

Optimal
Ranging

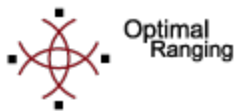
Orion Cable Tracker

Beyond Conventional Pipeline/Cable Tracking

NOSP Meeting, Stavanger, June 3, 2015

Agenda

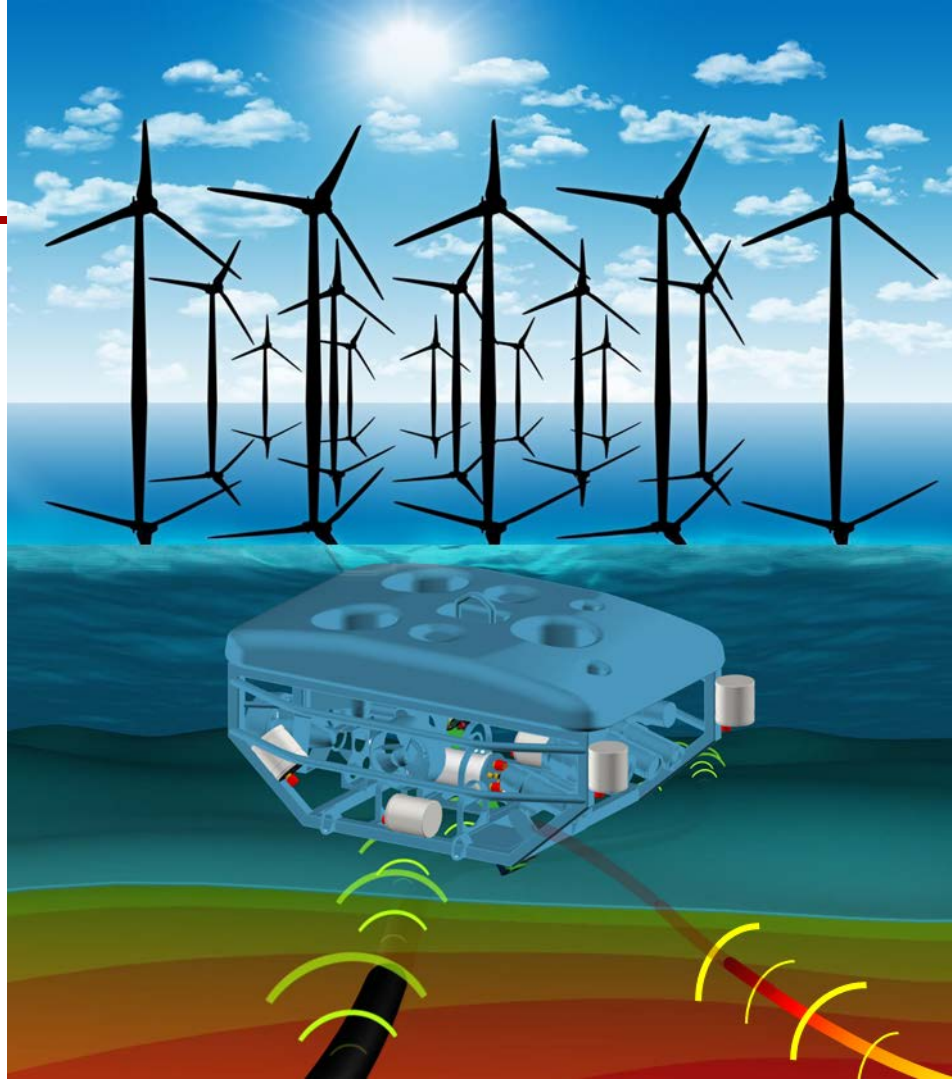
- Orion Subsea Cable/Pipeline Tracker
 - Technology overview
 - MultiSens: Tracking multiple targets
 - Brief system description
 - Multiple pipeline survey example
 - 3-phase HVAC cable example

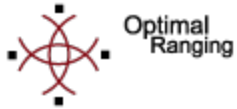


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Orion Technology

**Model-based
Estimation**





Orion Tracking Method

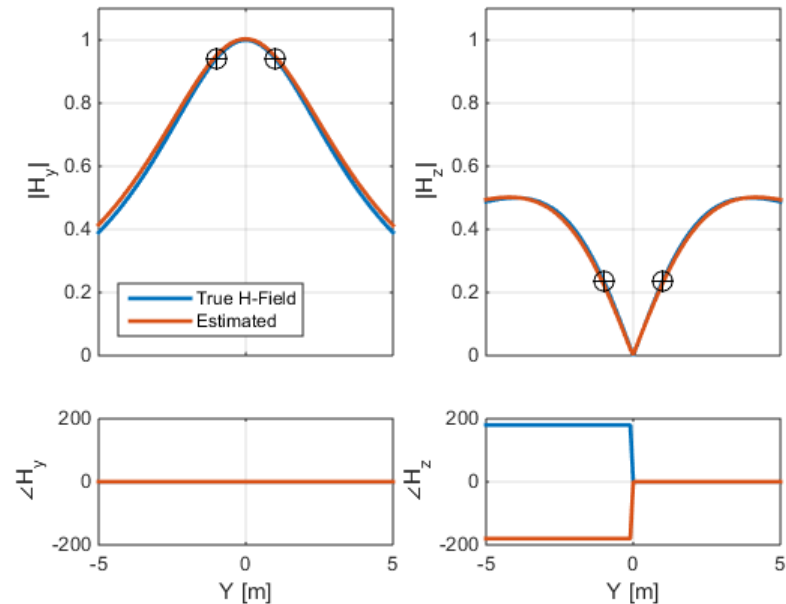
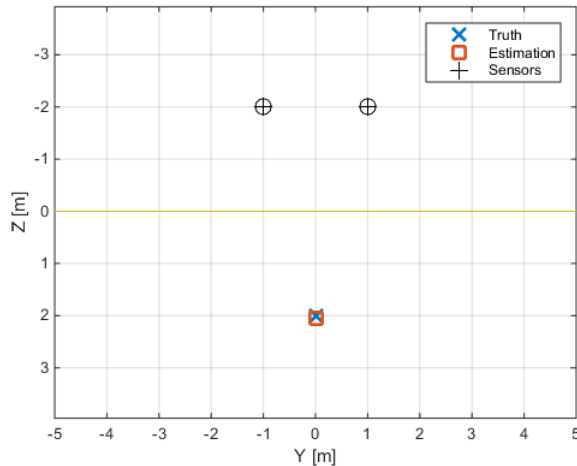
Estimate unknown states with indirect measurements

