What is a Submarine Pipeline and what are the Typical Pipeline Installation Methods?

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Agenda

- **Introduction**
- **Overview of Submarine Pipeline Installation Methodologies**
- **Conventional Pipeline Installation Methods**
- **Unconventional Pipeline Installation Methods**

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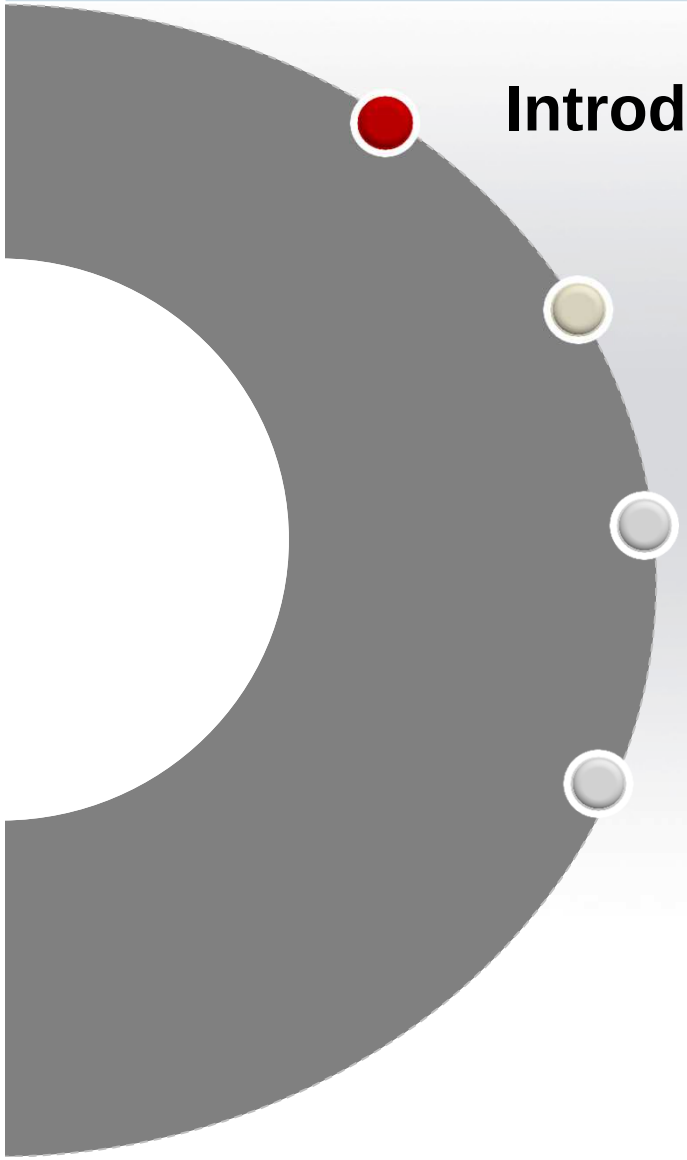

Introduction

Overview of Submarine Pipeline Installation Methodologies

Conventional Pipeline Installation Methods

Unconventional Pipeline Installation Methods

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What is a Submarine Pipeline?

- *A pipeline is a tube or conduit, usually metal, that carries liquids (e.g. as water and oil) or gas from one place to another.*
- *A submarine pipeline refers to a pipeline that is installed under water (across sea, river, lake, or bay).*
- *Pipeline can be flexible or rigid – typically, it is rigid.*
- *Pipeline arrangement can be single-pipe, pipe-in-pipe or bundled.*
- *Offshore Terminology:*
  - ***Subsea Flowlines (Infield):*** *transports fluid products between satellite wells or subsea manifolds and platforms.*
  - ***Riser:*** *transports fluid products from the seabed up to the processing facilities (e.g. Platform or FPSO).*
  - ***Export Pipeline (a.k.a. trunkline):*** *transports fluid products from the processing facilities to onshore.*

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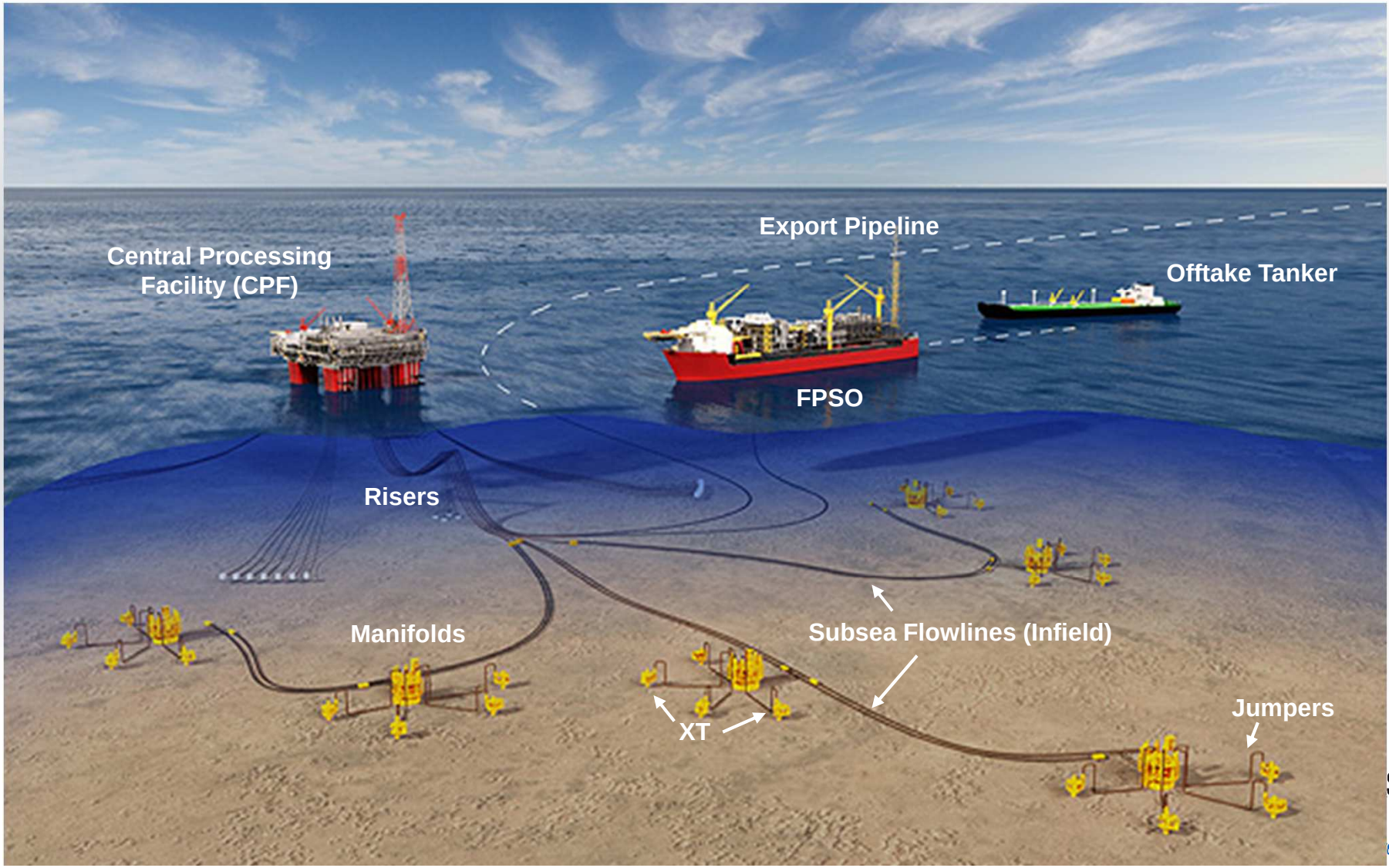
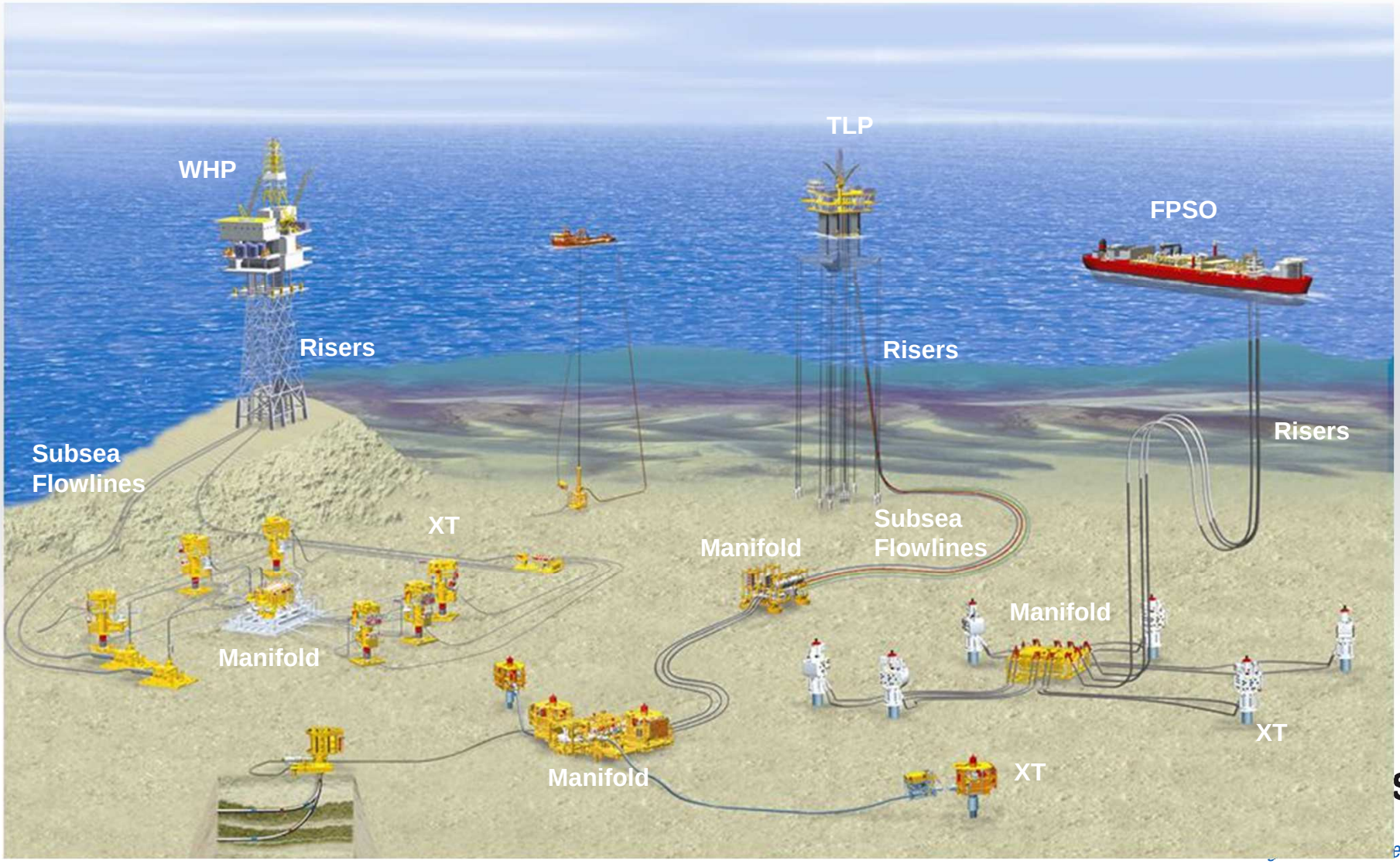
Subsea Field Development – Example



Subsea Field Development – Example



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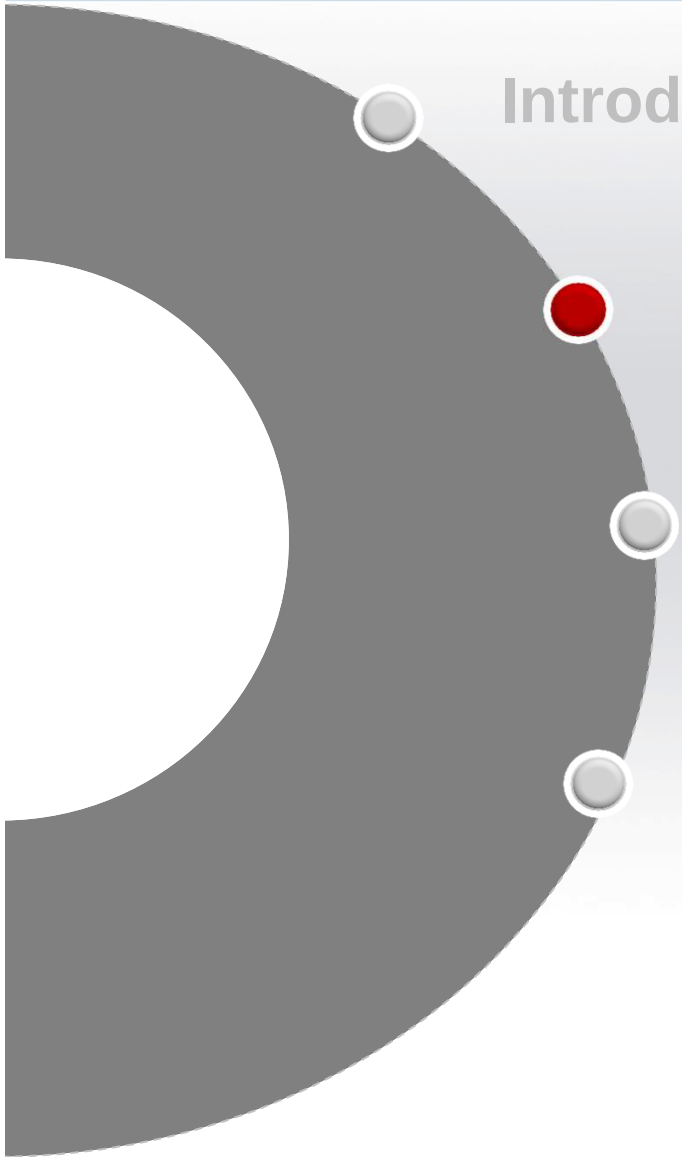

