Trenchless Pipeline Crossings
Overview

Where we started
• Horizontal Directional Drilling 1960’s
• Evolution of the process

Where we are today
• HDD
• Microtunneling
• Direct Pipe
• Crossing Process

Where we’re going
• UAV
• Steering
• Pressure modeling
• As-building

Trenchless Benefits
Where we started

- Martin Cherrington – 1963
- Testing various angles of discarded drill stem
  - Increased angles = increased lengths prior to bit surfacing
- Pajaro River, Watsonville CA – 1971
  - 1 Month
  - 150m
  - NPS4 Gas Pipe

Reference: Martin Cherrington
Evolution of HDD

- Magnetic Steering Systems – 1980
  - “Below ground compass”
- Mud motor with bent sub
- Slant face drill bit
- Commercialization
  - Bigger rigs
- Intersect method

Reference: Martin Cherrington
Where we are today – HDD

- Frequently used trenchless crossing technology
- Multi-phase, surface launched, steerable equipment

- Phases
  - Pilot hole
  - Reaming
  - Wiper
  - Lifting
  - Pullback
HDD – Pilot Hole

- Tooling available in various sizes
  - Hard rock / soft soils
  - Mud rotary
  - Jetting assembly

- Steering phase
  - Walk over
  - Wireline – magnetic field

- 20m road crossings
- 2,500m river valleys
HDD – Reaming & Cleaning

- Enlarge pilot hole to sufficient final diameter for product line
- Incremental enlargements based on geology
- Clean and assess hole condition prior to lifting and pullback
- Up to NPS48 (1524mm diameter) installations in Canada
HDD – Pipeline Lifting

- Elevated to minimize stress on pipeline during installation
HDD – Pullback

- Pullhead attached to product pipeline
- Use HDD rig to install product pipeline
Microtunnelling

- Shaft launched, steerable crossing method
- Continuously supported borehole
- Commonly used for on-grade installations
- “Micro” refers to < 3.0m diameter
Microtunnelling

- Surface controlled microtunnel boring machine (MTBM)
- Continuous pressure at cutting face to balance groundwater and earth pressures
- Cuttings transported in slurry
- Variable geology
  - Select cutting face
  - Sufficient bearing strength
  - Boulders up to 1/3 of cutter diameter
Microtunnelling

- Typical Drive lengths
  - 1200mm I.D. up to 700m
  - 1500mm I.D. up to 1000m
  - 1800mm I.D. up to 1500m

- Segmented pipes are hydraulically jacked along alignment
  - butt-end joint reinforced pipe
  - High compressive strength
  - 2.4m – 3.0m lengths
Direct Pipe

- Emerging trenchless technology in North America
- “Hybrid between HDD and Microtunnel”
- Thruster clamps directly onto product pipeline to advance the MTBM
Direct Pipe

- Installation of prefabricated pipe and borehole excavation in single step
- Pipe support as temporary structures
- Variable geology
  - Boulders up to 1/3 of cutter diameter
  - Sufficient bearing strength
  - Select cutting face
- Minimal exit side requirements
  - Job equipment located at entry
  - MTBM retrieval at exit
Direct Pipe

- Smaller annular overcut
- Reduced downhole pressures
  - Reduce depth of cover requirements
- Continuous pipeline installation vs. segmented pipe
- Large diameter pipelines (> NPS30 in Canada)
- Single side operations
- Continuous borehole support
## Method Comparison

<table>
<thead>
<tr>
<th>Metric</th>
<th>HDD</th>
<th>Microtunnel</th>
<th>Direct Pipe</th>
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</thead>
<tbody>
<tr>
<td>Length</td>
<td>3000m</td>
<td>1800m</td>
<td>1800m</td>
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<tr>
<td>Diameter</td>
<td>1219mm (NPS 48)</td>
<td>600mm – 3000mm</td>
<td>800mm – 1600mm</td>
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<tr>
<td>Phases</td>
<td>Multiple</td>
<td>Single</td>
<td>Single</td>
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<tr>
<td>Borehole</td>
<td>Unsupported</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Geology</td>
<td>Cohesive soils, Stable bedrock, Avoid granular</td>
<td>Various geology, Bedrock, Sufficient bearing</td>
<td>Various geology, Bedrock, Sufficient bearing</td>
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<tr>
<td>Launch</td>
<td>Surface</td>
<td>Shaft</td>
<td>Surface / Shaft</td>
</tr>
<tr>
<td>Application</td>
<td>Variety of pipelines, Steel / Plastic, Long distances, Off grade</td>
<td>Segmented pipe, Large diameters, On/off grade</td>
<td>Prefabricate pipe, Large diameters, On/off grade</td>
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Crossing Process – Planning

- Crossing location constrained by available pipeline geometry
- Optimize crossing alignment
- Minimize impact
- Workspaces
- Site access
Investigation

- Desktop studies
- Site reconnaissance
- Geotechnical drills
- Geophysical studies
- Environmental
Engineering & Design

- Required workspaces and pullback layout space
- Pipeline design
  - material properties, operating conditions, stress analysis, geometry
- Push/pull forces
- Drilling fluid pressure
- Borehole diameter
- Owner
  - Project objectives
  - cost, schedule, risk
Pipeline Stress Analysis

- Curved crossings utilize available elastic bending within pipe

- Pipeline specifications
  - Grade
  - Wall thickness
  - Temperature
  - Pressure

- Operating conditions

- Installation conditions
Engineering Challenges

- **Technical** – Is trenchless construction technically feasible with current equipment, tools, methodology and available expertise based on site geology and crossing geometry?

- **Contractual** – Are the project risks and costs known with enough clarity and sufficient accuracy to define in a scope and contract for execution?

- **Economical** – Can installation be achieved in a favourable cost & time relationship to the project stakeholders?

- **Environmental** – Will the installation method provide suitable environmental protection?
Where we’re going – UAV’s

- Aerial Surveillance
  - Chemical markers
  - Thermal scanning
  - Line of site monitoring

- Topography survey
  - 3-D ground profile
  - Logistics / planning

- Improved safety
  - Night time inspection
Drilling Fluids

- Annular pressure models are theoretical and variable
  - Ground conditions in Canada – Historic glacial activity
  - Existing fractures / fissures

- Improvements in fluid systems
  - Reduced drilling pressures
  - Processing equipment on-site
  - Drilling fluid engineering

- Reduced fluid losses
  - Ability to better seal fractures
  - Recycle drilling fluids
  - Less water
Steering

- Gyroscopic tooling
  - Eliminates requirements for wireline
    - Railways
    - Wide-fast flowing rivers
    - Canyons

- Improved steering accuracy
  - Increased safety working near existing infrastructure - Urban
  - Outside range of post installation locatable depth
  - Improved as-built data
Trenchless Benefits

**Protect The Environment**
- Minimal surface disruption between entry/exit points
- Preserves sensitive ecology – watercourses / wetlands
- Allows more direct routing with ability to cross below obstacles
- Reduced erosion and sedimentation
- No digging / open cutting – No disturbance and maintenance

**Minimize Public Impact**
- No closures to infrastructure - major roadways or railways

**Traverse Difficult Terrain**
- Able to cross below steep slopes and unstable banks which would be difficult or not possible to construct conventionally
Thank you

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