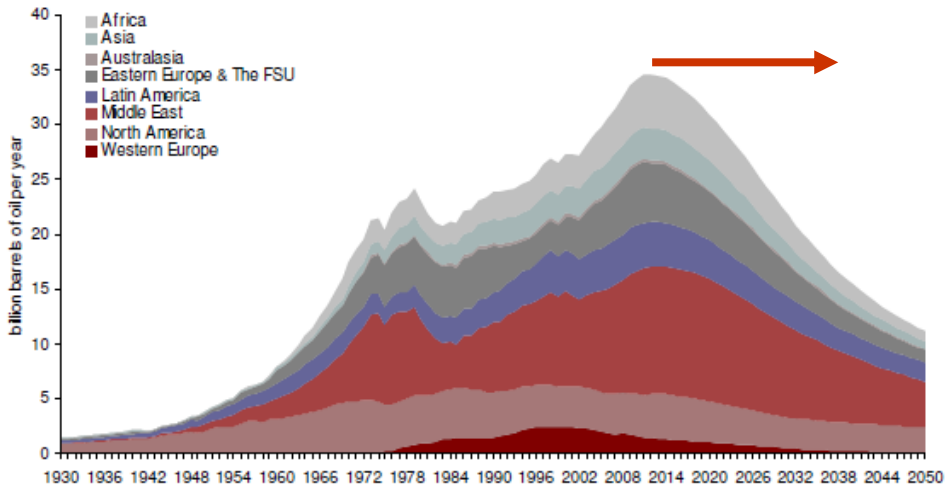
An introduction to well intervention

SPE Aberdeen monthly evening meeting
Jim Wright, The Douglas Hotel, 25th January 2011

Industry sector context

Oil

- Oil production continues to grow
  - Western Europe and North America mature basins in production decline
  - Reduction in discovery rates
    - “Easy” giant fields are now mature
- Peak Oil
  - Generally predicted on accessible reserves today.
  - Does not cater for new technology and demand
  - Previously inaccessible deepwater reservoirs shall be tapped



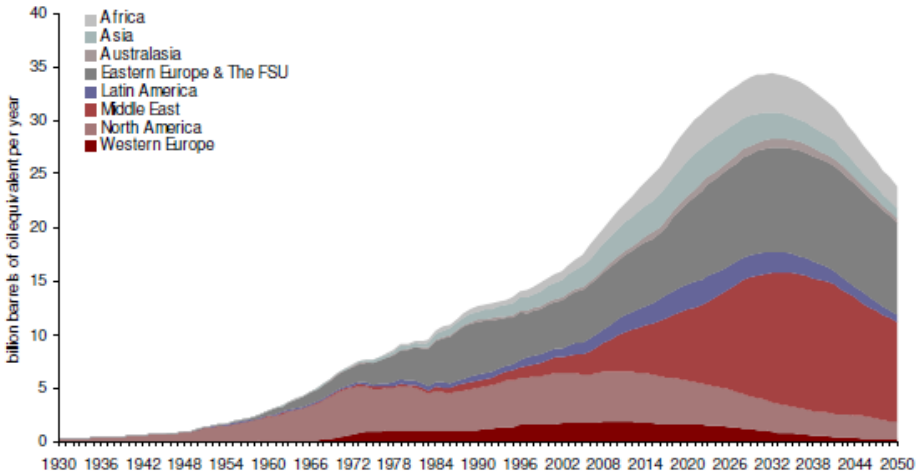
Global Oil Production 1930-2050

Source: ‘The World Oil Supply Report’ Douglas-Westwood

Industry sector context

Gas

- Gas production continues to grow
  - Eastern Europe & FSU dominate market
  - Potential peak is much later than oil
- Bridge carbon based energy supply to renewable
  - Abundance of natural gas
  - Cleaner energy



Global Gas Production 1930-2050

Source: 'The World Gas Supply Report' Douglas-Westwood

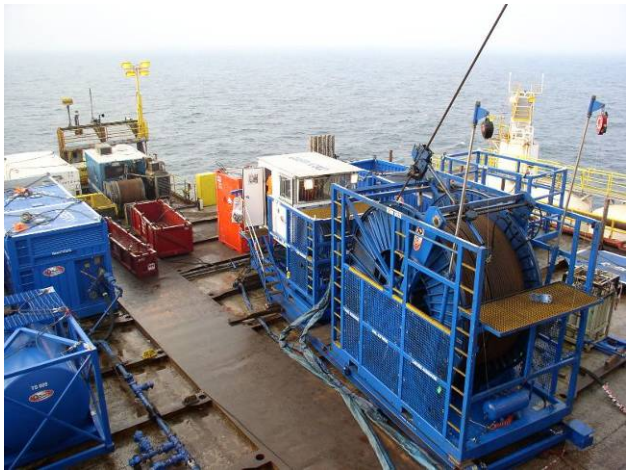
2011 UKCS

- Exploration activity fell to lowest level since 1960's
- Only five new fields came on stream (smallest annual addition in UKCS history)

What is well intervention?