Introduction

Overview of Submarine Pipeline Installation Methodologies

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Unconventional Pipeline Installation Methods

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Installation Techniques for Submarine Pipelines

Conventional Pipeline Installation Techniques

- S-Lay
- J-Lay
- Reel Lay

Unconventional Pipeline Installation Techniques
(Examples)

- Surface Tow
- Below Surface Tow
- Bottom Tow
- Bottom Pull
- Push Pull Method (for Shorepull)
- Control Depth Tow Method
- Horizontal Directional Drilling

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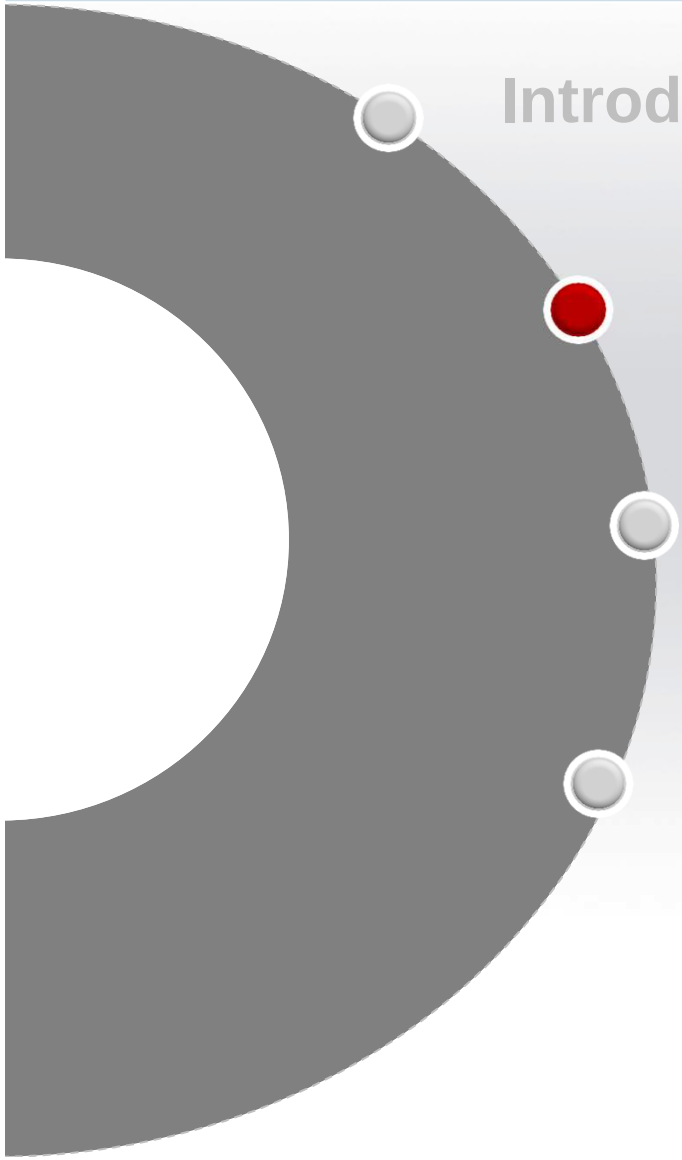

Introduction

Overview of Submarine Pipeline Installation Methodologies

Conventional Pipeline Installation Methods

Unconventional Pipeline Installation Methods

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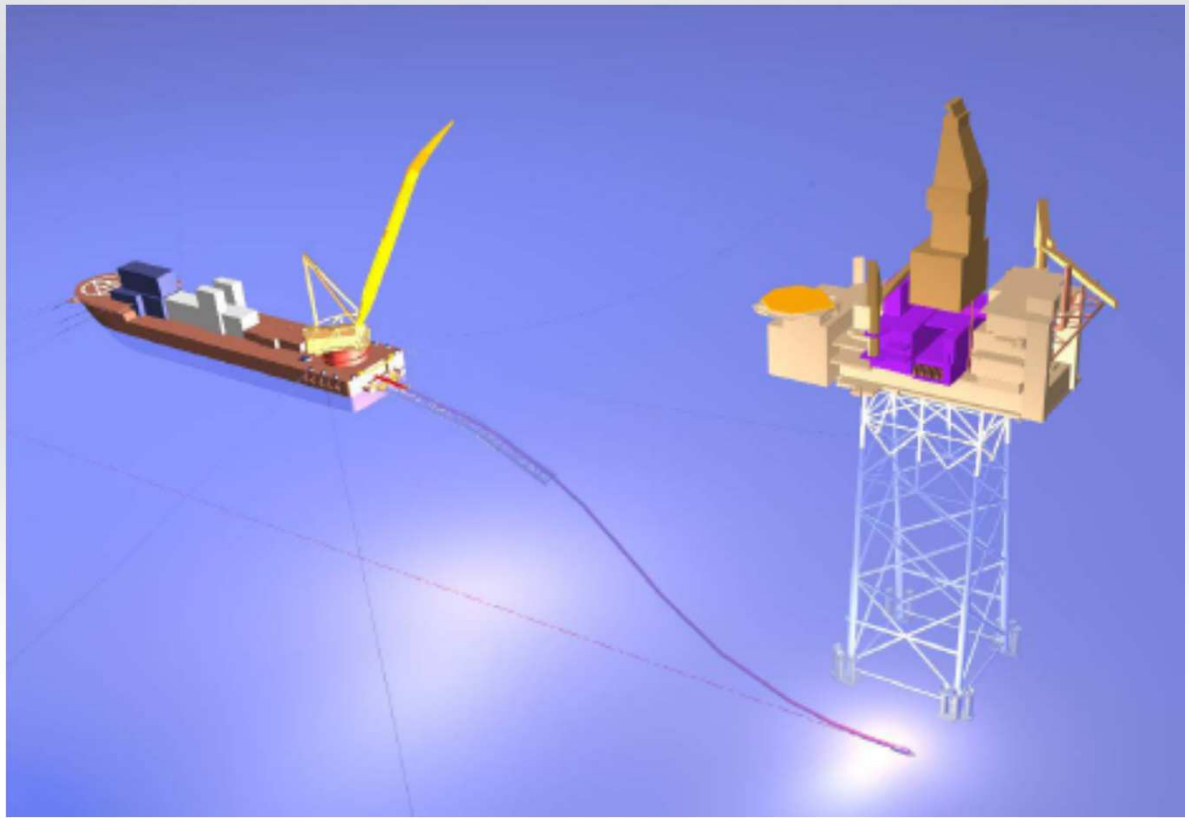
Conventional Pipeline Installation Methods

S-Lay

S-LAY INSTALLATION



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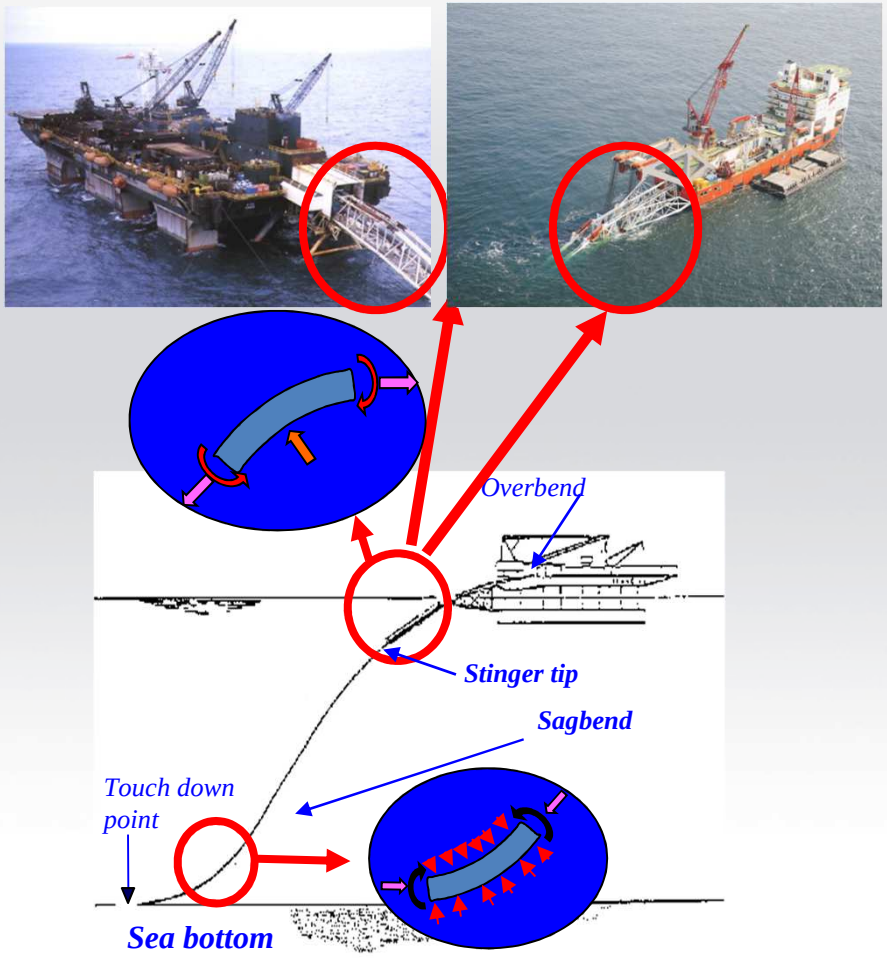
S-Lay

What is S-Lay?



- S-lay relates to the shape of the pipe curvature during the laying process.
- This is maintained by the stinger and tension that must be applied throughout the operation.
- It is a continuous process, with near-horizontal welding carried out over several stations in the firing line.
- Method can be applied to pipe diameter up to 60” (typically)
- Stresses/ strains are controlled by applied tension and stinger configuration
- S-lay technique may result in high residual tensions, which has disadvantage of increase span lengths and larger horizontal radii for routing.

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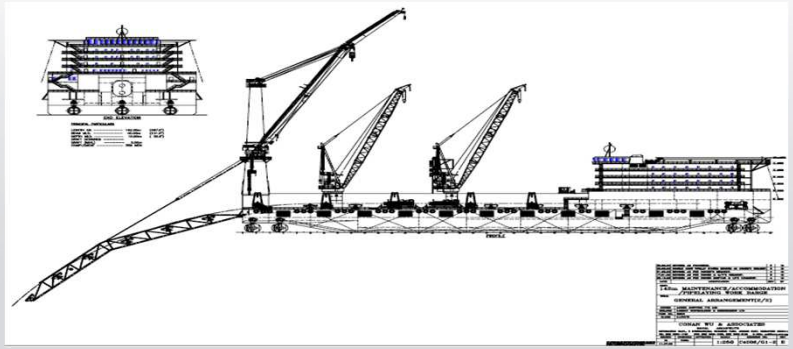
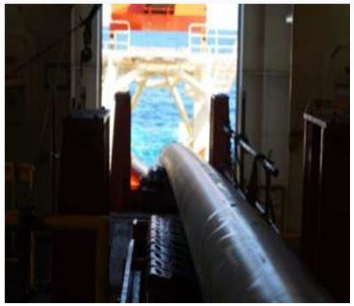
S-Lay

EMAS AMC's LEWEK CHAMPION

DP 2 HEAVYLIFT & PIPELAY VESSEL

Shallow to Medium Depths Pipelaying





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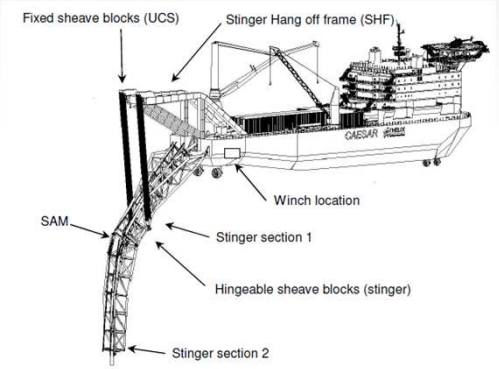
S-Lay

EMAS AMC's LEWEK CENTURION
(previously known as CAESAR)

