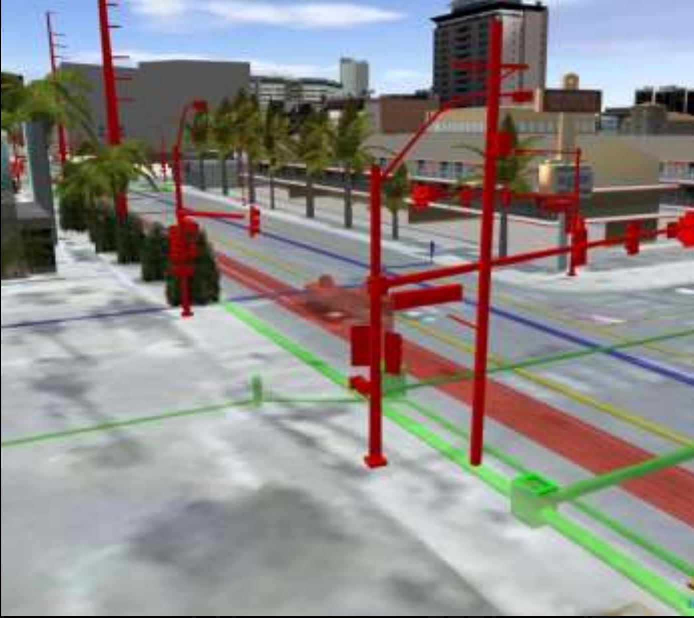
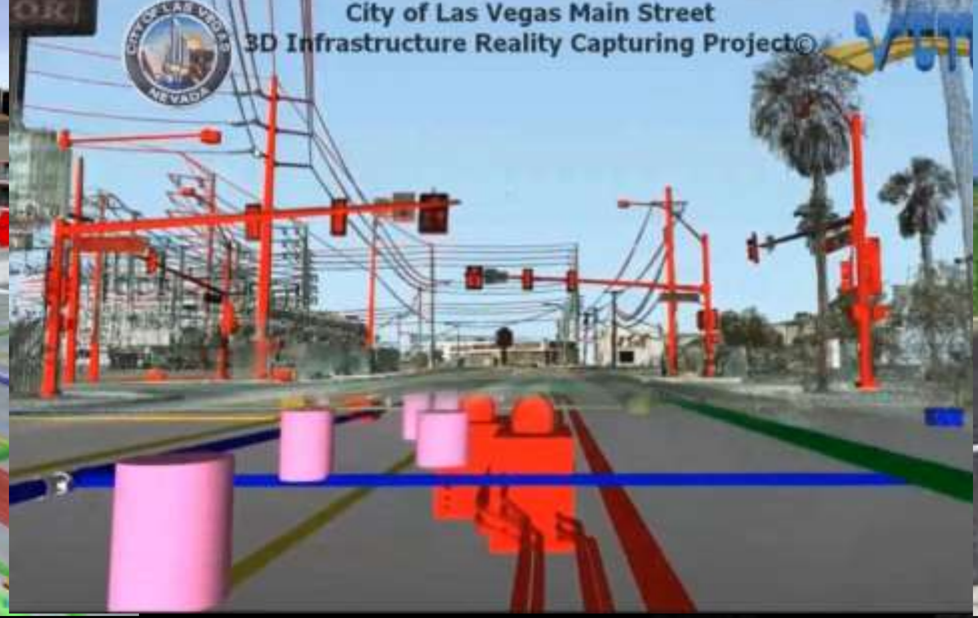
