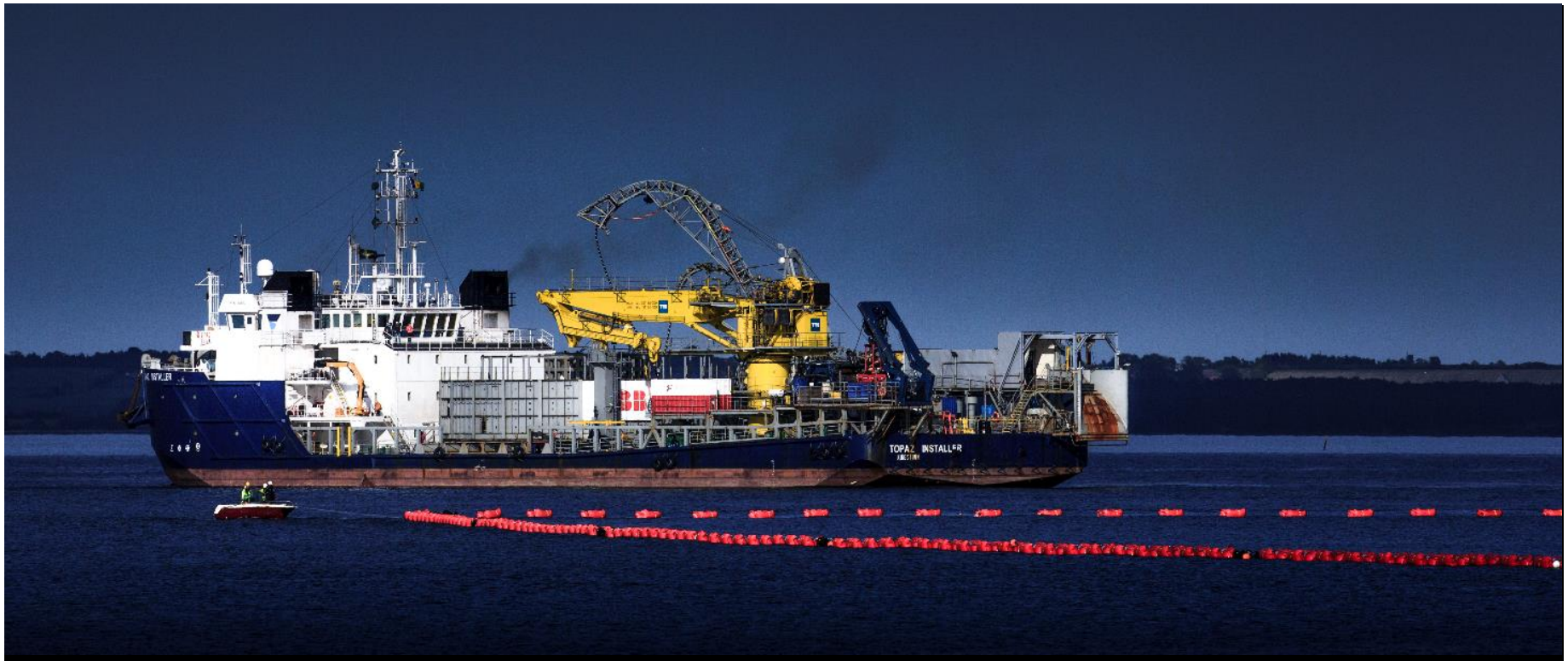


Darren Fennell, ABB High Voltage Cables 2015-10-21

ABB High Voltage Cables
Effective Installation of Cable Systems
Challanges and Lowering of Risk

Installation Challenges and Lowering of Risk
Agenda

1. Marine Surveys & Unexploded Ordnance
2. Burial Assessment & Burial Tool Selection
3. Route Engineering
4. MetOcean Analysis
5. Installation Engineering
6. DC Cables - Bundled verus Separate Lay

Installation Organization
Installation Portfolio

Complete Installation portfolio for all focus areas

Offshore Wind Farms

Offshore Oil & Gas

Undergrounding

Interconnectors

ABB

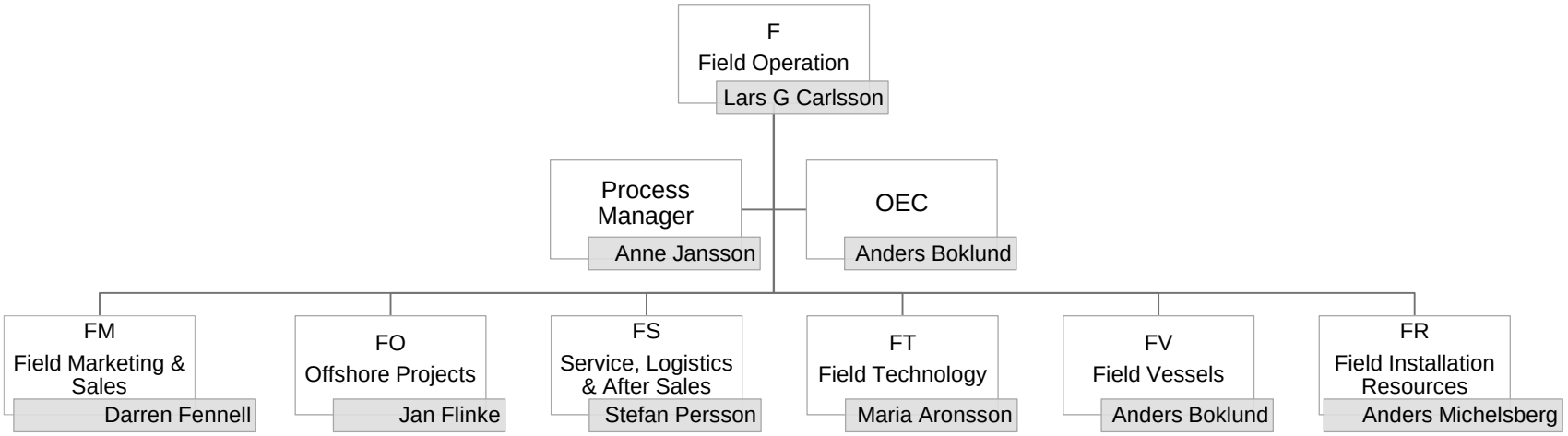
Project management
Risk management
Onshore & Offshore Engineering
*Cable laying
*Trenching equipment
Vessel management
Supervision
Erection and jointing
Testing after installation
Fault location if a damage occur
Repair of cable faults
Turn-key responsibility

Subcontracting

Route clearance
*Cable laying
Rock dumping
Dredging
Survey
Guard vessels
*Trenching equipment

*Dependent on suitability for Project – Case by Case Basis

Installation Organization
High Voltage Cables Installation Structure



Installation Assets
ABB Cable Lay Vessel (CLV)

- DP-Class III
- 2 Turntables
- 1 or 2 WROV (As required)
- Helideck supporting Sikorsky S92
- 2 Nr Cranes - 25T & 10T
- Insignificant dynamic load on cable
- Large weather window

