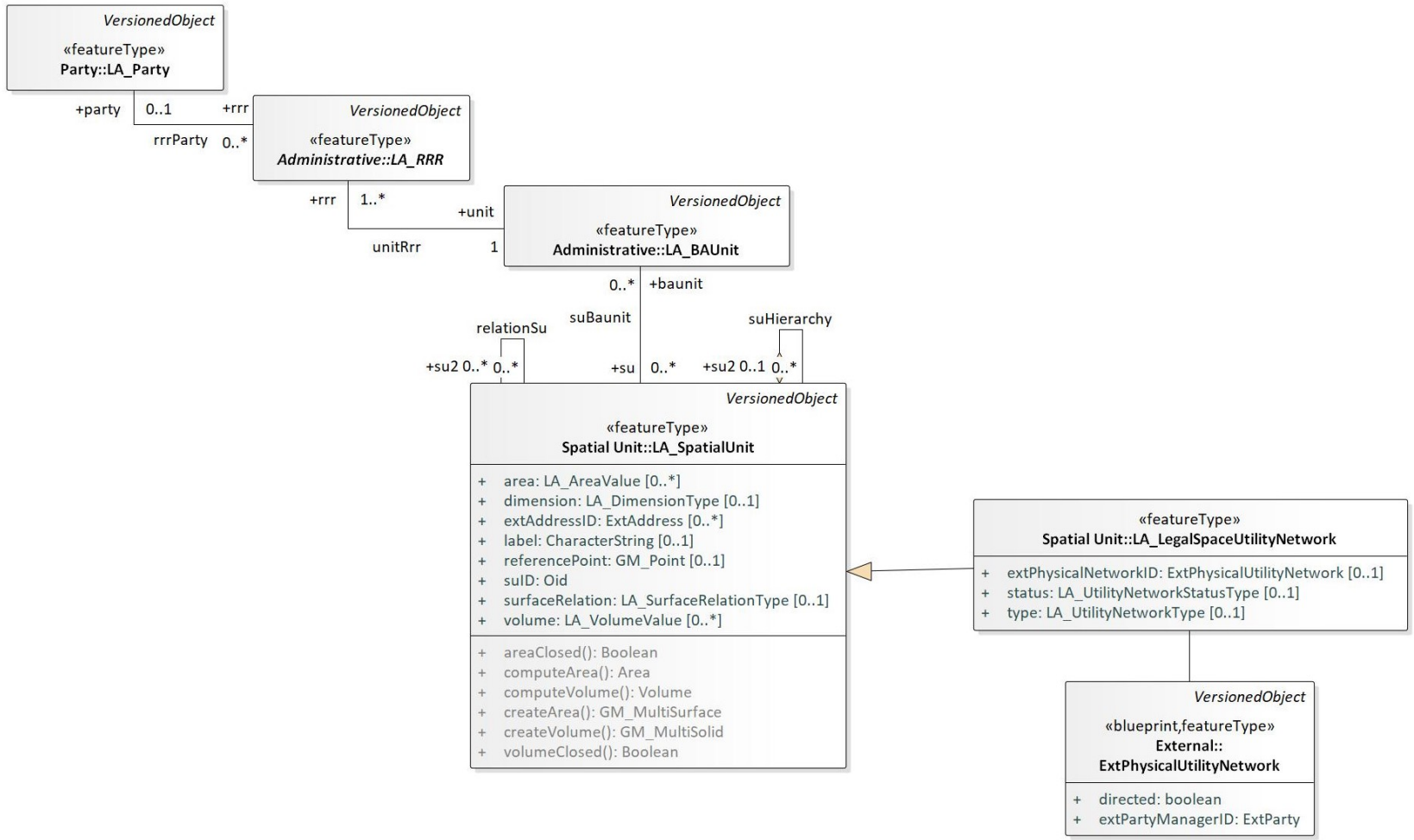
Underground Utility in Land Administration-- Background

- Good **standards**, **guidelines** and **practices** for underground utility mapping are key enablers for ensuring data **quality**.
- City of Zürich (GeoZ): a consolidated map of underground utilities
- UK begins to the registry of underground utilities and creates a national underground assets mapping platform in 2018
- LADM: a flexible conceptual schema from three main aspects: organizations, rights and spatial in formations.



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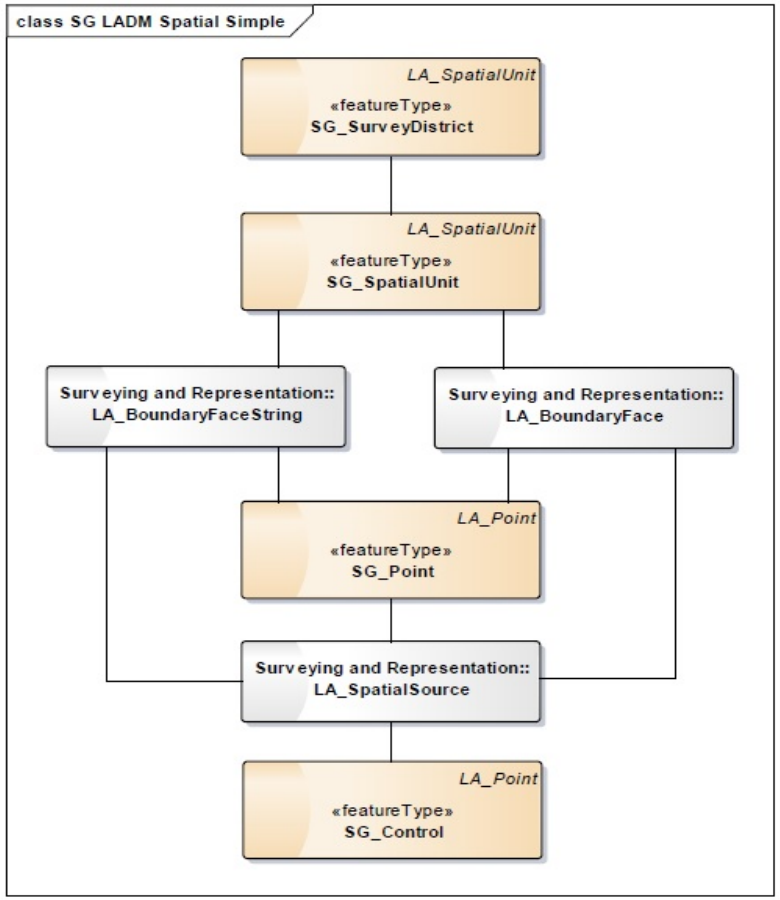
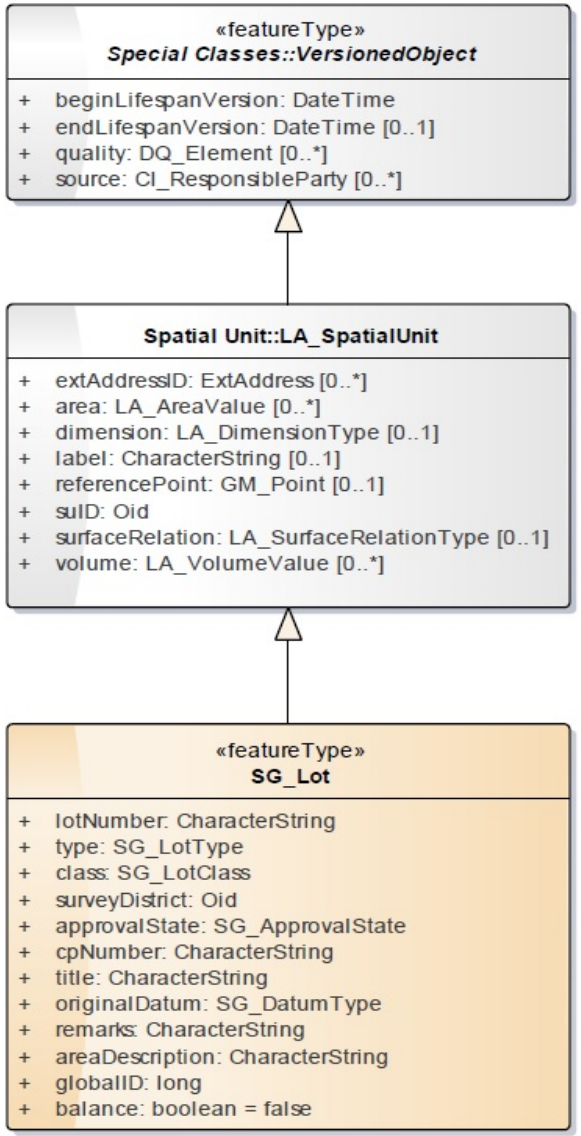
Land administration in Singapore