Well intervention

- An operation carried out on an oil or gas well to extend its producing life by improving performance or providing access to stranded or additional hydrocarbon reserves
- Typical interventions services include,
  - Wireline
  - Tractors
  - Coiled Tubing
  - Hydraulic Workover



Wireline

History

- Mechanical slickline was formerly known as measuring line
  - Flat tape with depth increments
- Schlumberger brothers considered the inventors of electric logging in 1927.

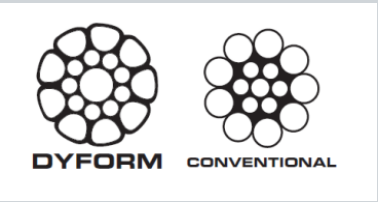
Wireline

Slickline wire

Nominal diameter	Material / Type	Breaking strain	Remarks
0.108”	UHT Carbon Supa 75	2730 lbs 2100 lbs	Poor corrosive resistance Sour gas applications
0.125”	UHT Carbon Supa 75	3665 lbs 2700 lbs	Poor corrosive resistance Sour gas applications

Braided wire

7/32”	Conventional Dyform	5400 – 6010 lbs 6500 – 8370 lbs	Dyform considerably stronger.
5/16”	Conventional Dyform	11,000 – 13,490 lbs 13,560 – 17550 lbs	Very high breaking force gives the operator better margins when carrying out fishing operations.



Electric line wire

7/32” Poly cable	Mono conductor cable widely used for e-line operations	Typically 5200 lbs	Cable type will depend of well conditions and operation conducted
5/16” Poly Cable	Commonly used for logging and perforating	Typically 11,000 lbs	Cerberus modelling with determine wire selection.

Wireline

Slickline applications

- Gauge Cutter / Centraliser runs. (Establish the well bore is clear from restriction)
- Setting / Pulling plugs
- Setting / Pulling gas lift valves
- Bailing sand and debris
- Bottom hole pressure and temperature surveys. (Memory)
- Shifting sleeves

Braided line applications

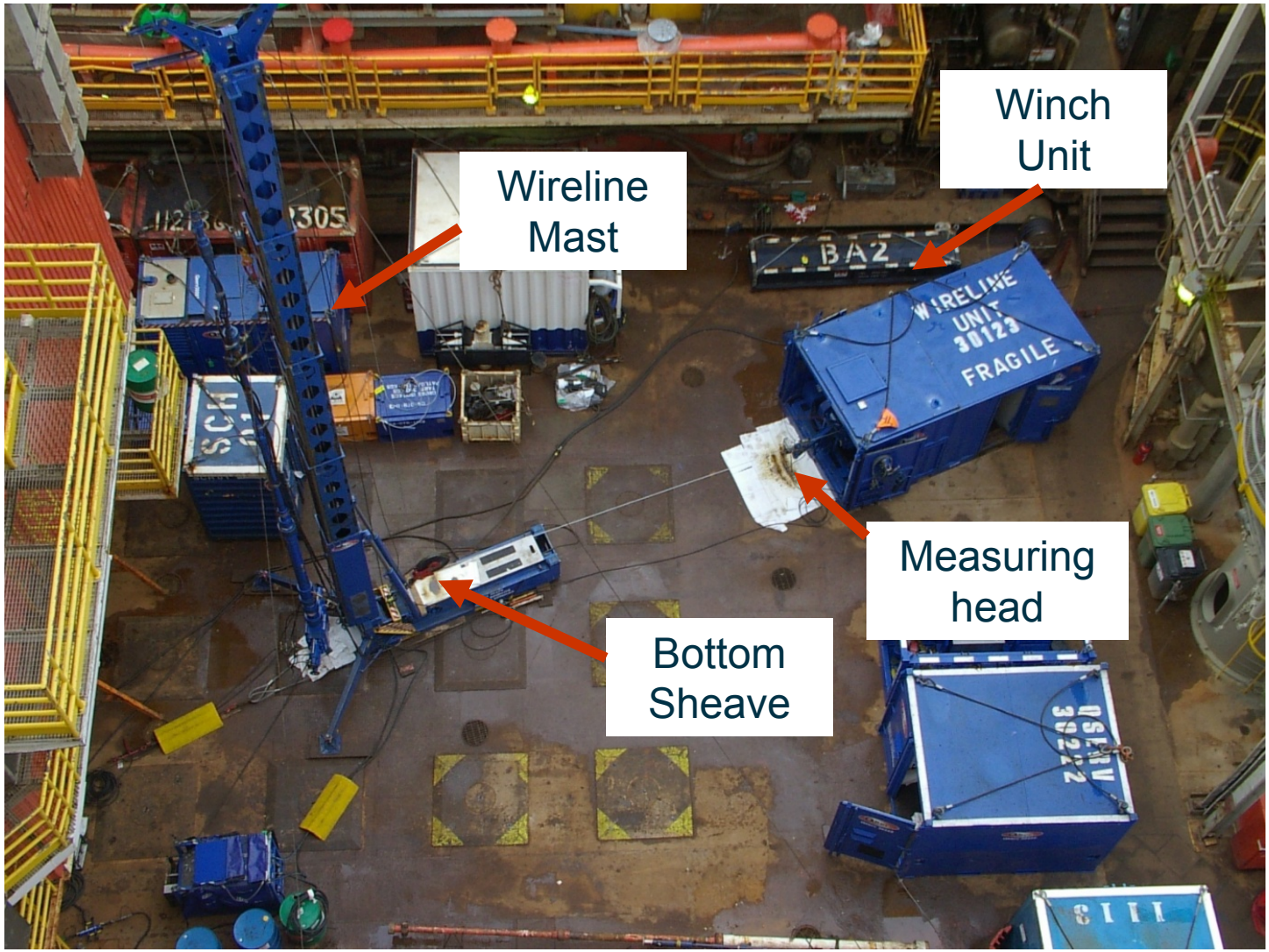
- Utilised where additional pulling force is required:
  - Fishing operations
  - Conveying heavy toolstrings
  - Deeper access

