Next Generation Utilities – 3D Modeling
Cesar Quiroga
Senior Research Engineer, Texas A&M Transportation Institute
SEC. 1304. INNOVATIVE PROJECT DELIVERY METHODS.

(a) DECLARATION OF POLICY.—

(1) IN GENERAL.—Congress declares that it is in the national interest to promote the use of innovative technologies and practices that increase the efficiency of construction of, improve the safety of, and extend the service life of highways and bridges.

(2) INCLUSIONS.—The innovative technologies and practices described in paragraph (1) include state-of-the-art intelligent transportation system technologies, elevated performance standards, and new highway construction business practices that improve highway safety and quality, accelerate project delivery, and reduce congestion related to highway construction.

(b) FEDERAL SHARE.—Section 120(c) of title 23, United States Code, is amended by adding at the end the following:

“(3) INNOVATIVE PROJECT DELIVERY.—

“(A) IN GENERAL.—Except as provided in subparagraph (C), the Federal share payable on account of a project,
“(B) Examples.—Projects, programs, and activities described in subparagraph (A) may include the use of—
“(i) prefabricated bridge elements and systems and other technologies to reduce bridge construction time;
“(ii) innovative construction equipment, materials, or techniques, including the use of in-place recycling technology and digital 3-dimensional modeling technologies;
“(iii) innovative contracting methods, including the design-build and the construction manager-general contractor contracting methods;
“(iv) intelligent compaction equipment; or
“(v) contractual provisions that offer a contractor an incentive payment for early completion of the project, program, or activity, subject to the condition that the incentives are accounted for in the financial plan of the project, when applicable.
What is 3D Modeling?

- **3D Modeling**: Process of developing a mathematical representation of any three-dimensional surface or object.

- **3D Model**: Object in a database that contains 3D (X, Y, Z) data and topology.
  - 3D imagery (e.g., a LIDAR point cloud) is NOT a 3D model.

- **3D Rendering**: Process to display a 3D model on a two-dimensional image (e.g., a computer screen).

**Most transportation projects are designed and built using:**
- 2D and 3D survey data collection processes: X, Y, Z data
- 2D modeling process
- 2D models: Plan views, profiles, cross sections
- Visualization: 2D surfaces and isometric views
• 2013 regional presentations
• 2014 webinar schedule:
  – Applications of 3D Models in the Construction Office (02/19/2014)
  – Applications of 3D Models on the Construction Site (04/02/2014)
  – Managing and Sharing 3D Models for Construction (05/07/2014)
  – Overcoming Impediments to Using 3D Engineered Models for Construction (09/10/2014)
  – Steps to Requiring 3D Engineered Models for Construction (10/15/2014)
  – The Future: Adding Time, Cost and Other Information to 3D Models (11/19/2014)
Civil Integrated Management (CIM)

- Building Information Modeling (BIM) – Vertical construction
- FHWA initiative:
  - Civil Integrated Management (CIM) – Horizontal construction
- Collection, organization, and managed accessibility to accurate data and information related to a highway facility. The concept may be used by all affected parties for a wide range of purposes, including planning, environmental, surveying, construction, maintenance, asset management, and risk assessment.

Applications:
- Alternative contracting
- Project management systems
- Surveying
- Real time verification
- Utilities
- Legal
- Information modeling

Real Time Verification
- Integrated with Construction
  - Intelligent Compaction
  - Pavement Thermal Imaging
  - RFID for materials quantity and certification transmittal
  - In-cab weight scales
  - Video surveillance for remote construction inspection and recording

Project Management Systems
- Integrated with Construction
  - Electronic document approval, transmittal, and storage
  - Online real-time status of materials sampling and testing
  - Electronic wage rate verification
  - Public Relations

Legal
- Integrated with Construction
  - Liability of plan and survey data
  - Long-term liability with as-builds

Utilities
- Integrated with Construction
  - 3D Mapping and data storage
  - RFID subsurface marking

Surveying
- Integrated with Construction
  - Light Detection and Ranging (LiDAR)
  - Equipment flexibility, precision and accuracy of survey, and data processing and storage
  - Laser Total Stations

Information Modeling
- Integrated with Construction
  - Public Outreach
  - Software applications
  - Optimizing construction means and methods
  - Earthwork balancing
  - Equipment automatic guidance control systems
  - 3/4/5/x D Modeling
3D Modeling for Utilities

- State of the practice
  - Utility location services:
    - Pipe and cable locators: X, Y
  - Test holes at specified locations: Z (X, Y if surveyed)
  - ASCE 38-02:
    - QLD: Review of existing records: X, Y
    - QLC: Survey of visible appurtenances: X, Y
    - QLB: Geophysical methods for underground utilities: X, Y
    - QLA: Exposed utilities at specified locations: X, Y, Z
      - Test holes
      - Valves
      - Manholes
      - Vaults
      - Building basement walls
Interpolation Alternatives