Installation Assets
ABB Cable Lay Vessel (CLV) – Topaz Installer

- DP-Class II
- 1 Turntable (3300 -3600 mT)
- 1 WROV
- Crane 35mT
  – Heave Compensated
- Cable laying speed ~ 500-600 m/h

Installation Assets
ABB Trenching Tool– OJ200

- Tool based on existing tools - Proven Design
- Jet Sledge - Developed by ETA
- Simultaneous Laying and Trenching
- Capable of burial depth up to 3m
- Equipped with depressor

Installation Assets
Trenching – Canyon Frame Agreement

Frame agreement with Canyon

- → Secured availability for ABB
- Supported by new built DP III vessel Grand Canyon

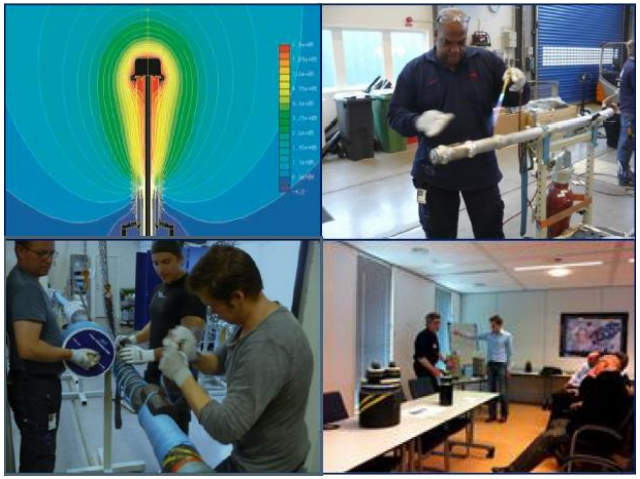
T1200 & T1500

- New built state of the art jet-trenching system
- Cable burial up to 3m
- Simultaneous laying and trenching or post-lay trenching

I-trencher

- Rock cutter trencher
- Can cut up to 2m deep trenches
- Pre-lay trenching or post-lay trenching

Installation Assets
ABB Training Center

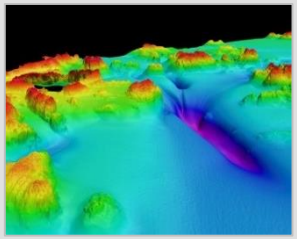
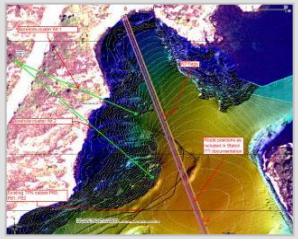
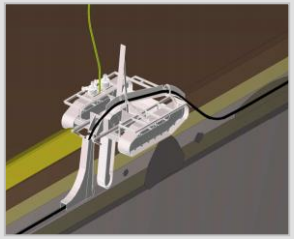
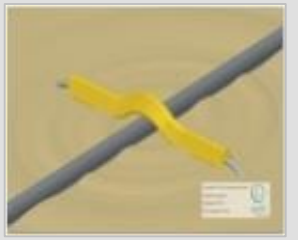


Training & Development of Employees

- Training, theoretical & practical
- Method development
- Tools development
- Test assembling of new accessories
- WPS, Welding Procedure Specifications
- Instructions
- Offshore Competence Group

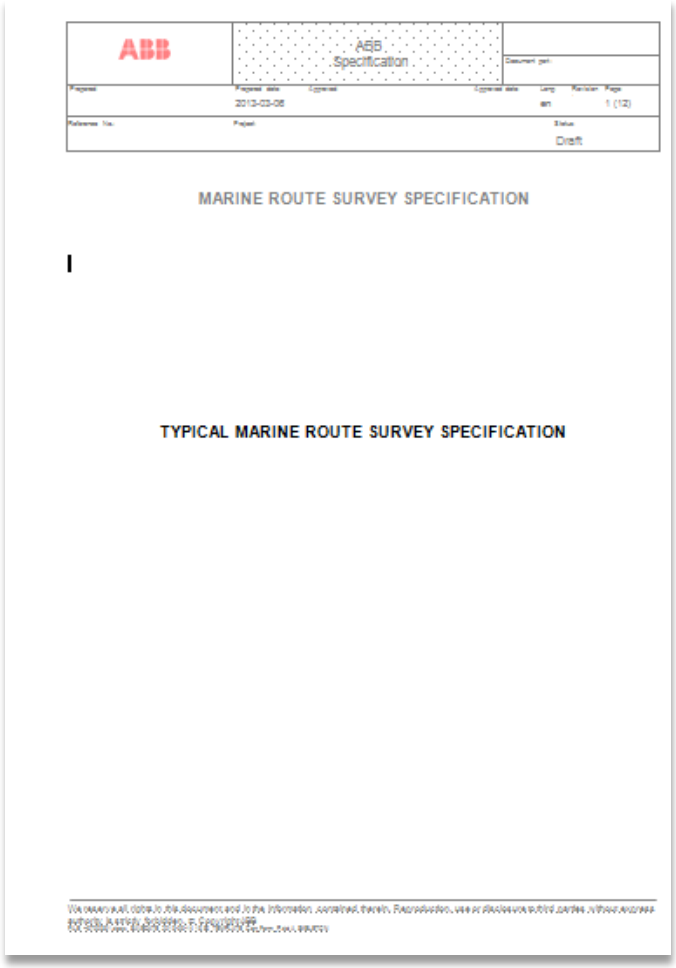
Offshore Engineering Centre (OEC)
Engineering Competencies

OEC Core Engineering Competencies

I	II	III	IV	V
Marine Survey	**Burial Assessment Studies**	**Route Engineering**	**MetOcean Analysis**	**Installation Protection Engineering**
Investigation and evaluation of geophysical and geotechnical reports	Investigation and evaluation of possible burial methods on a certain cable route	Optimisation of the route of a cable in a predetermined corridor	Investigate and evaluate the effect of weather dynamics on cable installation	Engineering of designs and cable behavior to ensure cable protection
				

- Focused on risk reduction management, in particular:
  - Project Planning
  - Execution Preparation
- Bringing together the main engineering components for offshore cable installation
- Founded in January 2012 in Rotterdam

1. Marine Survey
Assessment of Client survey information



ABB

ABB Specification

Draft

MARINE ROUTE SURVEY SPECIFICATION

TYPICAL MARINE ROUTE SURVEY SPECIFICATION

Recent Assessment of Client supplied surveys have highlighted the following:

- Gaps in survey coverage or narrow corridor
- Inadequate investigation of UXO items
- Inefficient Route Design
- Poor Burial Assessment Study (BAS)
- Results incorrectly presented on route alignment charts and reports