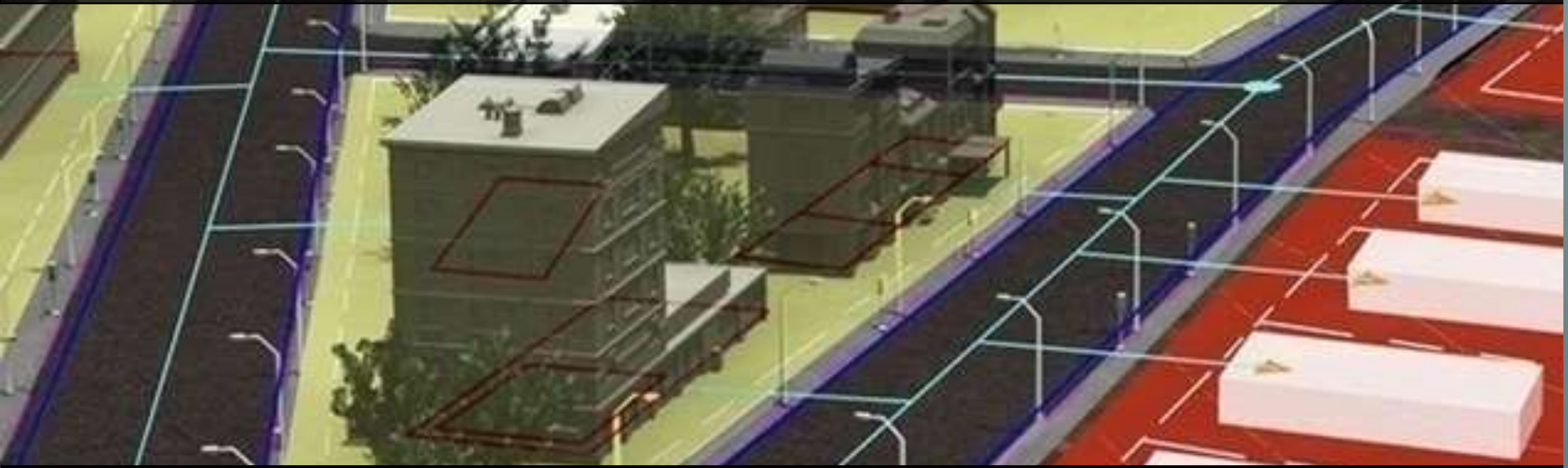
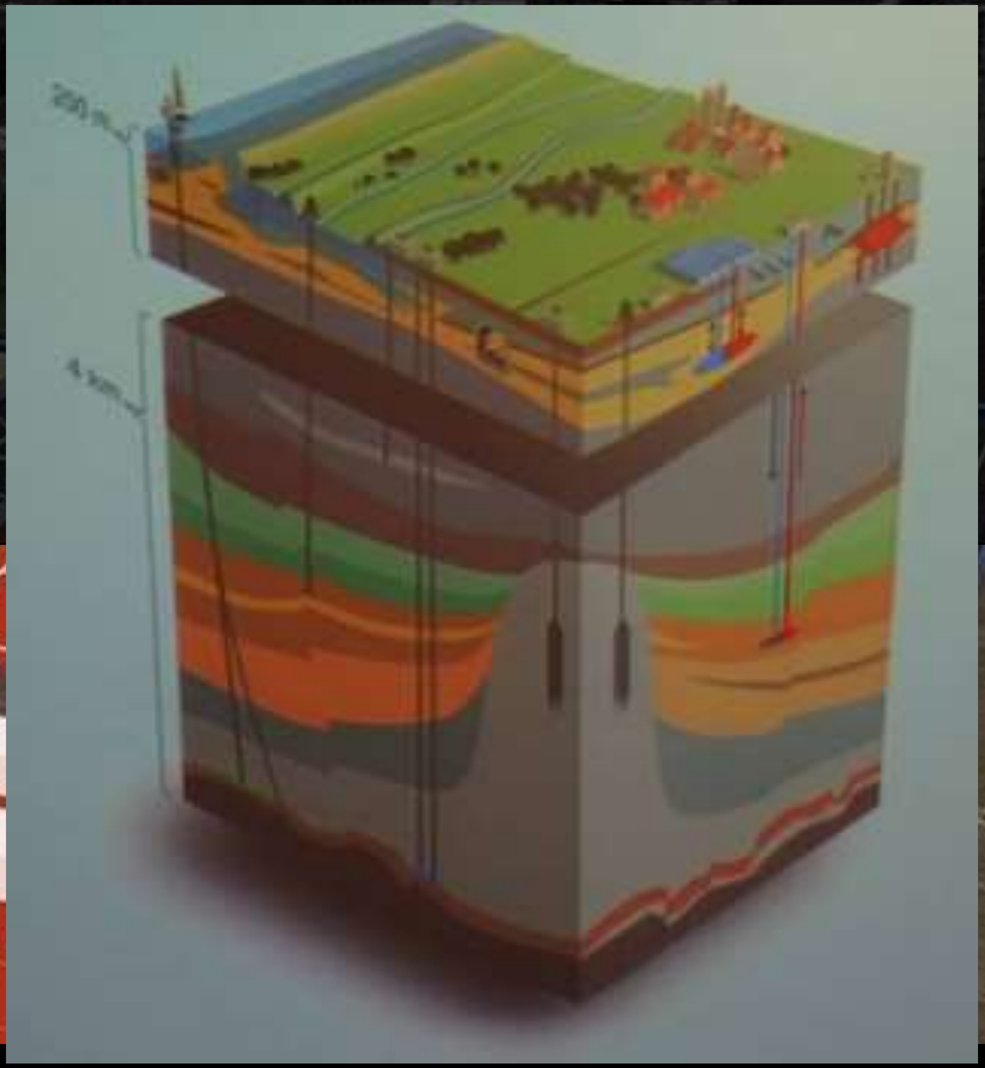




