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Subsea Time Domain Reflectometry

Lessons learned, best practice and new developments

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Subsea TDR
Contents

- Introduction
- TDR Theory
- Limitations of Topside Testing
- Subsea TDR Examples
- Challenges and Best Practice
- Optical Subsea TDR

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Simplify Subsea Testing

C-Kore History

600+ Units Deployed >> **100+ TDR Units Deployed!**

70+ Different Customers

50+ Assets Installed

90+ Different Fields

200+ Faults Located

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Simplify Subsea Testing

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Subsea Testing Tools

Cable Monitor

Subsea TDR

Sensor Monitor

Pressure Monitor

Optical TDR

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Simplify Subsea Testing

Subsea Electrical TDR
Specification

Discontinuity Location	>40km Range*
Location Precision	2nS (~15cm*)
Inputs	2 to 12 +Earth
Pulse Width	10nS to 10uS (auto)
Measurement Gain	-18dB to 56dB (auto)

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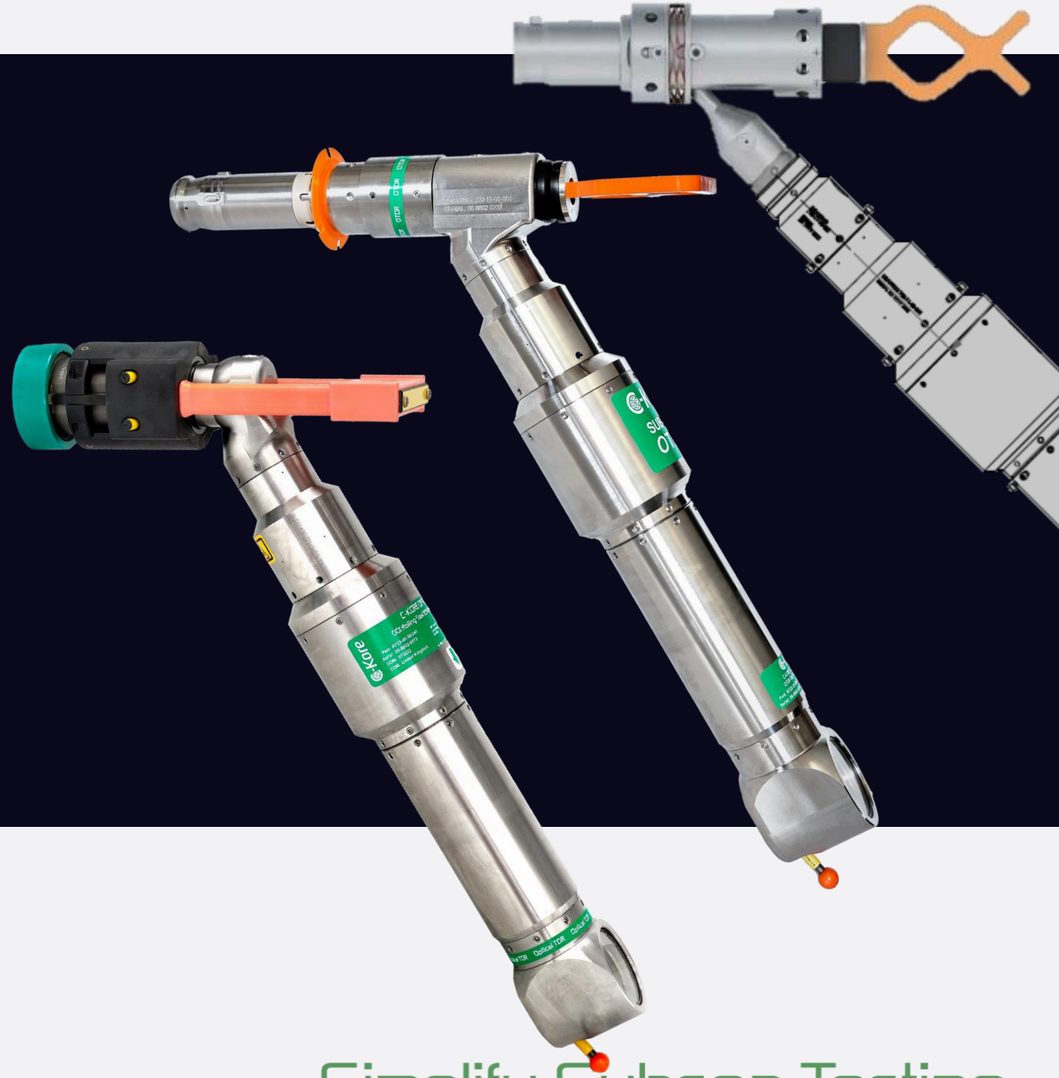
*Dependent on cable properties

Simplify Subsea Testing

Subsea Optical TDR
Specification

Discontinuity Location	>100km Range*
Location Precision	2nS (~15cm*)
Inputs	1 to 12
Wavelengths	1310nm and 1550nm
Pulse Width & Gain	Automated



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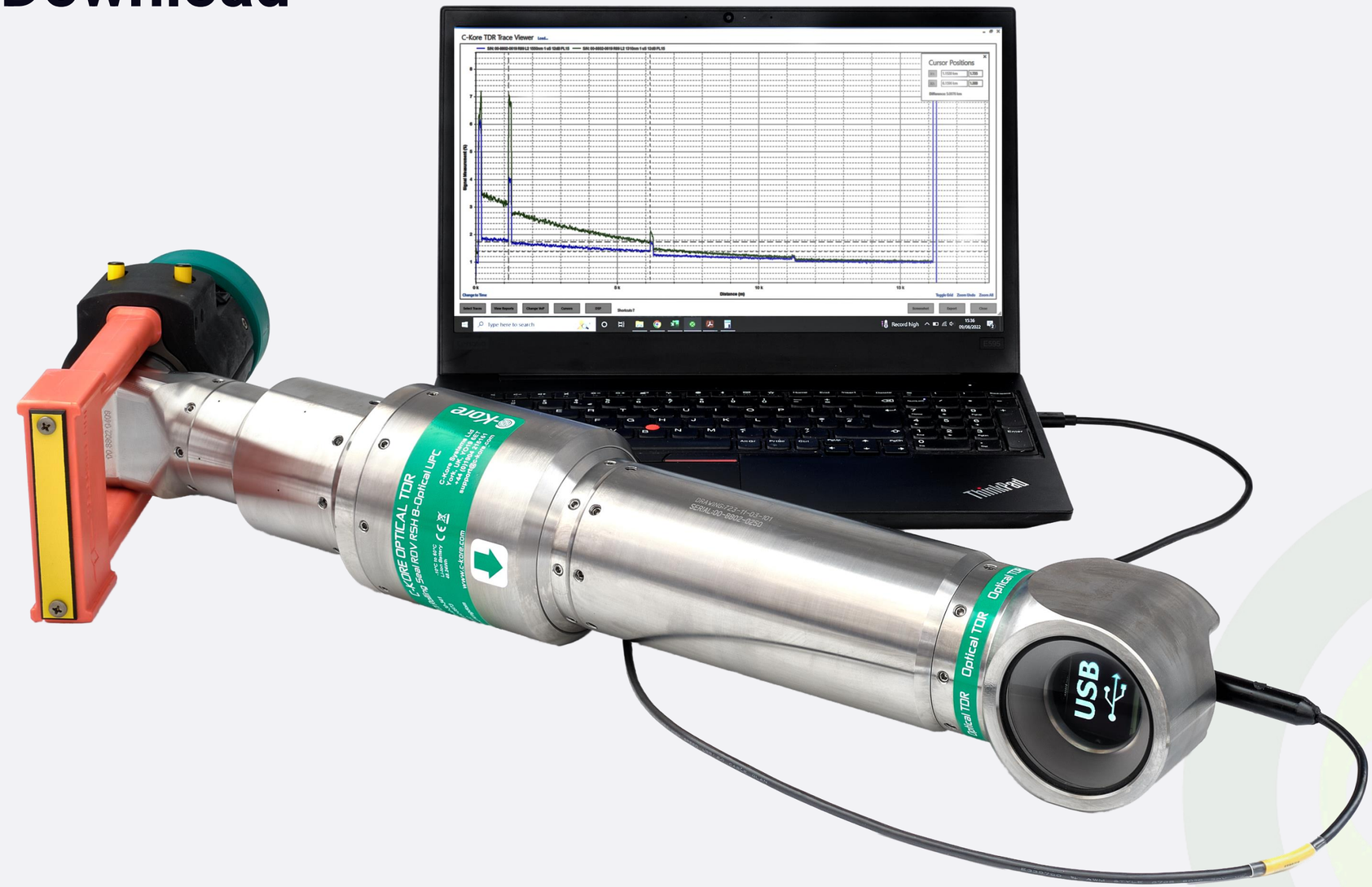
*Dependent on cable properties