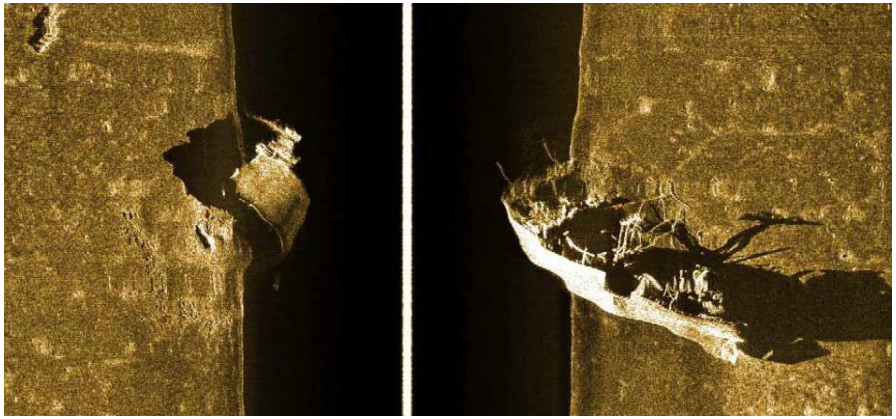
NOTE:

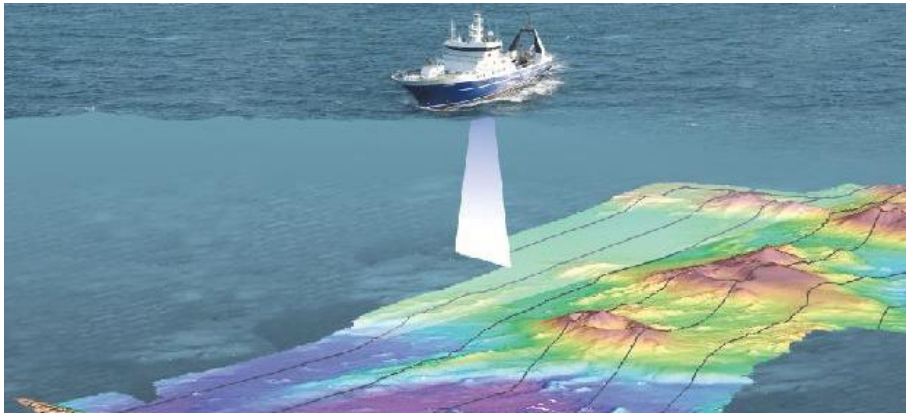
This may have a direct effect on the required scope of work, quality and ultimate contract price

ABB can supply a recommendation/typical marine route survey specification

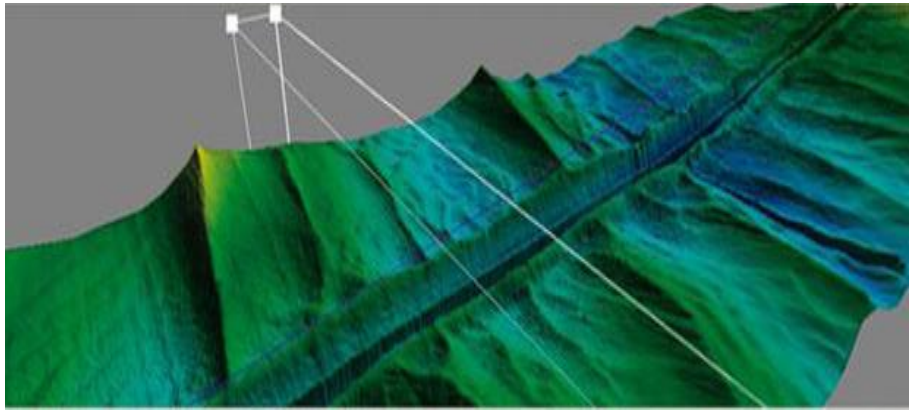
1. Marine Survey
Survey Elements

Side Scan Sonar

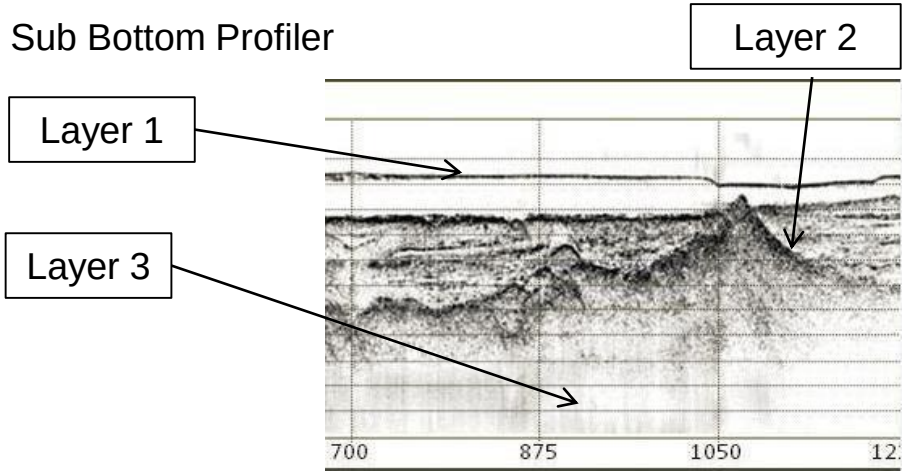




Multibeam



Sub Bottom Profiler



1. Marine Survey
Soil Data

Vibrocore

- Penetration of sea bed. Samples are recovered for route and trenching investigation.
  - Samples are normally sent to a laboratory for analysis

Cone Penetration Test (CPT)

- Provide information of soil type, stratification, shear strength in clays & relative density and angles of shearing resistance in sand
  - Results are immediately available

Recommendation

- The recommended number of sediment samples is in the region of 1 Nr per 1 km
- However, sea bed samples should be taken as required to confirm sediments

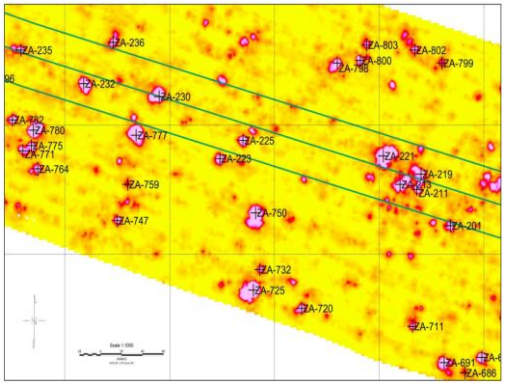
1. Marine Survey
UneXploded Ordnance (UXO) Risk

UXO dumping sites and minefields

- Conventional Ammunition
- Chemical Ammunition (Mustard gas)