- A Singapore-based LADM model: 2014
- Management of cadastral data of land parcels, cadastral survey data and land administration data.
- The Singapore profile inherit LADM objects, attributes and relationships.
- *SG_Lot* is inherited from *LA_SpatialUnit* to describe cadastral information of land parcel.





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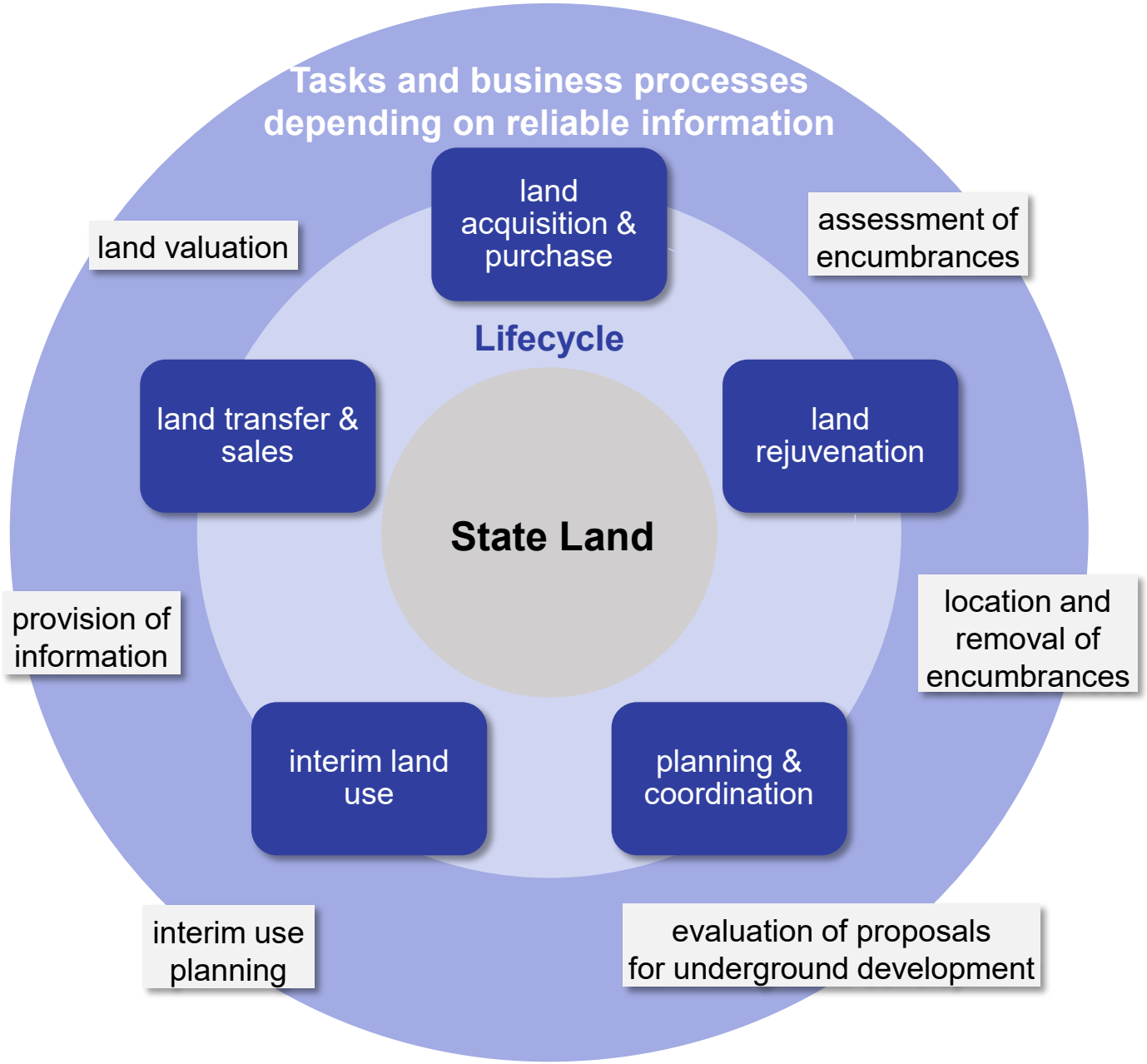
Underground Utility for Land administration in Singapore



- Current issues:
  - The existing data sources: hardcopy, 2D CAD and geospatial format
  - As built or as-designed data
  - Lack of information and unreliable