- Unknown states: AC current, depth, offset, yaw angle
- Sense magnetic fields created by AC current flow
 - Passive HVAC signals, AC overtones on HVDC cables, active Tone Generator, or Magnetic Induction
- Advanced model-based processing
 - Optimization of 3-D sensor data compared to a physical model
 - Outputs are the unknown states

Single Conductor Tracking

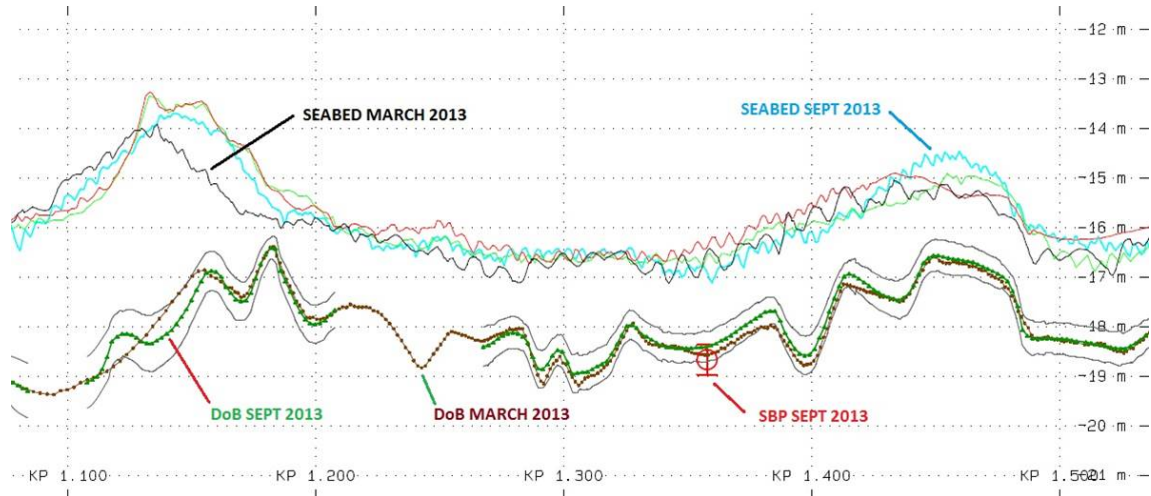
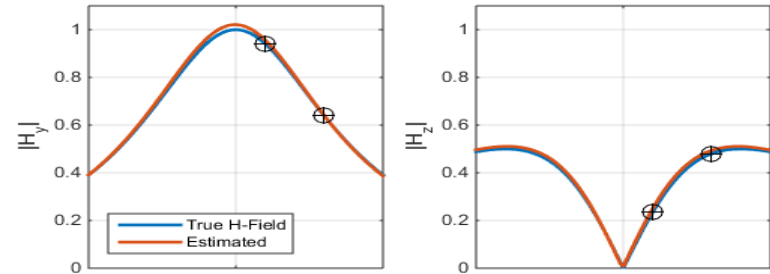
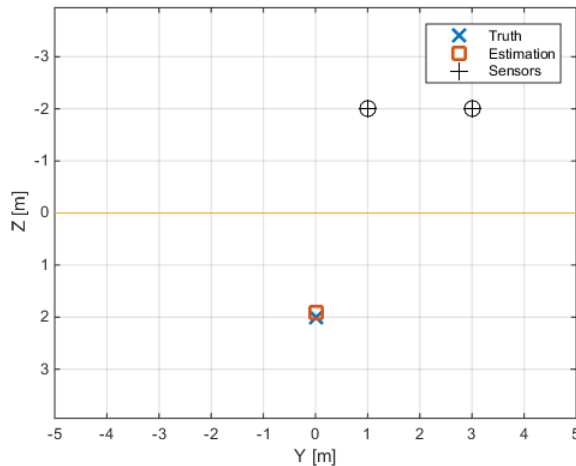
Two 3-D sensors (6 total channels) are sufficient

For example, an accurate solution and good fit is obtained for sensors centered over the cable



Single Conductor Tracking

Similar results are obtained with the sensors positioned to the side. An imperfect model fit results in a non-zero error estimate





MultiSens Estimation

Method supports an arbitrary number of 3-axis sensors and up to three targets

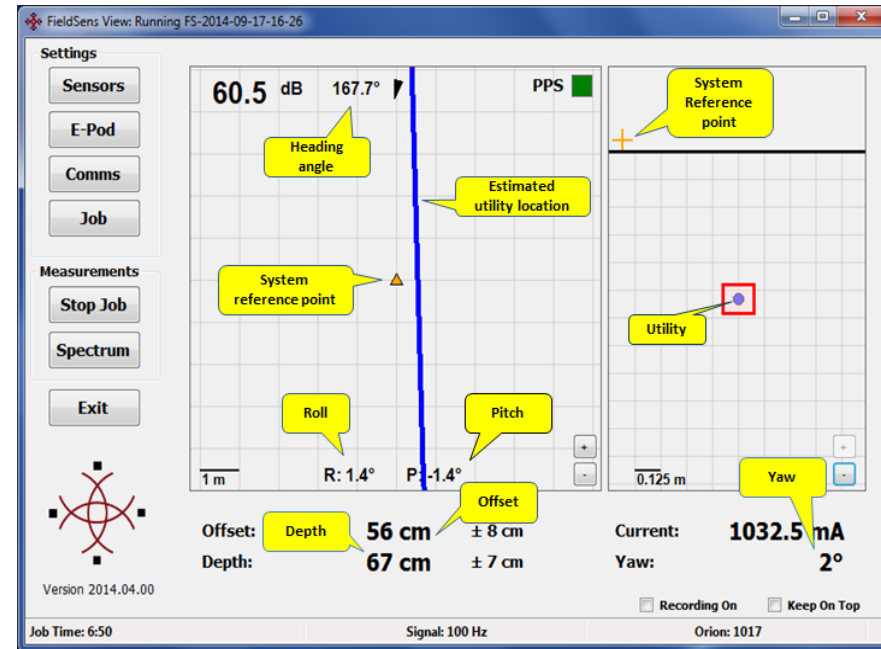
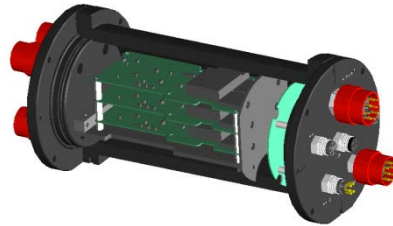
- Model formed from a superposition of >1 target
 - Parallel pipelines
 - 3-phase cable
- Requires more than two sensors
- 95% confidence available for each unknown
 - Degree of non-conformity to the modeled magnetic field