Detected with magnetic survey

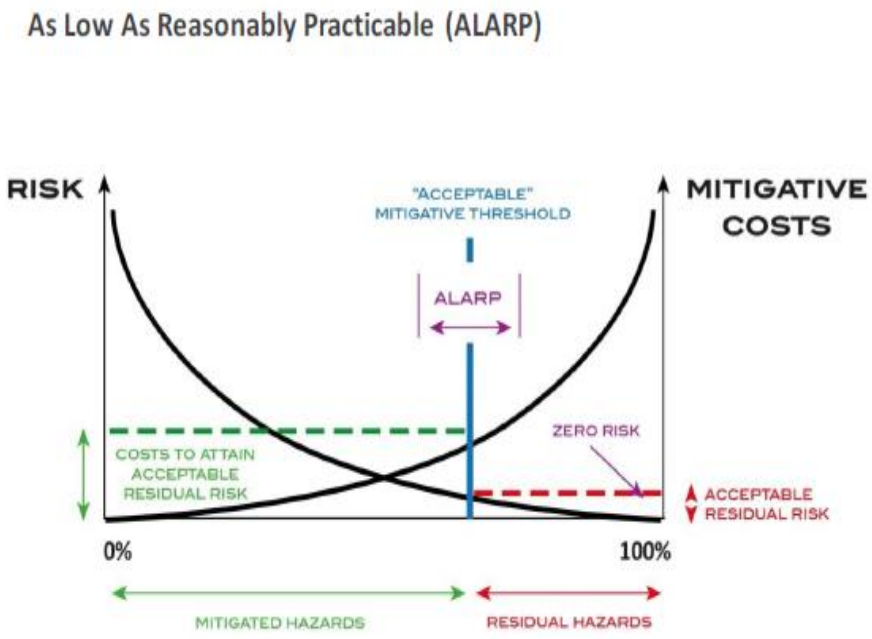
- Not every magnetic anomaly is an UXO
- Perform Proper UXO Survey & Desk top Study
- Density & Pattern of UXO's



Which of these buried magnetic contacts really is an UXO?

Magnetometer

1. Marine Survey
UXO Risks - Risk Management Framework Overview



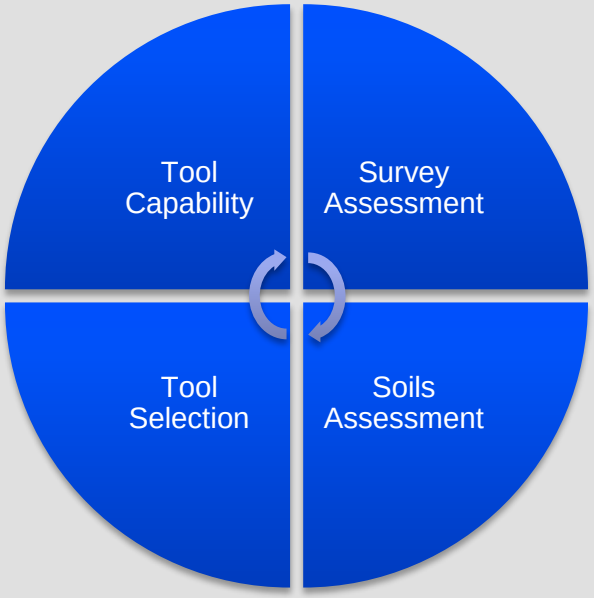
Risk Management Framework is Divided into 8Nr. Phases:

1. Hazard Assessment
2. Risk Assessment
3. Mitigation Strategy
4. UXO Specific Survey Requirements
5. Target Discrimination
6. Mitigation Actions
   - Avoidance – Route Engineering
   - Inspection
   - Disposal
7. Sign Off – ALARP Certificate
8. Deal with Residual Risk

2. Burial Assessment Study and Burial Tool Selection
ABB Burial Assessment Study (BAS) Process

Burial Assessment:- investigate the soil related risks on a cable route to define the optimal method of achieving the required protection

- Predictions of Burial Performance
- Updated BAS Matrix
- Update Summary Chart
- Mitigation suggestions
- Finalize BAS Report



- Access Quality of survey information
- Data Coverage
- Collaboration of all survey information

- Protection methodology
- Trenching Equipment Selection

- Geo-physical & Geo-technical Data
- Summary Chart
- Input to BAS Report

3. Route Engineering
Risk Management

Route engineering reduces the installation risks by avoiding problems whilst staying inside the provided corridor.

Sandwaves

“Problems” to avoid include the following:

- Steep slopes → > 12-15°
- Boulders → > 0.3 m heights
- Difficult soils → For instance Rock
- Archaeological findings → Wrecks
- When possible other (not involved) countries
- Sandwaves

Cable curvatures → Preferable R = 500m

- Curvatures with a radius < 500m are possible but not preferred

Optimize crossing locations/angle with other subsea assets

3. Route Engineering
Common concerns from Clients

"It makes the cable route longer"

- Yes in some instances, in other instances it makes it shorter
- Severe micro re-routing in the past has caused maximum increase in cable length of ~1%

"Any re-routing introduces new risks"

- Yes – it is very much about balancing risks.
- This certainly applies to UXO's
- Therefore surveys should not be too restricted in width

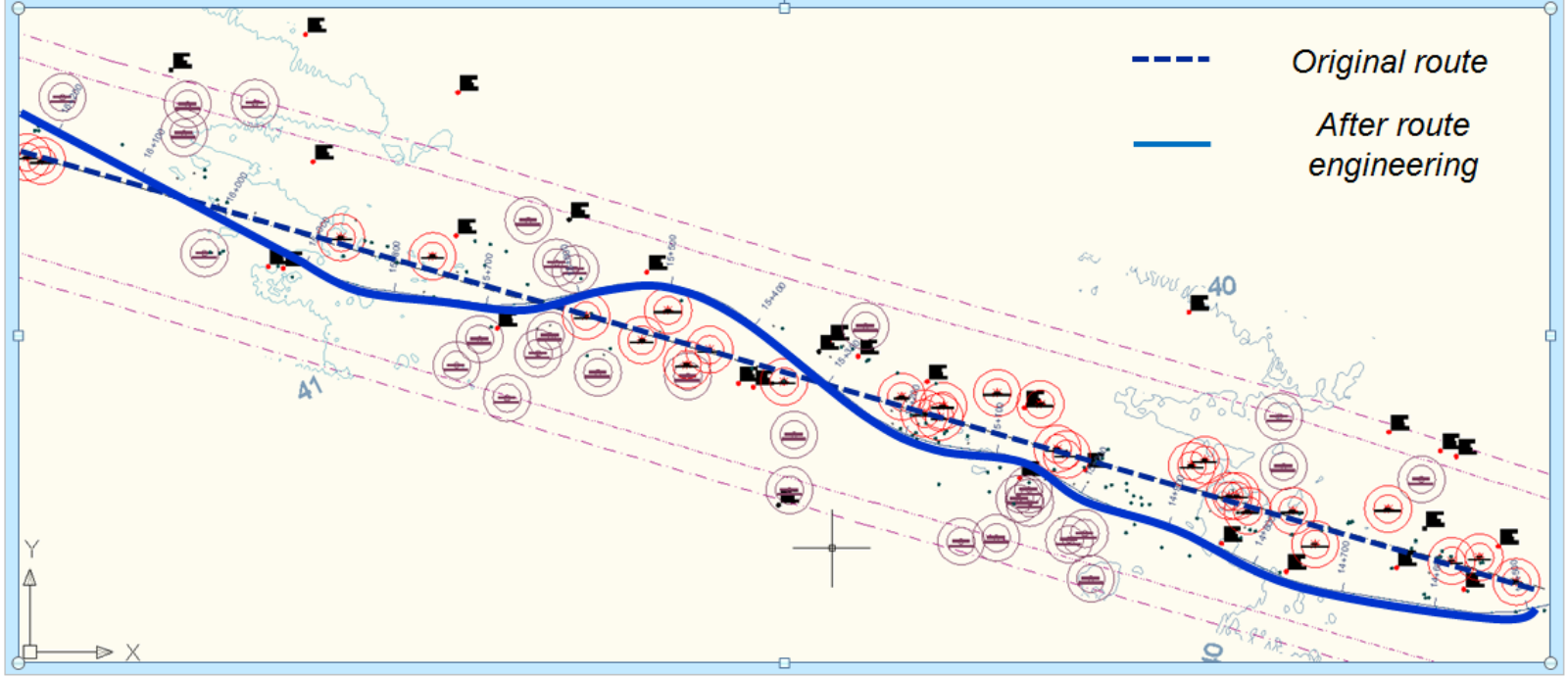
"It makes it all more complicated"