DP PIPELAY VESSEL

Medium to Deepwater Pipelaying



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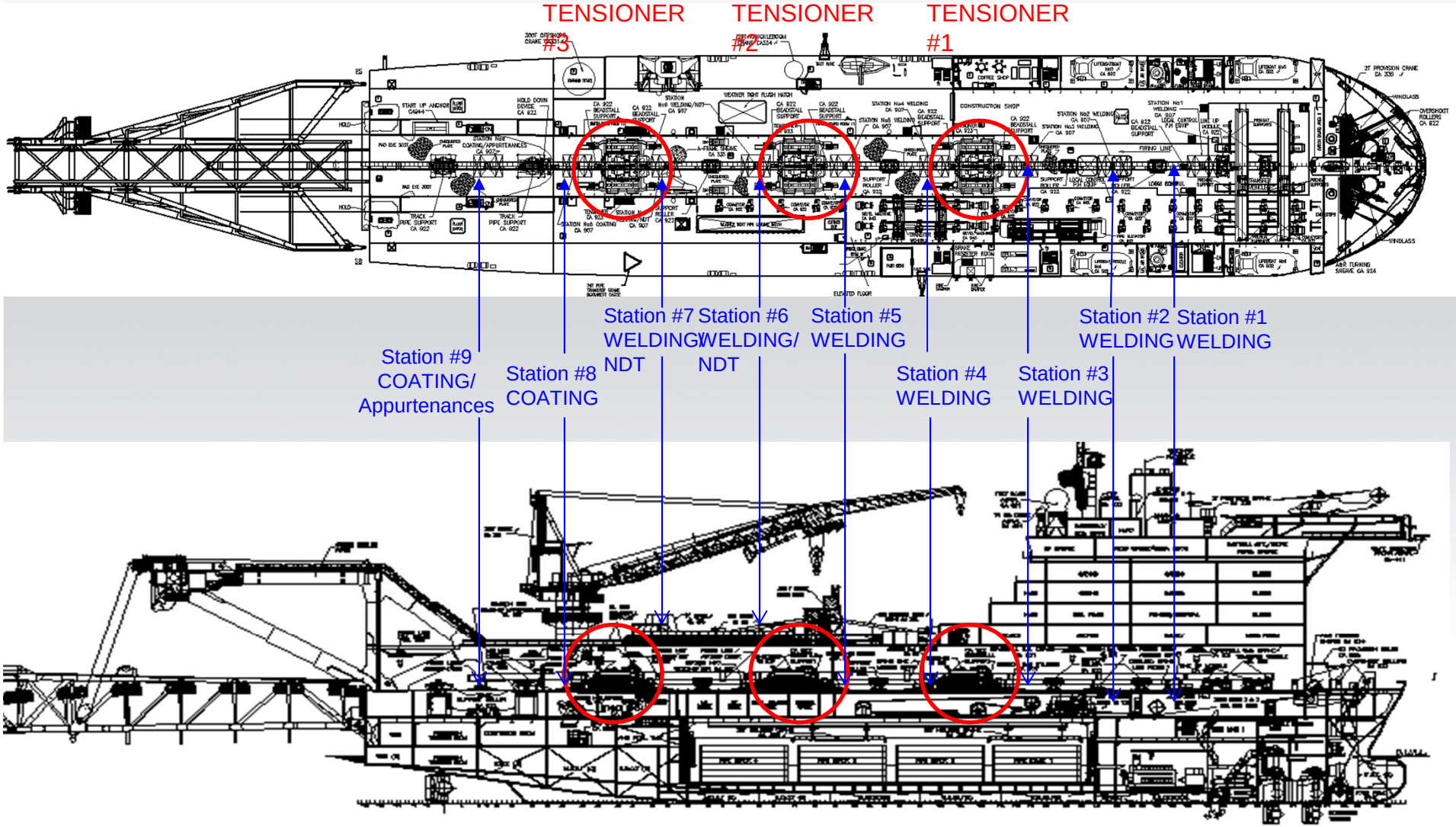
S-Lay

EMAS AMC's LEWEK CENTURION Equipment Layout

Pipe assembly on horizontal ramp on lay vessel



Conventional Pipeline Installation Methods

S-Lay

TYPICAL S-LAY OPERATION ON EMAS AMC's VESSEL

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S-Lay

Offloading of Line Pipes and Commencement of Pipelay (Start-Up)

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S-Lay

Welding of Line Pipes to Form Pipeline






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S-Lay

Perform NDT (Phased Array UT) and Complete Field Joint Coating






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S-Lay

Connect Laydown Head and Abandon Pipeline

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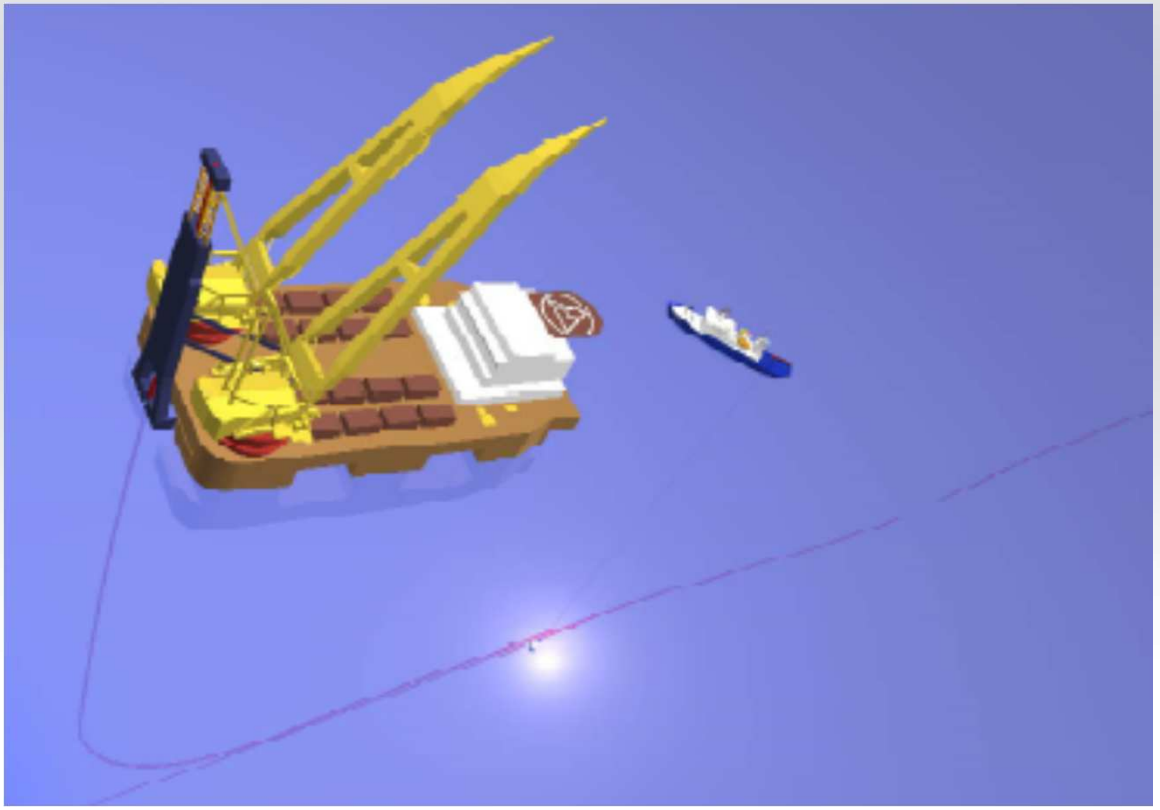
Conventional Pipeline Installation Methods

J-Lay

J-LAY INSTALLATION



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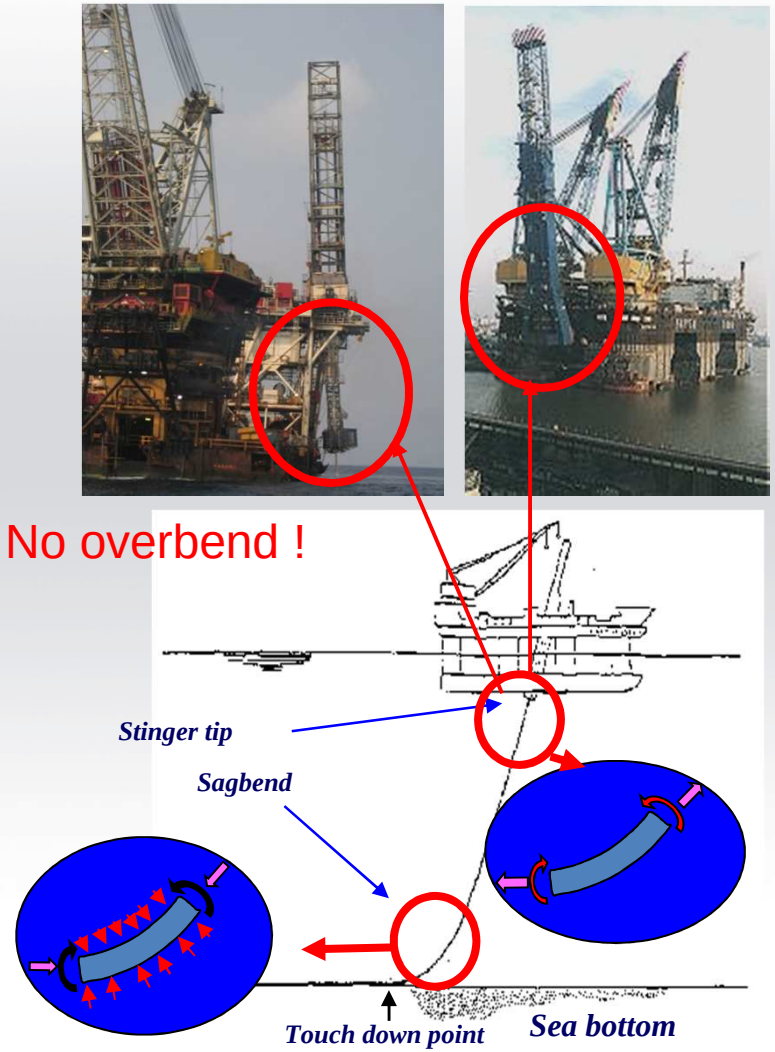
J-Lay

What is J-Lay?



- J-lay methodology is a proven technique for laying pipelines in very deep waters (not shallow water)
- The pipe is laid through an almost vertical ramp positioned on board the vessel.
- Typically there is only one welding station (slower lay rate) but J-lay pipes are normally pre-assembled in 2 (double joints), 4 (quad joints) or 6.
- J-lay offers the following advantages:
  - Allows the pipe to be laid in a more natural configuration
  - Pipe stresses are maintained well within the elastic limit
  - Lower tension required, resulting in reduced on-bottom tension – hence, reduced free spans
  - Less susceptible to weather conditions
  - Vessel is free to choose an optimal heading to minimise environmental forces
- Method can be applied to pipe diameter up to 32” (typically)

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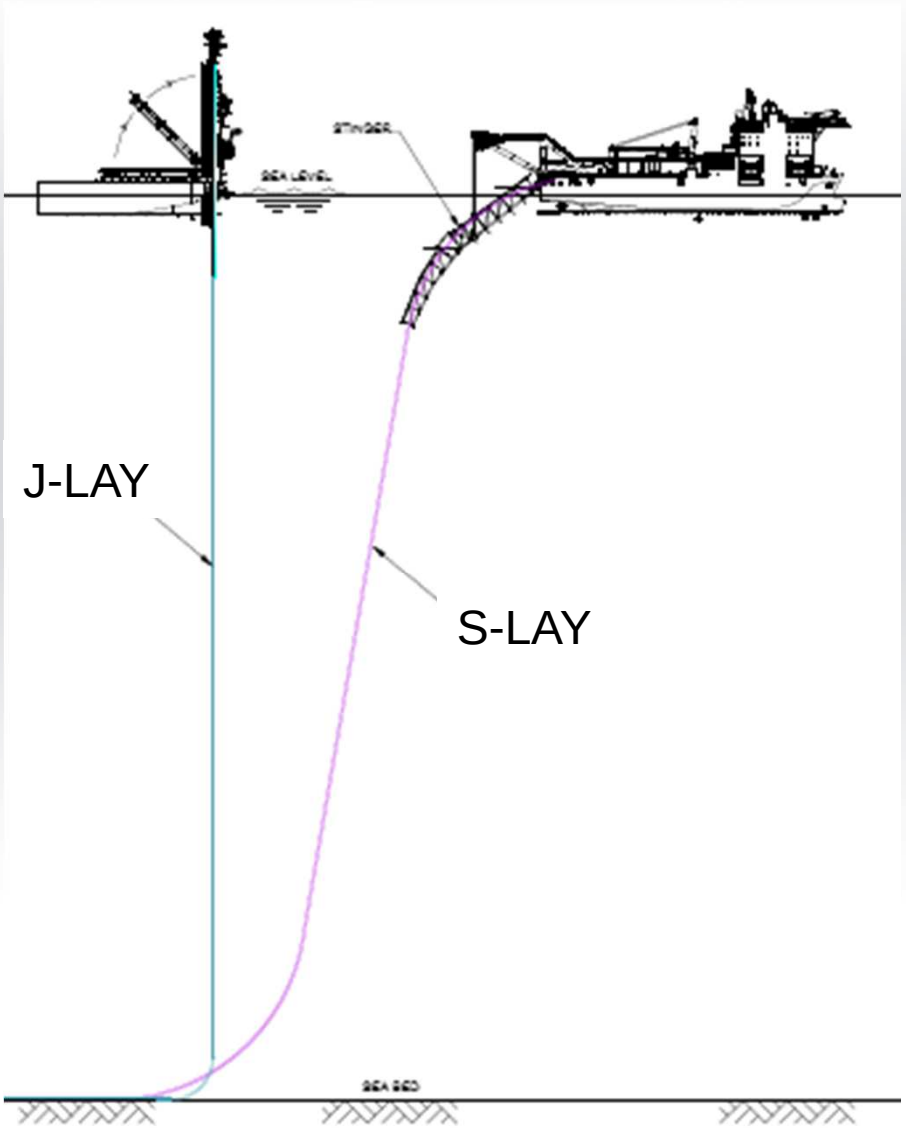
J-Lay vs S-Lay