System Components

ORION system core components

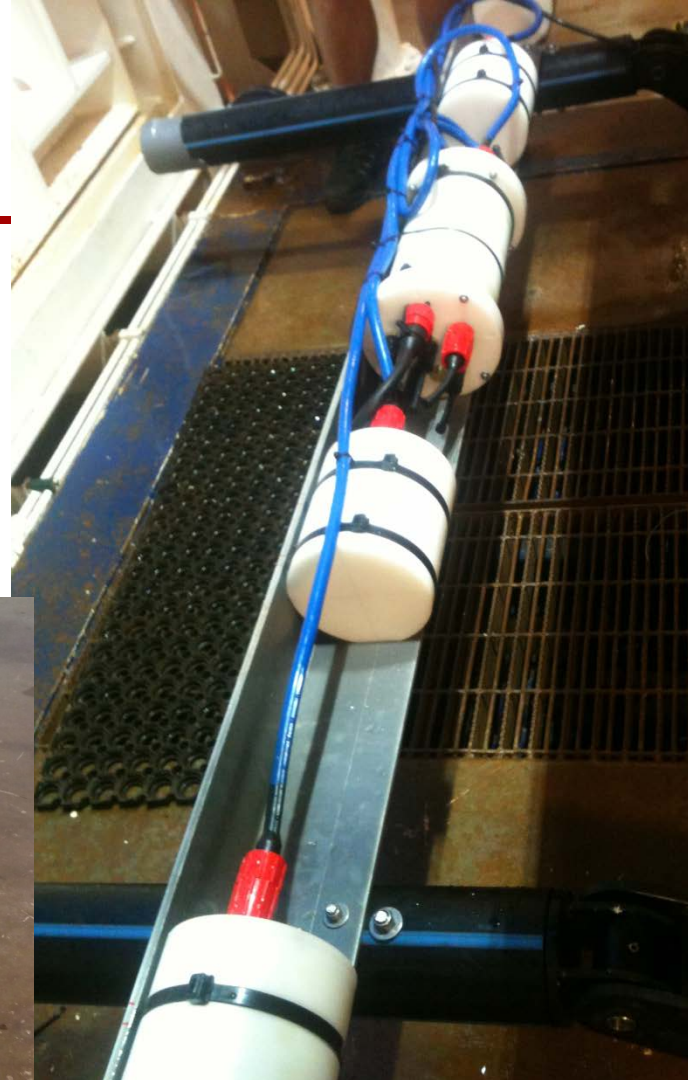
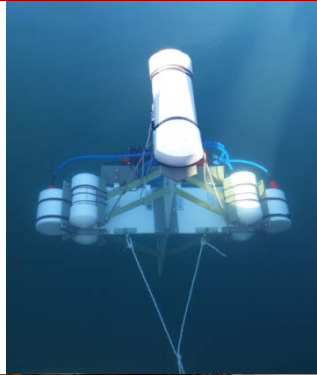
- E-POD
- Sensors
- FieldSens View Software
- Hydrographic Survey Software
 - QPS QINSy
 - EIVA NaviScan
 - HYPACK





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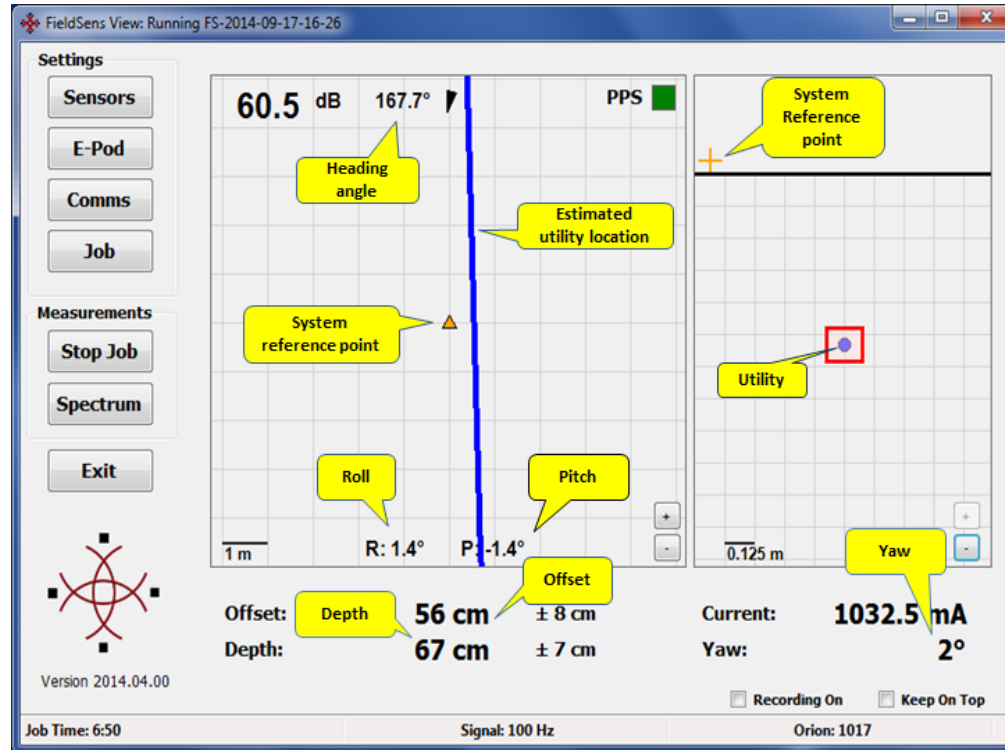
Sensor Mounting