Electric line applications

- Provides real time communication from well to surface
- Unparalleled depth control
  - Logging
  - Ballistic operations
  - Zonal isolation
  - Well integrity

Wireline

Unit components - Slickline



Wireline

Primary Well control

- Stuffing Box (Slickline)
- Grease Head (Braided/Electric line)

Secondary Well control

- BOP c/w Dual blind rams
  - Slickline
- BOP c/w inverted dual blind rams
  - Braided/Electric line
  - Grease injection between rams

Tertiary Well control

- BOP c/w Shear Ram
  - In the event tree MV cannot shear wire

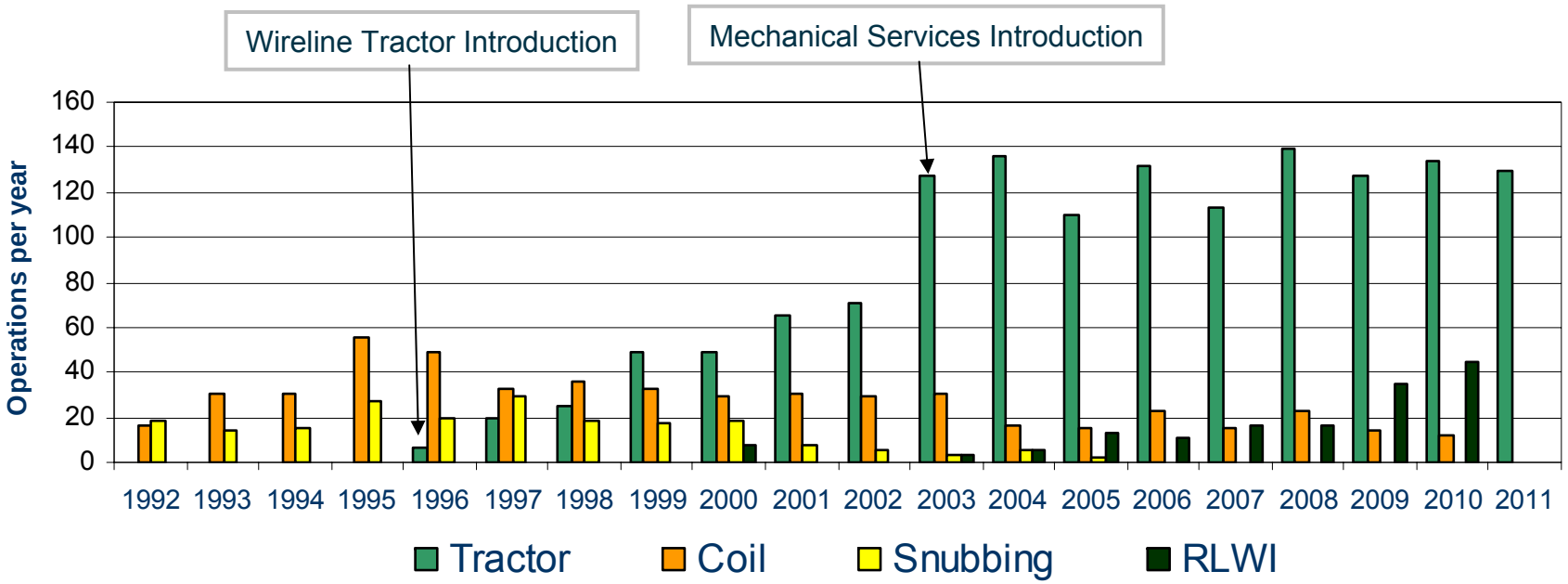
Tractors

History

- Deviated or horizontal wells now common place
  - Slickline relies on gravity for well access
- Tractors introduced in 1996
  - Provides driving force at the end of the wire via traction wheels
  - Speed and force dictated by number of drive sections
- Mechanical Services introduced in 2003
- Coiled Tubing Tractors