Mapping underground infrastructure: The next frontier of remote sensing

Geoff Zeiss
Principal
Between The Poles





Cost of unreliable underground utility location

- Underground utility hit every 60 seconds in U.S.
- Underground utilities are the biggest cause of highway construction delays in the U.S.

$1.5 trillion - estimated annual direct cost of damage to utilities

Direct cost of underground utility strikes in UK

Electricity	£ 970
Gas	£ 485
Telecom	£ 400
Fibre-optic	£ 2,800
Water	£ 300-980

Indirect costs estimated to be 30X direct

- traffic disruption, injuries and health impact

Source: Nicole Metje, University of Birmingham

Unreliable underground utility location inflates construction costs

- Safety of workers and public
- Increased costs - bids are routinely increased by 10% or more to account for risk of hitting underground utilities
- Liabilities – litigation because the disruption caused by a utility strike can be astronomical

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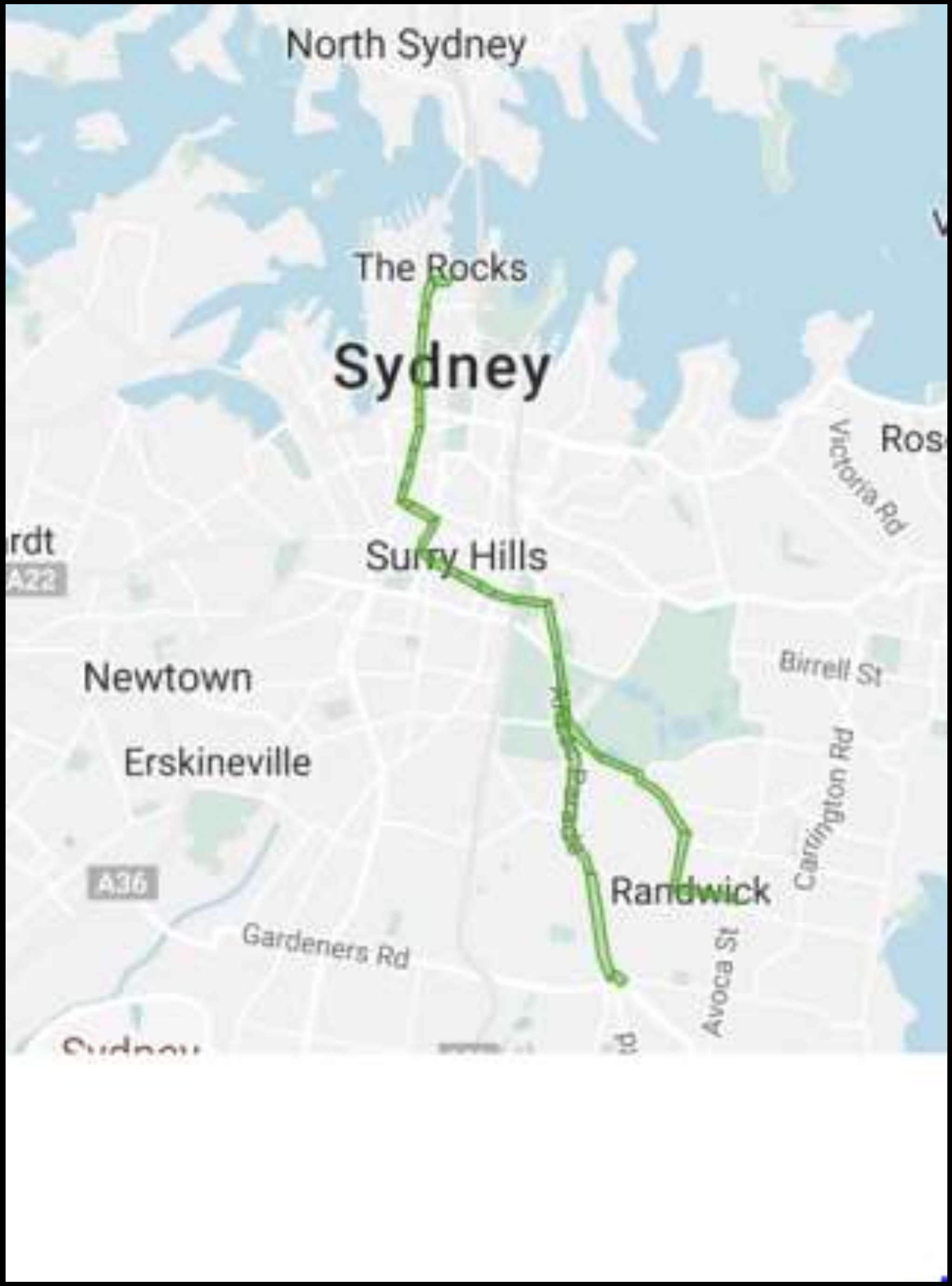
Sydney Light Rail Project

$2.1 billion PPP project for 12 km of light rail to be completed by 2019

- Department of Transport for New South Wales spent a year mapping 5,000 subsurface utilities along the proposed route.
- 500 existing subsurface utilities were identified for relocation to make way for the new light rail infrastructure.



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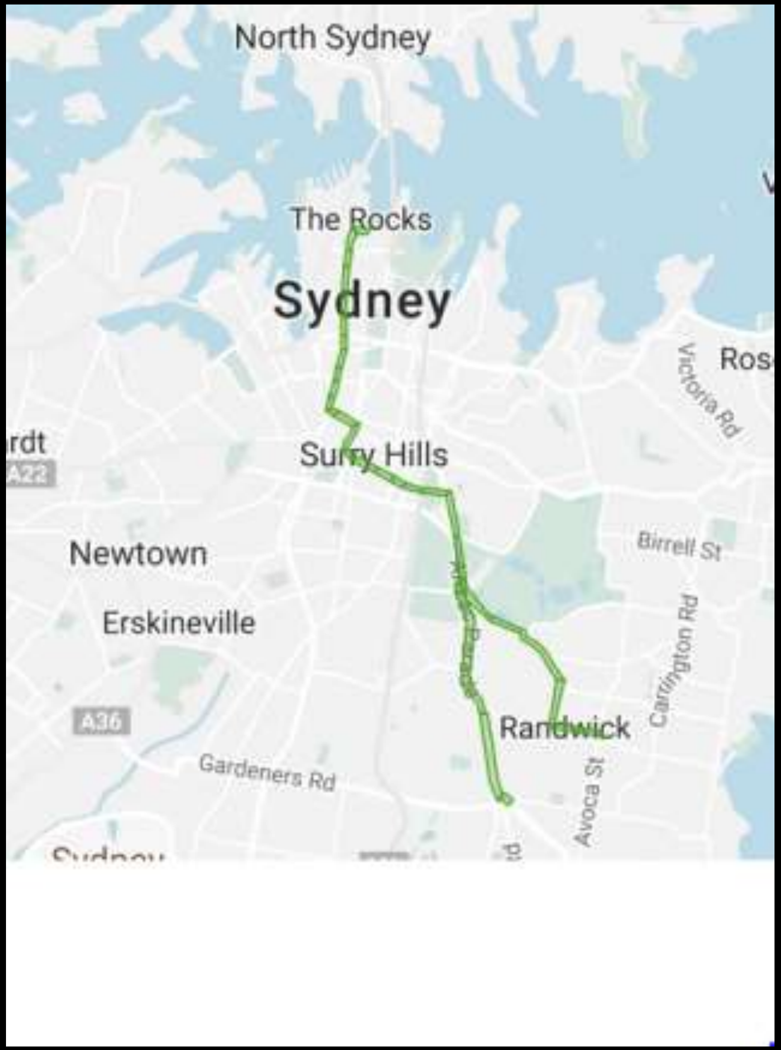
Sydney light rail project