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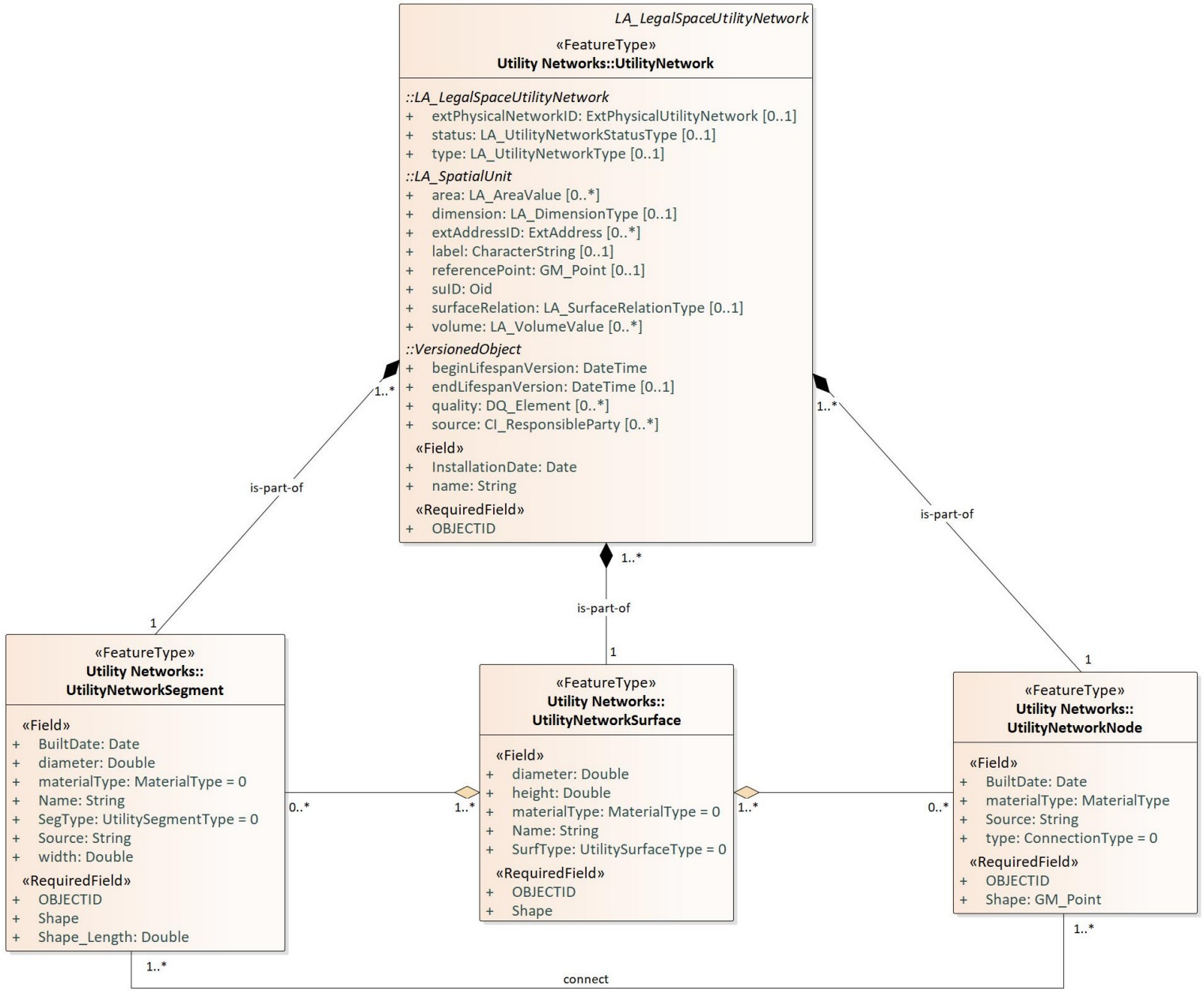
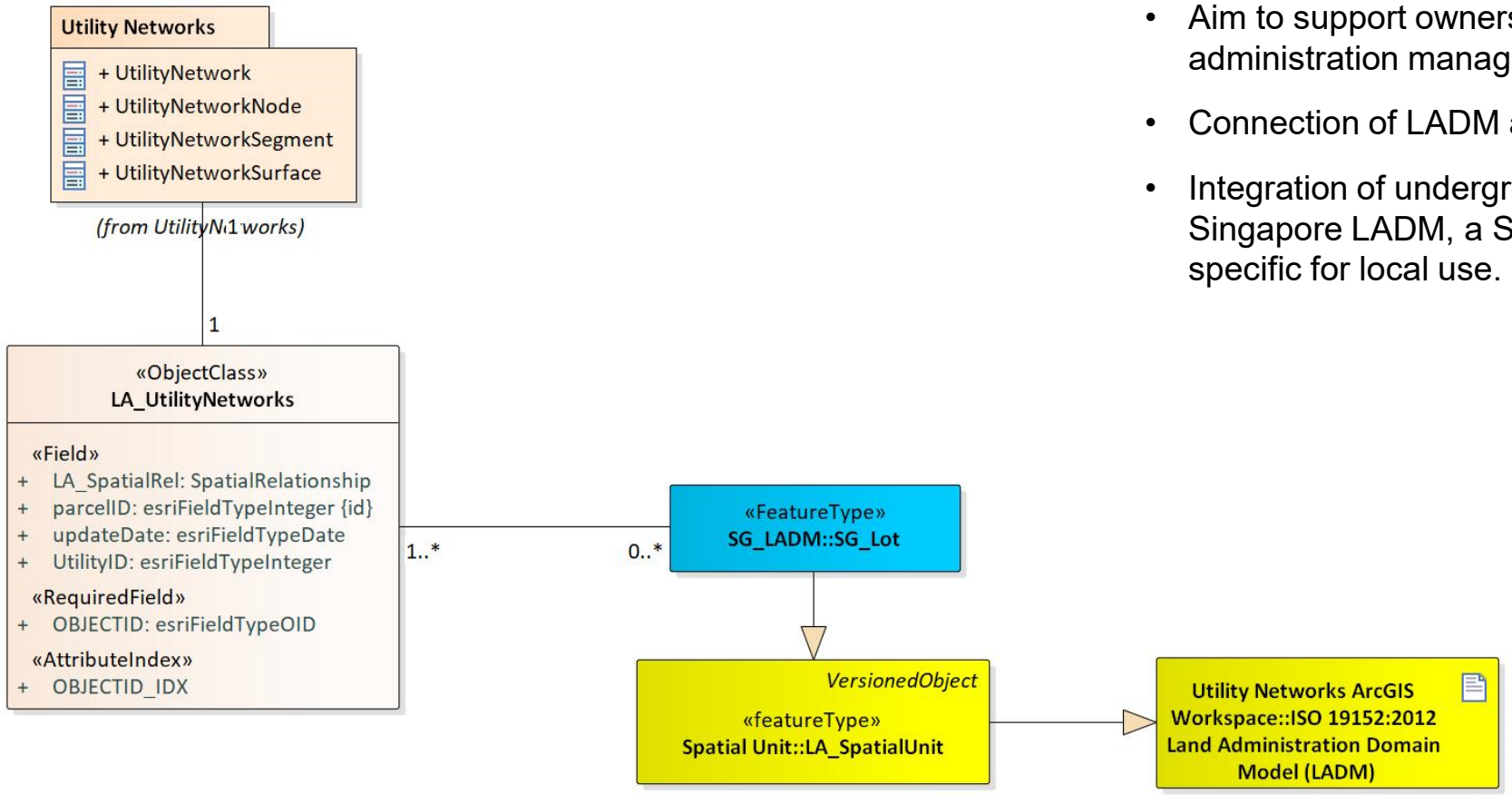
3D Underground Utility Data Model – Geometry



- *Utility Networks* is inherited from *LA_LegalSpaceUtilityNetwork*.
- The class *Utility Network Node (2D)*, *Utility Network Segment (2D)* and *Utility Network Surface (3D)* are components of *Utility Network*.
- Integration of 2D and 3D geometric information

3D Underground Utility Data Model – Land Administration



- Aim to support ownership management of utilities and land administration management.
- Connection of LADM and utility network
- Integration of underground objects with attributes from Singapore LADM, a Singapore-based LADM model customized specific for local use.