Test hole  Valve  Test hole  Manhole
Interpolation Alternatives

Test hole  Valve  Test hole  Manhole
Interpolation Alternatives

Test hole  Valve  Test hole  Manhole
Interpolation Alternatives

Test hole  Valve  Test hole  Manhole
3D Imagery
3D Model Generated from 3D Imagery
3D Visualization of Utilities
Sample of Recent Utility Research

- State DOT research
  - TxDOT 0-2110 and 5-2110
  - FDOT BDR74-2-977-03_DF-01
- SHRP 2 R01A
- SHRP 2 R15B and R15C
• FHWA DTFH61-12-C-00025
  – Feasibility of Mapping and Marking Underground Utilities by State Highway Agencies

• Objectives:
  – Cost to collect/maintain 3D utility location data
  – Cost to mark utilities with RFID technology
  – Barriers and recommendations for collecting utility location data
  – Benefits of accurate utility data during project development and delivery
  – Willingness to have state DOTs as the central repository of utility data within the ROW

• Deliverables:
  – Report, Implementation Guidance, Techbrief, Webinars
  – First draft (05/30/2014), Final draft (09/30/2014)
Examples of Practices

- California: 3D for visualization
- Connecticut: Five-legged roundabout, guidelines for use of 3D in projects
- Florida: Radar tomography
- Iowa: 3D for grading and automated machine guidance, standard specification for 3D
- Michigan: Linear features from LIDAR
- North Carolina: 3D visualization of utilities, some RFID (already standard at local level)
- Texas: Wide use of 3D for project design, training for internal use
- Virginia: RFID for utility monitoring and inventory
- Washington State: 3D for visualization
Iowa DOT Transition to 3D

Transportation Agency

- Road Requirements (size, location, ESAL, etc) & Prioritization
- Pavement Design
- Structural
- Surveying
- Site Conditions

DOT Generates 2D drawings

2D Data Transfer

Severals years old, sometimes

Contractor

- 3D Model
- Contractor Utilizes 3D Model for AMG

Design in 2D from Road Owner

2D Drawings

Contractor Creation of 3D Model for AMG

2D Drawings
Iowa DOT 3D Files
Iowa DOT 3D Renderings
FDOT – Sample 3D GPR Data
FDOT – Sample 3D Deliverable
3D Modeling - Port of Los Angeles

- Design consultant provided 2D plans
- Contractor developed 3D surface model
- Consultant collected GPR data
  - Output: 2D model of utilities + Z data from test holes
- Contractor developed 3D model of existing utilities
- Utility conflicts
- Communication protocol
  - Information request ticket with Port of Los Angeles
  - Design consultant addressed utility conflict and redesign
  - Contractor received solution via web-based system
  - Contractor implemented solution in the field
3D Modeling - Port of Los Angeles
3D Modeling - Port of Los Angeles
• 10 miles of surface streets mapped at QLB
• 3D models for utilities at critical locations where complex utility relocations were necessary
  – Spot elevations based on depth values (at test holes, vaults, basements, etc.) and 3D surface model
  – Subject matter experts and utilities estimated elevations between measured spot elevations
  – Additional test holes at critical locations
Alaskan Way Viaduct, Seattle, Washington
• Keeping utility mapping data current
  – Review utility-related construction permits from previous update time period.
  – Review all One Call tickets within the project area and screen them for construction that might possibly involve utility changes.
  – Contact utility owners and request information on any known changes.
  – Walk the project site and scan the area for evidence of new construction.
  – Conduct field investigation with designating equipment.
  – Update utility map.
VDOT – RFID Implementation
VDOT – RFID Implementation
VDOT – RFID Implementation
VDOT – RFID Implementation
As Built Documentation:
Highway plans (PDF) with RFID tag attributes
Cross sections (every 25 feet) showing utilities
3D model could be developed from this information
One-Call/RFID Marker Location Discrepancy
Cost Analysis
Rt. 29/Gallows Rd. Project

Possibilities with RFID Program
Total Utility Investment – $15M
Cost = $10,000
Costs includes:
• Materials
• Programming
• Installation

Possibilities without RFID Program
Damage
Repair of facility
Contractor down time
Delay to traveling public
Fire/Rescue/Police response
Lost revenue for property owner
Lost revenue for utility company

The average cost range to install a 24” water main is approximately $145.00 – 500.00 per linear foot.

The cost to install RFID tags at a rate of 4 marker balls per hundred linear feet of pipe as previously specified increases the cost per linear foot by $0.60
• 3D model of Gallows Project in Virginia
• Limited support for:
  – Utility attribute data: SDSFIE model
  – Utility conflict analysis
  – Information workflow
• Potential implementation has been postponed until 2015
For additional information:

Cesar Quiroga

Phone: 210-321-1229

Email: c-quiroga@tamu.edu