Schematic



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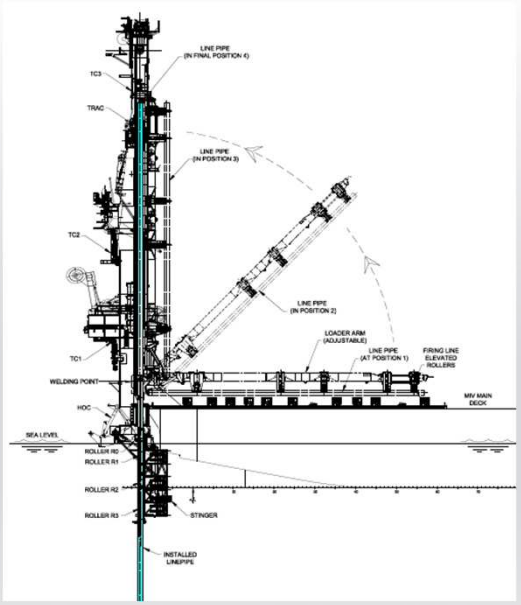
J-Lay

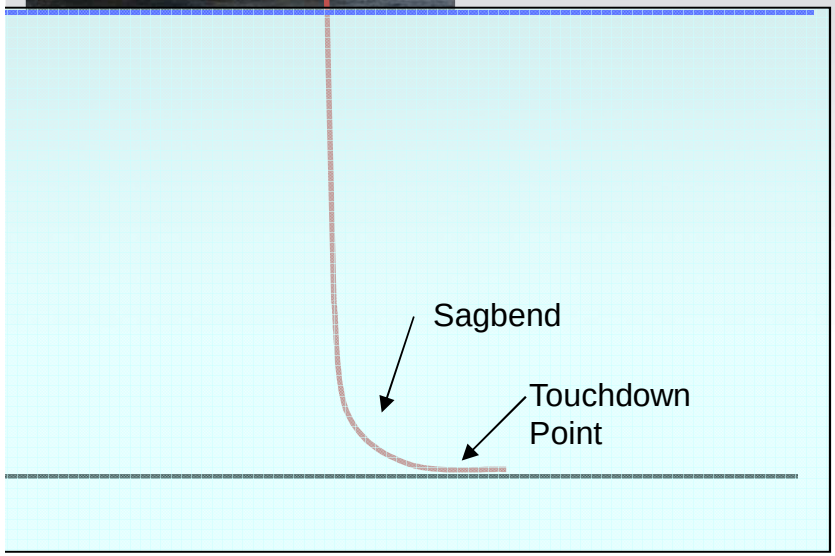
Typical Equipment Layout

Top Tension holding the pipe in place

J-Lay equipment layout varies with each vessel (depending on design of J-Lay tower) but typically consist of:

- Welding & NDT (1-2 stations)
- Field Joint Coating





- A complex handling system lift the stalks from horizontal position into J-lay tower
- Once in the tower, pipe stalk is aligned with preceding pipe string
- Weld connection & NDT
- Apply field joint coating
- Move vessel forward
- Pay out tensioner

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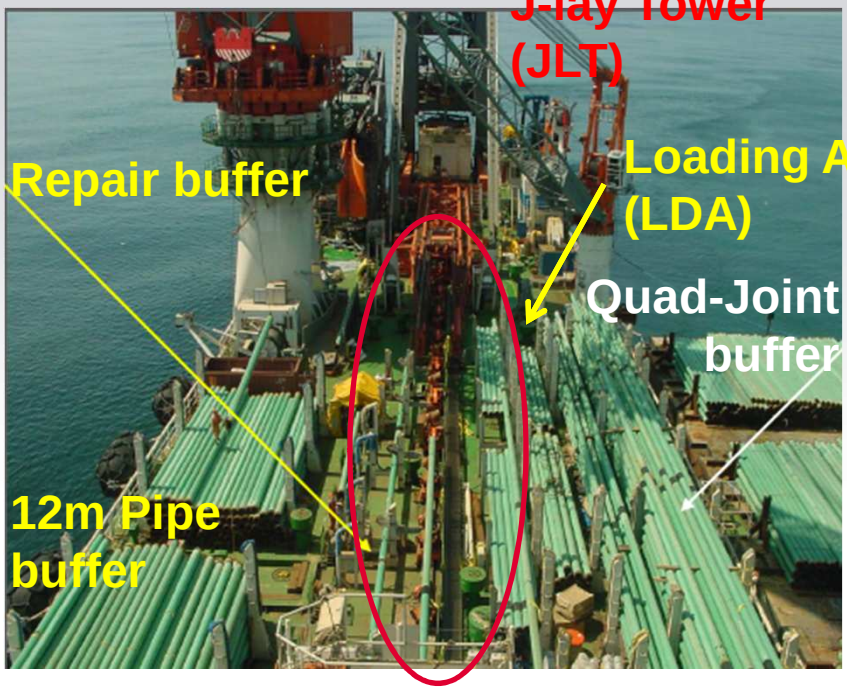
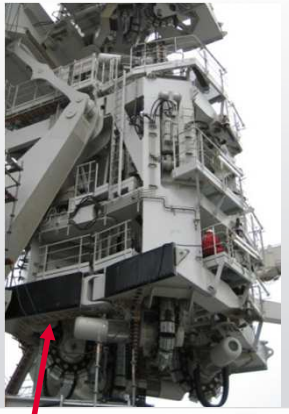
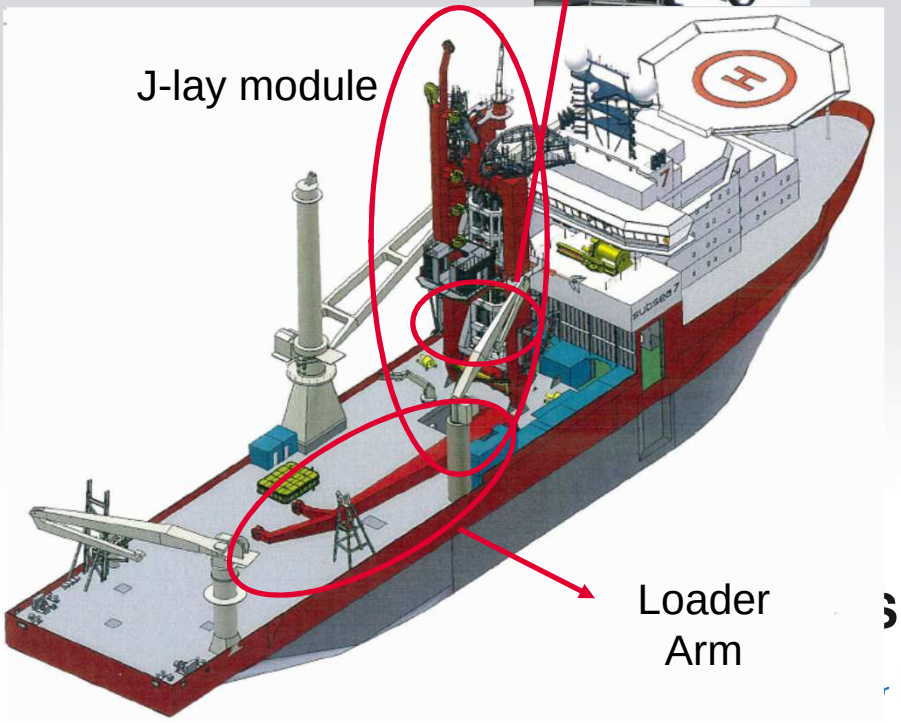
J-Lay

Typical Equipment Layout (Saipem's FDS 1 and Subsea7's Seven Seas)



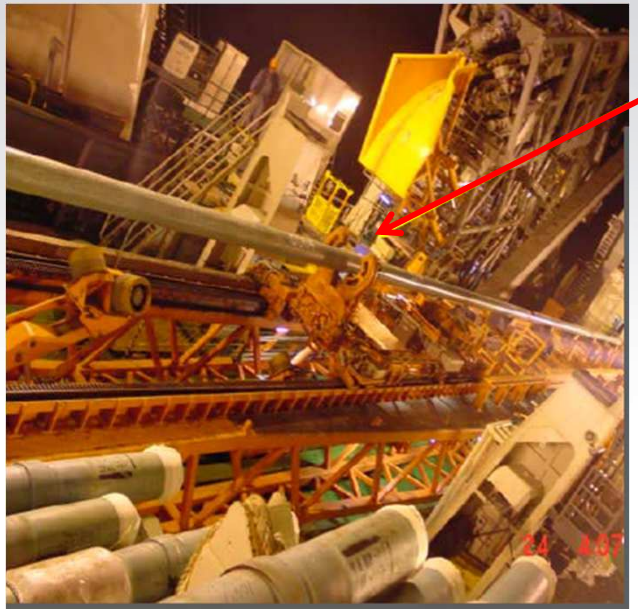
Tensioner





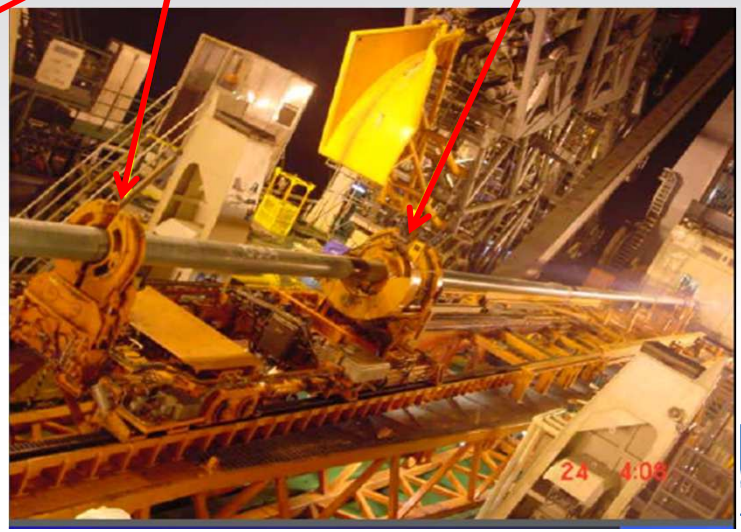
J-Lay

Welding of Single Joints to Form Double/ Quad Joints



Loading Arm Secures Quad-Joint

Clamp Trolley of Loading Arm



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J-Lay

Transfer of Quad-Joints for Alignment with Preceding String and Subsequent Welding

LDA in the tower, tower clamps in position & QJ lowered for line-up

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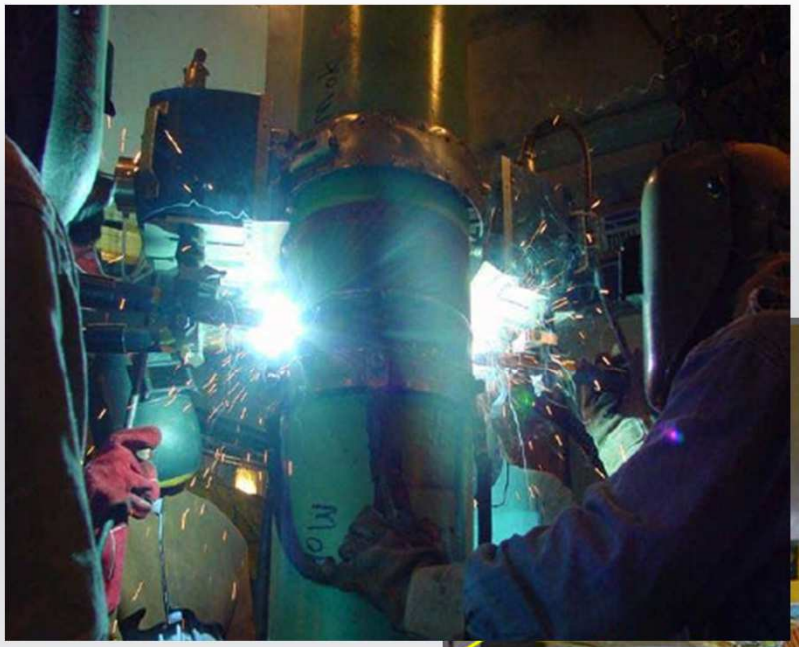
Welding of New Quad-Joints to Preceding String