- Yes – But rather onshore with no vessel than offshore with vessels & associated day costs
- It very much depends on what you compare it with; Sea cables are a main infrastructure projects.

3. Route Engineering - Practice
Examples – Object avoidance

Original Route:
- Potential threats: e.g. boulders and UXOs
- High risk on possible damage to the cables
- Increase in costs and possible delay due to removal of objects offshore

After Route Engineering:
- Minimise risk by adjusting the route
- Costs offshore are a factor > 8 higher than onshore → cost efficient
- A well done preparation pays off!!!



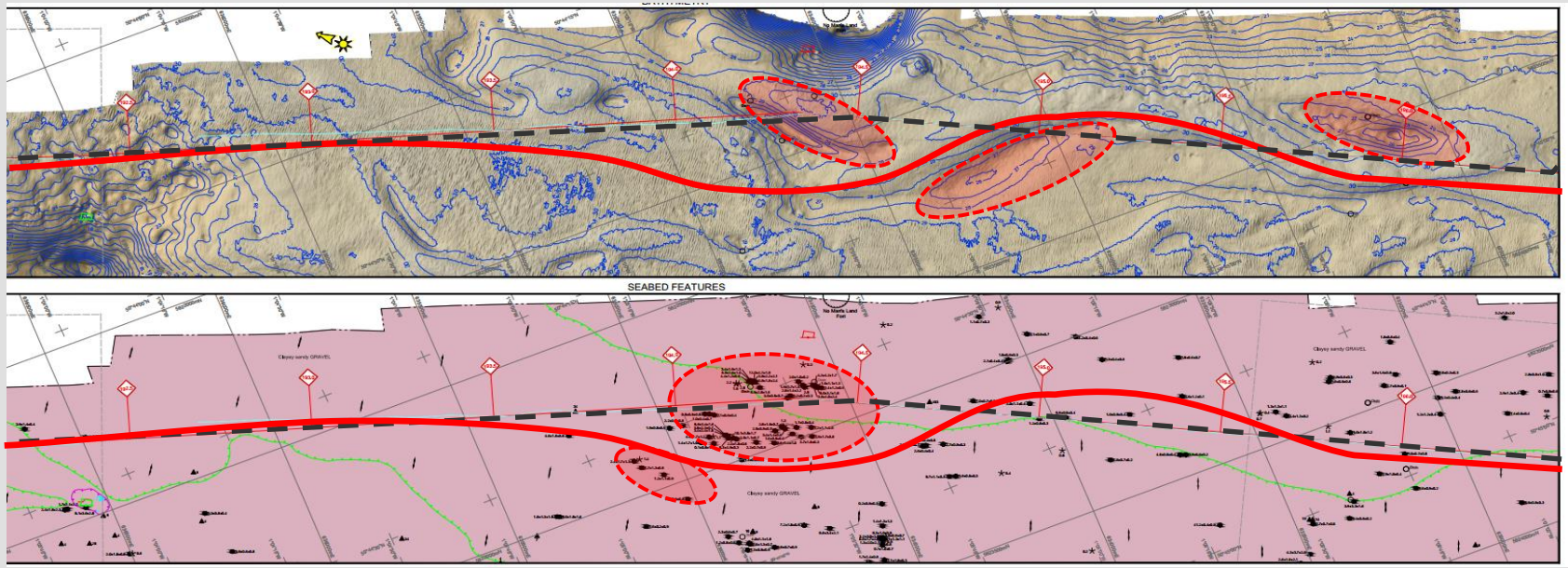
3. Route Engineering: Practice
Examples– Object and undulation avoidance

Original Route:

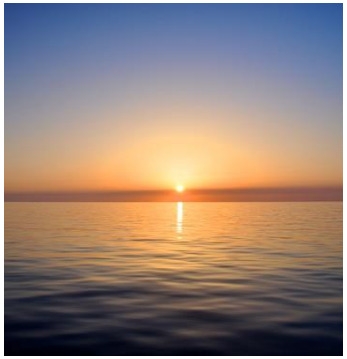
- Potential threats: Undulations and Objects
- High installation risk of possible damage to the cables & working above trencher capabilities
- Increase in costs and possible delay due to removal of objects offshore and risk of unprotected cable

After Route Engineering:

- Minimise risk by avoiding the obstacles
- Minimise risk by avoiding steep slopes
- Reduce risk of installation problems during the lay and burial campaign



4. MetOcean Analysis
What is Workability Assessment

Workability assessment looks at project specific weather risk for offshore installation operations.

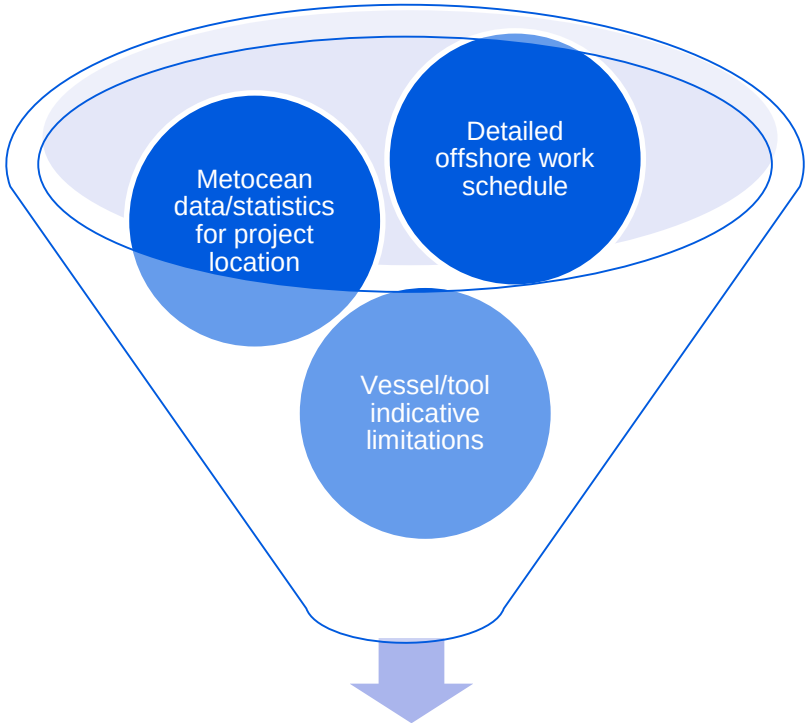
- It is an assessment of:
  - Vessel performance
  - Tool performance
  - Against expected weather conditions