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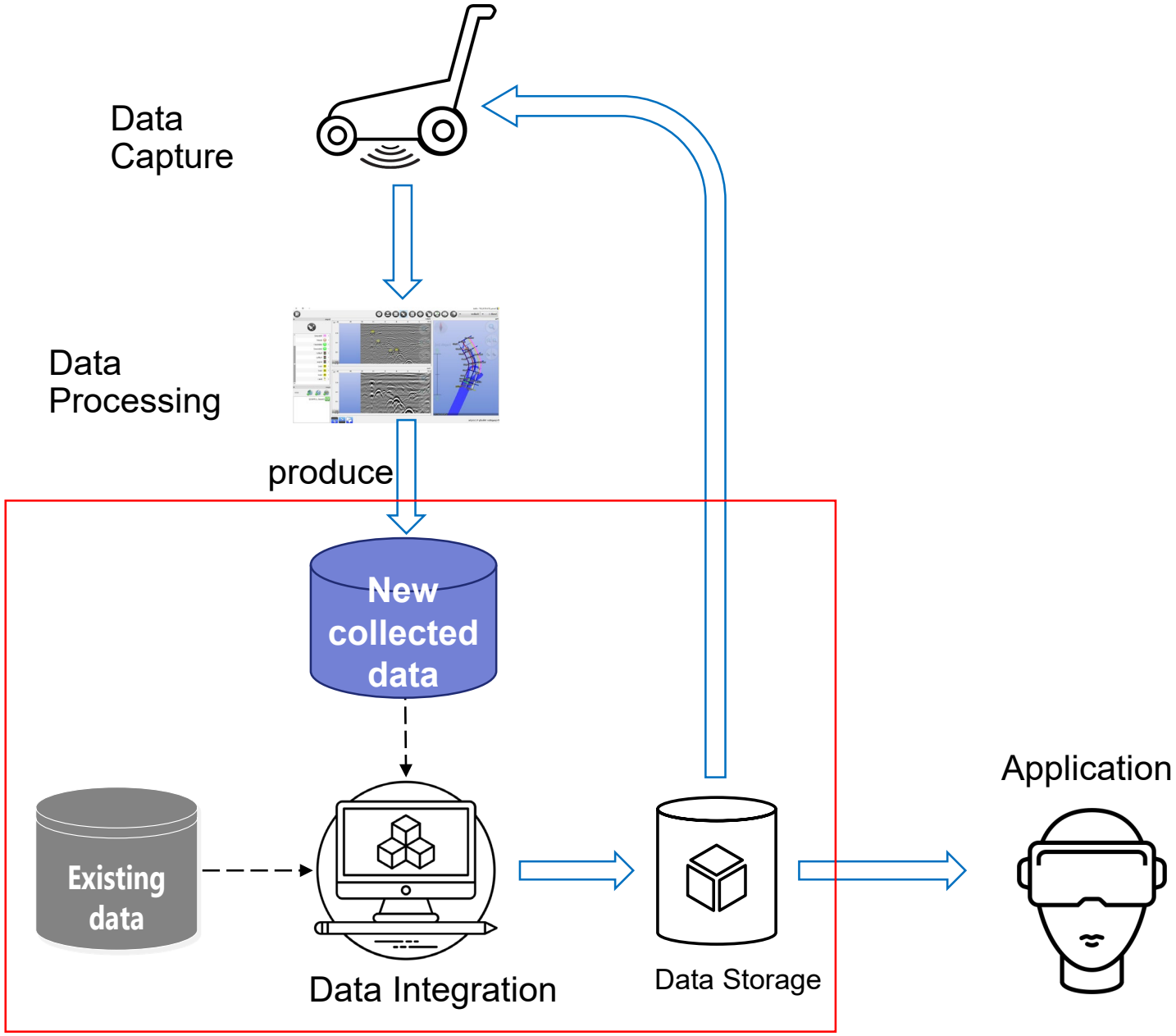
3D Underground Utility Mapping: Workflow of Case Study



Data Source: The Existing 2D Data

- The existing 2D utility data
- The 2D cadastre data

SINGTEL_ASBUILT_DUCT

OBJECTID *	SHAPE *	FMEL_UPD_D	INC_CRC	IGDS_LEVEL	IGDS_WEIGHT	SHAPE_Length
1	Polyline Z	19/3/2018 4:37:45 PM	79DF52A0D1A0E248	1	0	56.43511
2	Polyline Z	19/3/2018 4:37:45 PM	586CDB6CCD65CA12	1	0	143.871576
3	Polyline Z	19/3/2018 4:37:45 PM	B966180044999D9C	1	0	13.477438
4	Polyline Z	19/3/2018 4:37:45 PM	D68A9D1C9F83F4D0	1	0	13.240273
5	Polyline Z	19/3/2018 4:37:45 PM	9236FA3688A8171A	1	0	40.315298
6	Polyline Z	19/3/2018 4:37:45 PM	A77DC87A2C3E4006	1	0	30.434301
7	Polyline Z	19/3/2018 4:37:45 PM	648025E3B82354EC	1	0	44.847246
8	Polyline Z	19/3/2018 4:37:45 PM	8373D67FC0F8455B	1	0	27.164232
9	Polyline Z	19/3/2018 4:37:45 PM	0A4746B6B4F66346	1	0	32.917536

1 (0 out of 308146 Selected)

SINGTEL_ASBUILT_DUCT

PUB_WATER_MAIN

OBJECTID *	SHAPE *	DIA_MM	YEAR_INST	ACCU_STA	WATER_TYPE	RB_STATE	G3E_FID	INC_CRC	FMEL_UPD_D	SHAPE_Length
1	Polyline	150	1992	D	3	INS	66015	C924E45FB9D7DCAD	16/5/2018 11:17:46 AM	141.292605
2	Polyline	200	2002	D	3	INS	61174	8FCD3CAF77679A5B	16/5/2018 11:17:46 AM	112.857139
3	Polyline	150	1993	D	3	INS	106181	339450A3308C3FA3	16/5/2018 11:17:46 AM	60.08175
4	Polyline	500	1972	D	3	INS	79209	17F1ED8937926EDB	16/5/2018 11:17:46 AM	5.792601
5	Polyline	100	1995	D	3	INS	33790	8BCF0FB1D8C0AF36	16/5/2018 11:17:46 AM	27.417181
6	Polyline	100	1960	D	3	ABD	123625	689D1D61899BCDFE	16/5/2018 11:17:46 AM	16.673478
7	Polyline	150	1991	D	3	INS	109426	3B4A01E9E0F339F7	16/5/2018 11:17:46 AM	15.554937
8	Polyline	300	2004	D	3	INS	370431	F239336F8B0FEF07	16/5/2018 11:17:46 AM	3.22658
9	Polyline	100	1995	D	3	INS	400041	44E1B08B6288698C	16/5/2018 11:17:46 AM	121.549833

EMA_HIGHVOLTAGE

FID	Shape *	ID	INC_CRC	FMEL_UPD_D
0	Polyline	0	E61F6E0B63EF19C7	27/9/2017
1	Polyline	0	66AB219004B2E744	27/9/2017
2	Polyline	0	437DDA3F42FE8FC6	27/9/2017
3	Polyline	0	A8A3EA9EE3C4C288	27/9/2017
4	Polyline	0	FC59B4334BF7E783	27/9/2017
5	Polyline	0	292A50098D2E4DD5	27/9/2017
6	Polyline	0	53C4DD68B7E1F296	27/9/2017
7	Polyline	0	F46AB429B69D2DF9	27/9/2017
8	Polyline	0	27F4F28AF99141ED	27/9/2017
9	Polyline	0	03B71BDFE2B4A77F	27/9/2017
10	Polyline	0	40D1DD4F12F852FD	27/9/2017
11	Polyline	0	F221658787F5E8C7	27/9/2017
12	Polyline	0	DE1490841ED08C88	27/9/2017
13	Polyline	0	AB8F49F049CDA274	27/9/2017
14	Polyline	0	E8EE5AF847554B55	27/9/2017
15	Polyline	0	3775047E4351F61E	27/9/2017
16	Polyline	0	106061334B1BDE56	27/9/2017
17	Polyline	0	3B2F21BED8396E8B	27/9/2017
18	Polyline	0	3EBAD0E453824390	27/9/2017
19	Polyline	0	CA20A5D105C51DC6	27/9/2017
20	Polyline	0	060A2E8D67D42A92	27/9/2017
21	Polyline	0	58E2DFDC7BE6A301	27/9/2017
22	Polyline	0	87833E1D975A30C6	27/9/2017
23	Polyline	0	72EAF8D475172314	27/9/2017
24	Polyline	0	4EA694374C28DCBA	27/9/2017

