Navigation Options for Directional Environmental Wells

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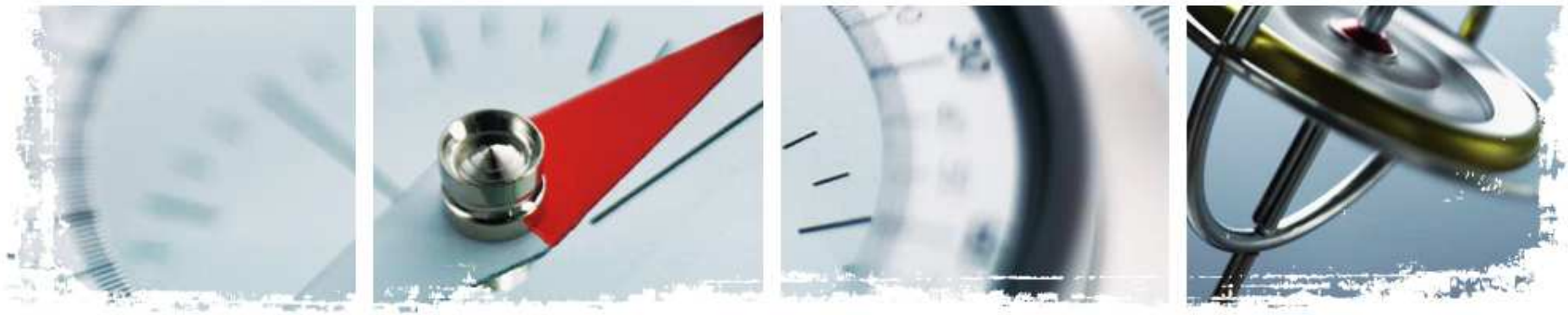
Overview

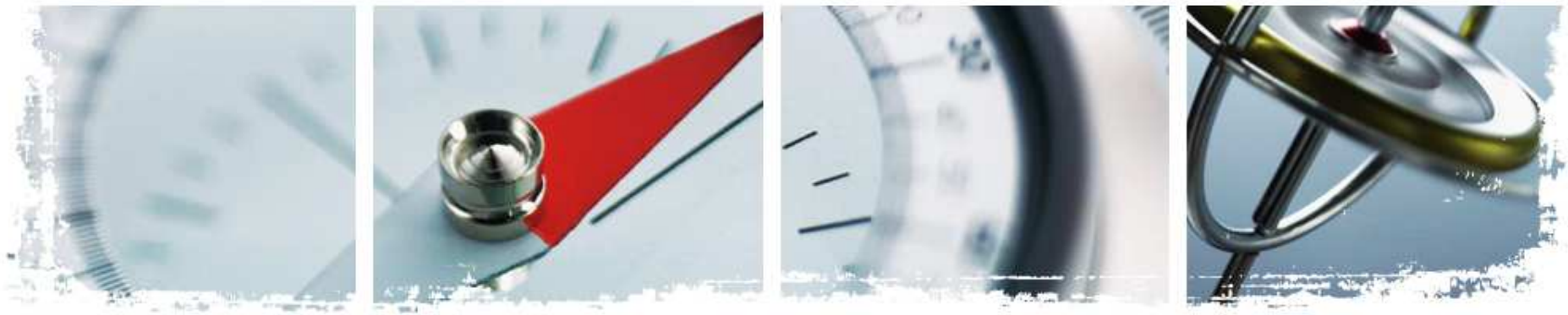
- What is *Navigation* in an HDD well?
- Locating vs. Steering
- Available Options
- Case Studies



What is Navigation?

Determining present location and trend
of downhole assembly and directing it along a desired path.

- Detects or transmits drill head location
- Provides 3D data on bit pitch, roll & yaw
- Calculates and/or confirms depth
- Provides steering corrections
- Integrates with directional capability to steer the desired path



Steering vs. Locating

- *Steering* directs the drilling tools along the desired path
- *Locating* shows you the current bit position…

Steering Accuracy

Steering accuracy depends on

- Lithology
- Tooling
- Driller skill

Locating and Steering accuracy are not synonymous!

- Equipment can locate to 1/10 of 1% pitch, but likely can't steer that accurately

Lithology/Geology

- Grain size distribution
- Compaction
- Matrix
- Cementation
- Fractures / Jointing

Hard Vashon Till – Puget Sound

Lithology/Geology

Challenging Drilling!