Tractors

History

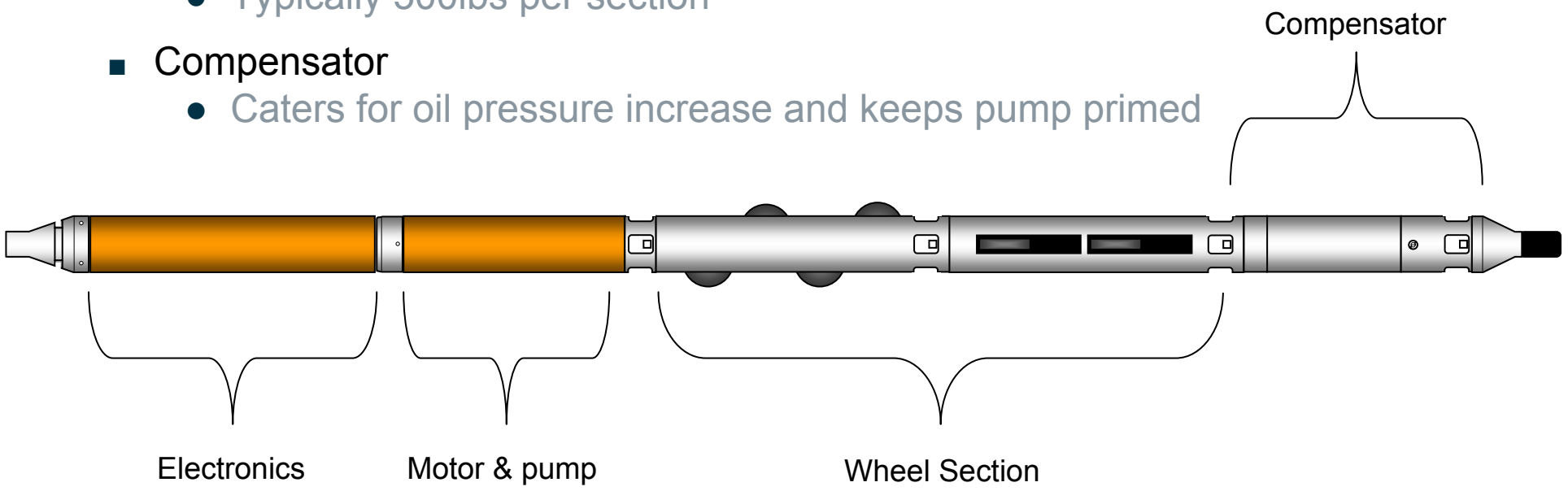


* Images and text courtesy of Statoil

Tractors

Unit components

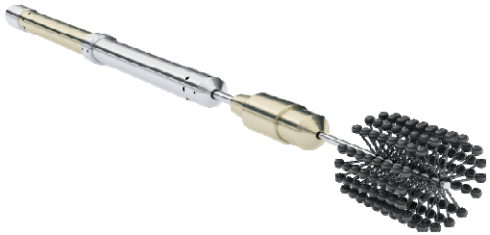
- Electrics
  - Powered from surface through wire
  - Control for motor & pump
- Motor & Pump
  - Generates hydraulic flow and pressure
- Wheel section
  - Provides axial force at end of wire
  - Typically 500lbs per section
- Compensator
  - Caters for oil pressure increase and keeps pump primed

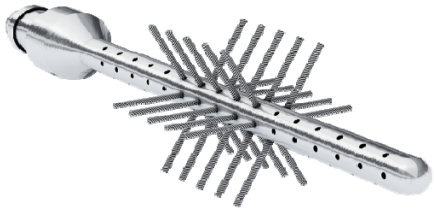


Tractors

Applications

- Well access
- Mechanical applications introduced in 2003
  - Scale milling
  - Brushing and polishing
  - Manipulation tools
  - Debris removal
  - Logging while Tractoring





- Bi-directional Open hole tractor

Coiled tubing

History

- Pipeline Under The Ocean (PLUTO)
  - Allied invasion in 1944
  - 3in pipelines, 70km long
  - Supplied fuel to allies in Europe
- 1st oilfield application in 1962
  - 15,000ft, 1.315in OD
  - Sand bridge cleanouts

Coiled tubing

Applications

- Vertical, deviated and horizontal wells on both land and offshore:
  - Fluid displacement
  - Logging
  - Perforating
  - Stimulation
  - Remedial cementing
  - Setting, retrieving bridge plugs
  - Fishing
  - Mechanical removal of blockages (milling)
  - ……..plus much more!!