4. MetOcean Analysis
Metocean factors to consider




- Wave height and direction
- Wind speed and direction
- Current speed and direction
- Visibility, sub sea and at surface
- Ice
- Temperature of air and water
- Tidal heights

4. MetOcean Analysis
Inputs - Overview



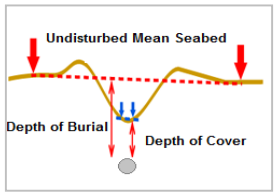
Workability Assessment

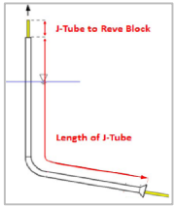
5. Installation Engineering
Design and engineer mitigation methods for cable threats

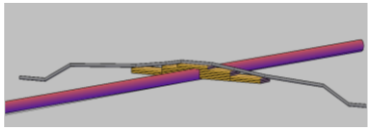
Engineering of cable protection design

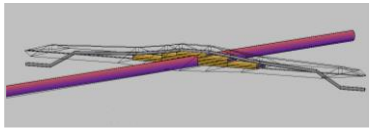
Design and engineering of cost efficient solutions for cable protection

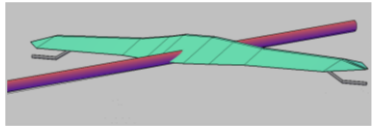
- Crossing design
- Rock placement design
- Trenching design
- Dredging engineering
- Pull-In engineering
- PLGR & route clearance design







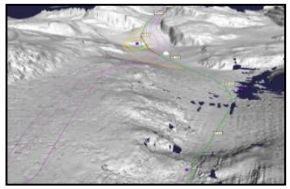


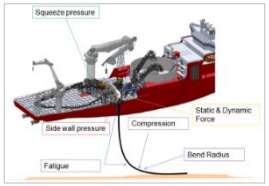


Cable installation design

Engineering and analysis of the cable dynamics during and after installation:

- Cable dynamics engineering
- Free span analysis



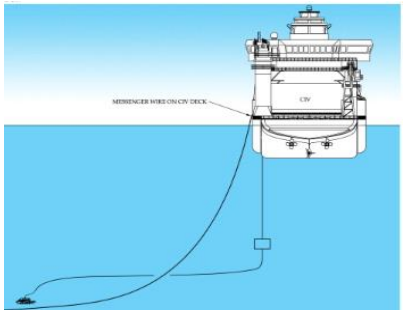


5. Installation Engineering
Cable Laying - Pull-in Works

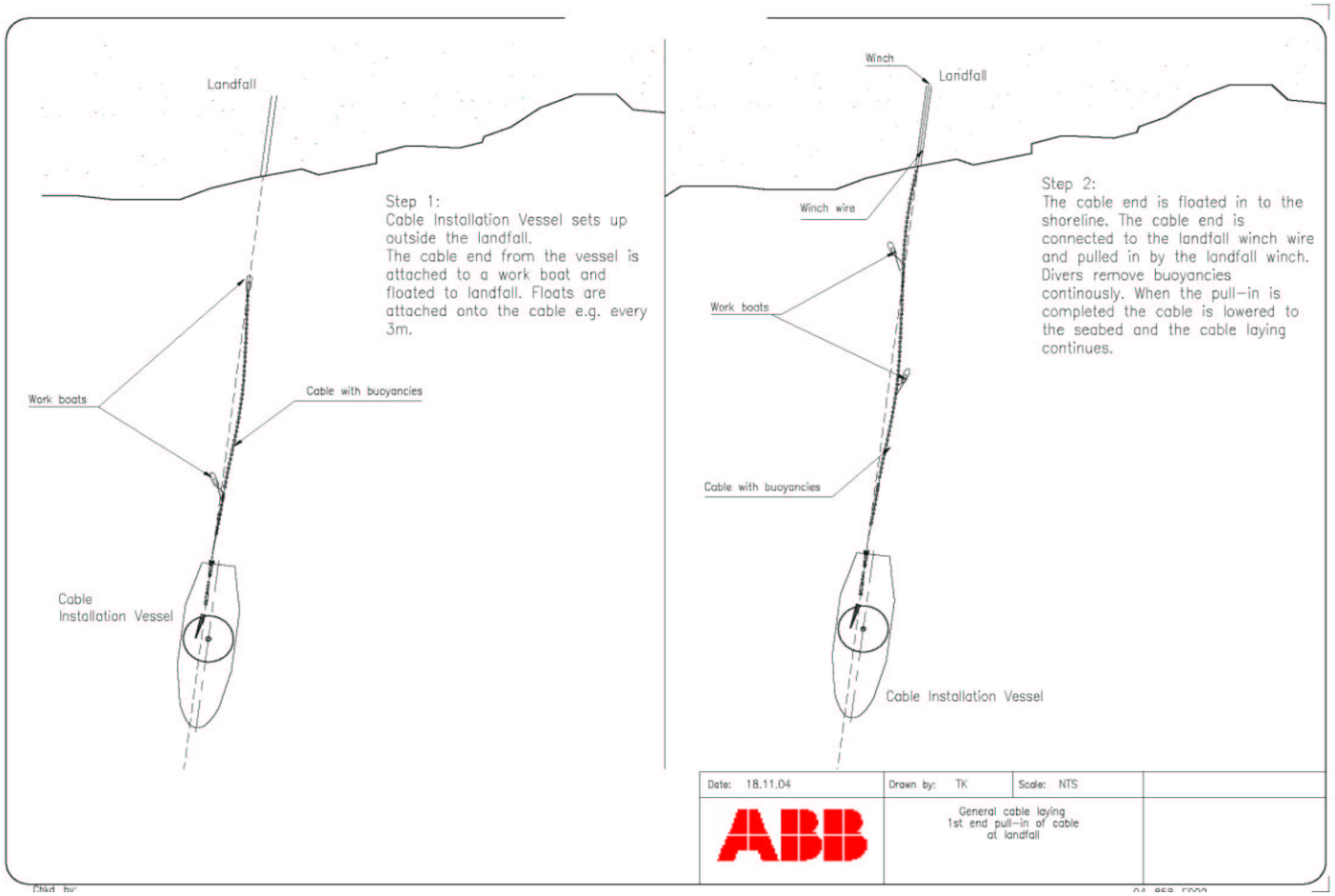
The world's first HVDC cable for 100 kV, 20 MW, Gotland-Swedish mainland. manufactured in 1953