- Non-cohesive
- Cobbles-boulders
- Non-uniform
- Caving zones

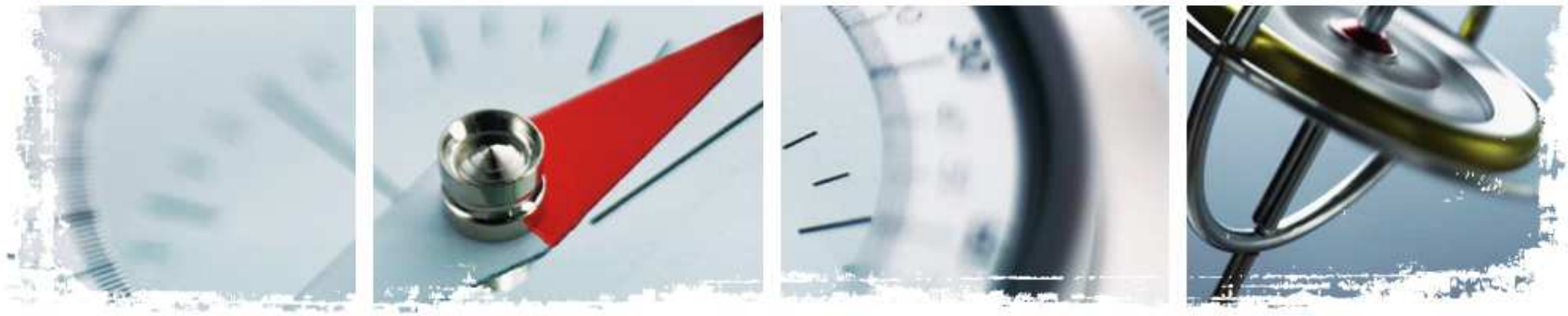
Ideal Drilling!

- Cohesive
- Fine-medium grained
- Compact
- No cementatation

Locating Accuracy

Locating systems are very accurate…

- Positional accuracy within 1-2% of depth
- In many cases, positional accuracy in inches
- Accuracy affected by:
  - Depth
  - Active interference
  - Passive interference



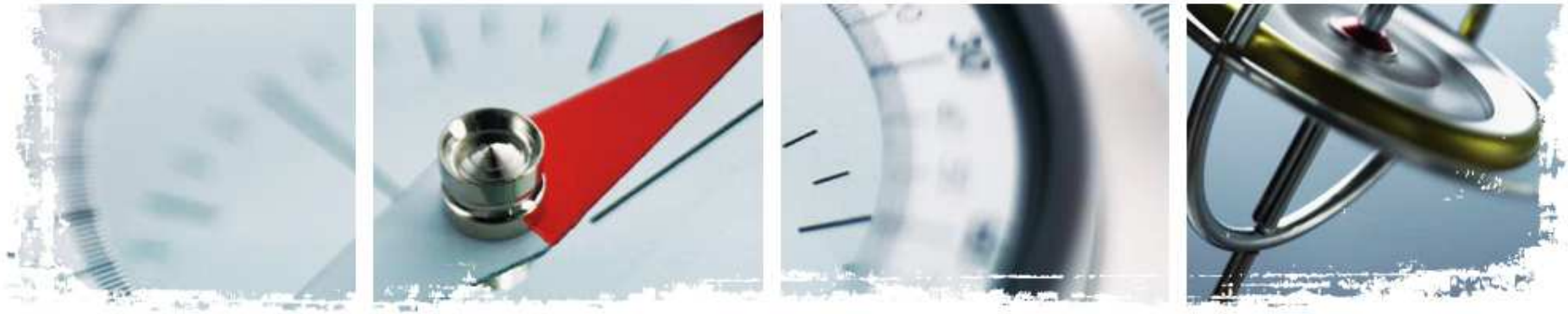
Active Interference

Passive Interference

US Dept. of Justice

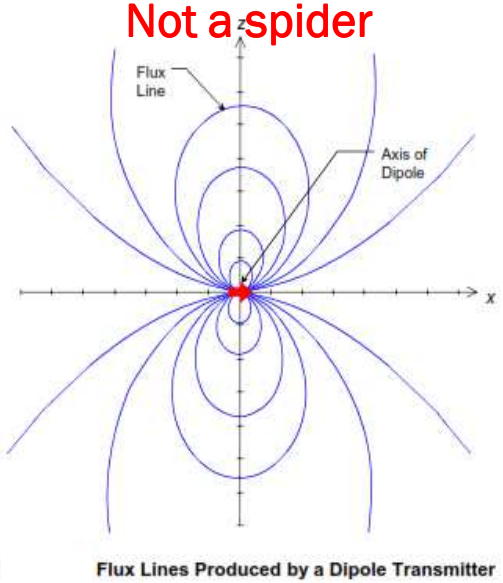
Locating System Fundamentals

- Magnetic
  - Electromagnetic
  - Geomagnetic
- Inertial/Gyroscopic
- Walkover vs. “Wireline”
  - All walkover systems are electromagnetic
  - “Wireline” systems may be magnetic or inertial