Simplify Subsea Testing

Subsea TDR
Setup & Download



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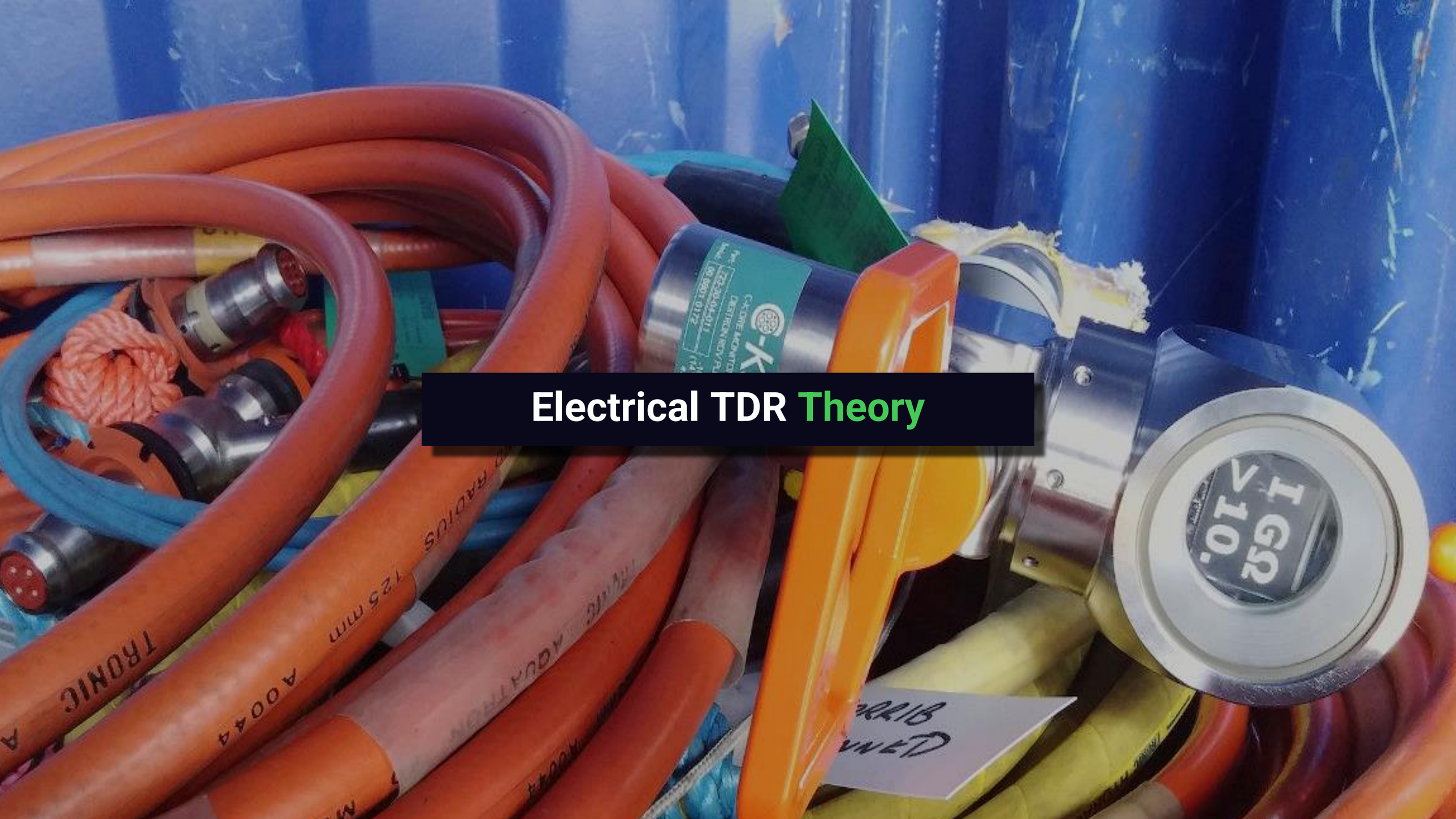
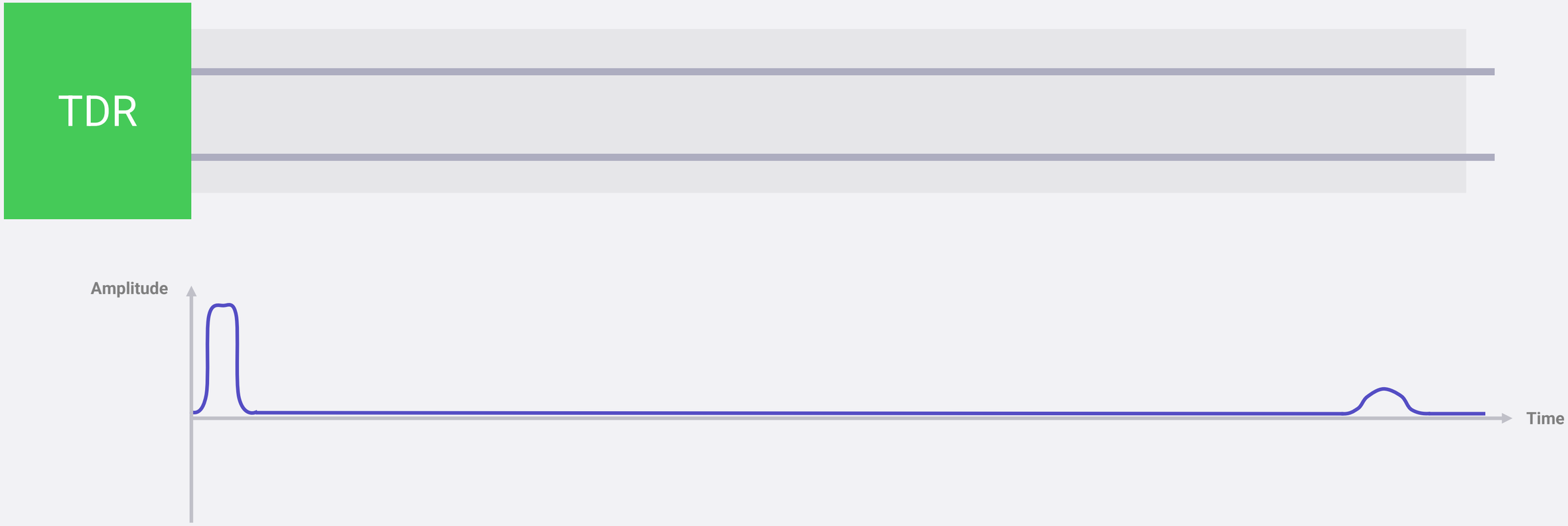
Simplify Subsea Testing