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Large Scale Underground Utility Mapping: Technology

- The Pegasus: Stream mobile mapping platform
- A Stream EM GPR
- Leica Pegasus Two photo and laser scanner

Overall weight	228 kg (500 lbs)
Max. acquisition speed	15 kph (9mph)
Power consumption	72W
Positioning	Survey wheel and/or GPS or Total Station
Scan Rate per Channel (@512 samples/scan)	87 scans/sec
Scan Interval	17 scans/m @ 200 MHz 33 scans/m @ 600 MHz
Antenna Footprint	Width 1.84m
Number of Channel	38
Antenna Central Frequencies	200 MHz (34 channels) 600 MHz (4 channels)
Antenna Spacing	6cm
Antenna Polarization	Horizontal (HH) and Vertical (VV)

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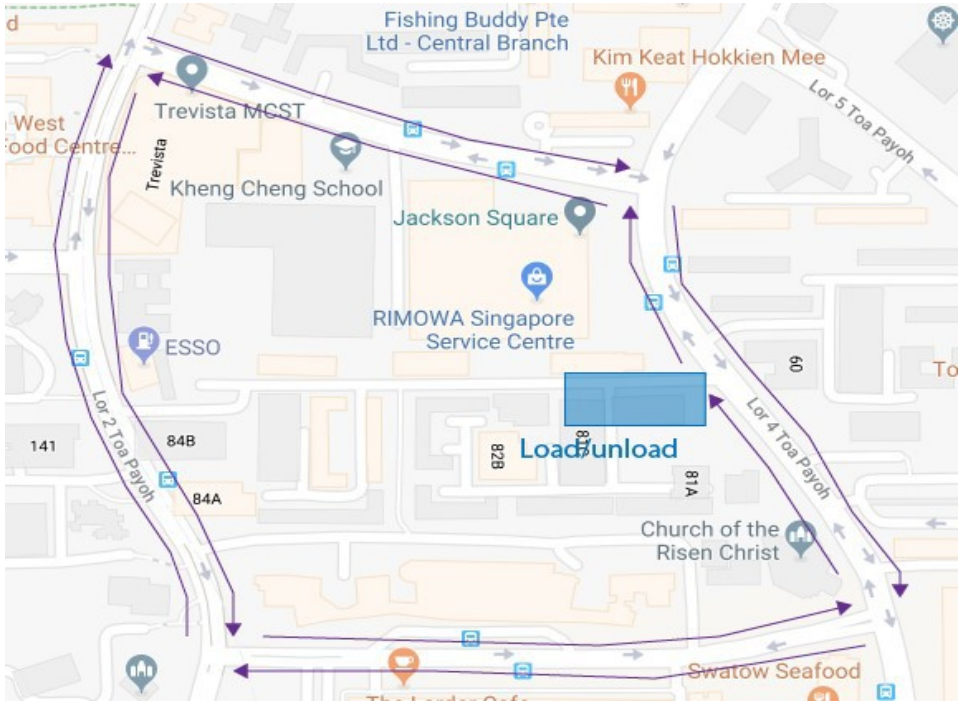
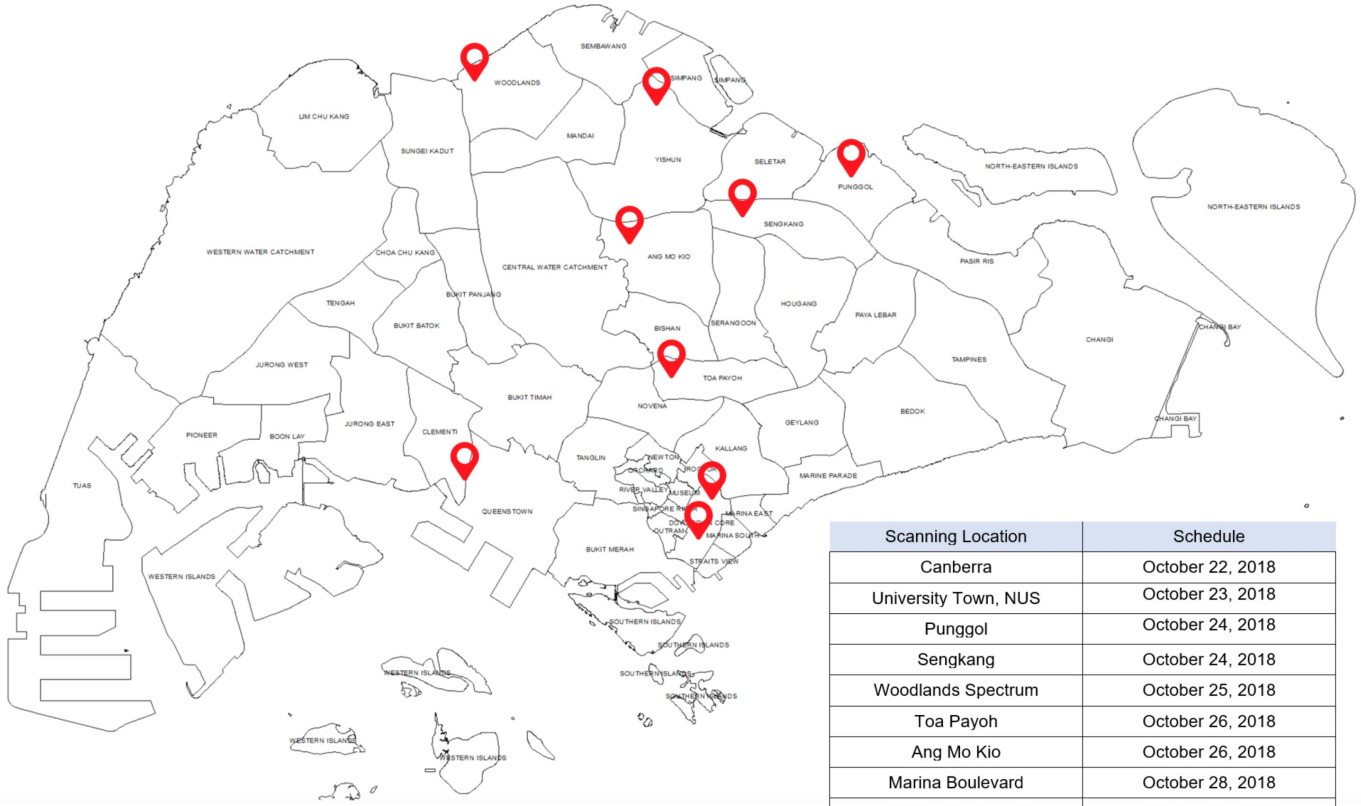
Large Scale Underground Utility Mapping: Study Area

- 9 study areas
- The Stream EM cover width: 1.75m
- Lane width: 3.2m+
- A single lane: 2 scan track
- Toa Payoh:
  - 1.8km
  - 4 lanes
  - 5-6 hours





Scanning Location	Schedule
Canberra	October 22, 2018
University Town, NUS	October 23, 2018
Punggol	October 24, 2018
Sengkang	October 24, 2018
Woodlands Spectrum	October 25, 2018
Toa Payoh	October 26, 2018
Ang Mo Kio	October 26, 2018
Marina Boulevard	October 28, 2018
Raffles Boulevard	October 28, 2018