Display Unit

Welding

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J-Lay

Welding of New Quad-Joints to Preceding String

Travelling Clamp

Tower Clamp

Travelling Clamp

Hang-off Clamp

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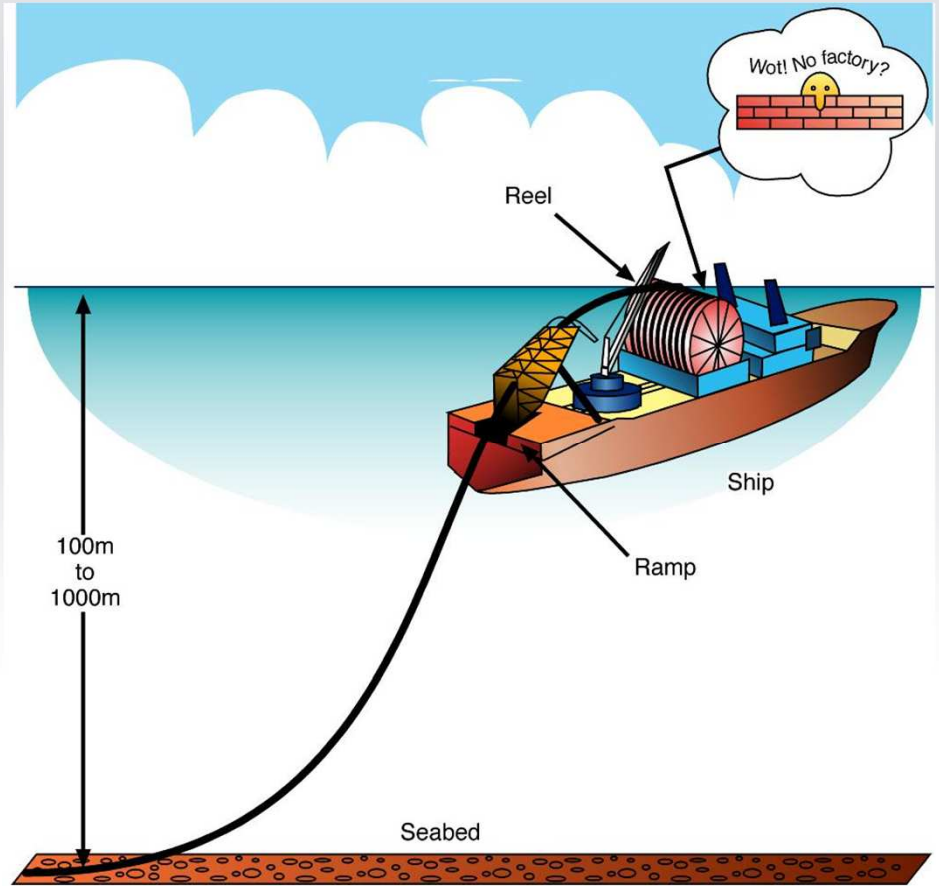
Conventional Pipeline Installation Methods

Reel Lay

REEL LAY INSTALLATION



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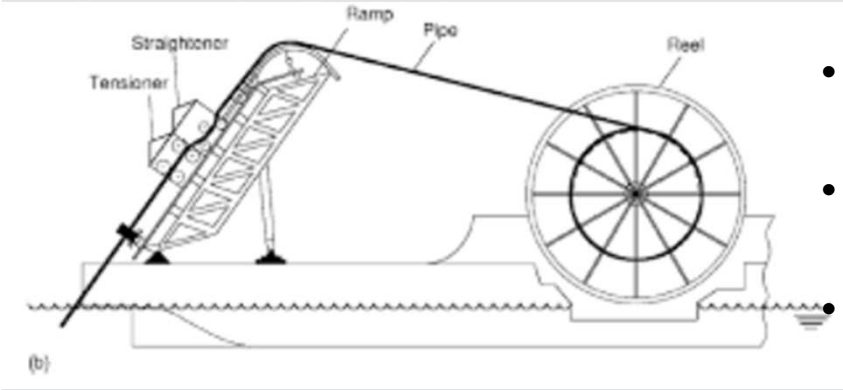
Reel Lay

What is Reel Lay?



- Reel-lay is the process where rigid (or flexible) pipe is un-spooled from a drum, straightened, tension applied, and then laid over a ramp to the seabed.
- Essentially, the pipe is fabricated onshore and reeled onto a large drum (on the laybarge).
- The pipe is unreeled, straightened, then passed through a tensioner prior to leaving the vessel.
- Majority of vessels have the reel positioned such that the pipeline unwinds in the vertical plane.
- Benefits of reeling as installation method:
  - Onshore welding and fabrication
  - Enables greater assurance of welds as they can be tested onshore
  - Minimize offshore welding and, hence, installation time, resulting in overall increase of lay rate in comparison with S-lay and J-lay techniques
- Often most economical method for pipeline up to 16” OD

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Reel Lay

What is Reel Lay (Cont'd) ?

- Pipe joints are welded to form stalks at onshore spool base
- Stalks are welded together as they are reeled onto spool on the reel barge
- Reel vessel travels to site

EMAS's Ingleside Spool base

Disadvantages:

- Higher steel wall thickness for allowable curvature during onshore spooling and offshore installation
- Limited max outside diameter (typically 16")
- Limitation of coating options
- Need for a spool base

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S-Lay

EMAS AMC's "LEWEK EXPRESS"

Express - Multi-service Vessel

Express is reel pipeline construction vessel having 2 reels capable of holding 3,000 tons of pipe up to 14 inches in diameter.

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Reel Lay

EMAS's Ingleside Spool Base – Texas, USA

Reel Lay

EMAS's Planned Spool Base – Halsvik, Norway

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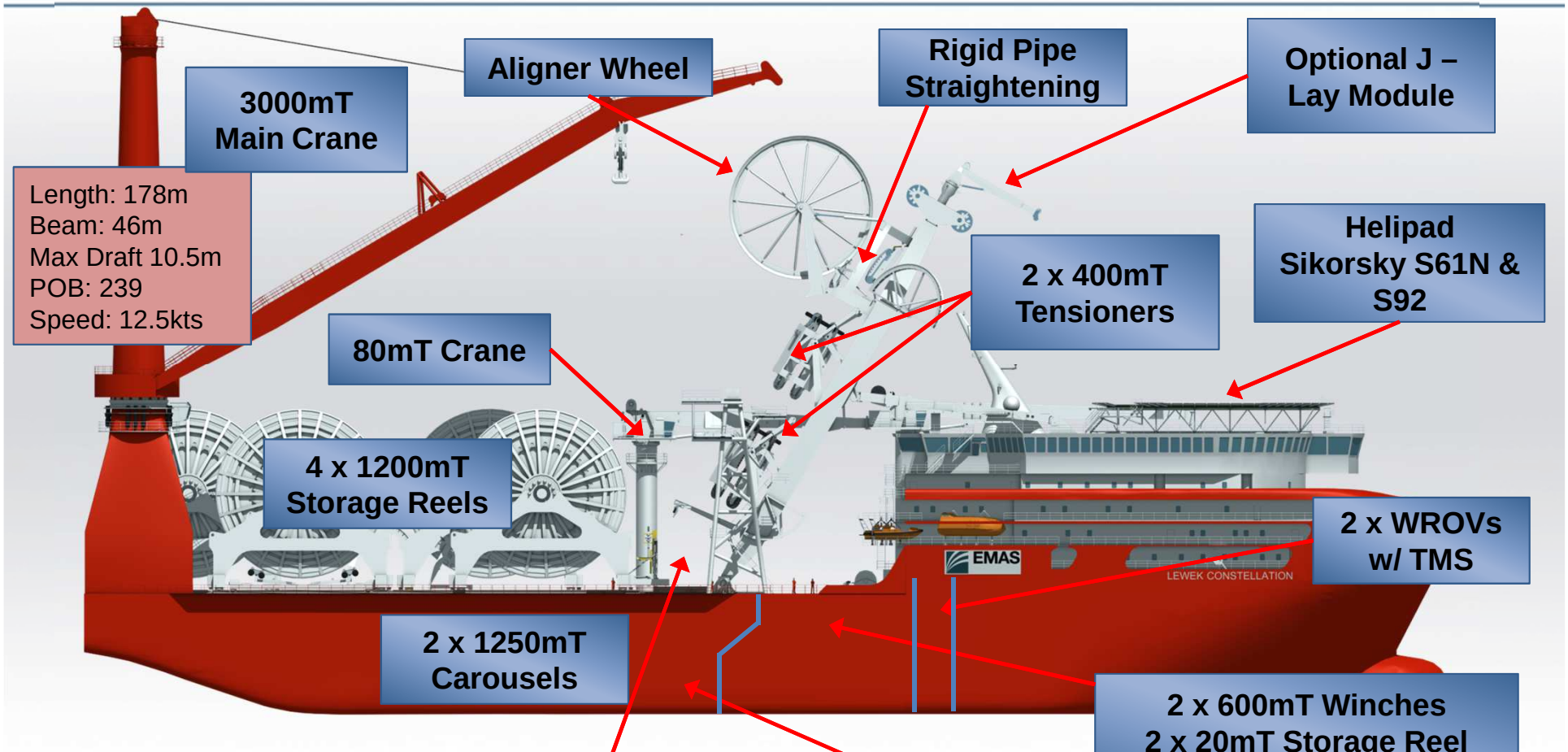
Reel Lay

EMAS's State-of-the-art Multi Lay Vessel "LEWEK CONSTELLATION"

OPERATIONAL 2014



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Reel Lay

EMAS's State-of-the-art Multi Lay Vessel "LEWEK CONSTELLATION"

OPERATIONAL 2014

- Rigid pipelines and SCR's up to 16" (by reel lay)
- Umbilicals and flexibles
- Flexible and Rigid Jumpers
- Heavy Lift / Subsea Construction
  - Topsides, Manifolds, Piles

Traditional vs Modern Reel Lay Vessel

Traditional: Pipe Spool fixed on the reel barge

- Limited pipe length

Modern:

- Pipe spools can be reeled on dedicated spools and transported offshore to be loaded onto the vessel to replenish pipe supply
- More pipes can be laid

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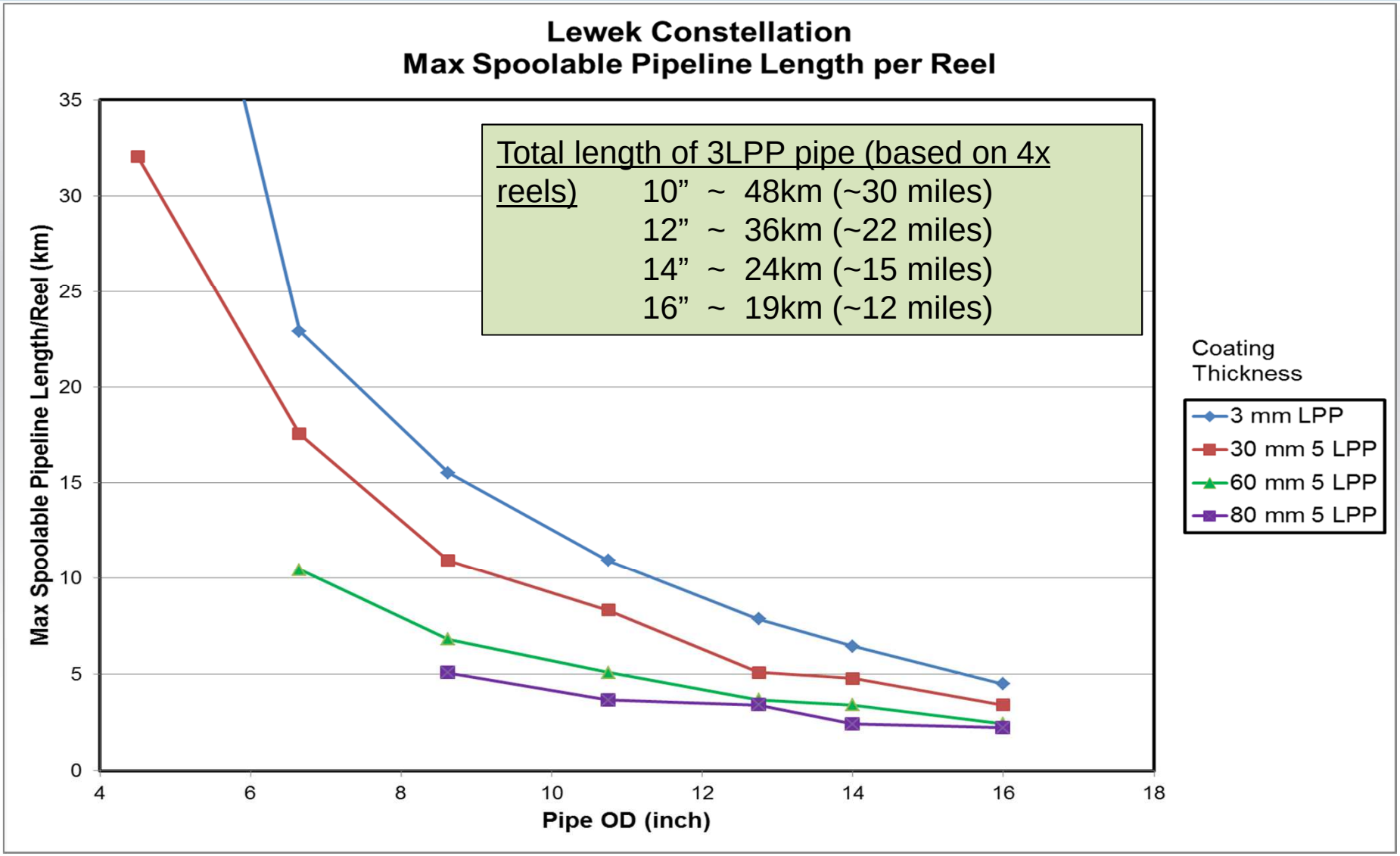
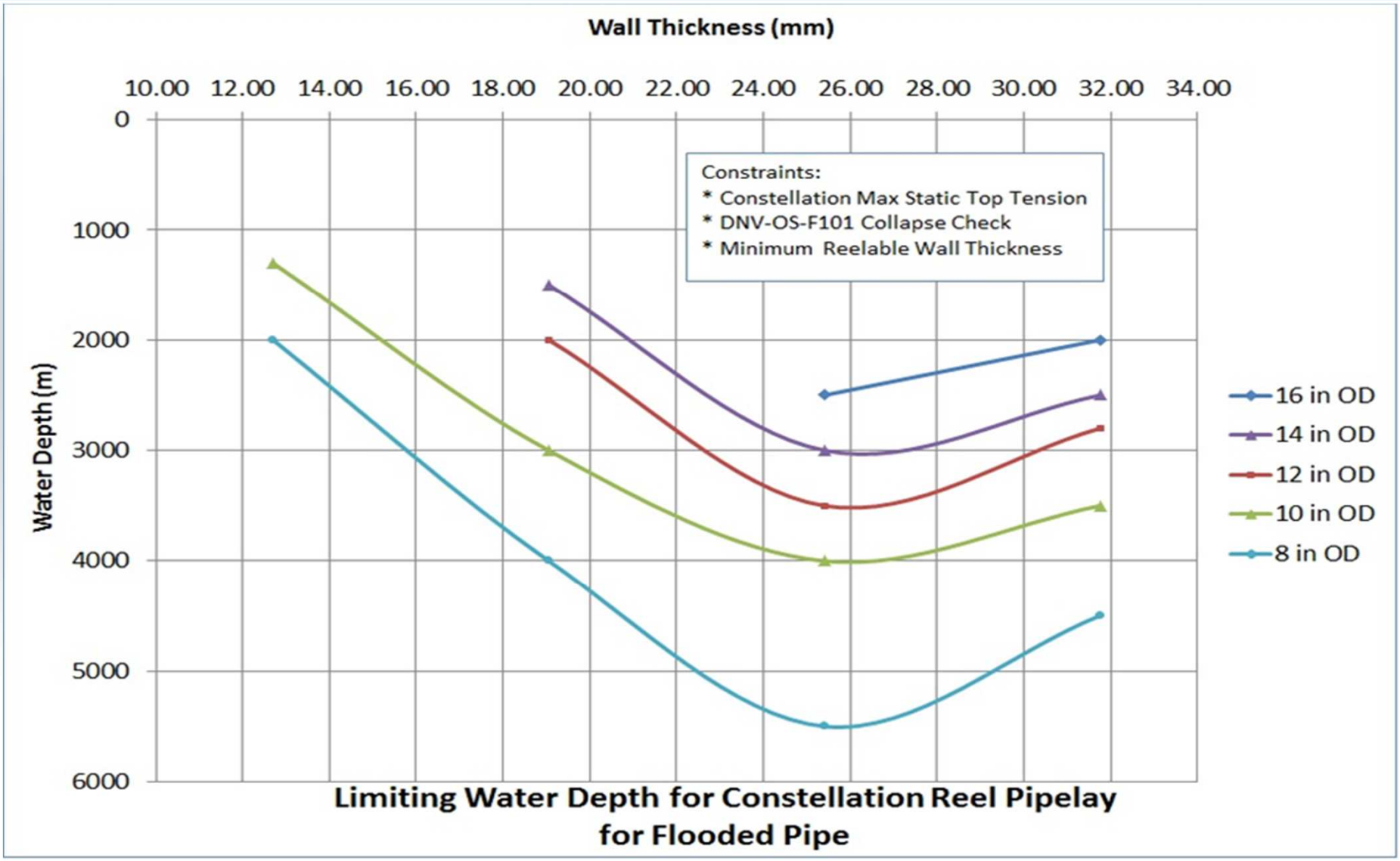
Reel Lay