Electrical TDR Theory

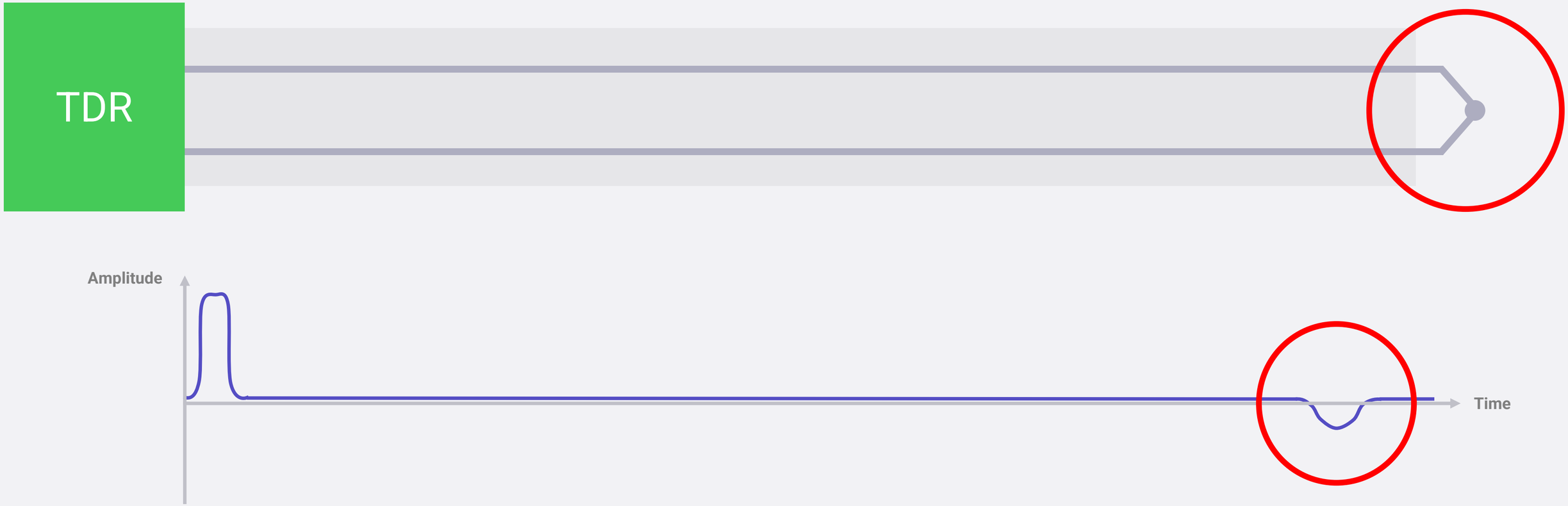
Electrical TDR
Theory of Operation

- **Operation:**
  - Transmits an electrical pulse and measures reflections (similar to sonar)
- **Identifies:**
  - Distance to end of line / discontinuity
  - Type of discontinuity / termination