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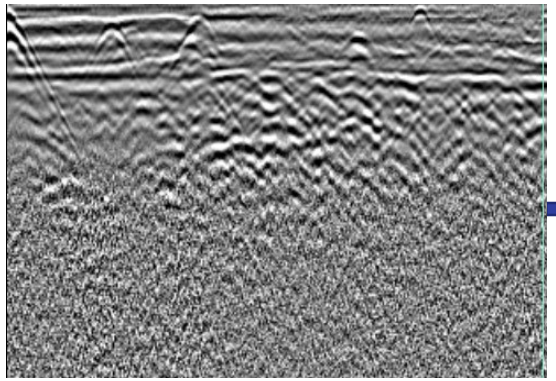
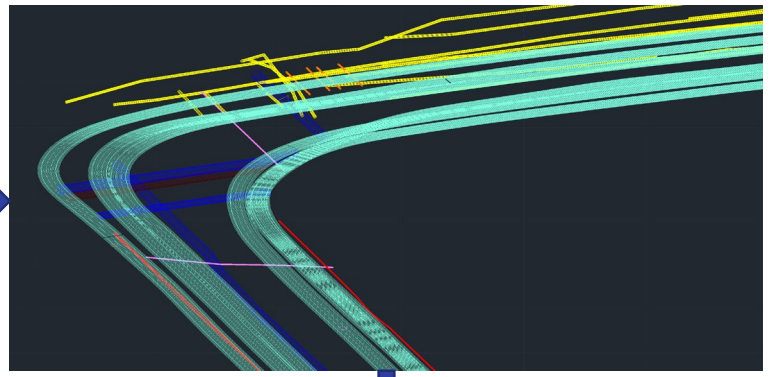
Newly collected GPR data

radagram



CAD



Field: Add Delete Calculate | Selection: Zoom To Switch Clear Delete

FID	Shape	START_X	START_Y	START_Z	MID_X	MID_Y	MID_Z	END_X	END_Y	END_Z
0	Polyline ZM	29414.340192	35509.591781	0	29415.334656	35508.143163	0.00005	29414.340192	35509.591781	0
1	Polyline ZM	29436.809232	35561.909923	-0.124216	29429.627246	35561.755928	-0.124192	29422.445261	35561.601934	-0.124168
2	Polyline ZM	29423.752592	35567.755462	-1.888125	29428.991853	35567.578518	-1.888098	29434.231115	35567.401575	-1.888072
3	Polyline ZM	29414.106827	35511.945832	-0.131477	29419.153149	35511.353114	-0.127823	29424.19947	35510.760396	-0.124168
4	Polyline ZM	29457.987879	35621.235134	-0.823726	29450.825744	35624.136247	-0.966693	29443.663608	35627.03736	-1.109661
5	Polyline ZM	29591.92529	35592.641708	-1.4575	29590.720696	35588.344791	-1.457474	29589.516102	35584.047873	-1.457447
6	Polyline ZM	29589.004672	35593.574703	-1.189956	29587.258969	35588.862697	-1.145065	29585.513266	35584.15069	-1.100174
7	Polyline ZM	29486.713161	35620.722594	-1.412026	29485.81038	35628.380927	-1.421454	29484.788106	35636.023883	-1.609239
8	Polyline ZM	29538.849588	35600.354287	-0.803851	29541.348411	35606.888729	-1.031643	29543.611267	35613.511037	-1.006735

FID	Shape	POINT_X	POINT_Y	POINT_Z
0	Point ZM	29622.520978	35571.252748	0
1	Point ZM	29571.768935	35591.992297	0
2	Point ZM	29478.632773	35638.598061	0
3	Point ZM	29496.841032	35619.919353	0
4	Point ZM	29521.792077	35609.732618	0
5	Point ZM	29444.413495	35589.102273	0
6	Point ZM	29601.931955	35582.763523	0

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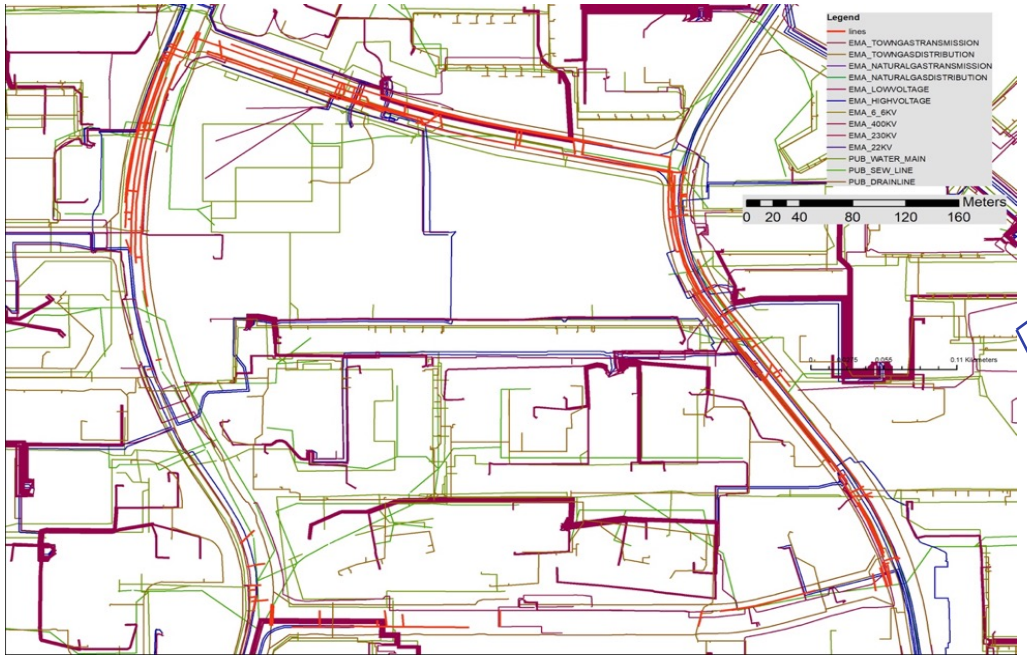
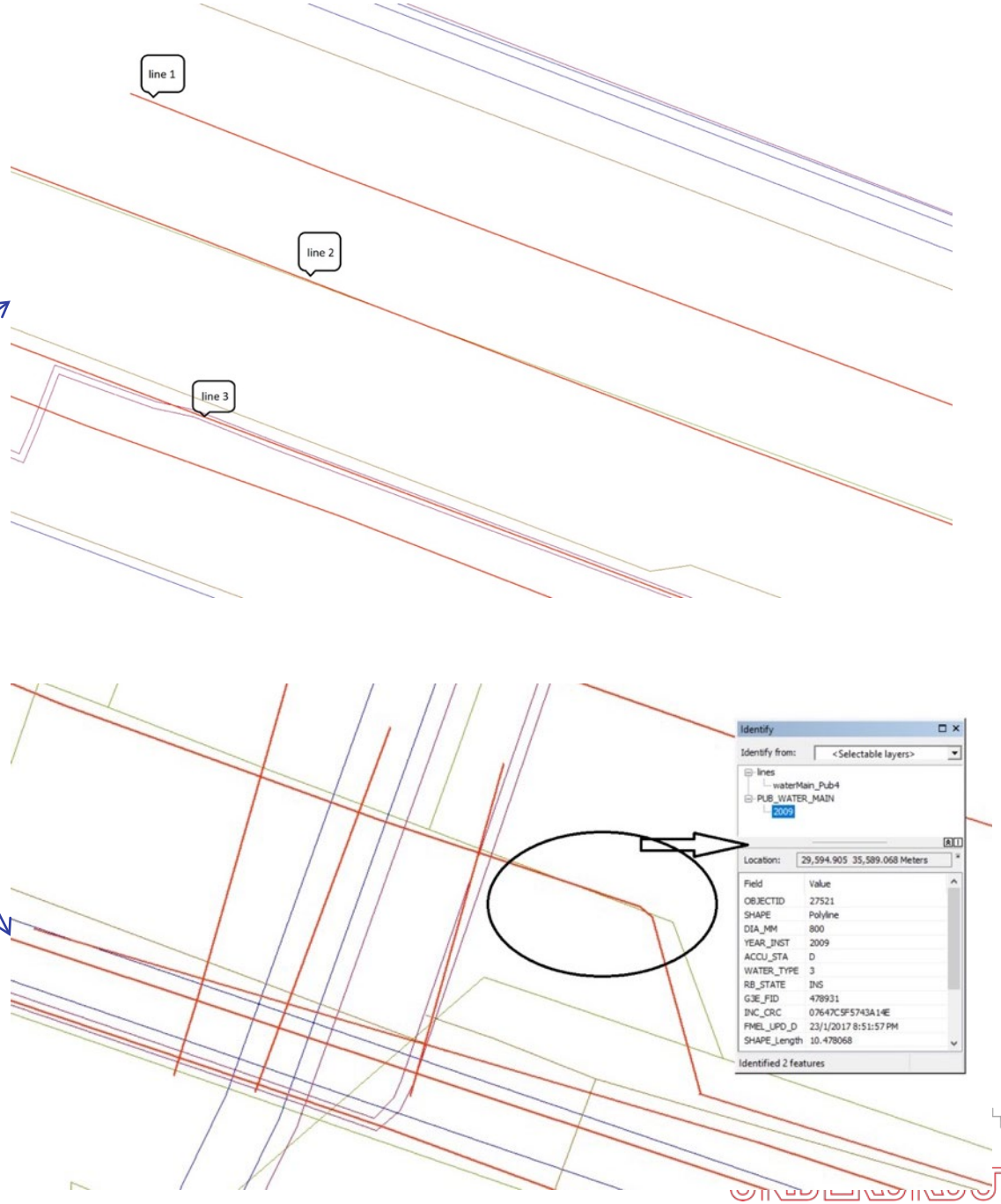
Identification

