How are you performing your Subsea Intervention & Decommissioning work scopes, an Intervention Riser System or Riserless? What options do you have? By Grant Pierce

It is amazing the leaps and bounds that we have made over the last 3 decades. Over that short amount of time, we have moved from water depths of less than 100 m now surpassing 3000 m, with the ability to perform a large percentage of subsea intervention and abandonment work with lighter assets and advanced technologies.

In the mid 1970's Flopetrol designed the first subsea well intervention lubricator and executed the first trials at a depth of 20 m in the Zakum Field, offshore Abu Dhabi. Then in 1984, a JV between BP and Camco further developed the system. Same system was subsequently deployed and used on wells throughout the North Sea. In the same year, Otis Engineering filed a patent for a subsea intervention lubricator of their own.

Since that time, Light Well Intervention Vessels (LWIV) and Well Intervention Units (WIU) with both Intervention Riser Systems and Riserless Intervention Systems, have become standard methodology in the North Sea & Gulf of Mexico in addition to more acceptance with campaigns across Australia, Brazil, and across West Africa.

There is general increase in acceptance from Operators and that has equated to expansion of services globally between LWIV, WIU, & most recently purpose built P&A/ Decommissioning Rigs.

In this space there is an established list of experienced contractors that provide integrated wells solutions; some provide vessel & some don't. Those contractors are: AKOFS Offshore (Aker Solutions), Baker Hughes, C-Innovation, Enovate Systems Ltd (Aker Solutions), Expro Group, FTAI Ocean, Halliburton, Helix Energy Solutions, Oceaneering, Optime Subsea, Sapura Energy Well Services, TechnipFMC (TIOS Group), Trendsetter Engineering, Worldwide Oilfield Machine, & Well Safe Solutions. Key partnerships also exist between other major service providers with the contractors above.

The LWIV, WIU, & purpose built Decom Rigs in operation (in the subsea space) consist of the following:

- C-Innovation - Island Performer, Island Intervention, Island Venture
- FTAI Ocean - Pride
- Helix Energy Solutions - Q4000, Q5000, Q7000, Seawell, Siem Helix 1, Siem Helix 2, Well Enhancer

- Sapura Energy Well Services - Constructor
- TechnipFMC - Island Constructor, Island Frontier, Island Wellserver
- Well Safe Solutions - Guardian

So, what options do you have and what is required for your specific well operation? Which equipment spread (or method) can you utilize that gives you best combination of safety, productivity, and efficiency?

Let's first define vessel types used in LWI - Decommissioning. There are 3 other classes, but we won't discuss them here. Operators loosely define them like this:

1. Category A: Light vessel able to perform wireline operations, subsea inspection, and repairs

2. Category B: Vessel can perform workover (pulling and running tubing) and riser operations with coiled tubing (CT) ability

3. Category C: Drilling rigs capable of performing all well operations through marine riser and BOP; heavy intervention capability.

Category A & B vessel-based approach provides cost savings compared to the contracting of a drilling rig. MODU's or Cat C are conventional rigs with low-pressure risers traditionally used for drilling and completing wells. In addition, these units are equipped with workover equipment which implies that they can perform *full* P&A operations and a variety of well interventions.

Cat B vessel have some of the same capabilities as a MODU but tend to have a lighter set-up. This unit also uses a riser from the vessel to the subsea XT and are able to handle the return flow of hydrocarbons. The cost of this method is slightly lower than a conventional rig (MODU) but cannot be compared to the savings of using a Cat A vessel.

Cat B vessels/rigs have a high-pressure small-bore riser (Intervention Riser) and are traditionally necessary to perform heavy interventions like coiled tubing. Cat A is commonly known as a riserless light well intervention (RLWI) vessel and has traditionally been used in wireline operations.

These vessels are generally cheaper and use less time to mobilize and rig-up than the other two types of intervention vessels. They enable equipment to be temporarily installed when needed and hence create flexibility in which operations they can perform.

As for the basics of a LWIV or Well Intervention Unit, the vessel or unit itself is dynamic positioning compliant, with DP2 or DP3 classifications, as station maintaining ability when over a well or attached to a well is paramount. DP2 and DP3 compliant vessels simply means with a single failure they should not lose position. With DP3, more redundancy is built in.

Traditionally a Module Handling Tower (MHT) or Multi Purpose Tower (MPT) with a large enough capacity Active Heave Compensated (AHC) winch to convey and extract heavy equipment to and from seabed is the basis for equipment stackup and stability of same equipment. Though, in recent years vessels have been developed without a MHT with larger deck space including a larger moonpool hatch to facilitate larger equipment to be moved around such as XT's and subsea equipment that makes up subsea field architecture.