Lewek Constellation's Reeling Capacity



Reel Lay

Lewek Constellation's Water Depth Capability



Agenda

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Overview of Submarine Pipeline Installation Methodologies

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Unconventional Pipeline Installation Methods

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Unconventional Pipeline Installation Methods

Push-Pull Method

PUSH-PULL METHOD

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Push-Pull Method

Project Example – Ref. Geocean

Dredging for Pipeline Installation from Shore Approach to Landfall

Buoyancy Drums to Provide Positive Buoyancy

Completion of PUSH-PULL Installation & Reinstatement

Unconventional Pipeline Installation Methods

Surface Tow Method

SURFACE TOW METHOD

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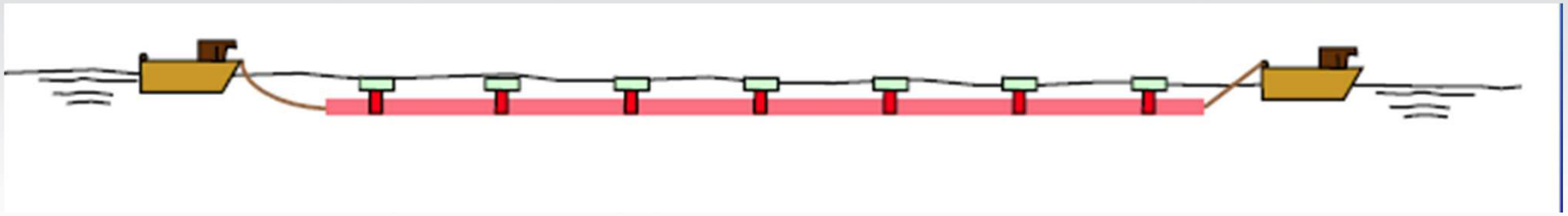
Surface Tow Method (Rentis)

Installation Methodology for Short Pipelines

- In this method, the required pipe string length is fabricated onshore and fitted with buoyancy devices at a given spacing, then it is launched and finally towed to the desired offshore location.
- One end of the pipeline is connected to a pre-installed line on the platform.
- After positioning and aligning of the pipe string, the buoyancy devices are stripped by one of the tugs in a control manner so that the pipeline settles to seabed due to its own weight in a controlled manner.



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Surface Tow Method

Project Example – Location: Brunei

Pipe Strings at BSP's Telisai Yard

- Typical fabrication yard : BSP at Telisai.
- Pipes are welded together to form pipe strings.
- Strings x-rayed, flushed, scraped, gauged and hydrotested.
- Then strings will be purged dry, field joint coated, capped at both ends and stored in the storage area.
- When required, pipe strings are rolled over on to the trolleys on the launching track.
- Finally, the floatation drums and a stripping wire are strapped onto the pipeline.

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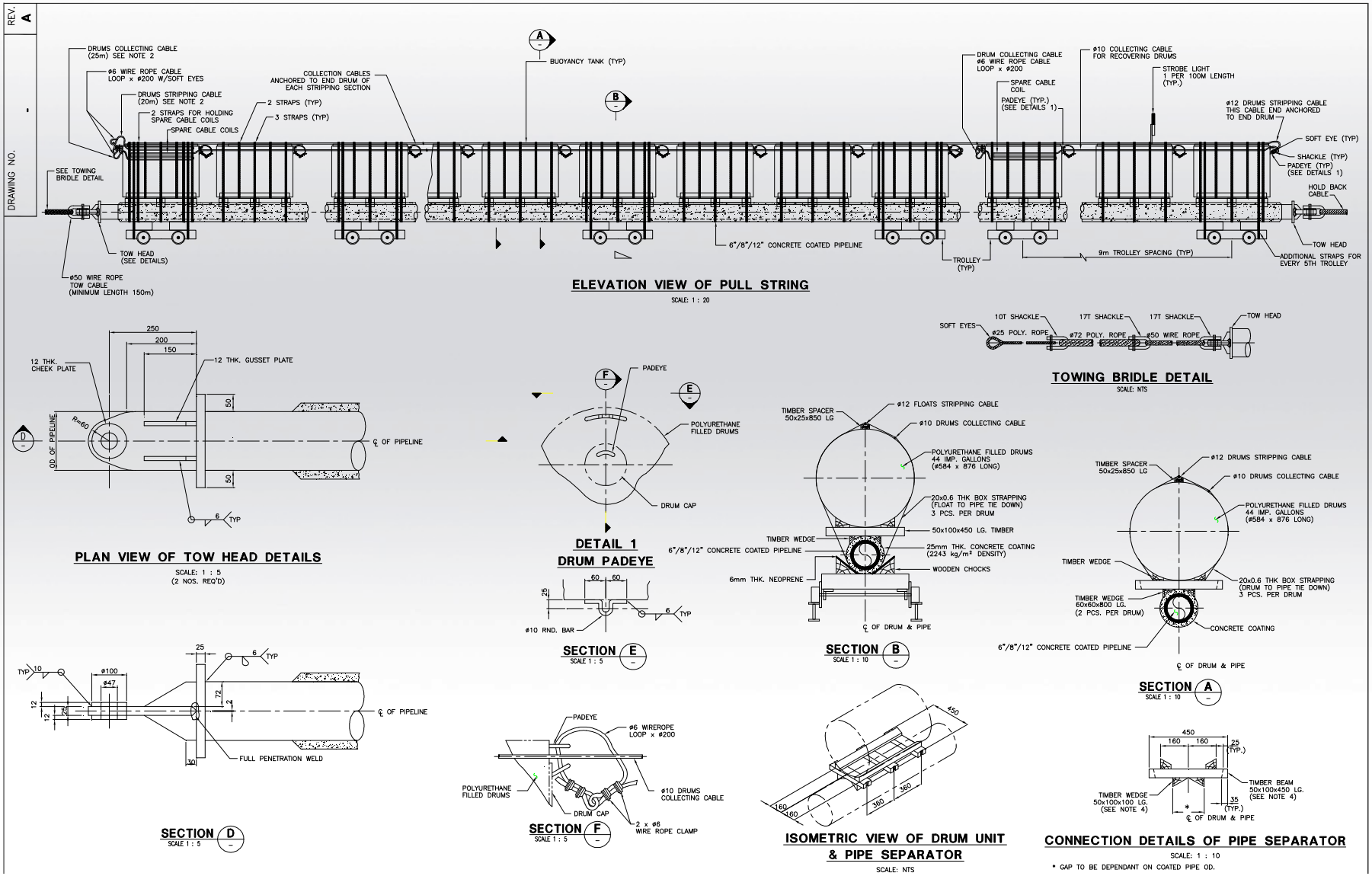
Surface Tow Method

Attaching Oil Drums and Stripping Wire to Pipe String

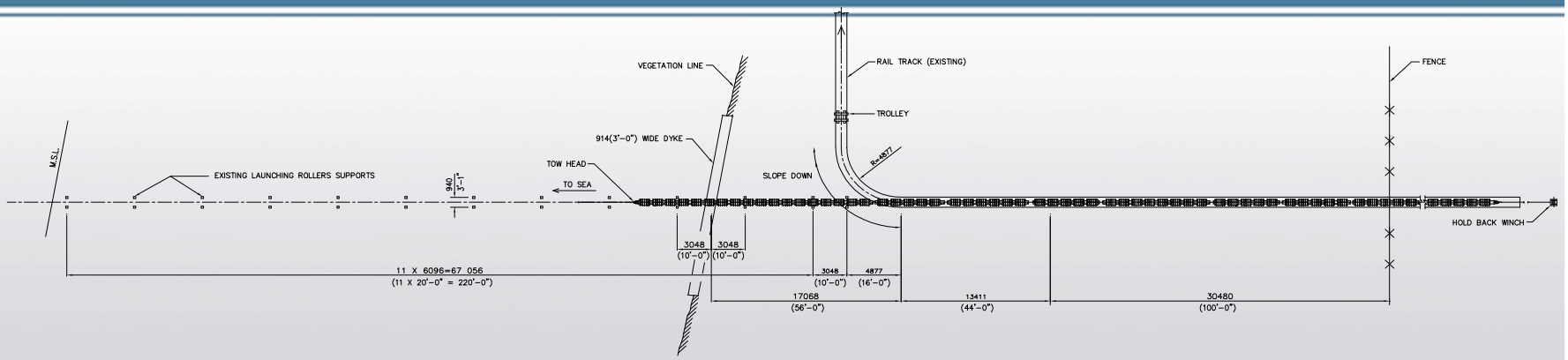
Surface Tow Method

Typical Strapping Details for Rentis Installation

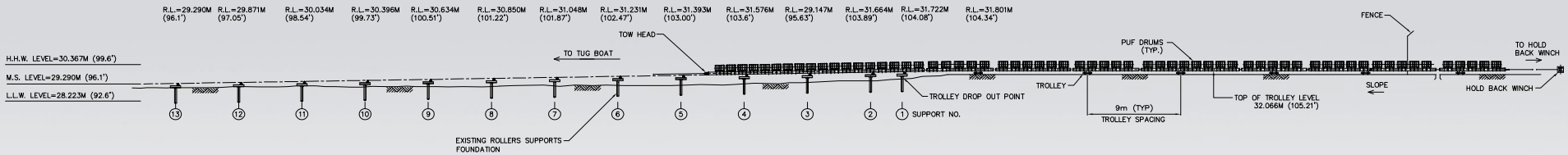


Surface Tow Method

Launchway Arrangement at BSP's Telisai Yard

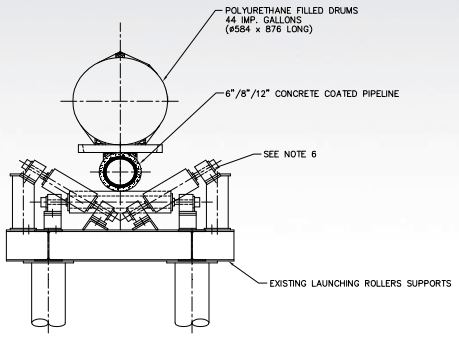


PLAN
SCALE 1:200



LONGITUDINAL ELEVATION
SCALE 1:200

TABLE 1	
PIPE SIZE	DRUM SPACING (M)
6"	–
10"	–
12"	–



GENERAL ARRANGEMENT OF ROLLERS NOS. 1,2 AND 3 ONLY (SEE NOTE 5)
(LOOKING FORWARD FROM SEA)
SCALE 1:15

DRUMS ARE TO BE INSTALLED ON THE PIPELINE WITH A UNIFORM SPACING AS GIVEN IN
, FOR THE ENTIRE PIPELINE. BUOYANCY TANKS TO BE USED IN LIEU OF DRUMS AS
TION AIDS FOR LIFTING END OF PIPE TO SURFACE FOR TIE-IN.