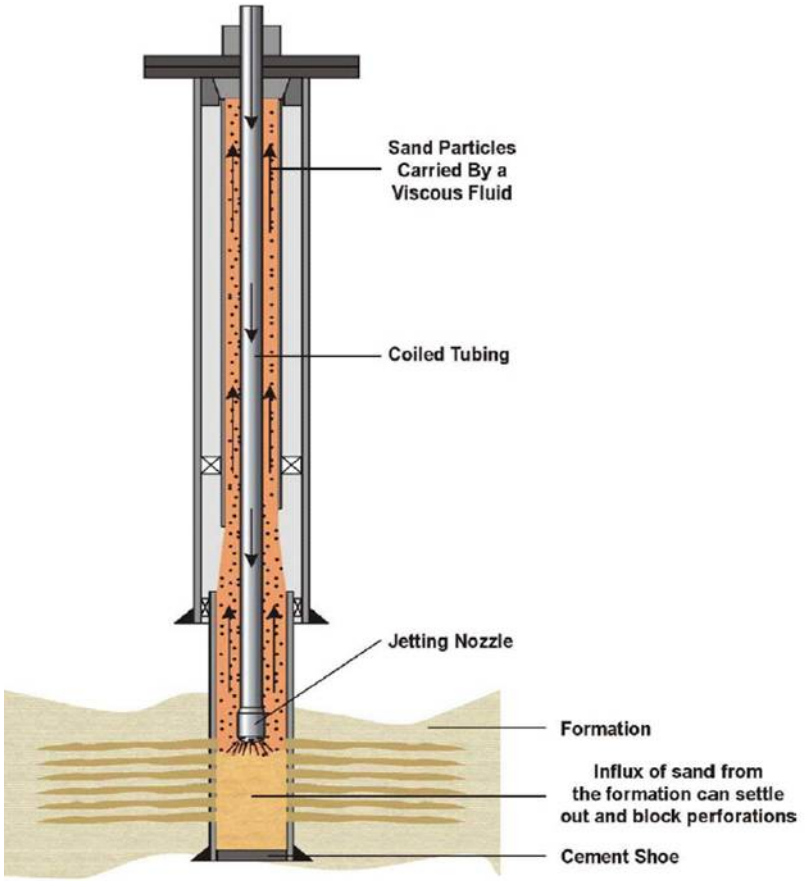
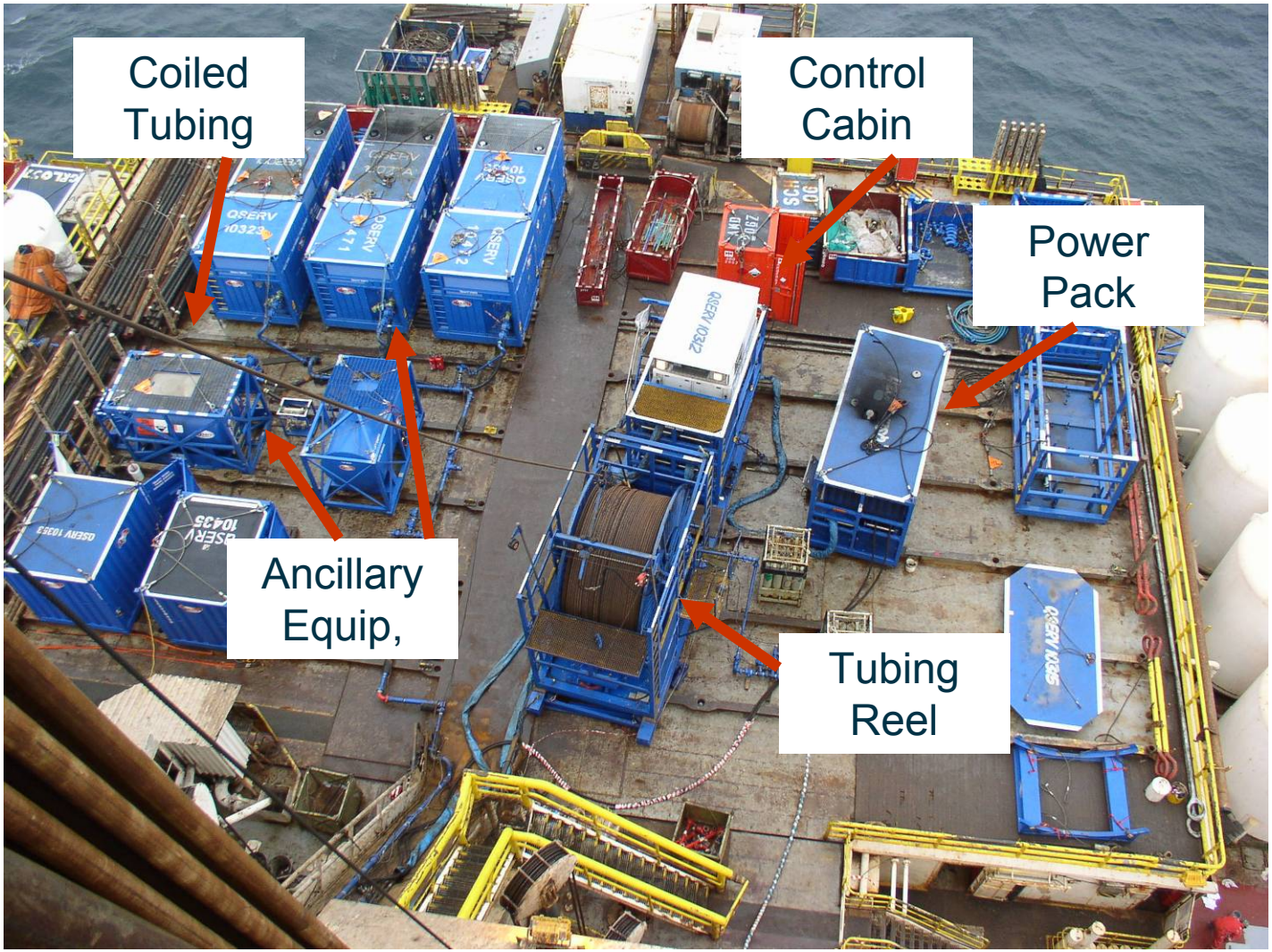