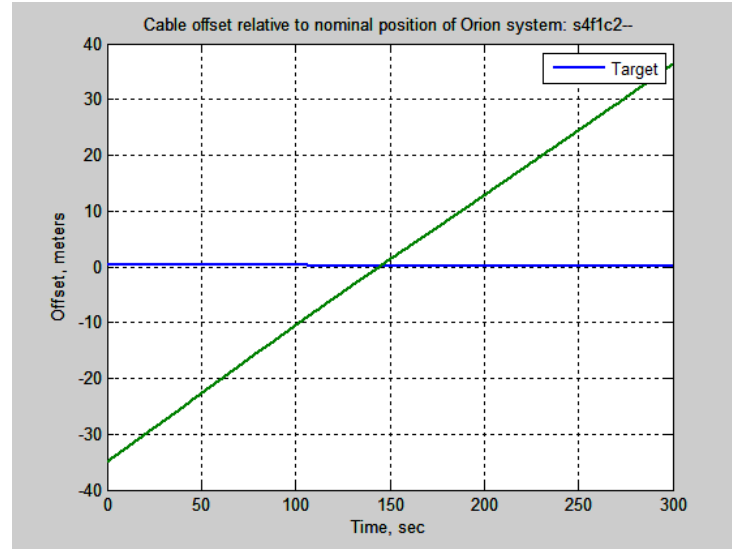
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FieldSens View



MultiSens Example



Common issue:

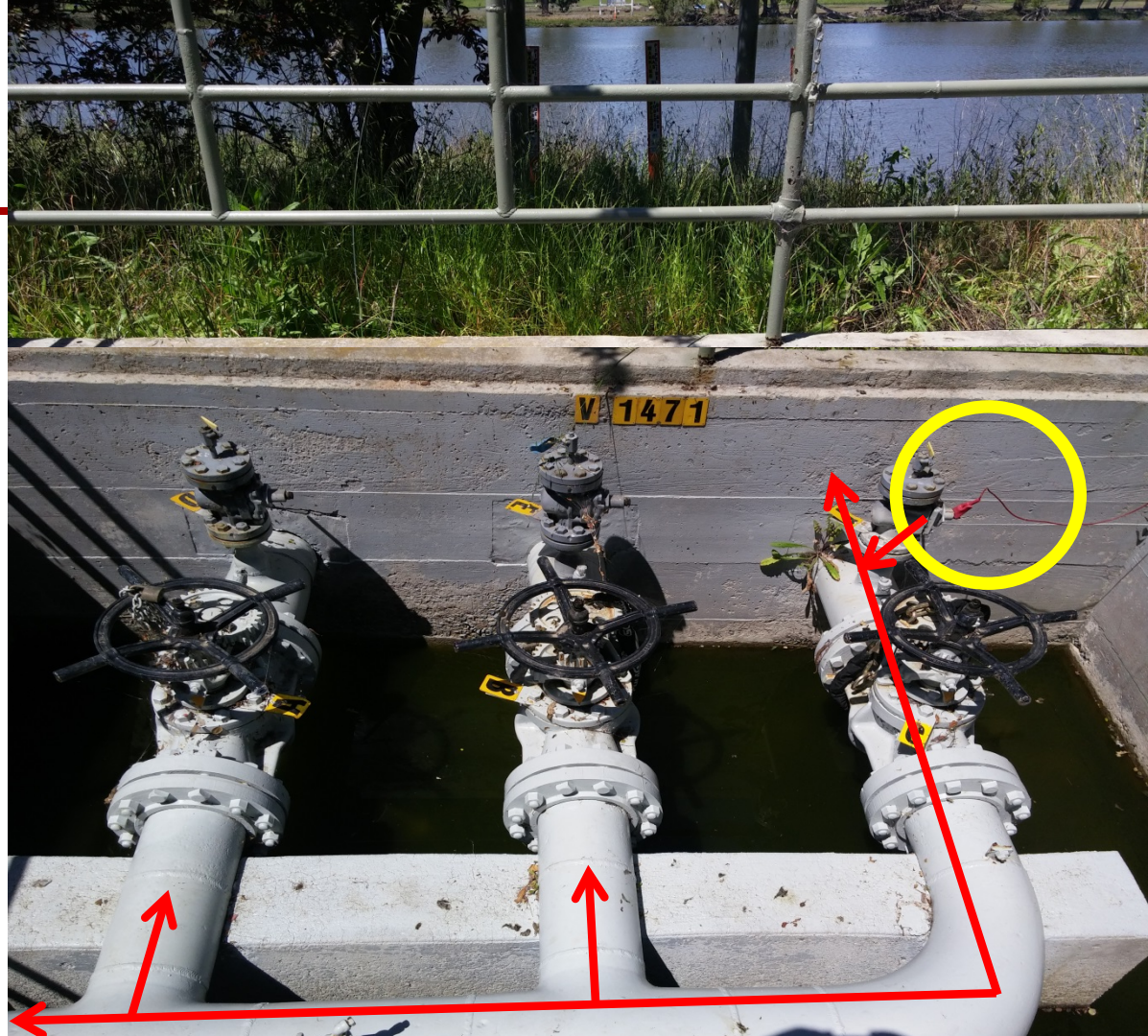
- Pipeline crossing or parallel lines in the same right of way

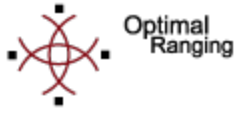


3-lines

Napa River crossing:

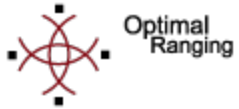
- Tidal river near Napa, Calif.
- Single gas main split into three for redundancy
- Transmitter current is known and split roughly in 4 equal parts