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Surface Tow Method

Project Example (Miri, Sarawak) – Bundle Pipe Pull to Beach

Commencement of Bundle Pipe Pull to Beach (Fabrication site was few kms from shoreline

Pipe Bundle Approaching Beach

Two bull-dozers were used as land towing vehicle

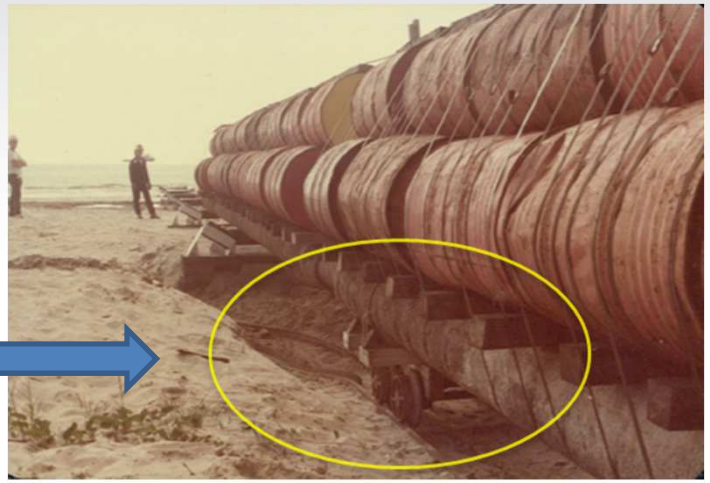
Surface Tow Method

Project Example – Bundle Pipe Pull to Beach
Note: Diverter used to allow pulling vehicles to turn 90º to avoid entering water

Pull wire diverter at 'landfall' is required to allow bull dozers to pull the pipe string bundle into the sea

On reaching the diverter, pull wire needs to be disconnected from the tow bridle and attached to the intermediate pull clamp

Straps on trolleys are cut and trolleys drop into a collection station



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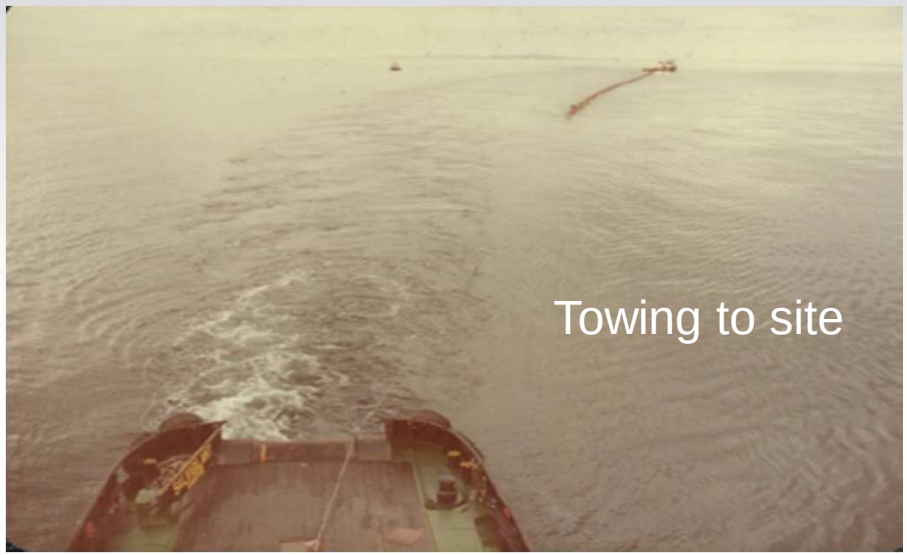
Surface Tow Method

Project Example – Connecting tow wire from tow tug to bundle pulling bridle, and launching pipeline into the sea (via onshore equipment)

Surface Tow Method

Project Example – Most Critical Moment of Operation is when Trailing Wire is released and before 2nd tug takes over this wire



Surface Tow Method

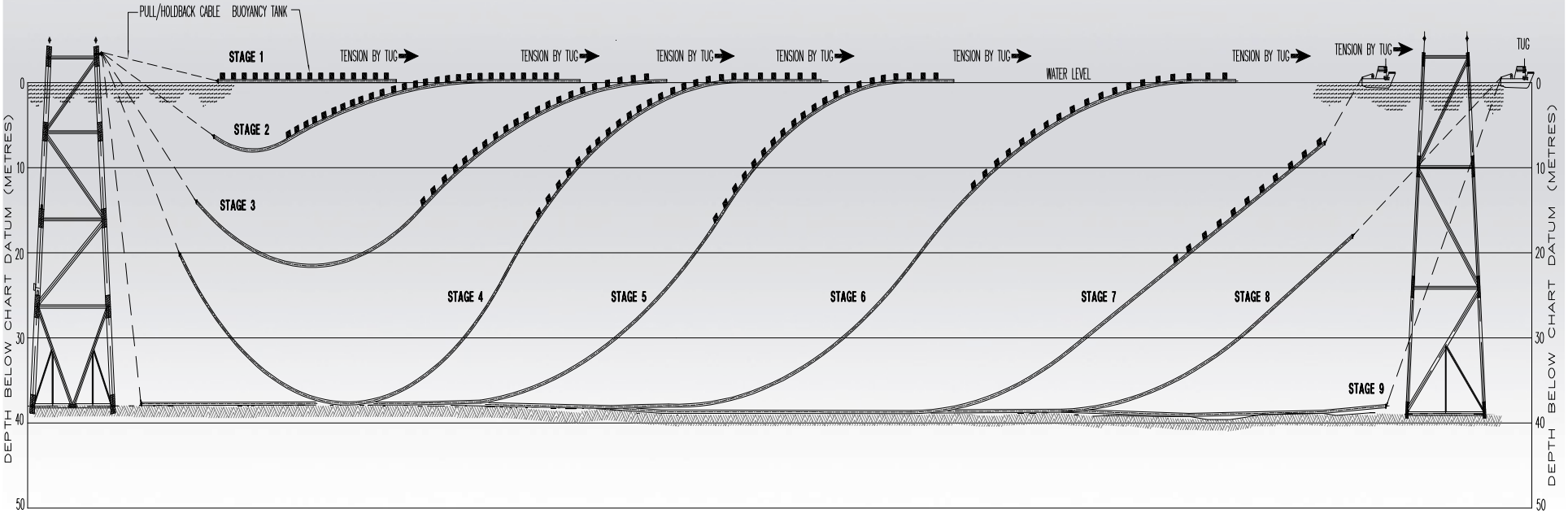
Project Example – Connecting Pull head to Pre-Installed Line on Platform & Retrieval of Stripping wire for Commencement of Pipelaying

Surface Tow Method

Project Example – Stripping of Buoyancy Drums

Surface Tow Method

Schematic: Stripping of Buoyancy Drums and Laying of Pipeline



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Unconventional Pipeline Installation Methods

Bottom Pull Method (Landfall to Landfall)

BOTTOM PULL METHOD
Landfall to Landfall

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Bottom Pull Method (Landfall to Landfall)

Project Example

Project Requirement:

- 8 Pipelines
- 2 Fiber Optic Cables

Installation Concept:

- Build Pipeline & Cable Bundle at Bukom
- Bottom Pull across Shipping Channel
- Protect with Rock Berm

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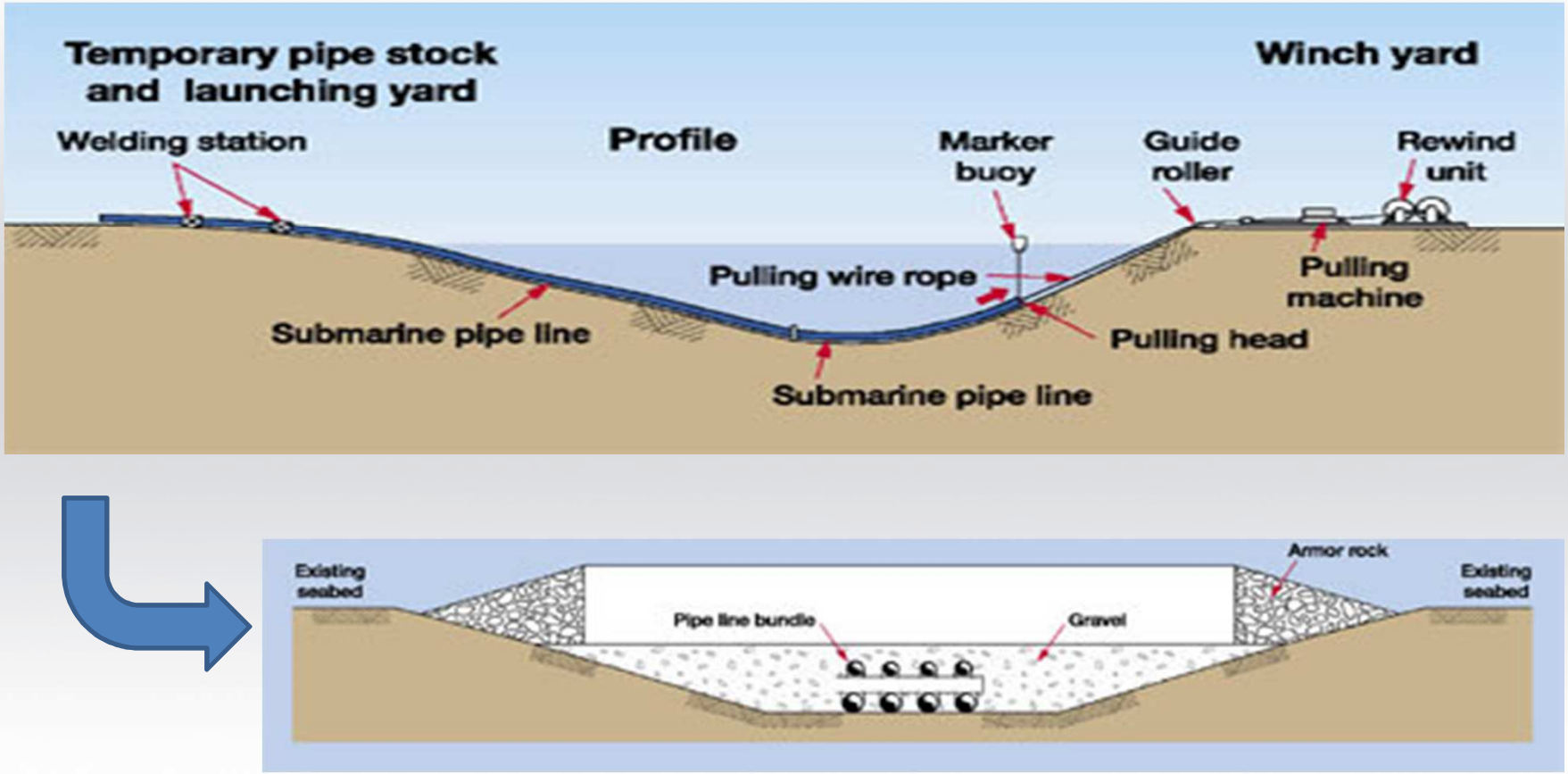
Bottom Pull Method (Landfall to Landfall)

Schematic



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Bottom Pull Method (Landfall to Landfall)

Preparatory Works: Pipe Bundling

Pullhead for Pipe Bundle

Bottom Pull Method (Landfall to Landfall)

Preparatory Works: Cofferdam Construction

Bukom End




Penjuru End (Singapore)




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Bottom Pull Method (Landfall to Landfall)

Preparatory Works: Construction of Holdback Anchor

Construction of Holdback Anchor for Linear Winch



Linear Winch Base Construction and Arrangement for Pipe Pull



Bottom Pull Method (Landfall to Landfall)

Preparatory Works: Dredging and Blasting Works

Dredging of Channel along Pipeline Route to Required Seabed Profile

Drilling and Blasting Works along Pipeline Route to shatter rocks to enable Dredging

Bottom Pull Method (Landfall to Landfall)

Commencement of Pulling of Bundled Pipe

Pipeline Bundles ready for Pull

Launch of Pipe Pull

Pipe Bundle (with BT) on Launch way

Linear Winch

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Bottom Pull Method (Landfall to Landfall)

Pipeline Installation : Alignment and Tie-In of new String to Preceding String

Bottom Pull Method (Landfall to Landfall)

Pipeline Installation: Arrival of Pulling Head at Destination Point & Installation of Risers

Arrival of Pulling Head

Installation of Risers on Pipe Bundle

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Unconventional Pipeline Installation Methods