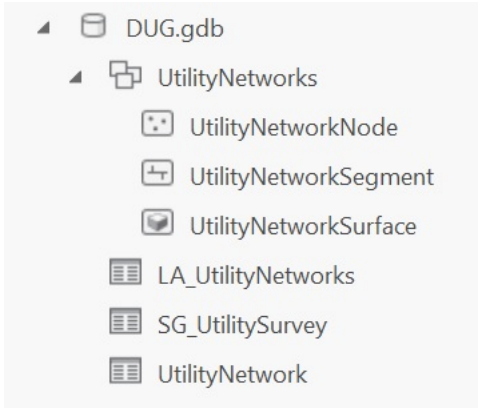
Overlay of GPR and the existing data



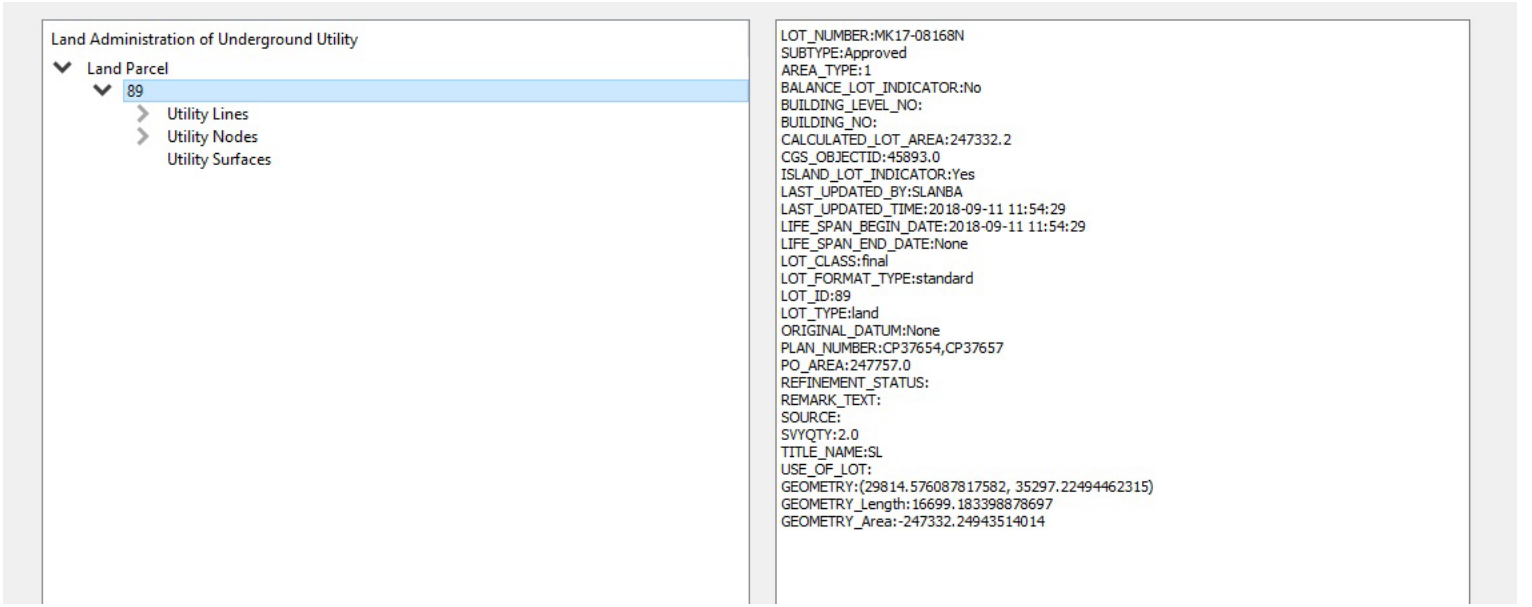


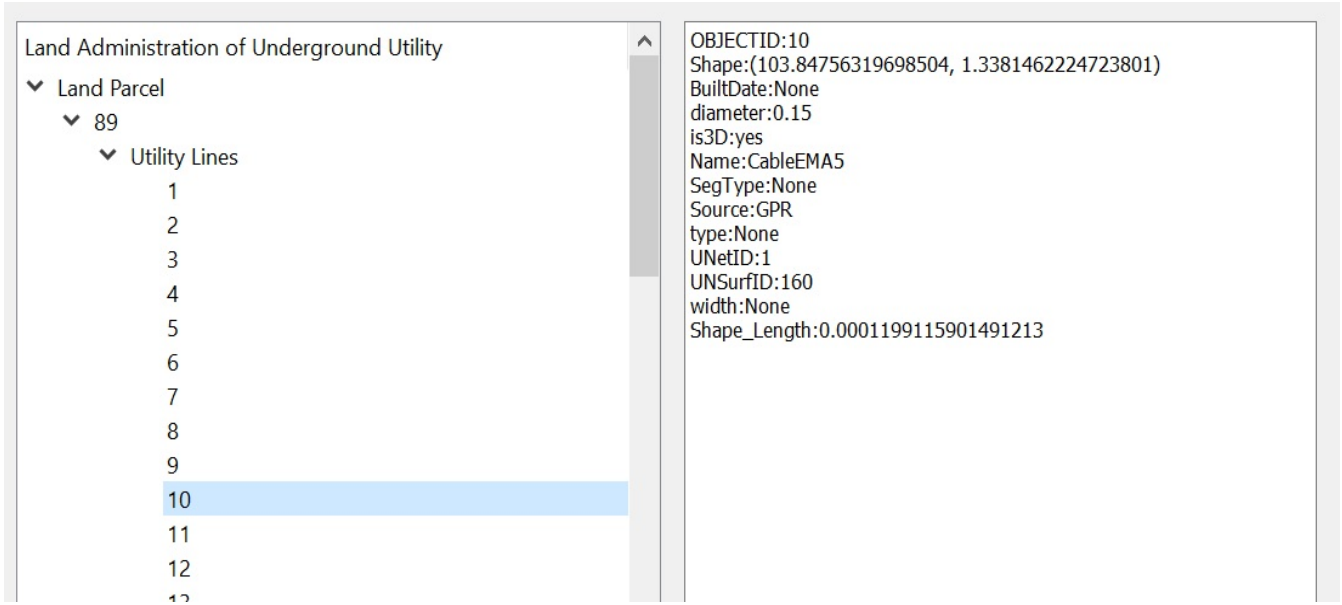
- Line 1: No matching existing record
- Line 2: The maximum distance < 0.5 m
- Line 3: The distance < 0.3 m
- Intersect, and the maximum distance 1m.
- 30 out of 109 detected utility segments were identified

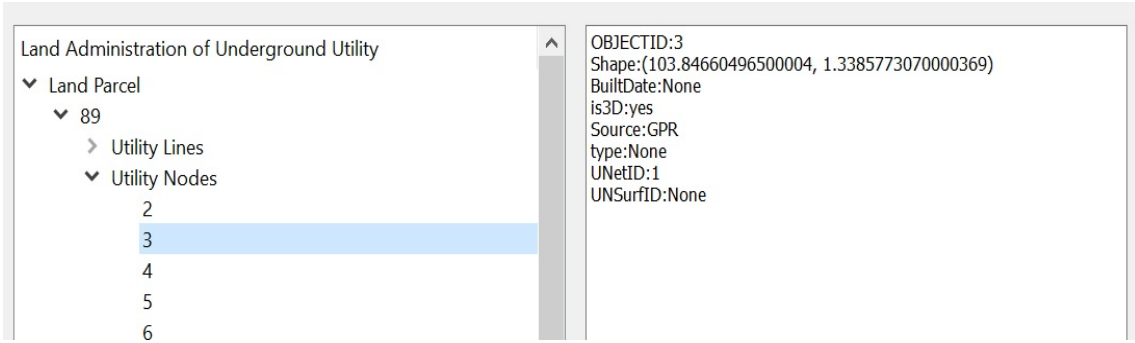
Implementation -- Querying



- Connection of land parcels and utilities through spatial relationships: contains.







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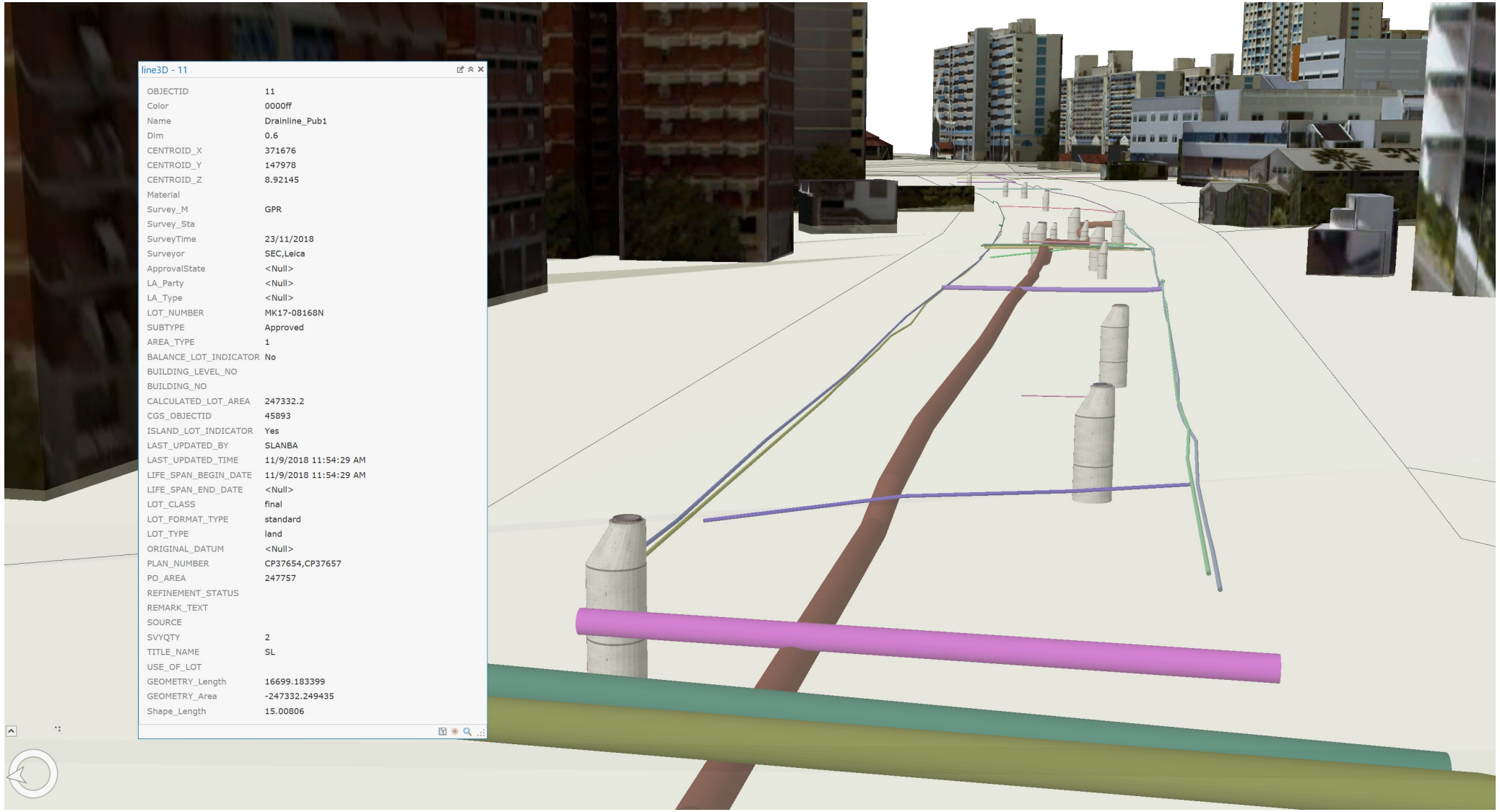
Implementation -- Visualisation



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Conclusion

- To develop a study case to organise 3D underground utility data for land administration.
- The relationship of underground utilities and surface is very **import** in the land administration.
- Current significant issue: lack of **accurate and reliable** underground information.
- **Integration** of GPR data and the existing data.
- How to use the existing data?
- How to integrate the existing and new collected data?
- How to integrate different newly collected data?
- We need **3D cadastre** to support underground utility in land administration.

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THANK YOU

Jingya Yan, Kean Huat Soon, Siow Wei Jaw and Gerhard Schrotter: A LADM-based 3D Underground Utility Data Model: A Case Study of Singapore

https://digitalunderground.sg/

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