Underground utilities: challenges

1. Unreliable as-built information from utilities - incorrect location, incorrect materials

2. 400 unmapped services were detected
   - Unknown utility service treated as potentially live
   - All utilities had to be contacted to try to identify the service (most no longer in service)



Caused unnecessary costs to the construction program

Delayed relocation of utilities by 5 months

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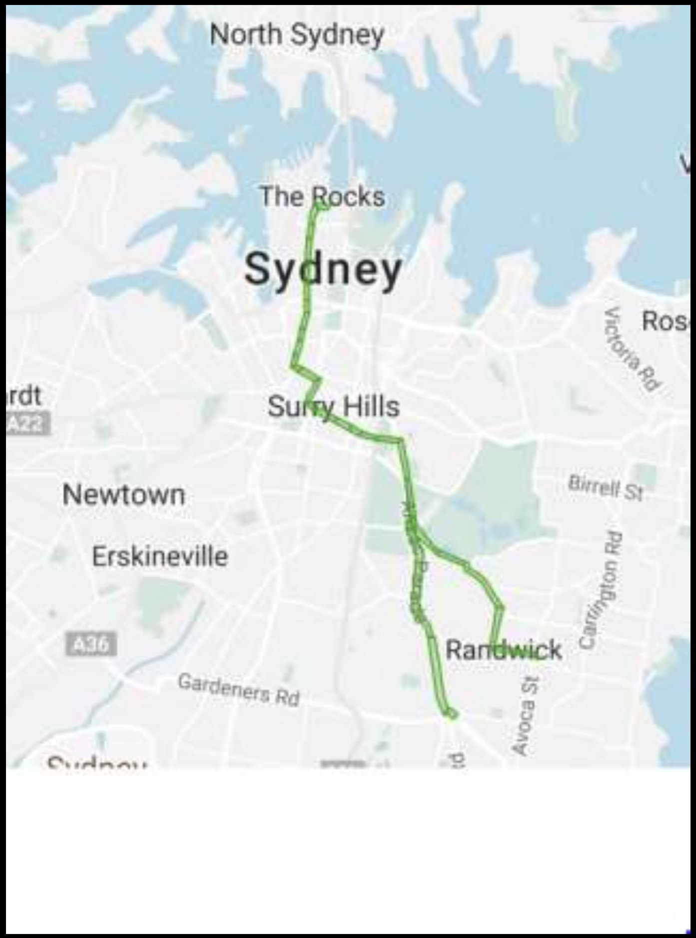
Sydney light rail project



Impact of unmapped underground utilities

- Project could have been completed at least one and a half years sooner
  - If a complete and reliable 3D map of underground infrastructure at project planning stage had been available
  - Also at less cost with a much lower level of risk (ACIL Allen)

- Project apparently remains 'on time and on budget'
  - Only because risk of delays and additional costs resulting from unidentified underground utilities were included in original contract pricing and schedule (ACIL Allen)

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International efforst to map underground utilities:
Las Vegas: 3D model of urban infrastructure

Source: VTN Consulting

International Efforts to Geolocate Underground Facilities

- Delhi – Project by Survey of India to map underground utilities
- Netherlands - Basisregistratie Ondergrond (BRO) or Key Registry for the Subsurface. The law mandates that if you excavate or drill you have to share your data with the registry. In addition if when using the data in the registry you find something is incorrect you have to report it.
- Chicago – Innovative pilot to collect photos of excavations, extract 3D data and share.
- France – A nation-wide multi-billion euro project underway to map France's underground utility infrastructure to 40 cm.
  - PLAN CORPS de RUE SIMPLIFIE* (PCRS)

PCRS 2.0 http://cnig.gouv.fr/?page_id=11745

International Efforts to Geolocate Underground Facilities

- Penang, Malaysia – Penang-s Sutra D'Bank(Penang State Government Subterranean Data Bank is maintained by a joint venture company EQUARATER (PENANG).
- Bahrain - Bahrain's Intelligent Decision Support System (iDSS) provides single repository for all underground facilities.
- Sao Paulo, Brazil – The City of Sao Paulo's GeoCONVIAS project integrates data from 20 to 30 utilities which operate in the city of Sao Paulo.
- Rio de Janeiro, Brazil - The City of Rio de Janeiro has a similar project GeoVias funded by the government of the City of Rio de Janeiro and four utilities.

International Efforts to Geolocate Underground Facilities (cont.)

- Tokyo, Japan (now deployed in major Japanese cities) – Many years ago Tokyo developed the mainframe-based Road Administration Information Center (ROADIC) system. Used by major Japanese cities.

- Sarajevo, Bosnia – Over 40 years ago as part of the permitting process, Sarajevo mandated the recording the location of all utility and telecommunications infrastructure in the city.