Figure 1 - Sand Cleanout with Coiled Tubing

Coiled tubing

Unit components



Coiled tubing

Coiled tubing string design

- **Continuous length of pipe**
  - 1 1/2” – 3 ½” OD
  - Typically 22,000ft long
- **Tapered ID design**
  - To withstand combination of forces in hole
  - Adequate stiffness “lock-up”
  - Plastic deformation consideration
  - Circulation rates and pressures
  - Logistic considerations

Tubing guide arch & injector head

Function

- To support, straighten and align the tubing into the injector head
- Provides the surface drive force to run and retrieve the tubing

Design Consideration

- Arch radius should be **at least** 30 times tubing OD (API 5C7)
- Must withstand the loading caused by reel back tension
- Must withstand side loading caused by fleet angle
- 120% of max force expected pull the tubing from the well (API 5C7)
- 120% of max force expected to snub the tubing into the well against wellhead pressure (API 5C7)

Pressure control equipment (PCE)

Function

- Stripper provides dynamic primary seal around the tubing during tripping and a static seal around the CT when there is no movement
- BOP provides secondary wellbore pressure containment and facilitates tubing severance, tubing support and seals around the tubing

Design Consideration

- Rated working pressure must exceed maximum anticipated surface pressure
- Stack-up height. Ram configuration to suit application
- Pipe severance under anticipated conditions

Hydraulic Workover (HWO)

History

- Mr R H.C. Otis Snr. designed and built first unit to run pipe under pressure in 1929
  - Rig “snubbed’ pipe in via series of chains and pulleys
- 1st generation HWO unit introduced in the 1960’s.
  - No requirement for rig
  - Typically run pipe in singles
- Rig assist (RA) units returned in late 1990’s to support UBD activity
  - Hydraulic jacks

Hydraulic Workover (HWO)

Applications

- Through tubing intervention – washing, unloading, stimulation etc. etc.
- Milling inside tubing or casing
- Running or pulling production strings
- Through tubing drilling (over or under balanced)
- Abandonment
- Deploying perforating guns under pressure
- Blowout recovery operations

Hydraulic Workover (HWO)

Unit components

- Ginpole & winch
  - Facilitates a crane boom
  - Picks up tubing joints to the work basket
  - Not required for Rig Assist Units
- Travelling Slips
  - Two sets of slips to cater for pipe heavy and light scenarios
  - Incorporates rotary head
- Work Basket
  - Accommodates crew and unit controls

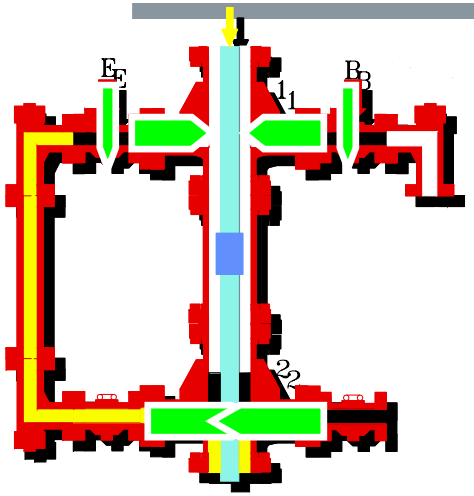
Hydraulic Workover (HWO)