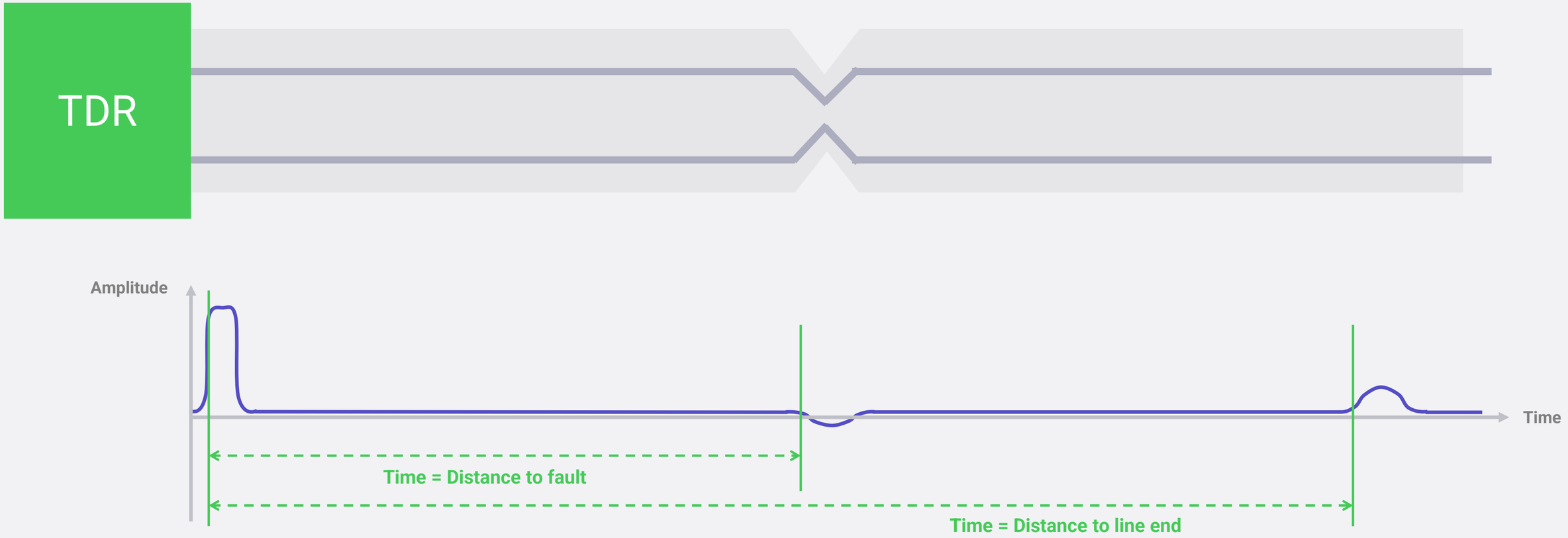
TDR Reflection
Open-Circuit



TDR Reflection
Short-Circuit

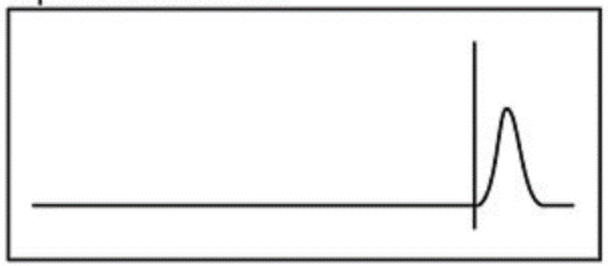


TDR Reflection
Impedance Change

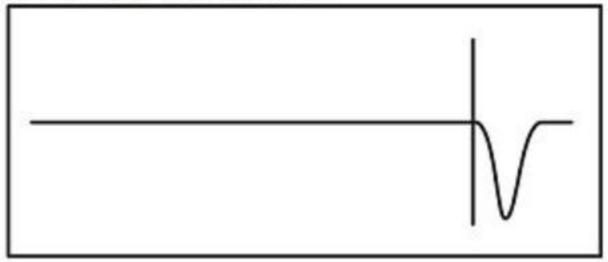


TDR Reflection
Further Examples

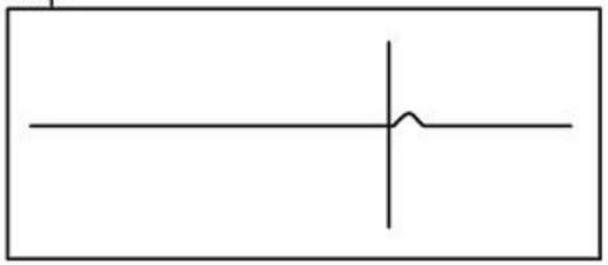
Open conductor



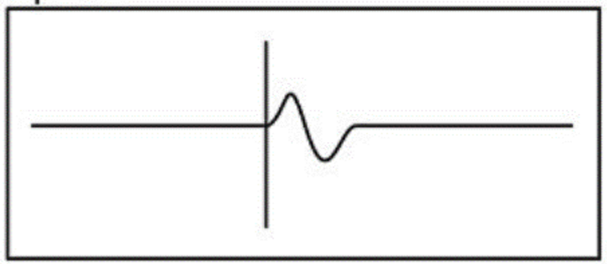
Shorted conductor



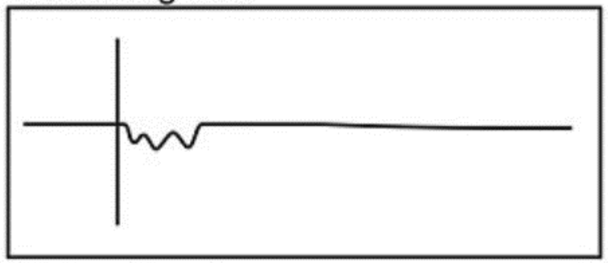
Tap



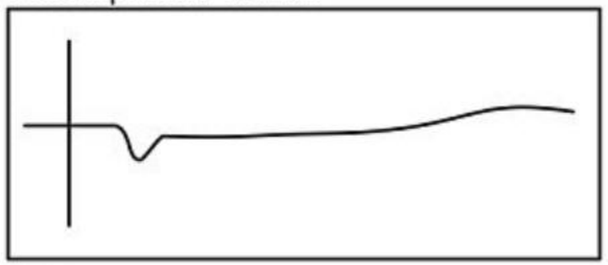
Splice



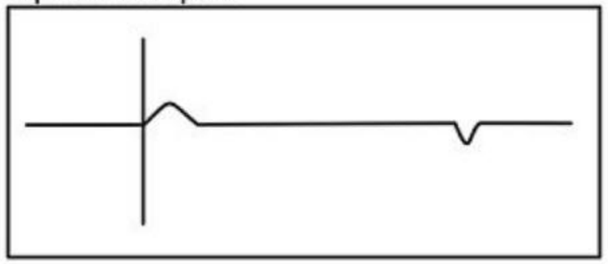
Water ingress



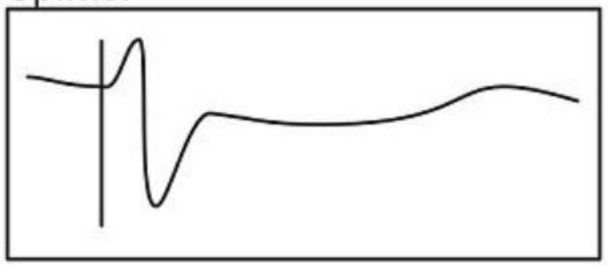
Wet splice / water



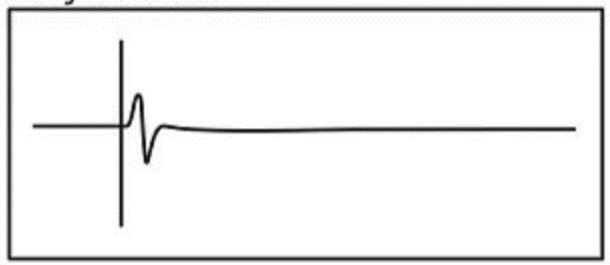
Split / resplit

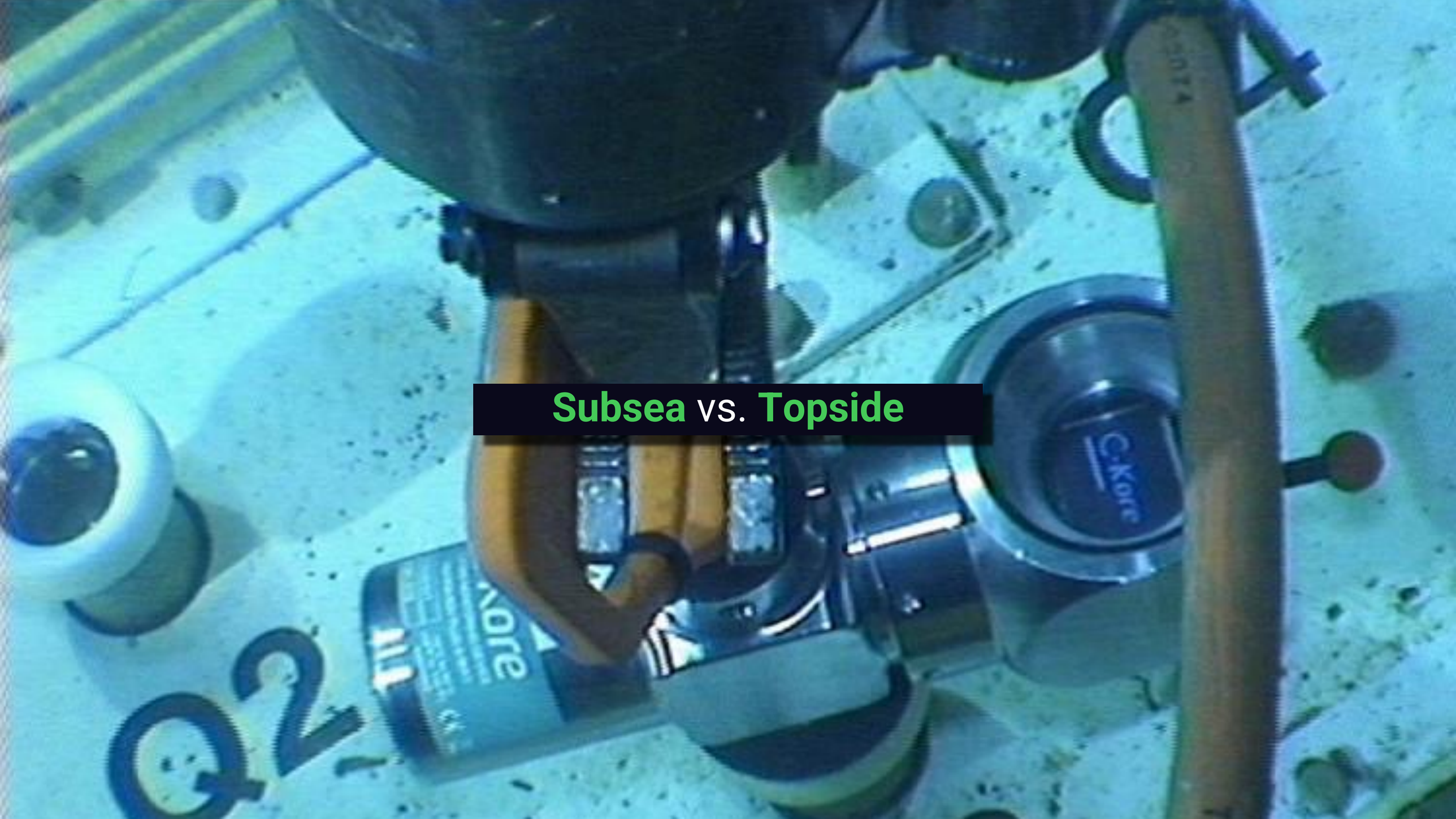


Splitter

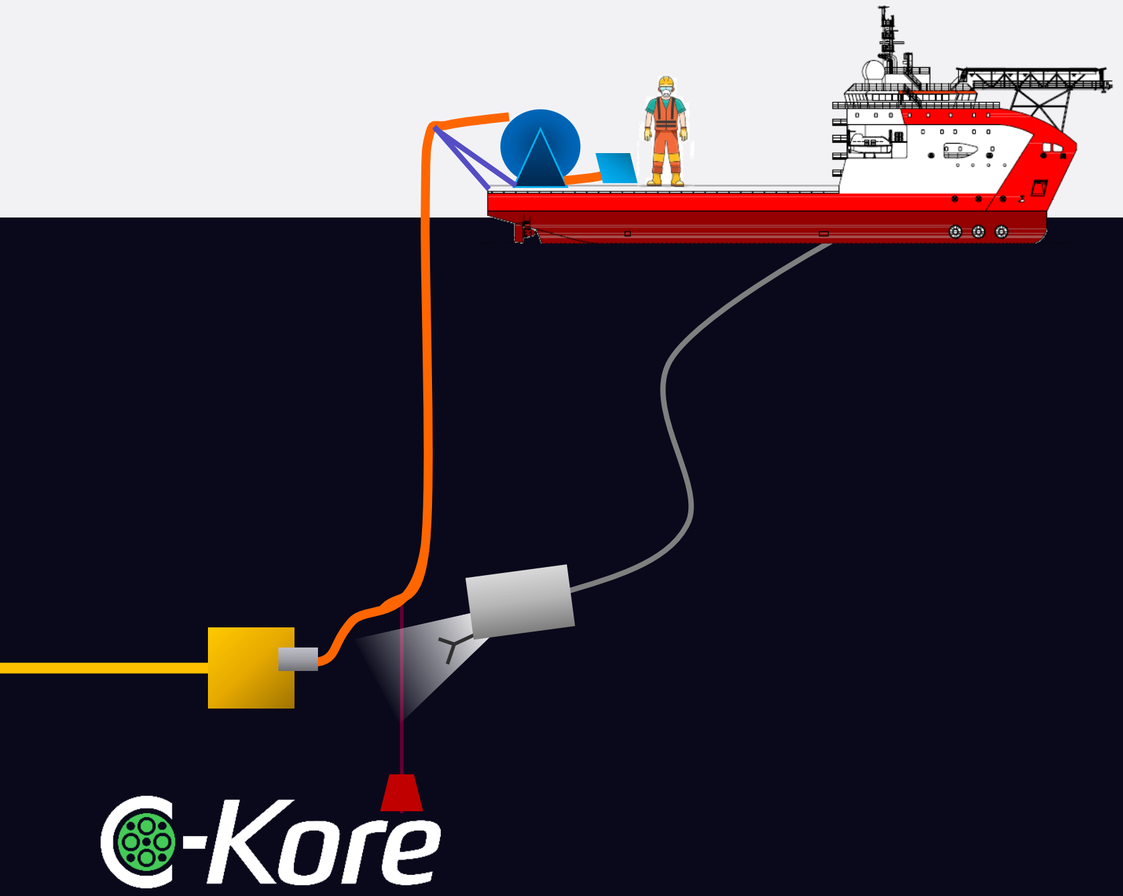


Frayed cable




Subsea vs. Topside

Deployment
Topside Testing



1. Vessel arrives in field
2. ROV launched
3. Downline deployed (move to safe distance)
4. ROV derigs and connects downline
5. Testing from back-deck

Downline Issues:

Slow mobilisation and deployment

Downline faults and attenuation

Impedance mismatches and reflections

Technician skill under time pressure

Quality of saved data

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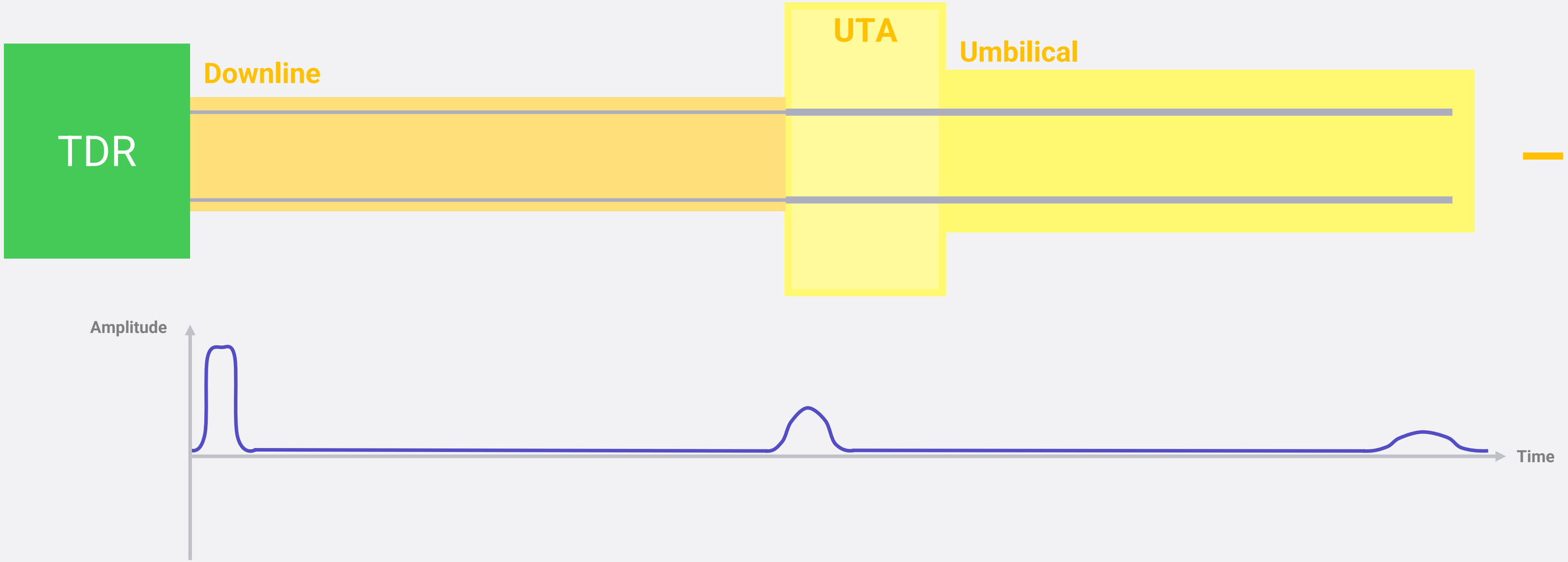
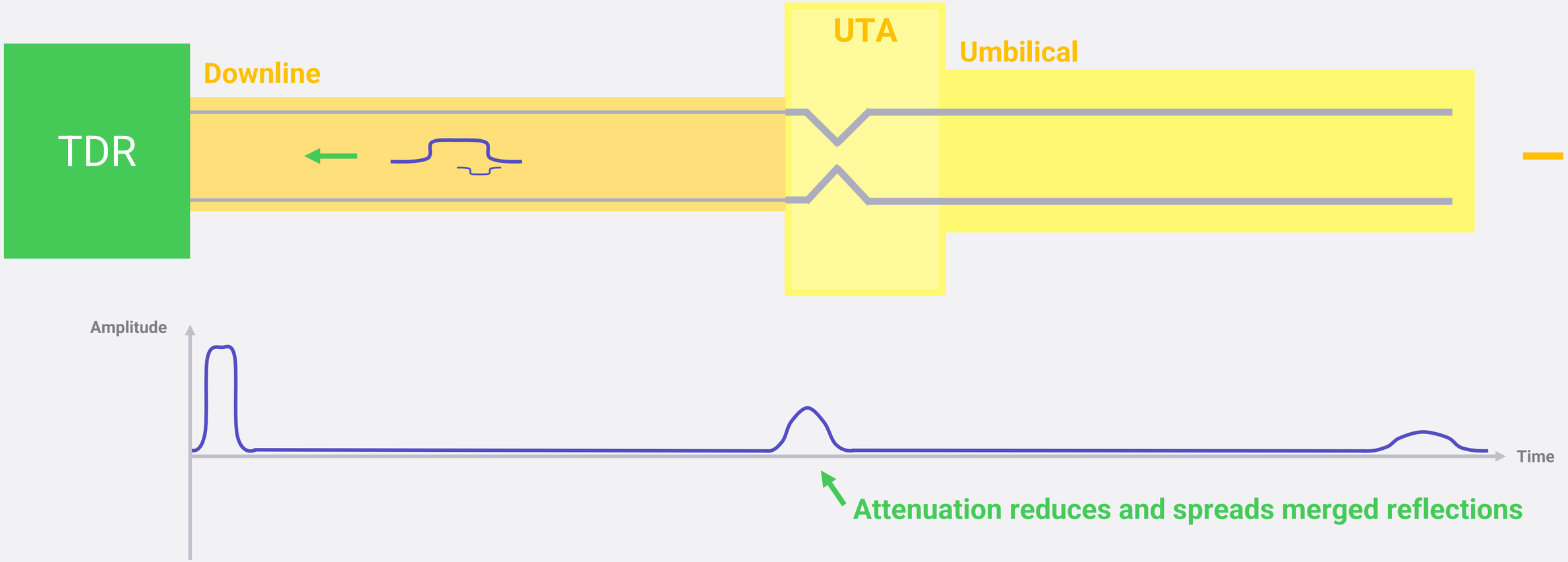
TDR Reflection
Umbilical via Downline

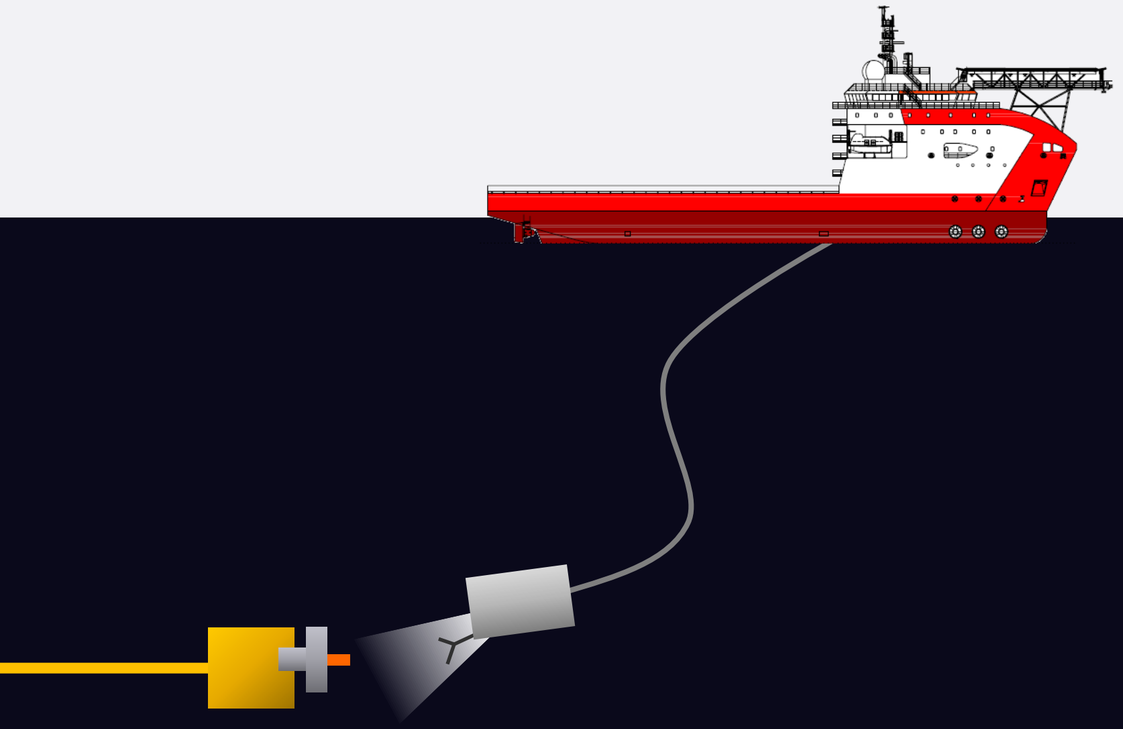


TDR Reflection
Downline to UTA Fault



Deployment
Subsea Testing

1. Vessel arrives in field
2. ROV launched
3. ROV connects and triggers C-Kore unit



Subsea Benefits:

Fast deployment subsea

No back deck equipment or permits

Direct measurement

Automated and repeatable

Interactive result analysis

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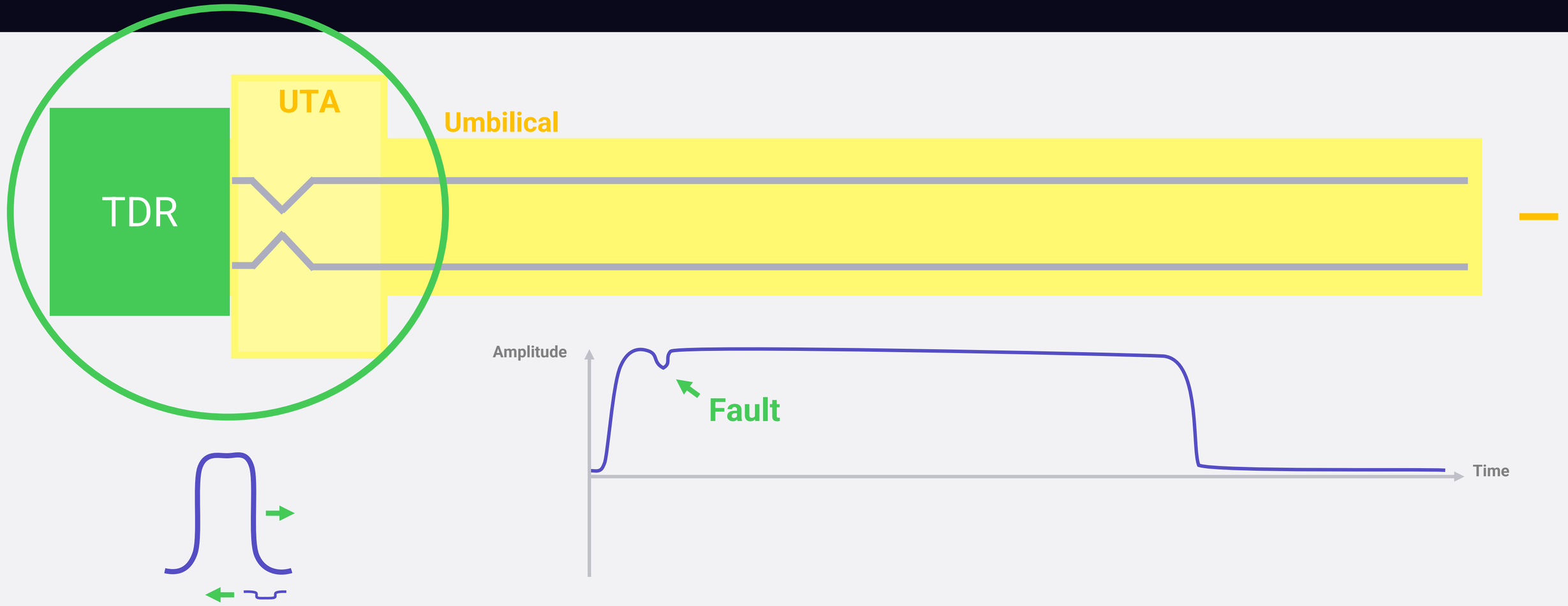
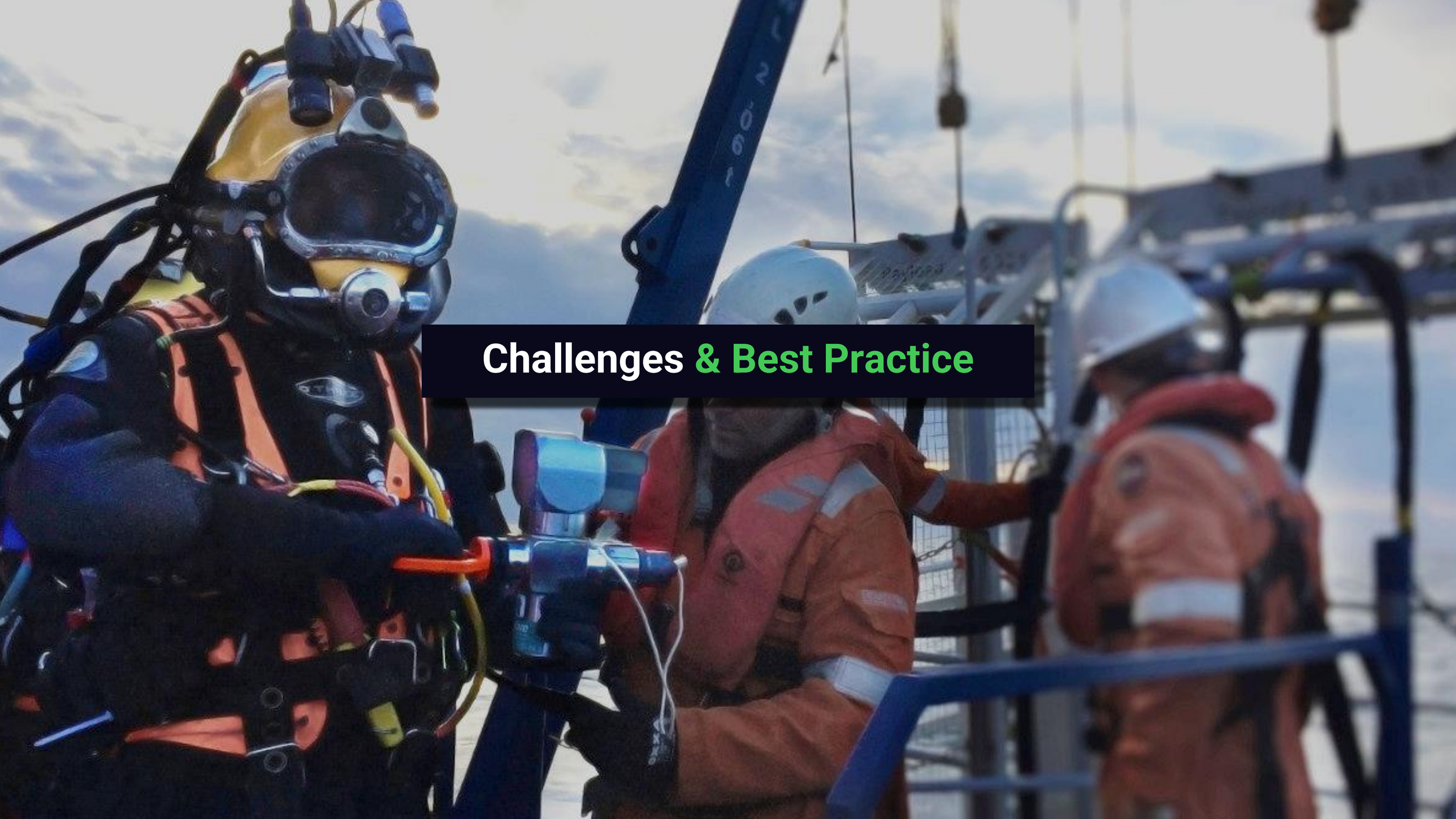
TDR Reflection
Umbilical Direct Subsea

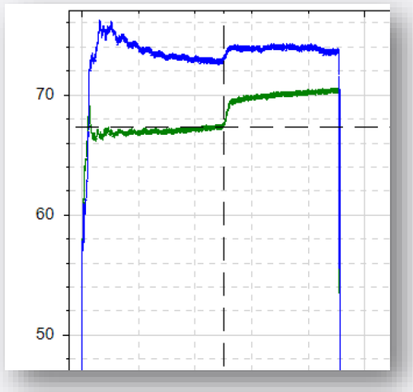


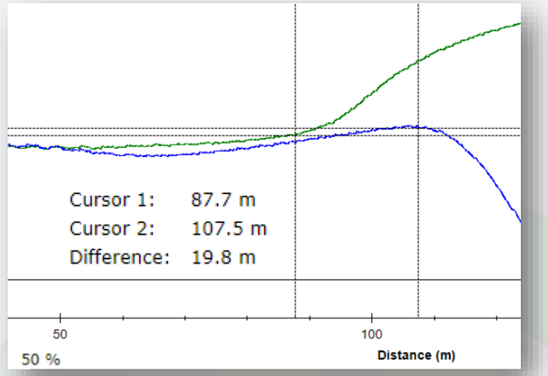


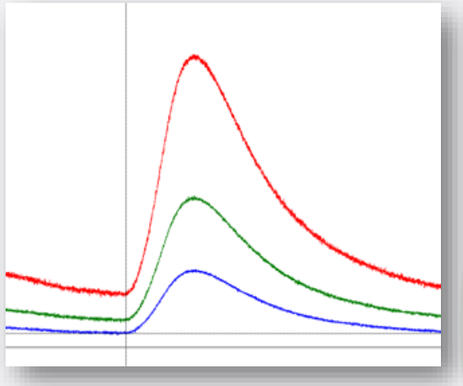
Challenges & Best Practice

Challenges
Configuration

- Characteristic Impedance
  - Cable specification or previous testing
  - Energy injection and absorption
- Velocity of Propagation
  - Distance measurement
  - Adjust after testing
- Other Settings
  - Inputs to test
  - Pulse width
  - Measurement gain