- Calgary, Alberta – A number of years ago the City Government passed a by-law which mandated that all utilities and telecoms working within city limits must provide data showing the geolocation of their infrastructure to the city's Joint Utility Mapping Project (JUMP).

- Edmonton, Alberta - Edmonton, Alberta has a shared facilities mapping database.

Advances in remote sensing of underground utilities

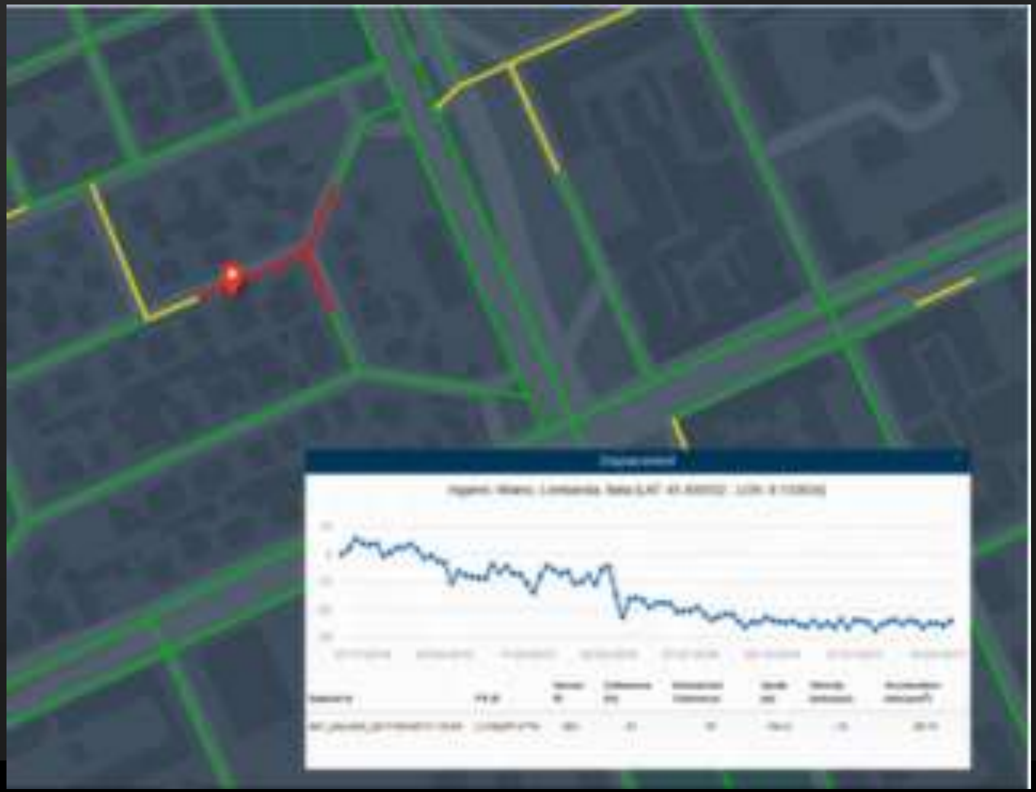
Application of satellite remote sensing to detect leaks in drinking water system

ESA Sentinel-1 - two satellite constellation for land and ocean monitoring

- Images the entire Earth every six days - allow changes in land cover to be closely monitored.
- C-band synthetic aperture radar (SAR) interferometry detects ground movements of a few millimetres – across wide areas

Planetek "Network Alert"