Pull-in to Landfall

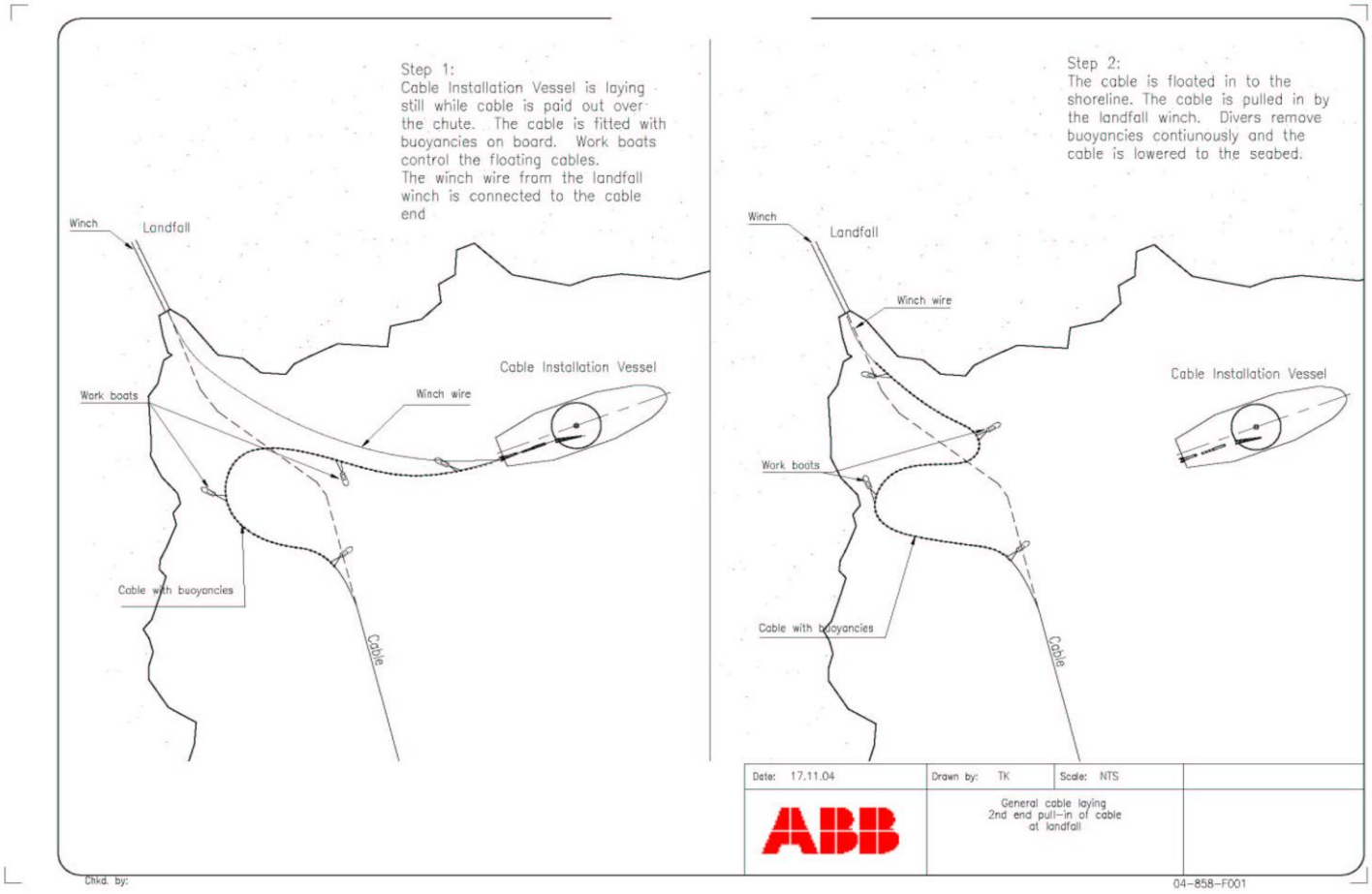
- Float in (Distance from Shore)
- Connect cable to messenger wire prior to pull in
- Shallow water vessel (Beach if required)
- Transition joint -Onshore cable to Offshore cable



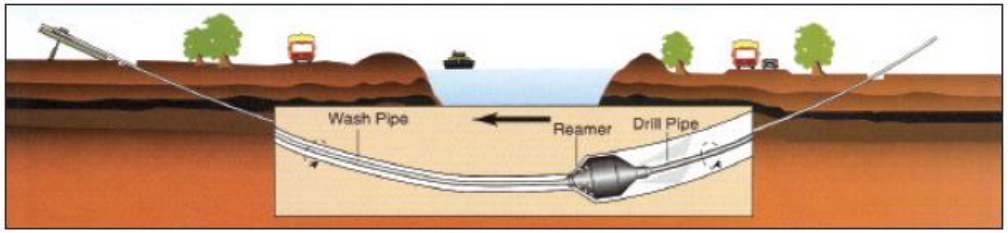
5. Installation Engineering
Schematic – Shore Pull 1st End



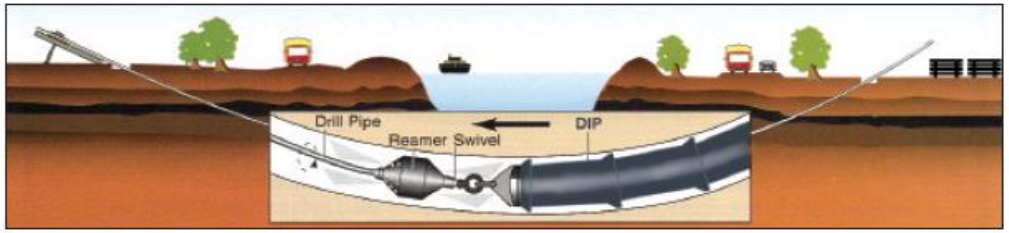
5. Installation Engineering
Schematic – Shore Pull 2nd End



5. Installation Protection Engineering
Landfall Preparation



PRE-REAMING



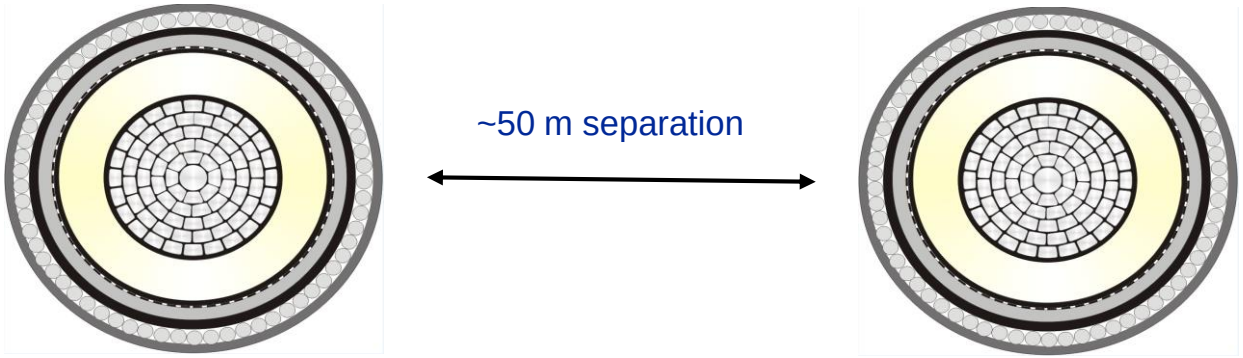
Schematics are courtesy of the Directional Crossing Contractors Association

