Subsurface Utility and Void Detection in Petrochemical Facilities
Factors involving subsurface voids and utility locations

- Safety (voids and utility locations)
- Environmental (leaks)
- Reliability (leaks)
- Efficiency (leaks)
Technologies

• Subsurface Interference Radar (SIR) also known as Ground Penetrating Radar (GPR)

• Impact-Echo

• Electromagnetic Survey (EM)
Applications in petrochemical facilities

- Pavement evaluation
  - Locating subsurface voids & sinkholes
  - Thickness surveys
  - Cover surveys
- Underground leak detection
- Buried object detection (UST’s)
- Utility location
- Concrete Imaging
Two Electrical Properties of Importance to SIR/GPR Surveys

- Electrical Conductivity (inverse of resistivity)
- Electrical Permittivity “Dielectric Constant”
The ability of a material to conduct electric current

The value is primarily controlled by water content and/or clay content

Higher conductivity makes radar signal penetration difficult:

**Low Conductivity – Excellent Radar Conditions 3-4 meters deep**
- Air, concrete, asphalt, dry limestone and granite

**Medium Conductivity – Average Radar Conditions 2 meters deep**
- Freshwater, ice, snow, sand, silt, dry clay, seawater ice

**High Conductivity – Poor Radar Conditions about 1 – 1.5 meters**
- Wet clay, wet shale, seawater
Relative Dielectric Permittivity (Dielectric Constant) Affects the strength of the reflected signal

• Dimensionless measure of the capacity of a material to store a charge when an electrical field is applied

• The value ranges from 1 to 81 (1=Air, 81=Water, 4 to 9=Concrete/Asphalt)

• Contrasts in the dielectric properties of two materials will cause a reflection of a portion of the radar energy back to the antenna transmitter/receiver. The amplitude of the reflection and its two-way travel time can be measured. The strength of the reflection is controlled by the contrast of the two materials.

• Differences as small as 1 can cause reflections.
Leaking Pipes

Subsurface void
Utility Location
Utility Location

Voids
Utility Location

Manhole

Voids
Case study: Storage tank settlement
Case study: Storage tank settlement

Erosion

Sulfur Tank

Sulfur Tank

Voids

Pump Base
Case study: Storage tank settlement

Leaking Acid Cooling Unit eroded the soil underneath the pavement
Case study: Potholes appearing in concrete pavement of a process unit

• Pre-turnaround concern about placement of a large crane in the roadway and general vehicular traffic safety due to a pothole.
Case study: Potholes appearing in concrete pavement of a process unit

Voids Found
5’ x 2’ x 2’ deep
18’ x 7’ x 2’ deep

Soil subsidence / possible void below slab

Soil subsidence / possible void below slab

Metal Access Plate
Consequences of unknown voids / sinkholes

- Safety
- Environmental
- Structures
Consequences of unknown voids / sinkholes

6” Clay Water Pipe

2” Gas Pipe
Consequences of unknown voids / sinkholes

6” Clay Pipe
Consequences of unknown voids / sinkholes
Voids beneath foundation slabs & behind walls

Proof of concept demonstration
Voids beneath foundation slabs

Warehouse floor
- Trucks breaking through the slab
- Proof of concept void detection and sizing
- NDE technologies:
  - GPR
  - Laser Elevation survey
Voids beneath foundation slabs
Voids beneath foundation slabs

Scan Area

Known Void
Voids beneath foundation slabs

Known Void vertical depth:
Approximately 3” as measured
Voids beneath foundation slabs
Voids beneath foundation slabs
Voids beneath foundation slabs

560’ x 100’ void & elevation survey
Wharf & bulkheads
Wharf Surveys / bulkhead walls
Wharf Surveys / bulkhead walls
Wharf Surveys / bulkhead walls

Concrete Bulkhead Wall
Wharf Surveys / bulkhead walls

Cross section of a wharf

Eroded soil underneath a slab

C-Scan of a concrete bulkhead

Voids