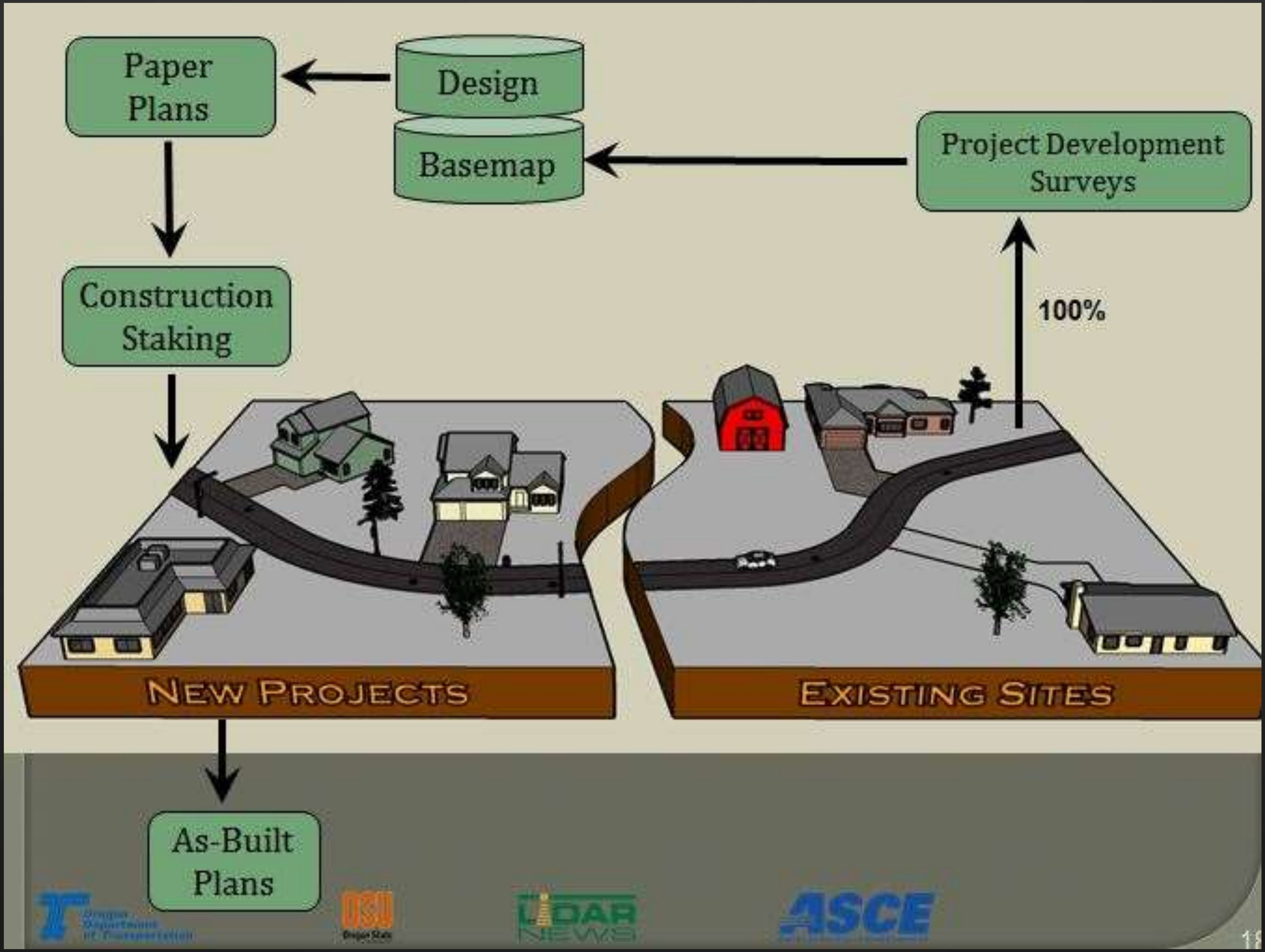
- *Detects ground displacements indicative of leaking pipes in water pipeline network*
- *For example, a 3 cm subsidence over one and a half years identified a substantial leak*



Underground utilities in highway construction

- Underground utilities are the biggest cause of highway construction delays in the U.S.

Current construction project lifecycle



Ron Singh, Chief of Surveys, Oregon Department of Transportation

Subsurface utilities are a huge problem

Survey - Construction projects initiated with survey of the area

- Does not provide reliable information about underground utilities

Design - typically done with limited knowledge about underground utilities

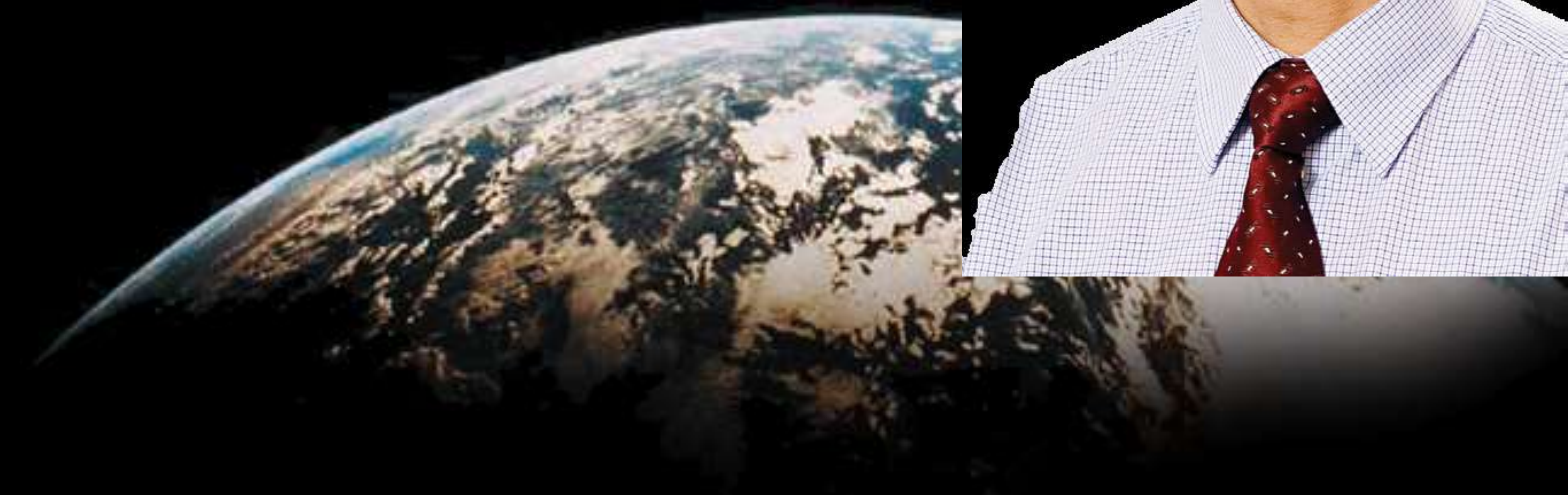
Utility locate - After design utility crews identify underground utility infrastructure (pipes and cables)

- Most of the time no depth information and the accuracy is typically plus or minus two feet