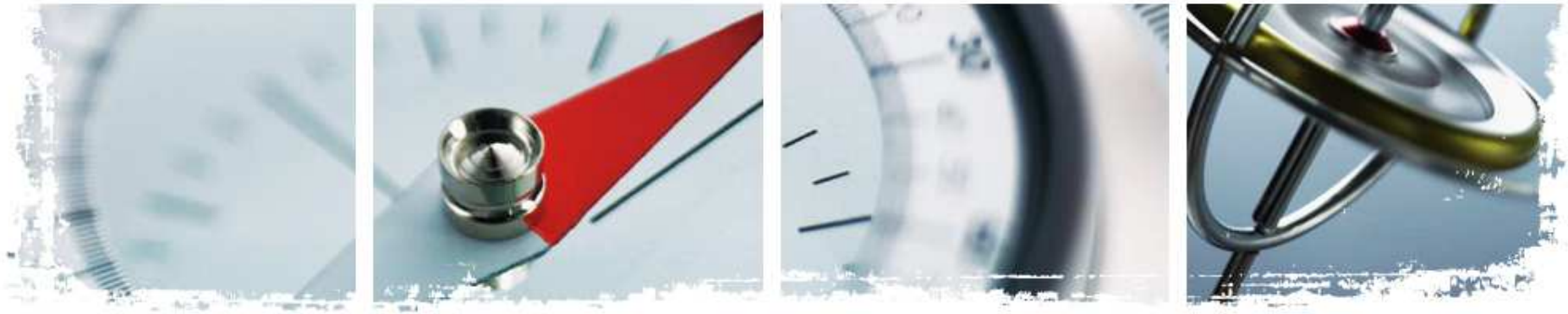
Walkover Systems

Not a spider



Flux Lines Produced by a Dipole Transmitter

- Electromagnetic systems
  - Powered by battery or rig (wire)
  - Field generated by downhole sonde
  - Lines of flux detected by handheld device
- Depths 0-50 (80) feet
- Accuracy - ~ 2% of depth (± .5 ft. @ 50’ depth)

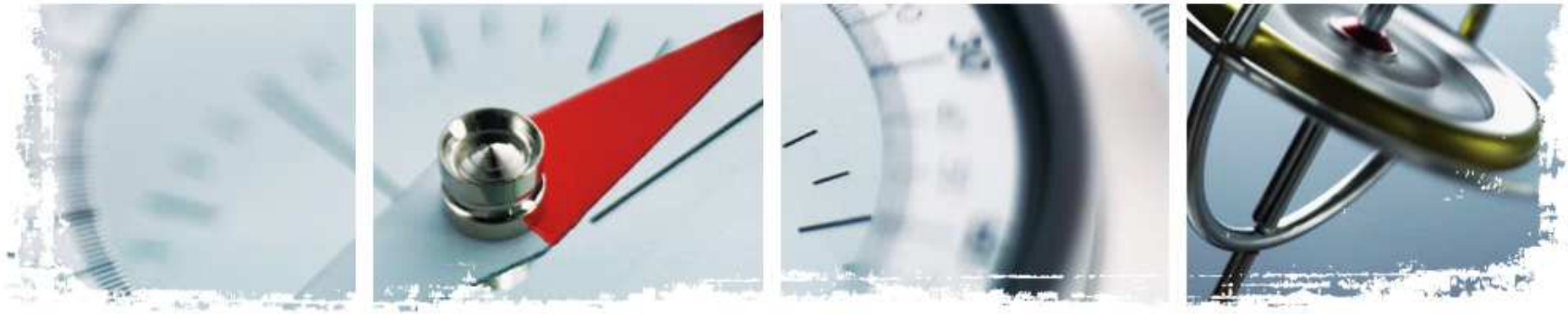


Walkover Setup

- Technician access over bore path
- Path must be visually marked

Walkover Pros & Cons

- Least expensive method (no added cost)
- Minimally intrusive
- Any sized drill rig
- Minimal setup
- Most affected by interference
- Limited to about 75’ in ideal conditions