Shore Approach by HDD

SHORE APPROACH BY HDD

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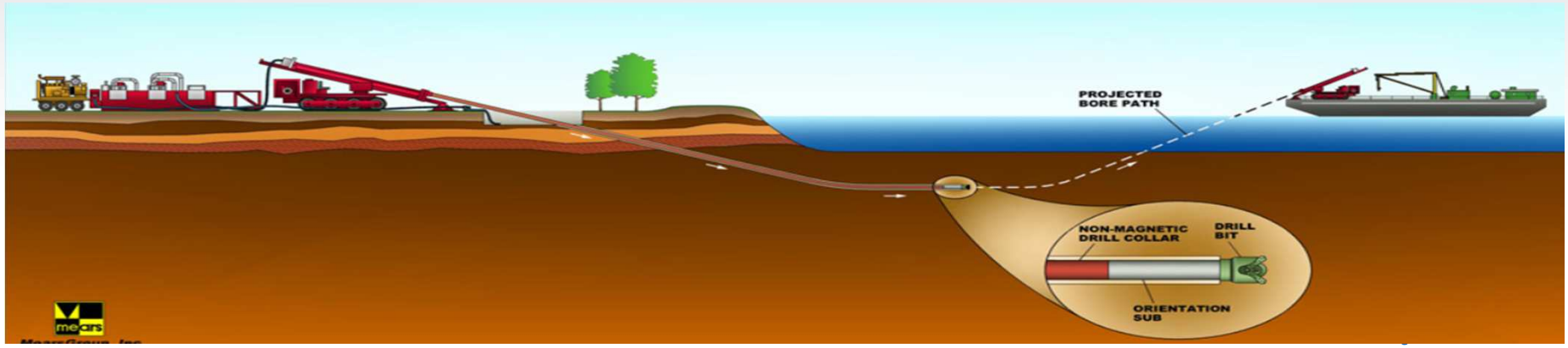
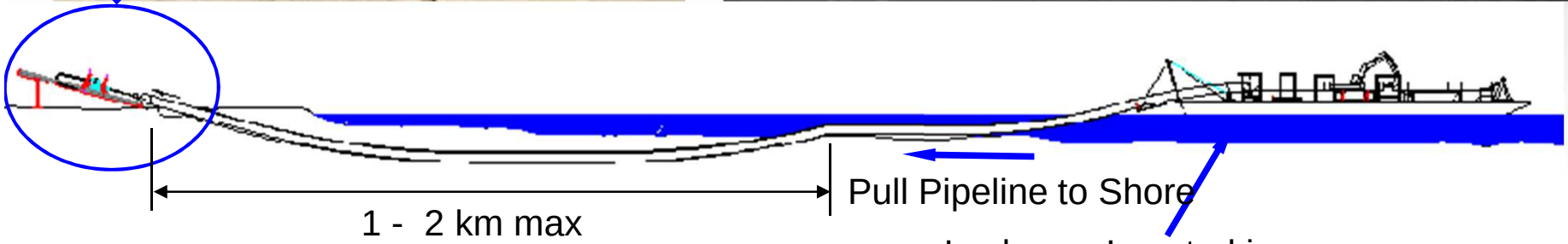
Shore Approach by HDD

What is HDD?

- HDD is a trenchless construction method utilizing equipment and techniques from horizontal well drilling technology & conventional road boring
- 3 stages of HDD:
  - Drilling an initial pilot hole with a down-hole navigation package, relaying the position & depth of the drilling device
  - Increasing the hole diameter by using different types of reamers depending upon ground conditions
  - When the hole is opened to a suitable diameter, pulling the pipeline into position
- It has been used for offshore pipeline construction mainly for shore approach pipeline installation, typically, for following reasons:
  - To avoid damaging and disturbing environmentally sensitive areas (mangrove swamp, home to protected species, etc)
  - To avoid difficult terrain, and minimize construction cost, where applicable, etc.



Shore Approach Installation by HDD: Typical Concept



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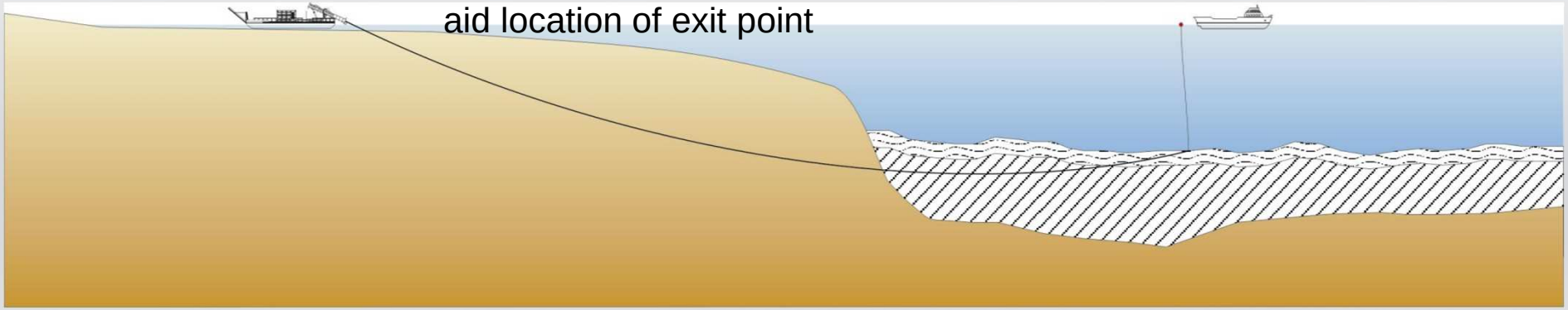
Shore Approach by HDD

Operation Sequence (typical)

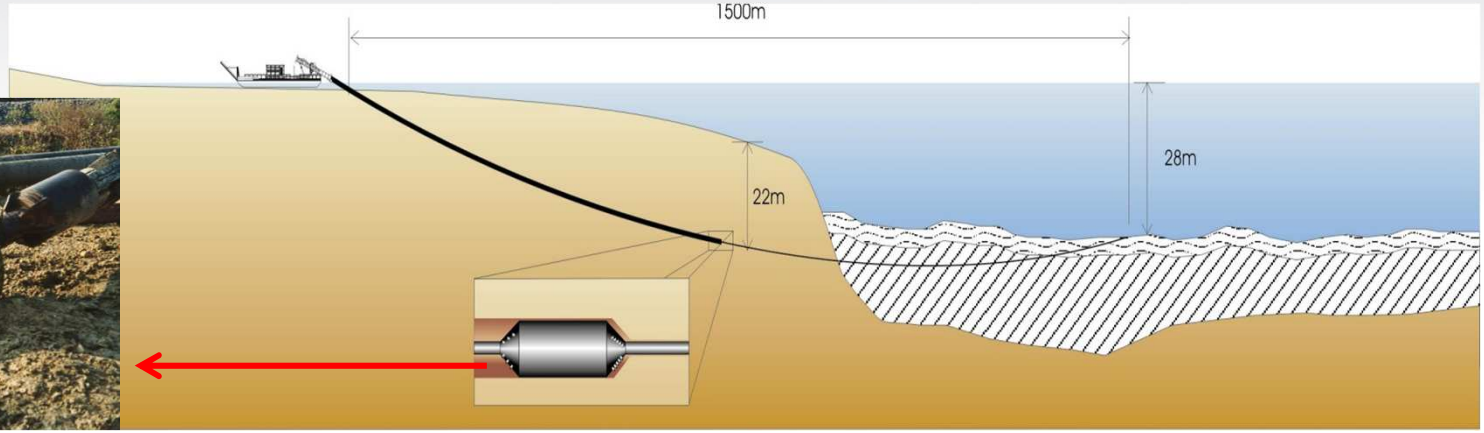
Drilling of Pilot Hole

- Pilot hole is drilled from shore based HDD equipment to a designated "exit" point offshore
- A jet-head assembly is used at the "front" of the drill pipe
- On exiting the seafloor, compressed air is blown through the drill bit to aid location of exit point



Reaming of Pilot Hole

- Pilot hole is forward reamed using barrel reamers
- Hole diameter will be 50% larger than size of product pipe

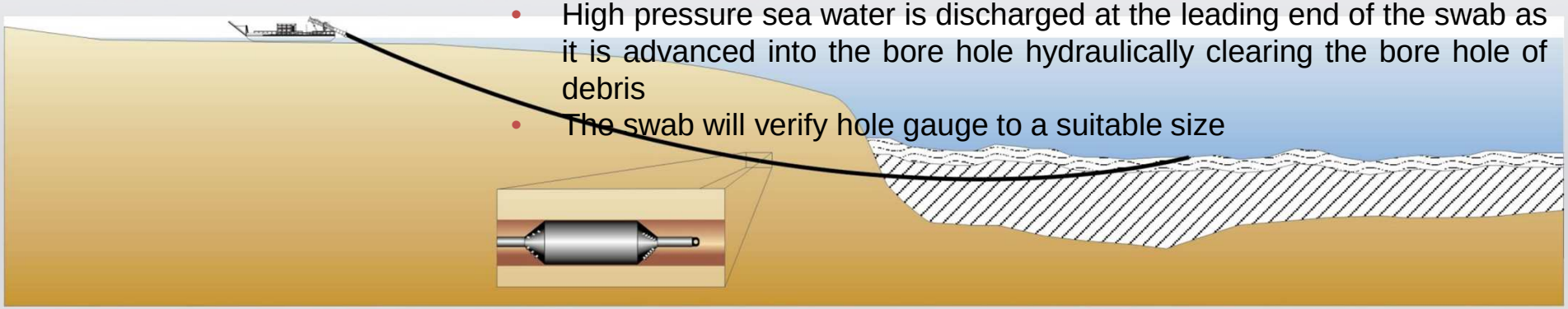


Shore Approach by HDD

Operation Sequence

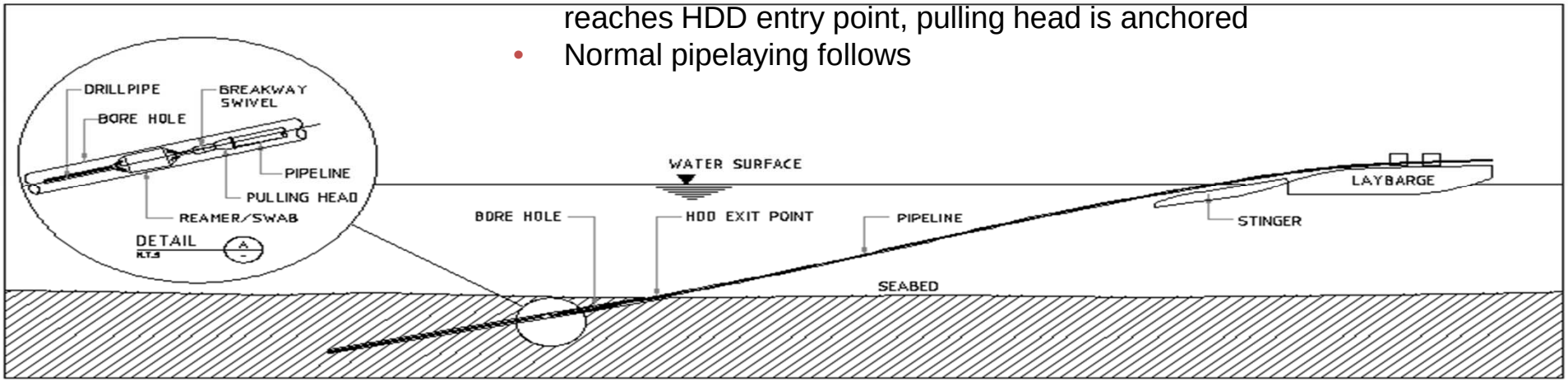
Hole Swabbing/ Cleaning

- On completion of the reaming the bore hole will be swabbed with a suitable size barrel swab
- The swab is advanced from the entry surface to the sub-sea exit location and then back to the entry surface location
- High pressure sea water is discharged at the leading end of the swab as it is advanced into the bore hole hydraulically clearing the bore hole of debris
- The swab will verify hole gauge to a suitable size



Pull-in of Product Pipeline

- Retrieve reamer on laybarge & connect to pullhead
- Pipeline is pulled into the HDD bore hole – when pipeline pullhead reaches HDD entry point, pulling head is anchored
- Normal pipelaying follows

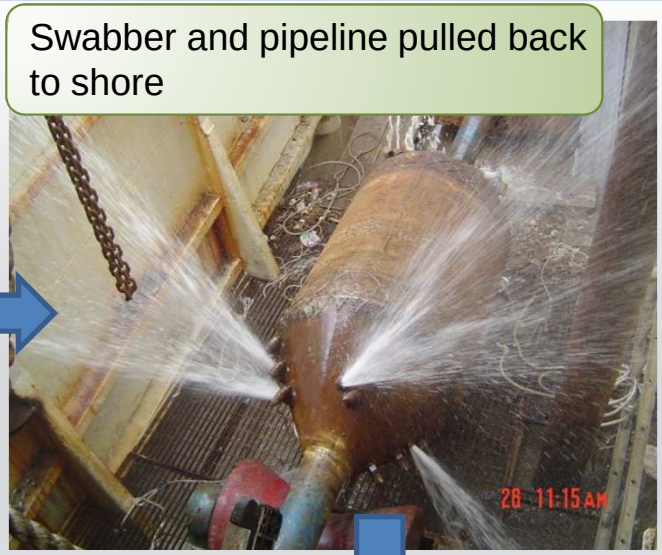


Shore Approach by HDD

Operation Sequence

Swabber/ reamer on laybarge and connected to pullhead

Swabber and pipeline pulled back to shore



Other Unconventional Pipelay Techniques

Bottom Tow Method

Other Unconventional Pipelay Techniques

Control Depth Tow Method

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Thank You!

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