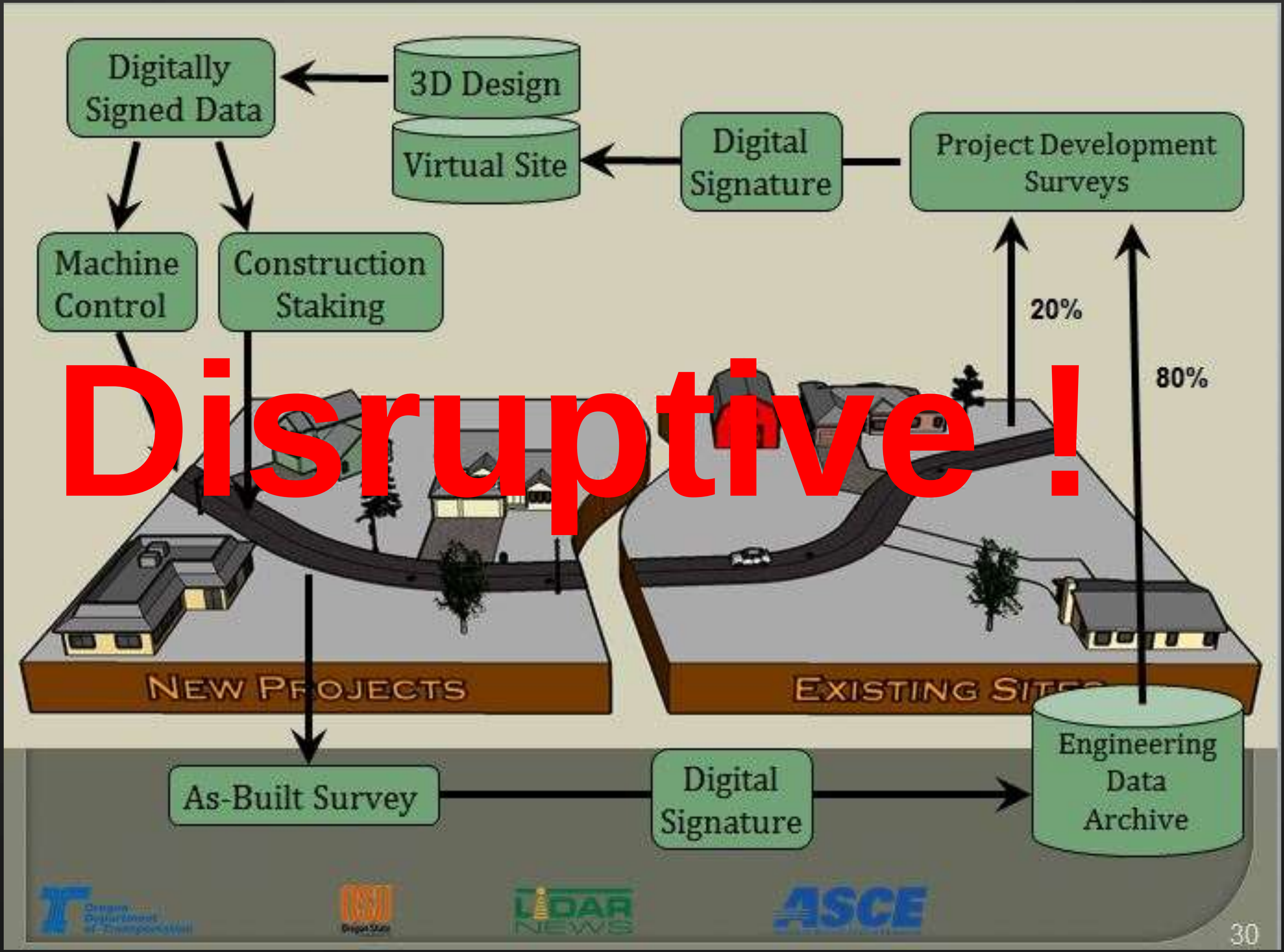
Utilities are then moved – increases costs and delays project

“*We need to stand the construction process on its head*”