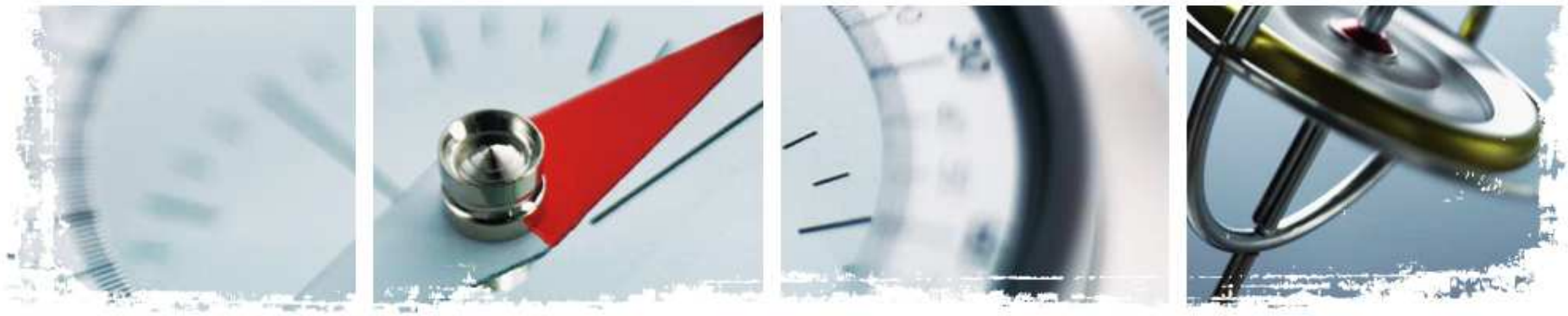
Geomagnetic Systems

- References geomagnetic north pole
- Requires wireline for power/signal
- DCI Short Steering Tool (SST) or Sharewell Magnetic Guidance System (MGS)

Photo courtesy DCI

Geomagnetic Setup

- Requires careful setup of reference azimuth
  - Isolation from large metallic objects, magnetic fields, etc.
  - Entry point and bore azimuth should be surveyed



Geomagnetic Pros & Cons

- No over-tool access needed
- Can fall back to walkover operation (SST)
- More expensive than walkover, less than other options
- May be affected by strong magnetic fields
- Limited contractor adoption

Coil Tracking Systems

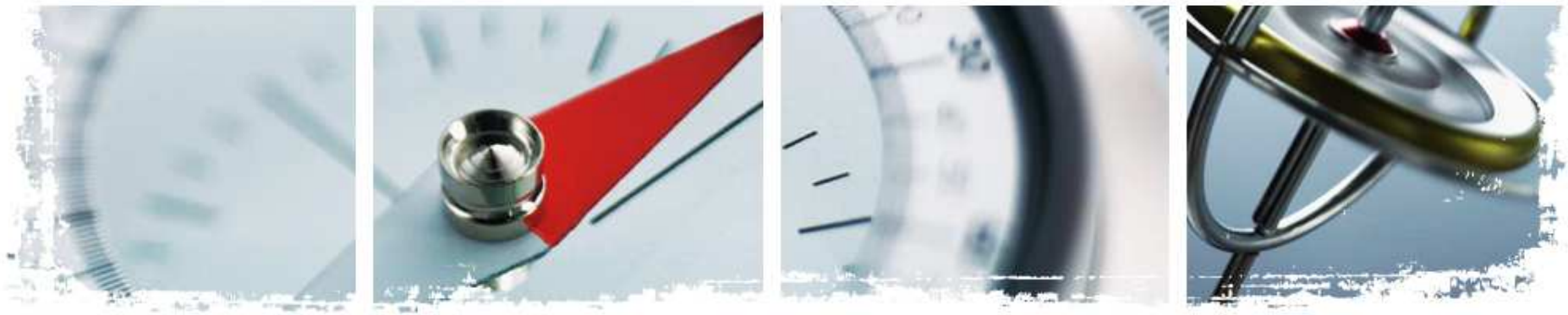
- Enhancement to magnetic guidance systems
- Uses surface coil to create electromagnetic field to overcome interference
- Depths to ~ 200 feet
- Accurate to 2% of vertical bore depth
- TruTracker + Sharewell Magnetic Guidance System (MGS)