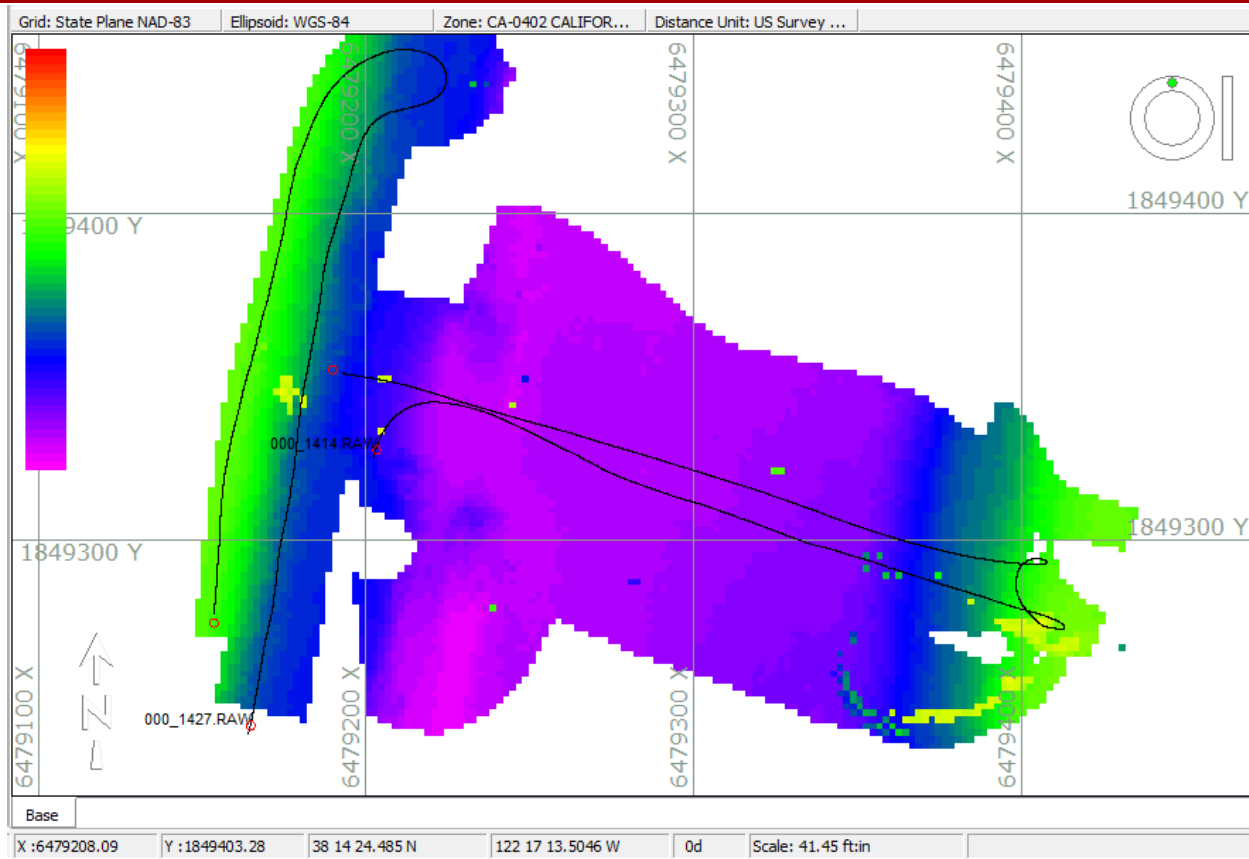


Tracking from a vessel-fixed mount

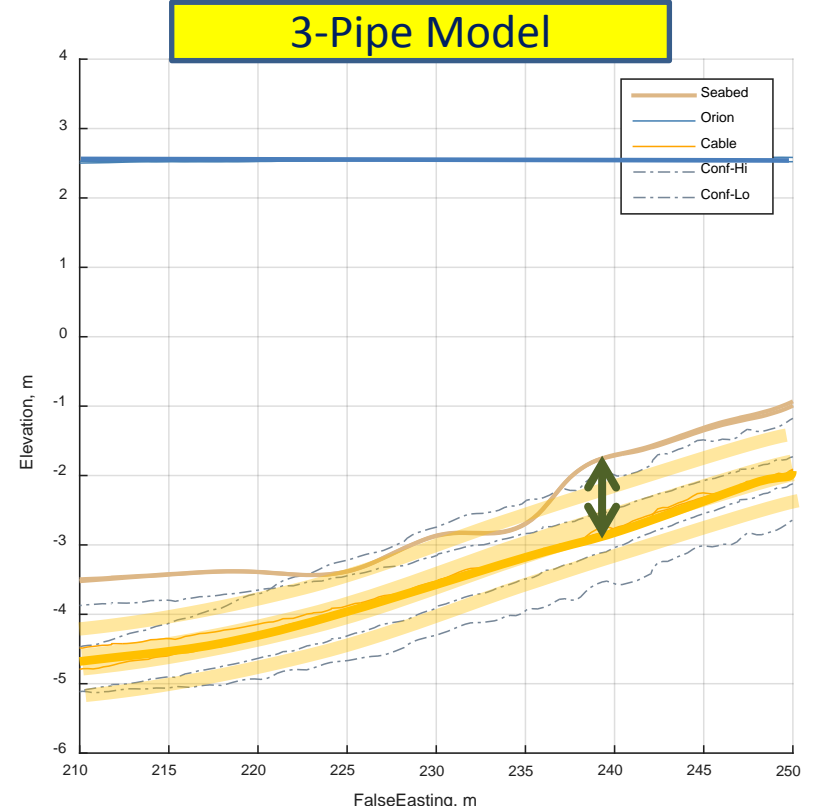
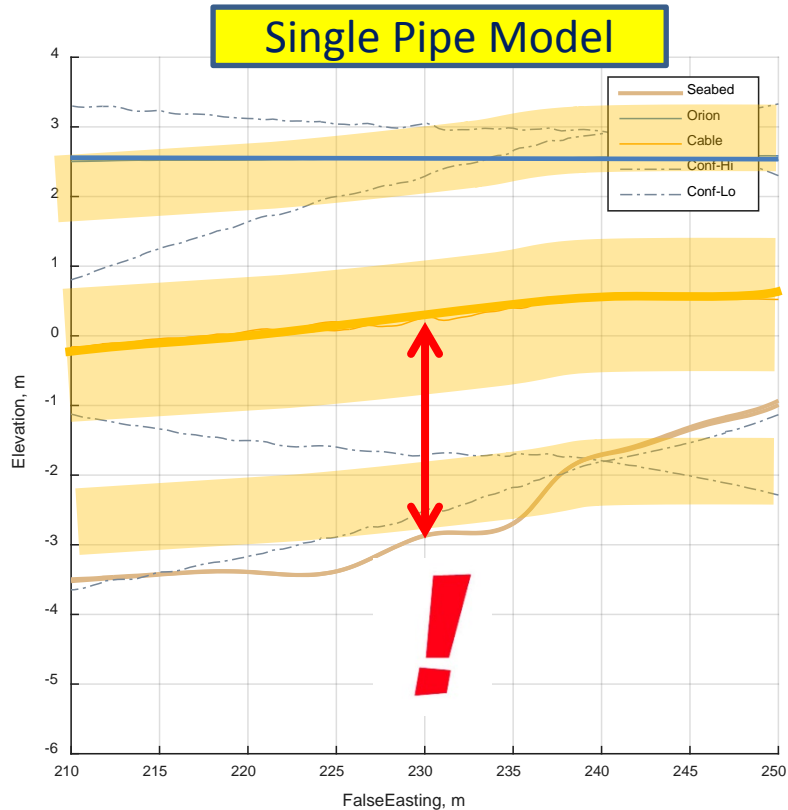