Unit components

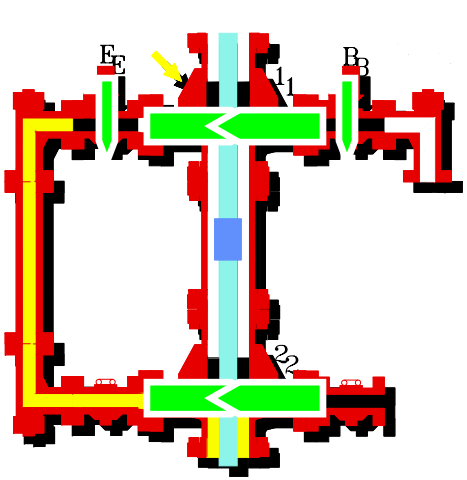
- Hydraulic jack
  - Provides the appropriate force to run and pull tubing string
  - Typically <600klbs
- Stationary slips
  - Holds tubing string when travelling slips are disengaged
- Annular BOP
  - Secondary well control when stripping/snubbing pipe
- Stripper 1 & 2
  - Primary well control when snubbing/stripping pipe
  - Equalising loop for running upset joints/collars
- BOP’s
  - Tertiary well control
  - Pipe/Blind/Pipe

Hydraulic Workover (HWO)