Coil Setup

- Access for coil installation
- Traffic accommodations, etc.
- Precision survey needed of coil configuration

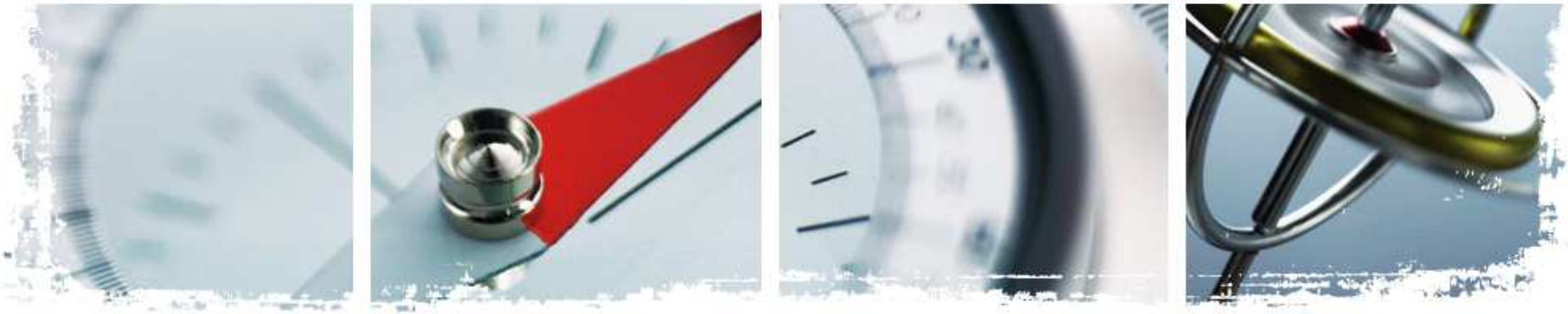
Coil Pros & Cons

- Accurate to most environmental well depths
- Intrusive access required to set coil
- Traffic accommodations, etc.
- Powerful fields can still cause interference



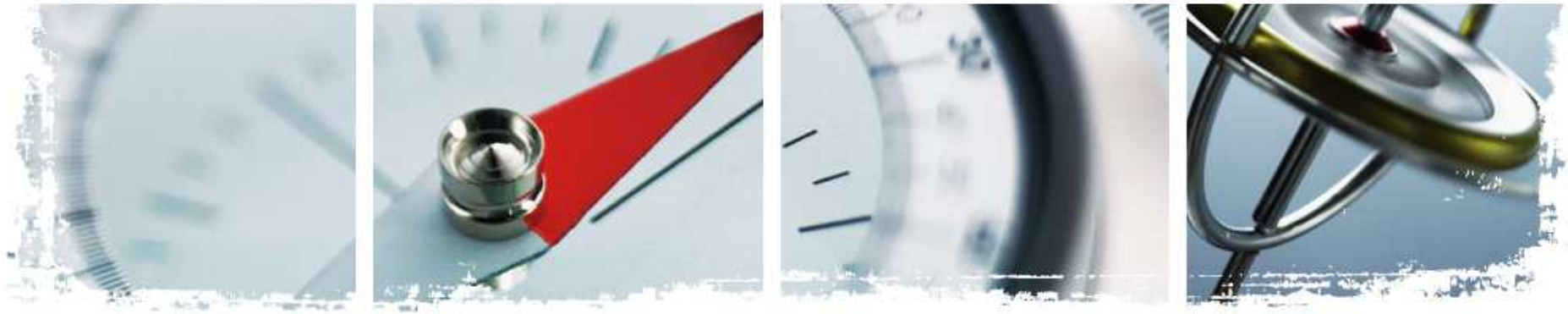
Inertial Systems

- Reference internal solid-state gyro
- Require wireline for power/signal
- Based on inertia, not magnetics
- Extremely accurate
- DrillGuide Gyroscopic Steering Tool