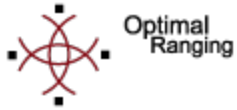


Riverbed Map



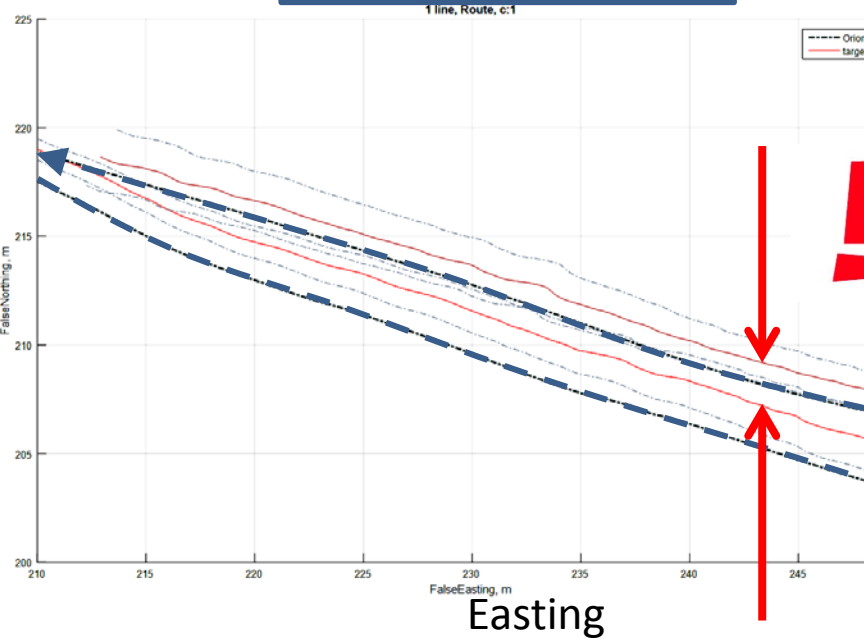
MultiSens Improvements



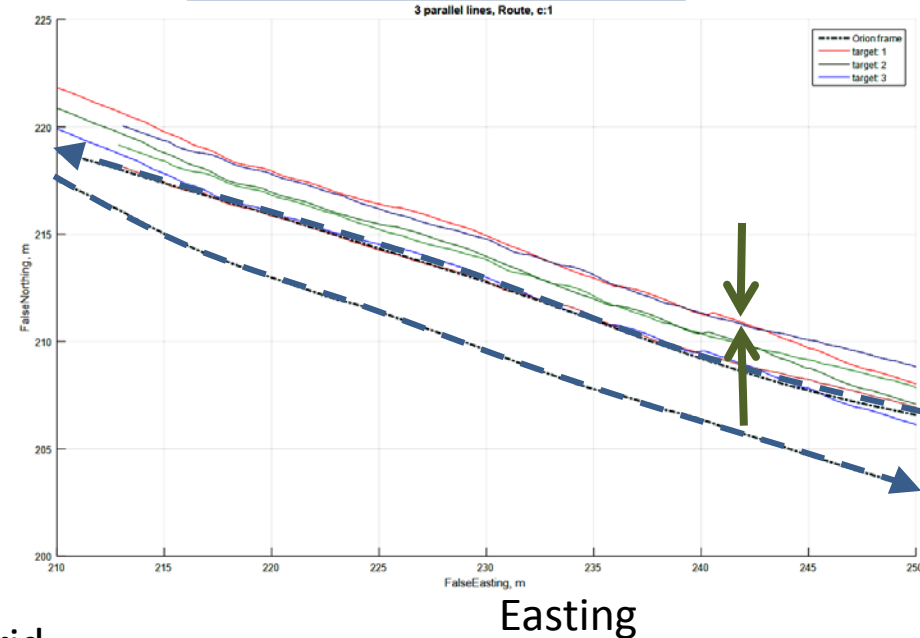


Pipeline Track Repeatability

Single Pipe Model



3-Pipe Model



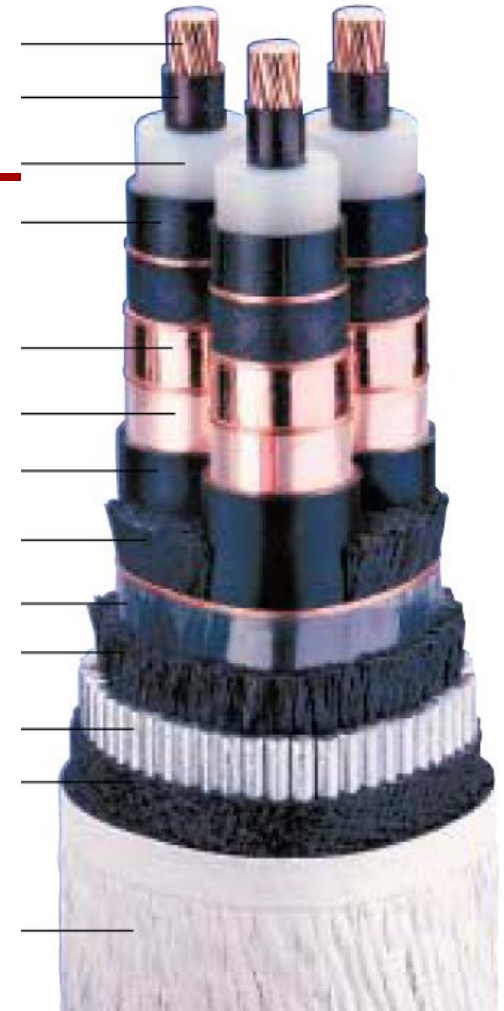
3-phase HVAC

Live 3-phase cables present special challenges:

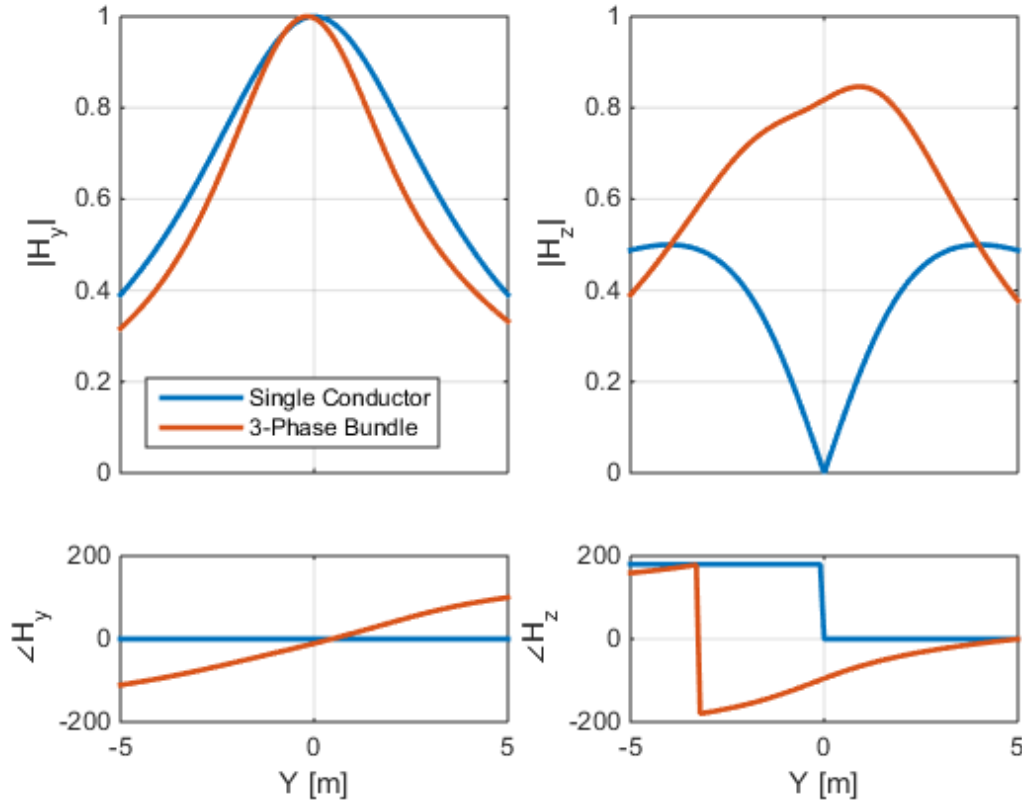
- Very closely separated conductors
- Unbalanced loads
- Sheath and armor

Orion approach to the problem:

- Model enhancement via superposition

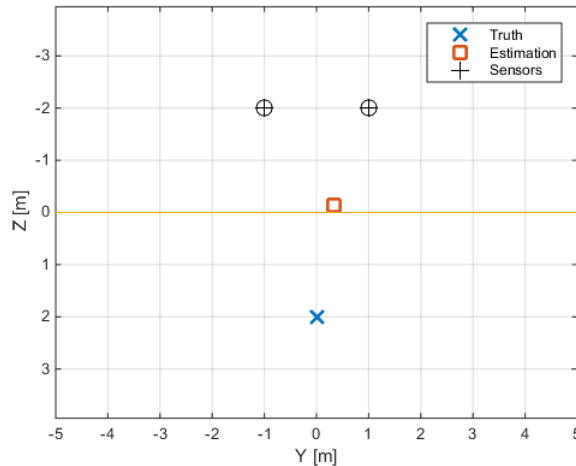


1- vs. 3-phase cable fields

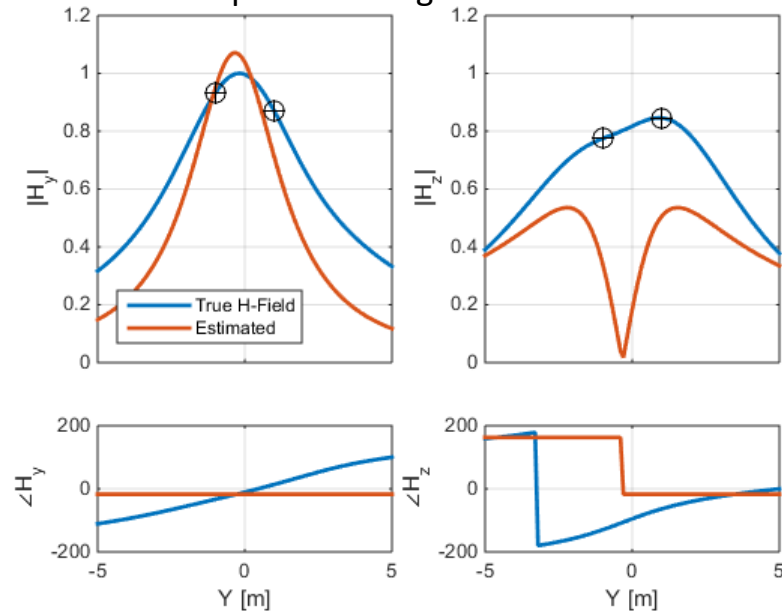


Single Conductor Model

A single conductor model cannot track the 3-phase bundle



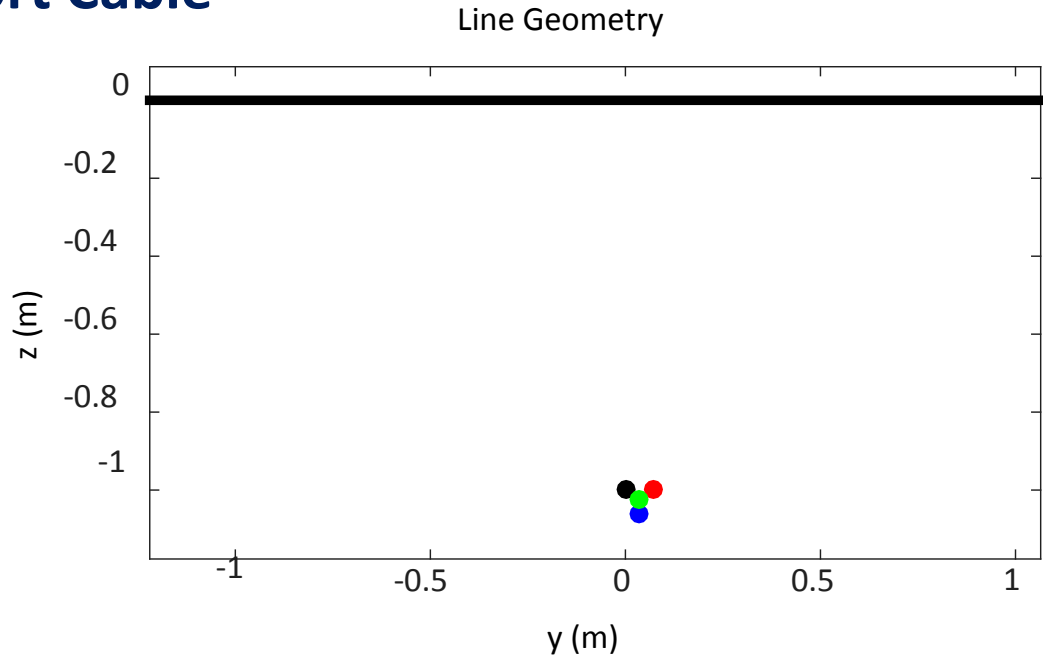
H-Field at Sensor Level and
Equivalent Single-Phase H-Field



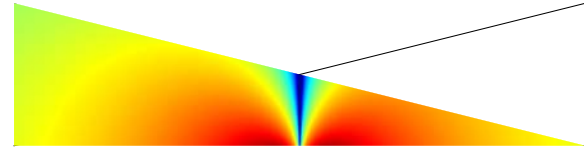
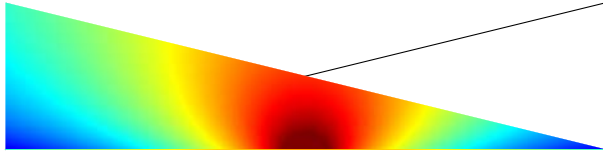
3-phase cable field model

Typical Wind Farm Export Cable

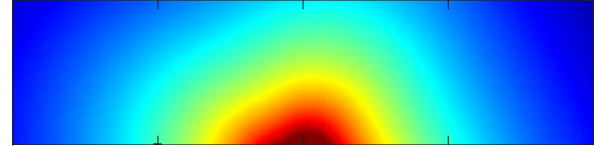
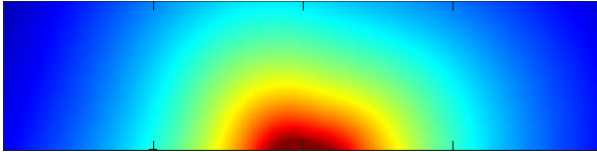
- 110 KV
- 30 MW
- 200 A per phase
- ~balanced load
- 5 A induced in armor



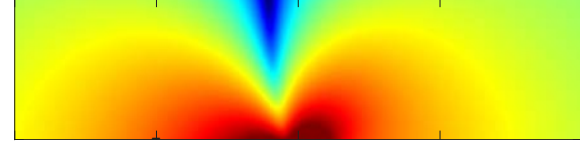
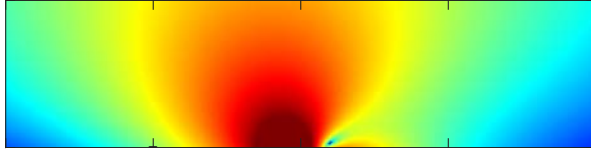
Single phase baseline fields



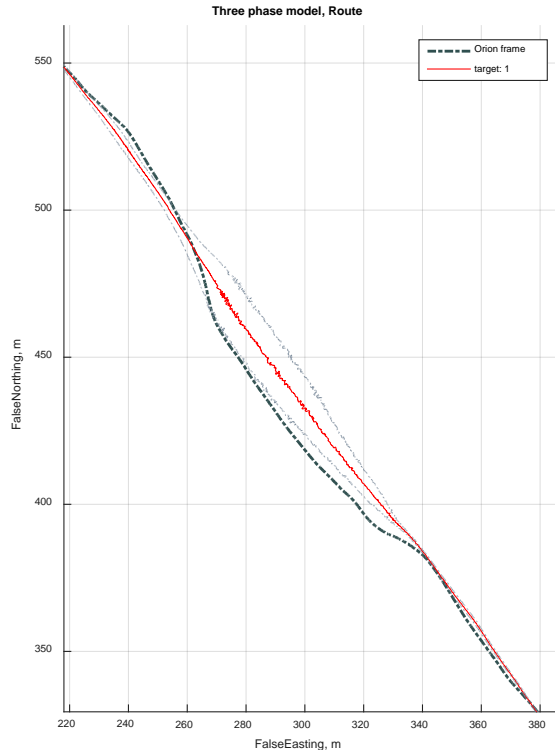
3-phase with no armor current



3-phase with small armor current



3-phase with small armor current



Model describes the measured data, but confidence is less good then desired.

- **Improvements are expected**

Thank you!

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