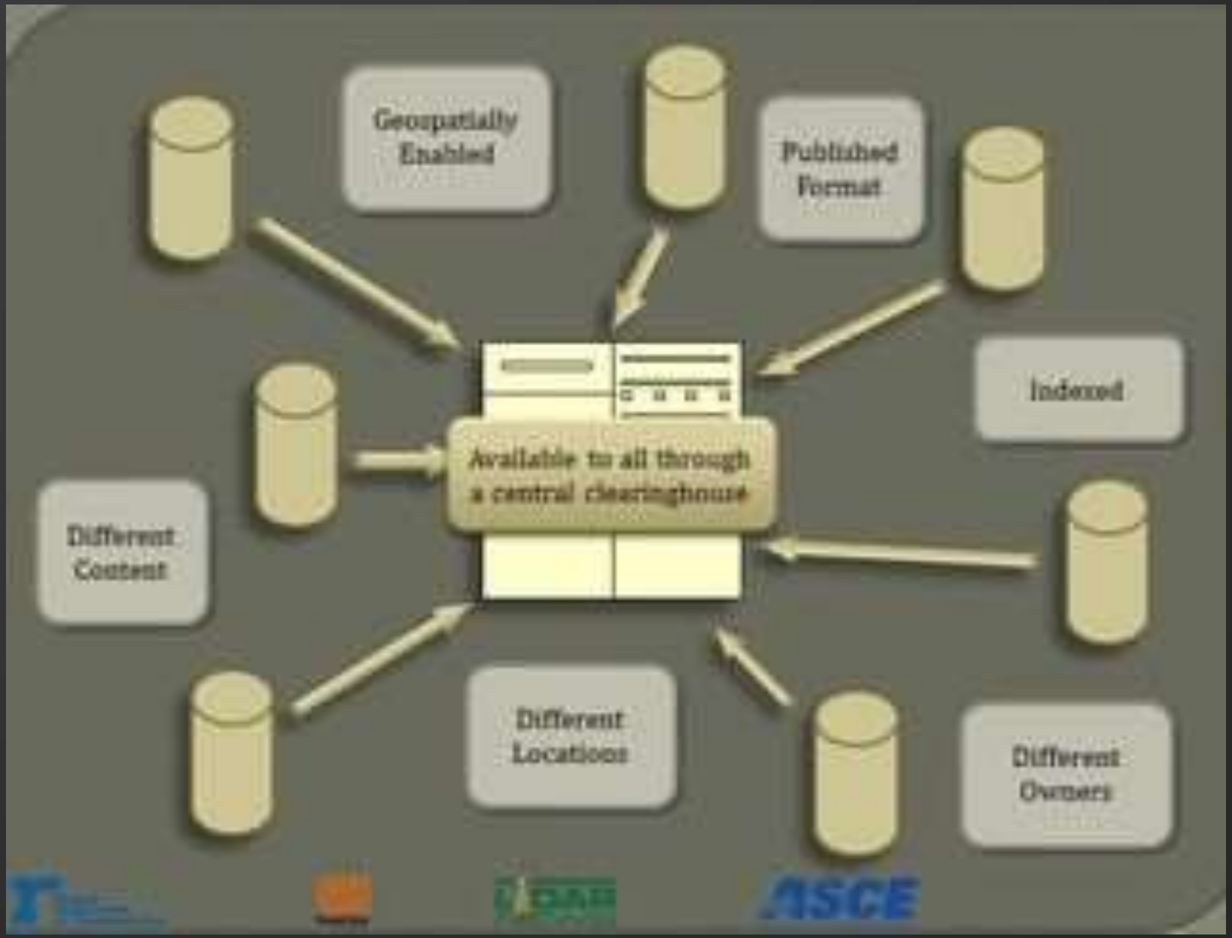
Ron Singh, Chief of Surveys, Oregon DOT



Future construction project lifecycle



Intelligent highways



3D as-builts

- During and post-construction 3D scans
- Above and below ground
- Including utilities

3D design models

- BIM

Engineering data archive

- 3D geospatially-enabled
- Metadata
- Provides 80-90% of data required to initiate design

Benefit: Autonomous vehicles

Autonomous vehicles will be data hungry. Currently cars are using real-time sensing of their location and what is around them.

But they will require high precision maps of the highways and roads that they drive on. For example, for driving on snow-covered highways and under extreme conditions.

Some takeaways

Unreliable information about location of underground infrastructure costs $ trillions every year

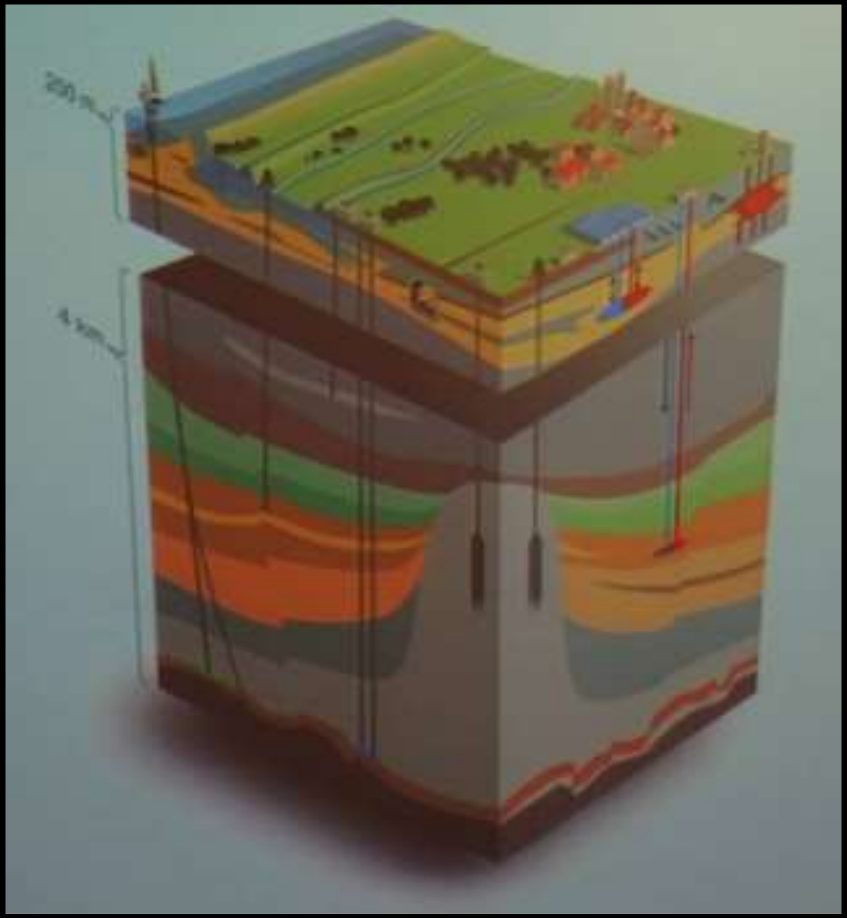
- Adds risk to every construction project

Location data about subsurface utilities is rarely shared

- Lack of standards for sharing subsurface utility information

Cities, regions, and nations recognizing the benefits of reliable underground infrastructure

New scanning technologies are standing the construction process on its head



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