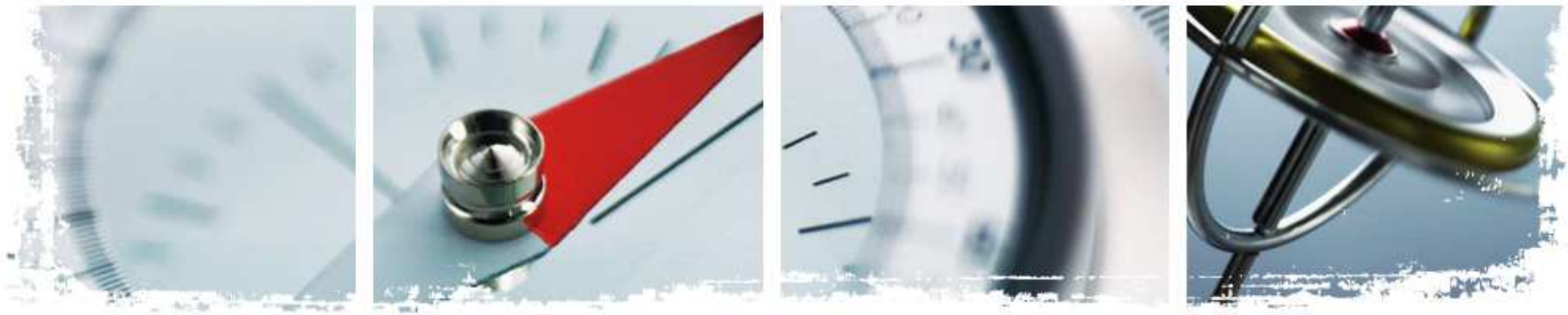
Inertial Systems Pros & Cons

- No over-path access required
- No depth limitations
- Immune to active or passive interference
- Requires wireline for power/signal
- Heavy tooling – requires larger rig
- About $7-8000/day – locating only



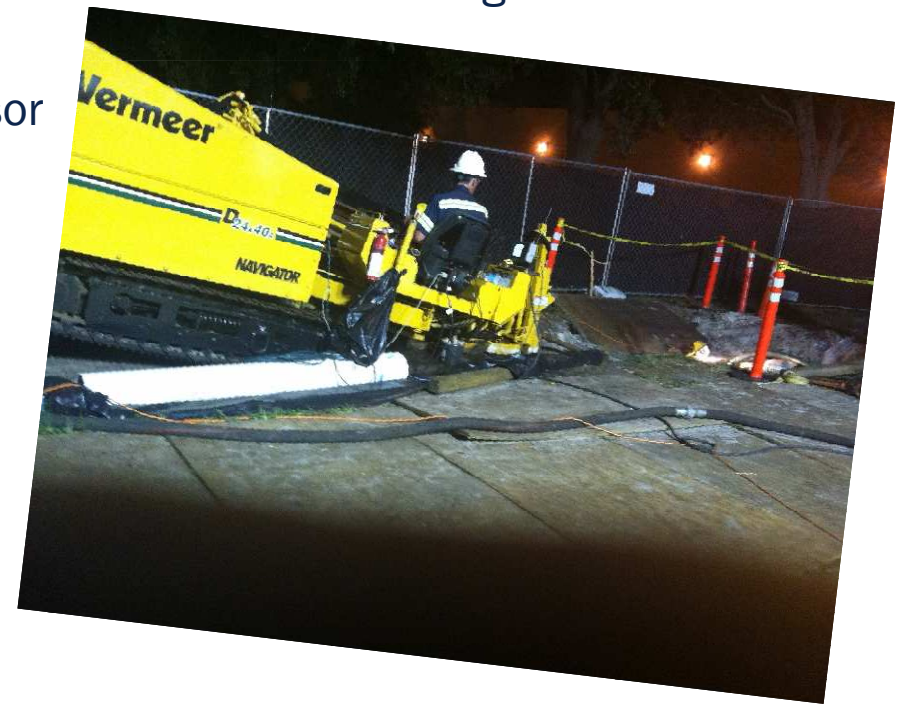
Selecting a System

- Depth – 1st cut, eliminates walkover
- Access – 2nd cut, eliminates walkover, coil
- Interference
- Cost



Case #1: Secure DOE Facility

- Legacy DOE site with high security DOD tenants
- DCI Digi-Trak F5 with SST
- SST used for all under-building drilling
  - Walkover used from rig to edge of building and to confirm locations after exiting secure area inside building
  - Walkover receiver used in combination with magnetic sensor to locate manually when a control box failed
- 8 wells
  - 4 x 19’ deep; 4 x 29’ deep
  - 350-470’ long
- Night shift to accommodate tenant activities.



Case #2: Longest Blind AS Wells

- Longest single-ended air sparge wells yet installed – two wells, ~1500’ long
- 130’ deep beneath active manufacturing facility
- DrillGuide Gyroscopic Steering Tool / SlimDril locating technician
- Bore chased with DTD Knock Off tooling to place well screen and riser

Questions and Contact Info

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