PULL-BACK

Landfalls

- Horizontal Directional Drilling (HDD)
- Open cut
- Transition Joint Bay (TJB)
- Concrete foundation for winch

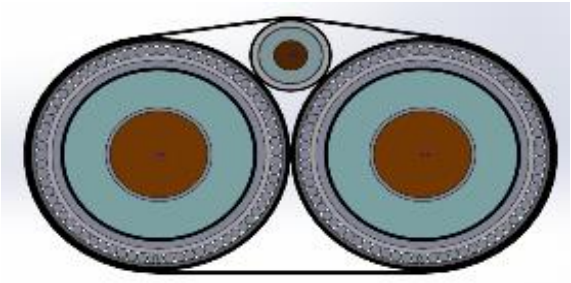
6. Single Lay vs Bundled Cables
HVDC Single Cables - Advantages



- No need of double turntables on cable lay vessel
- If an electrical failure occurs only the damaged cable has to be repaired.
- If an emergency cut and seal is required only one cable will be affected
- Possibility to lay longer lengths in one campaign without jointing (i.e. only utilize the larger turntable)
- Possibility to reduce size of conductor

6. Single Lay vs Bundled Cables
HVDC Bundled Cables - Advantages

- Significantly lower installation cost
- Half the Operational Time
  - *Reduced risk for Waiting on Weather (WoW)*
  - *Reduced risk for incidents during laying/trenching due to half the operational time*
- Half the soil and UXO risk
- Favorable in areas with high currents (more stable)
- Reduced loading time since two turntables can be loaded simultaneously
- Half the environmental impact (Trenching, Dredging, Rock Placement, PLGR etc)
- Half the number of crossings (cost, permits and crossing agreements)
- Reduced risk of mechanical failure (due to one “target” for trawlers and anchors)
- Half the quantity of Pre-sweeping (if required)
- Significantly less jointing time
- “Beneficial” for getting permits
- Earlier completion date
- One Route Engineering



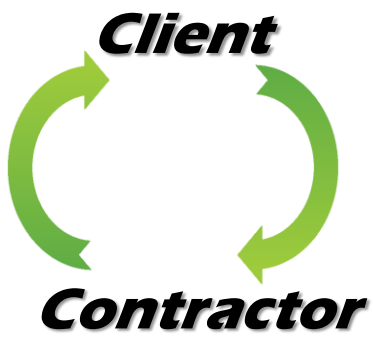
Risk Management
Client – Contractor Interaction

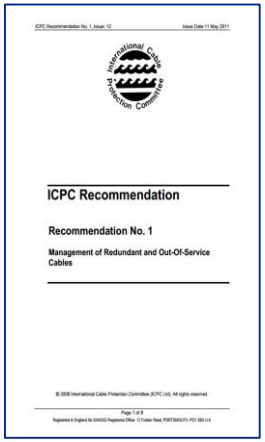
The Client – Contractor interaction is an very important aspect of the project

"If everyone is moving forward together, then success takes care of itself."
- Henry Ford

Good Communication
- Teamwork
- Good and open contact between all involved parties
- Open working relationship

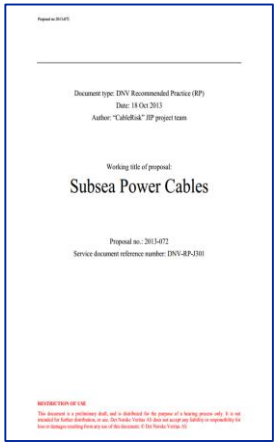
Use of Subsea Power Cable standards
- Recommendations of the ICPC
- DNV-RP-J301: Subsea Power Cable
- Applying standards may save time & money




ICPC Recommendation

Recommendation No. 1

Management of Redundant and Out-Of-Service Cables


Document type: DNV Recommended Practice (RP)
Date: 18 Oct 2013
Author: "CableRisk" JIP project team

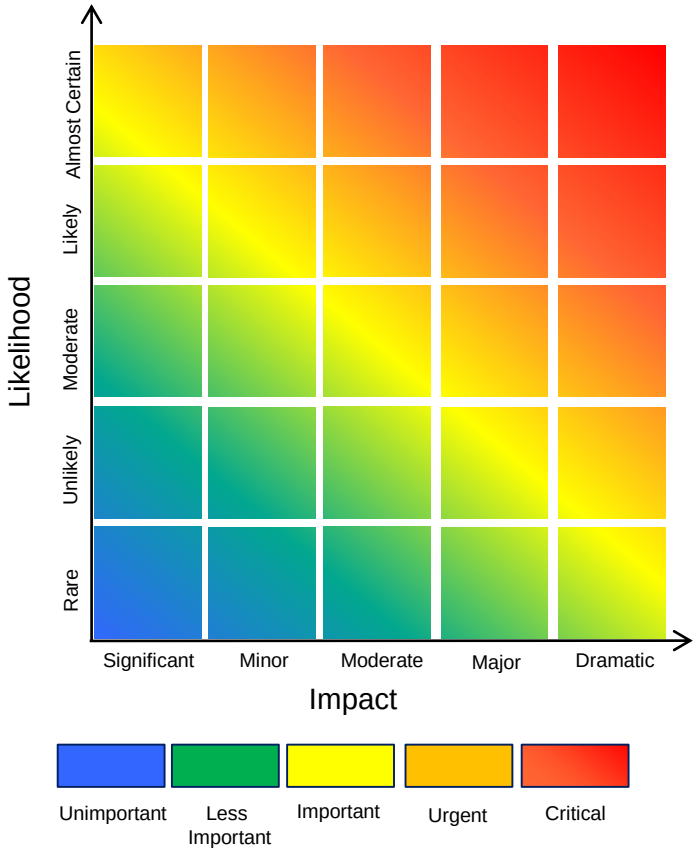
Working title of proposal:

Subsea Power Cables

Proposal no.: 2013-072
Service document reference number: DNV-RP-J301

Effective Installation
Summary

- Monitor and coordinate residual risks during all installation phases
- Take proper mitigation methods to keep these risks as low as reasonably possible



Avoidance & Mitigation

- Good quality information
- Risk Assessments
- Cable Protection Assessment
- Route Engineering
- Client – Contractor Interaction

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