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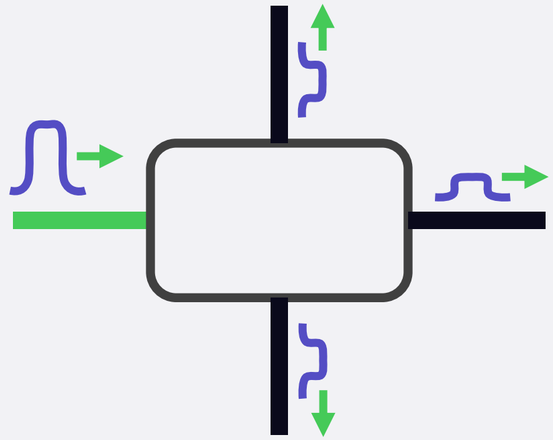
Simplify Subsea Testing

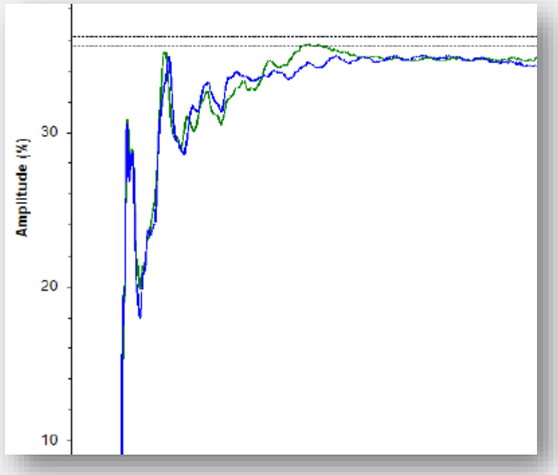
Challenges
Topology

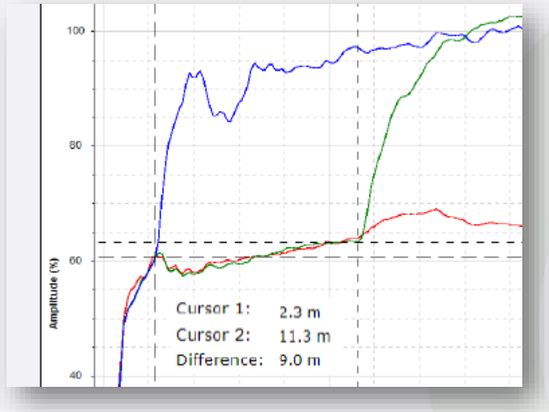
- Connected Networks
  - Suboptimal – narrow down with IR testing
- Attenuation
  - Test close to fault (e.g. subsea UTA)
  - Measure from both ends
  - Test from topside

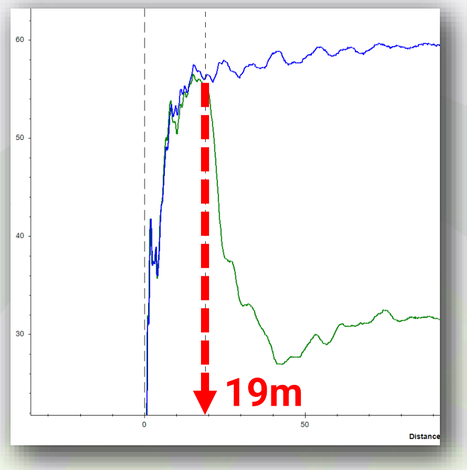


Challenges
Response

- Expected Response
  - Changes in impedance
  - Splices, junctions, terminations (FACTs)
- Comparisons
  - Healthy line with fault
  - Baseline test against installed
- EFLs & Test Leads
  - Test separately to isolate response







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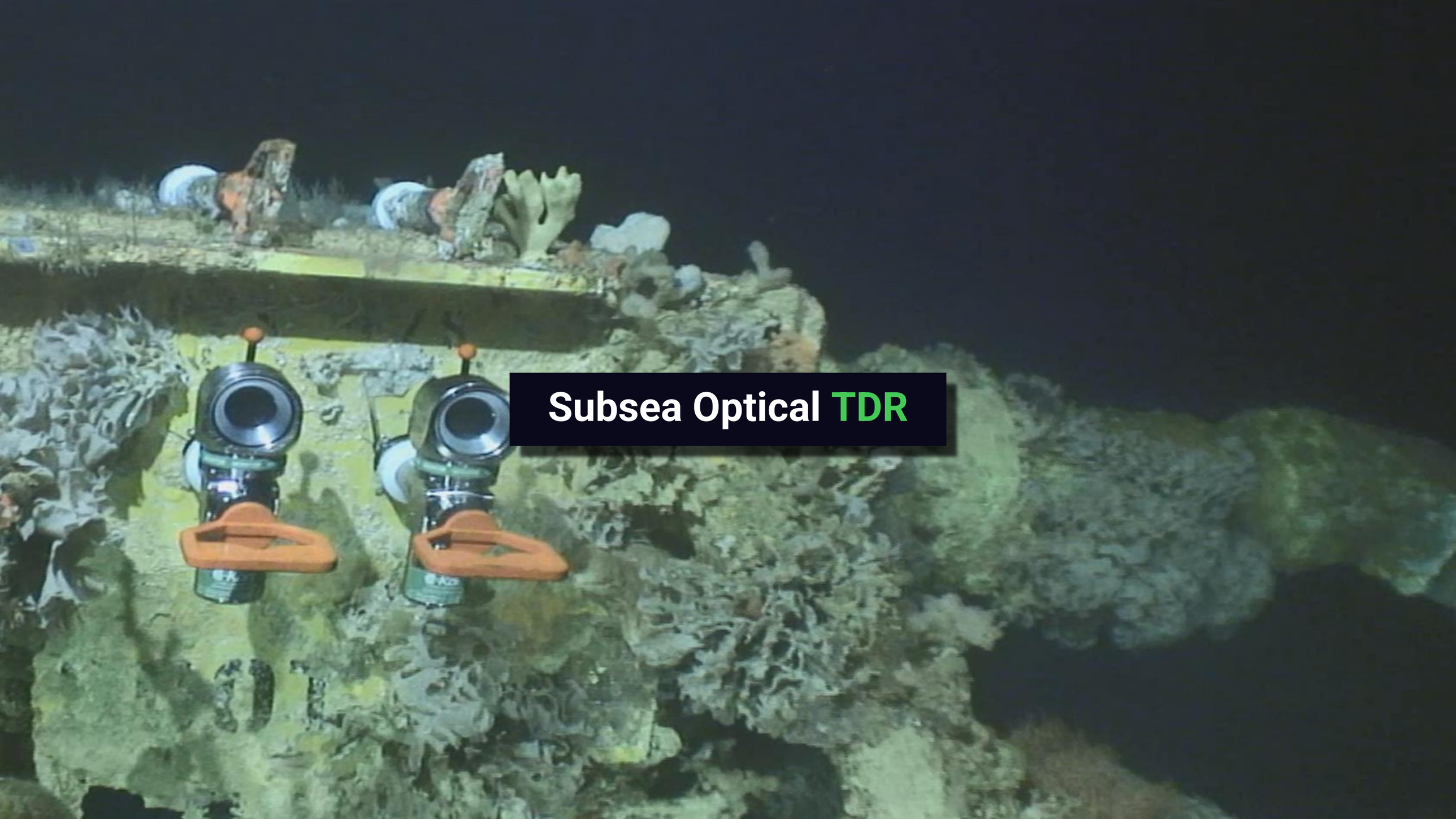
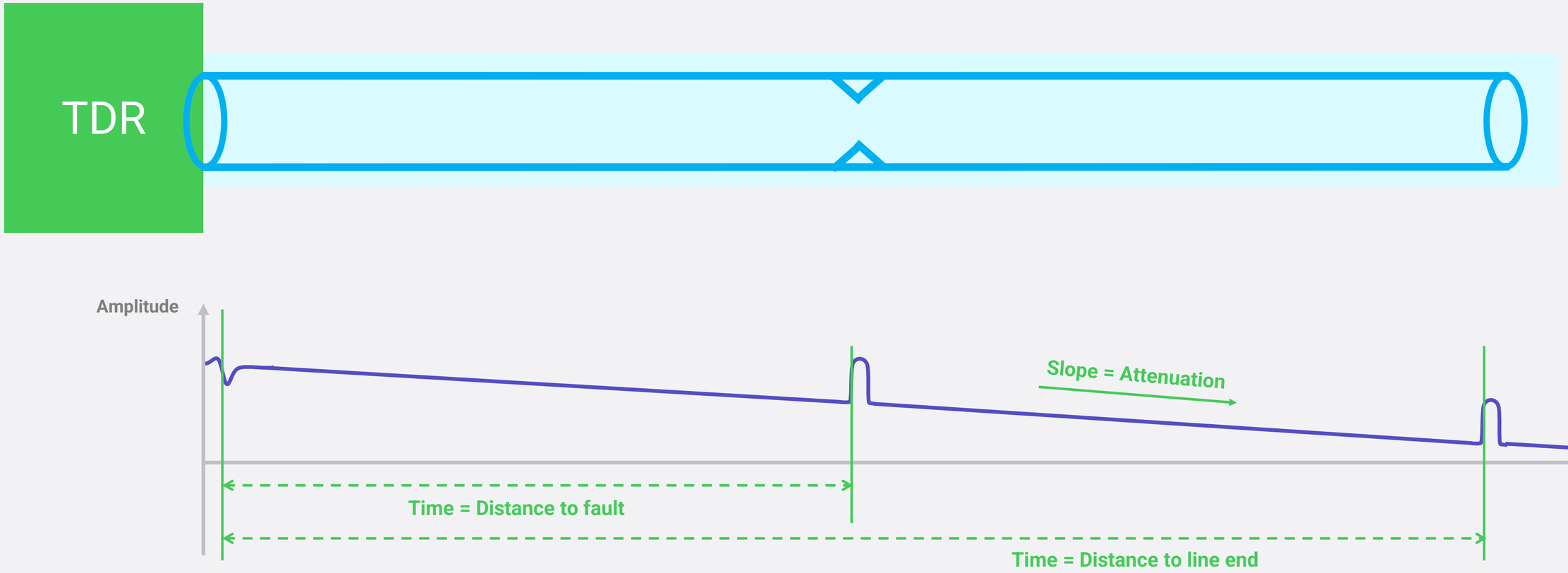
Simplify Subsea Testing