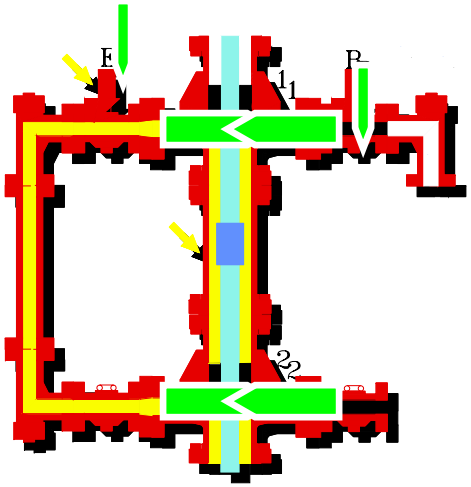
The stripping process



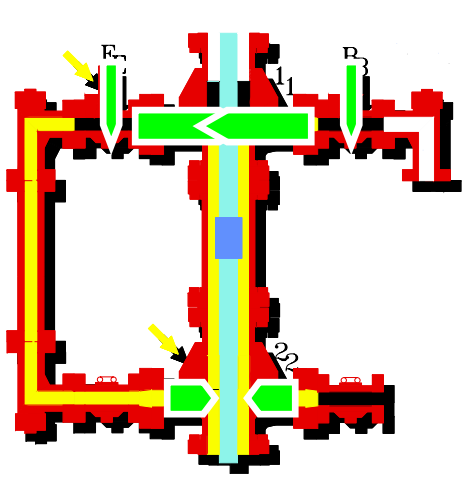
2 closed - Lower Tool Joint



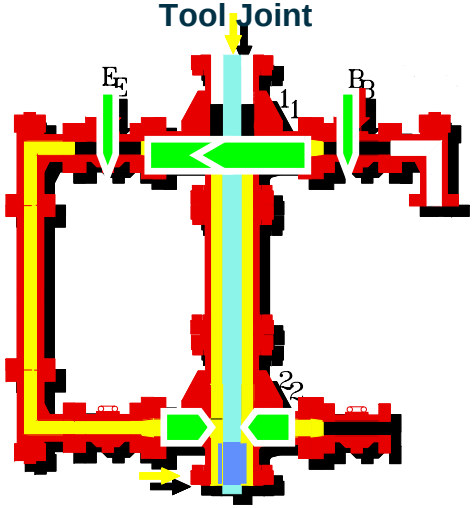
Close #1



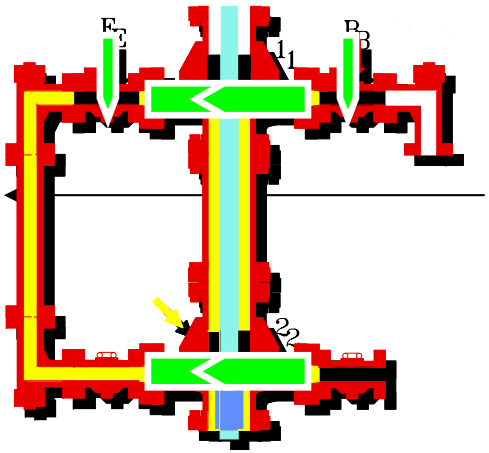
Equalize



Open # 2



Lower Tool Joint



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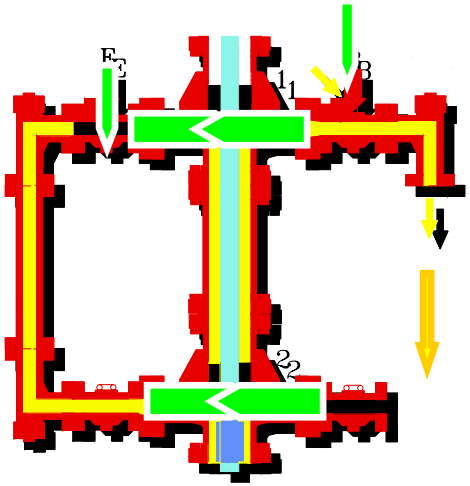
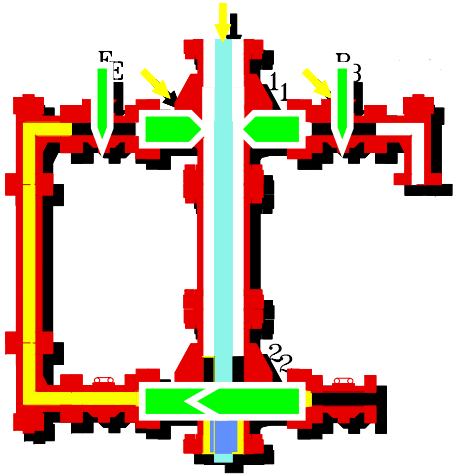
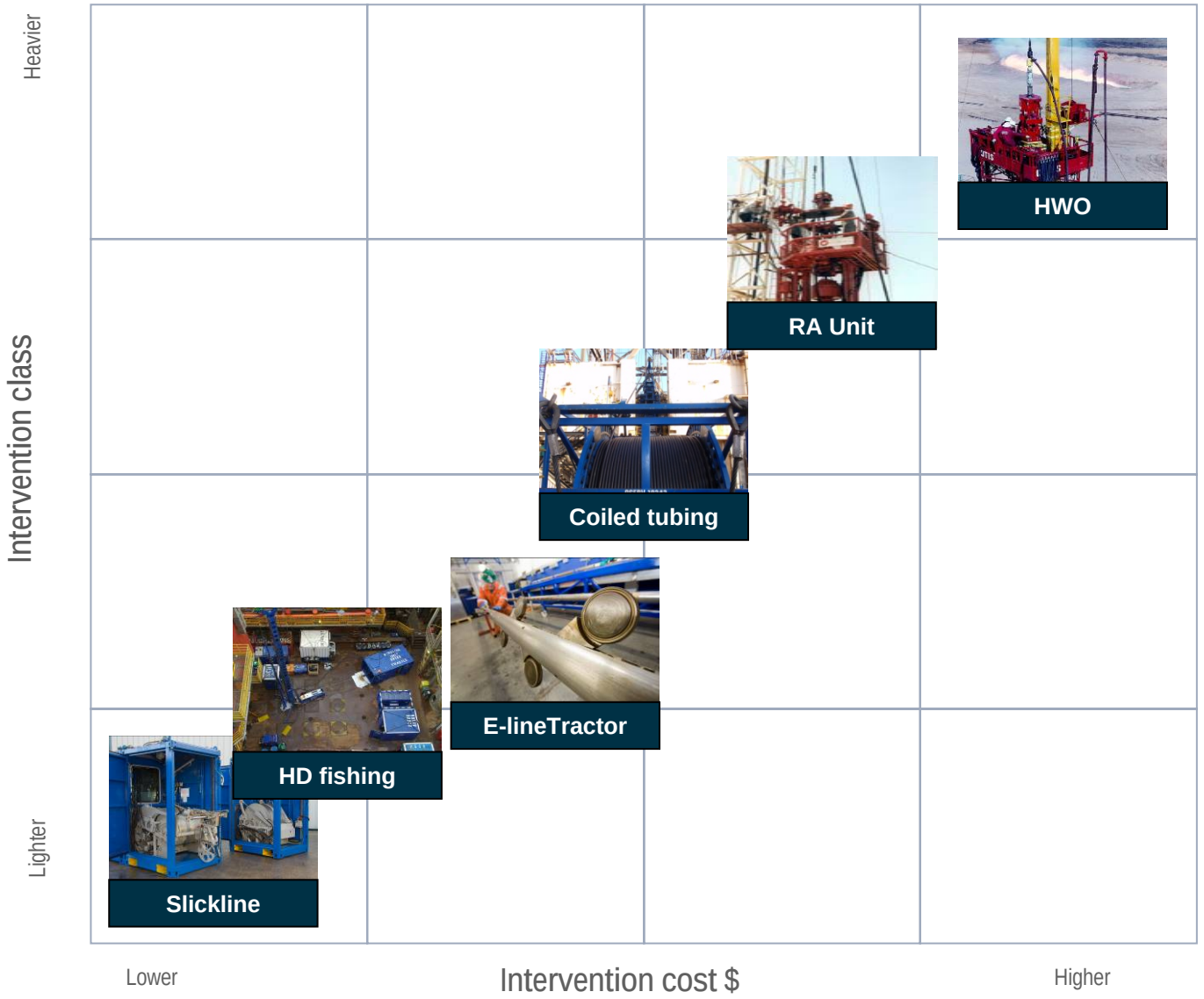


Bleed Off PSI



Open # 1 & Lower Tool Joint

Service positioning



Recent/Future developments

Subsea

Development of service units
- Cat B – heavy intervention rigs
- Cat A – intervention mono hull vessels

- Conveyance challenges
  - Fatigue management

Real time data

- Digital slickline
- Real time coiled tubing

Product development

- Well integrity/abandonment
- Composite SL and CT
  - Lighter, less friction
- Riserless coiled tubing

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