Subsea Optical TDR

Optical TDR
Theory of Operation

- **Operation:**
  - Transmits an optical pulse and measures reflections
  - Single line rather than differential measurement
- **Identifies:**
  - Distance to end of line / discontinuity
  - Cable loss / attenuation

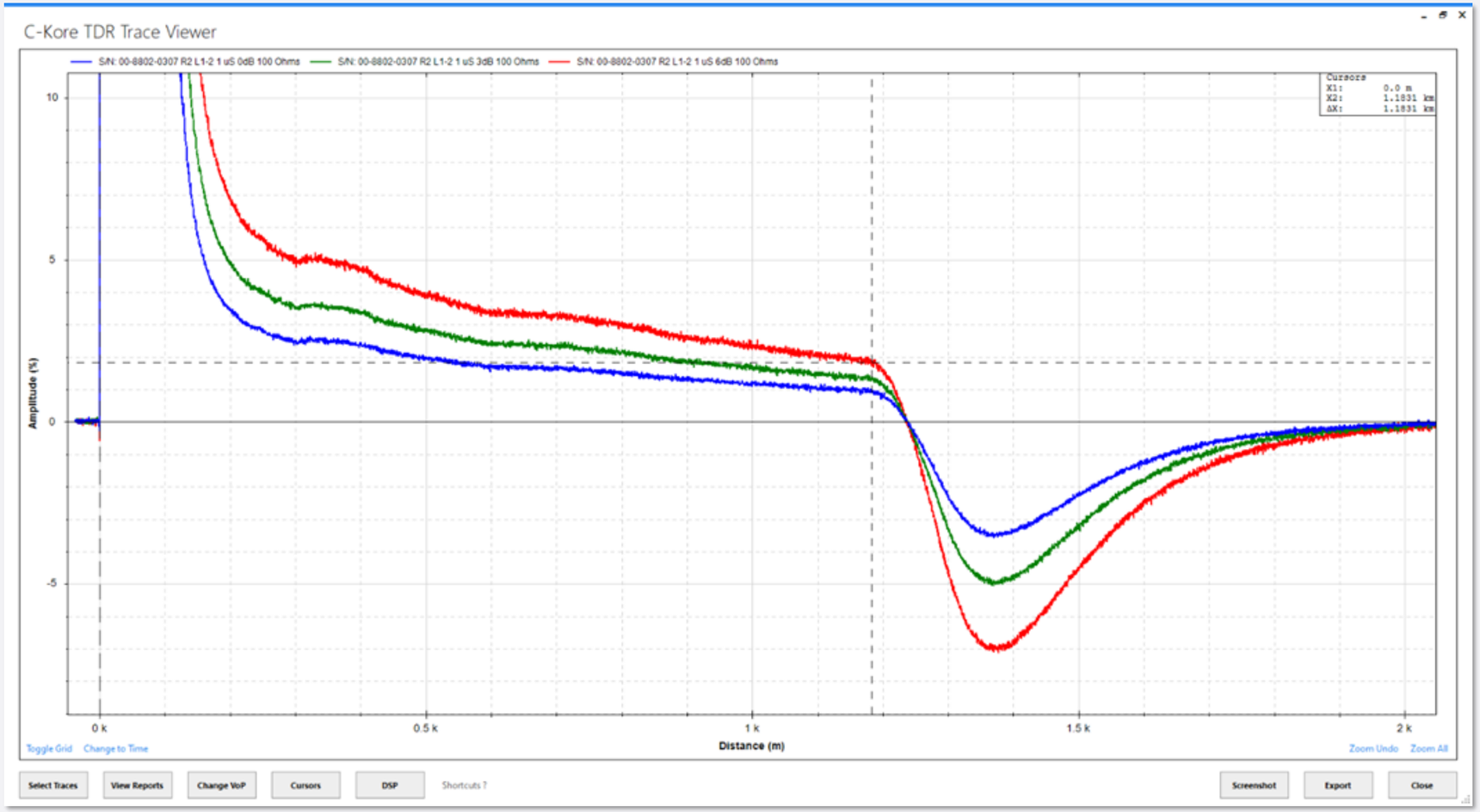
OTDR Reflection
Discontinuity

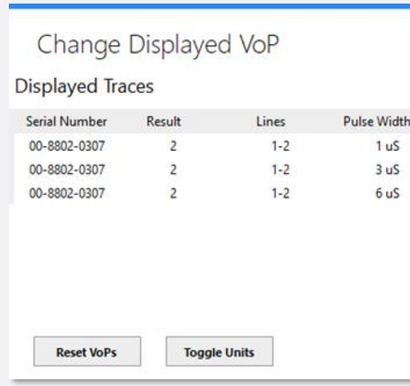


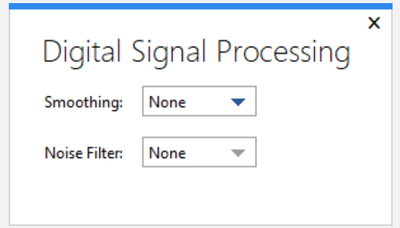
Subsea TDR
Enhancements

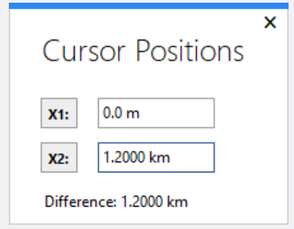
- Repeated Measurement Averaging
  - Reduces noise and increases fidelity
- DSP & Advanced Filtering
  - Identify subtle features on longer lines
- Viewer Enhancements – Multiple Traces & VOPs
  - Draw comparisons to identify discontinuities

Subsea TDR
Enhancements









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Simplify Subsea Testing

Subsea TDR
Summary

- Introduction
- TDR Theory
- Limitations of Topside Testing
- Subsea TDR Examples
- Challenges and Best Practice
- Optical Subsea TDR

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Simplify Subsea Testing

Thank You
Any Questions?

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