These vessels will consist of a moonpool (or similar to a traditional rig floor with the WIU) with easily accessible hatch so as to convey Well Control Packages, XT's, etc through with safety and efficiency paramount. Also in this MHT there are a number of auxillary winches that are utilized to pick up tooling and hold wireline sheaves while work is underway. A critical piece of equipment will be the Active Heave Compensated (AHC) crane (or a combination of crane and winches) onboard utilized to convey equipment to seabed and extract same back to vessel for those over the side lifts.

Typically nearby the MHT a control cabin will be housed that is much like a drilling cabin. From this control cabin the equipment is remotely controlled such as Wireline, Pumping, Coiled tubing. The equipment is controlled using a centrally controlled ergonomic chair, much like the chairs in drilling cabins. Dynamic safety features ensure full protection of the subsea wellhead stack in the event the vessel drifts off station, eliminating excessive loads on the subsea stack through tension control. The fully remote operation and support incorporates CCTV, fiber optic connectivity, software, and data interrogation. Remote handheld control and central deck stations allow preparation of non-active equipment for sequential phases, minimising vessel down-time between tasks.

The main deck of the LWIV or WIU is usually sectioned off with guide rails (which hold deck skidding systems). On these rails, handling pallets are secured which hold the subsea gear which is going to be run and extracted subsea. You may have different rated pallets based on weight of specific gear onboard. For instance, 50 Ton, 100 Ton, etc. The pallets are moved around by hydraulic pallet skid units.

Also in today’s safety conscious setups, there might be walk to work equipment or maintenance platforms nearby the towers or in the 'garage' to access the equipment at high reach places and to also maintain these lengthy Well Control packages. This is to keep man riding to zero and working at height to zero.

For the larger WIU and also a number of monohull vessels (Siem Helix 1, Siem Helix 2, Helix Q7000) there are Intervention Tension Frames (ITF) to assist in safe deployment of tools subsea. The ITF provides a safer working environment from which coiled tubing and wireline operations can be conducted and has three platform levels, is accessible via a telescopic gangway and removes the need for engineers to use rope access systems. This means that from a relatively small vessel, a suite of tools can be exchanged without having to come off the well in addition to the swift and efficient manoeuvring of personnel. The ITF is attached to the Multi Purpose Tower.

With the ITF, vessels productivity is greatly enhanced, with crews able to quickly access the wells, using the tools they have, moving from well to well and tooling suite to tooling suite safely and effectively. This ensures that the right people are at the right equipment at the right time, and that maintenance can be carried out as swiftly as possible.

Most recently FTAI Offshore together with OSBIT have developed a Smart Tower System (STS) for the MV Pride. The STS facilitates riserless and riser-based well intervention operations in water depths of 80 to 1,500 metres, providing an Active Heave Compensated platform for surface pressure equipment, slickline & e-line operations and for the building, operation and recovery of CWOR and intervention systems. Designed to operate in adverse weather conditions and certified in accordance with DNVGL-OS-E101.

The STS incorporates a dual-level Heave Compensated Platform, which allows easy access to the surface pressure control equipment whilst reducing stresses into the riser. The platform is actuated with a ram rig hoisting system which enables the deployment and recovery of 90ft CWOR joints and subsea pressure control equipment of up to 250-tonnes.

For the Well Control Package (WCP) and associated equipment there will be a hydraulic power unit (HPU), a Master Control Station (MCS) which controls all the functions of the WCP from opening/closing valves to MEG injection to shearing and disconnecting in an emergency situation, and a Chemical Injection Unit (CIU).

For communication to the WCP there will be a control umbilical (hydraulic/electrical) which will be mounted nearby the moonpool on a powered reel. If MHT is utilized then a series of guide sheaves route the umbilical up to the top of the MHT and down through well center where it connects with an Umbilical Termination Head (UTH) to the WCP.

Onboard the vessel or unit a survey crew and their equipment with be present and also ROV crews with preferably 2x Work Remote Operated Vehicles (WROV). WROV's allow the ability to maintain control of heavy equipment packages while moving to latch or unlatch from subsea XT. Various setups exist and one is where both ROV's were housed in a workshop forward of the MHT with Moonpools & Launch and Recovery Systems (LARS) for both ROV's, and also LARS over port or starboard side whereby ROV could be launched in less rough weather.

Additionally, in the UKCS for instance, some of the vessels there have the ability to perform Saturation Diving operations in addition to utilizing ROV's. On the North Sea based vessels you may still find a Sat Diving spread.

Regardless of which method being used the Well Control Package makes up an integral part of the Subsea kit and a Riser based package typically consists of a Well Control Package (WCP) including Lower Marine Riser Package (LMRP) with a XT connector below, an Emergency Disconnect Package (EDP), and Riser back to surface.

With an Riserless Light Well Intervention kit you would have Well Control Package with a XT connector below, Lower Lubricator Package (LLP), Upper Lubricator Package (ULP) which acts as your containment mechanism for tools to be run in the well, and a Pressure Control Head (PCH). *Please note these RLWI notations are specific to TFMC Stack #4 so will vary between contractors and specific stacks; other names for these RLWI stacks are SILS, SIL, RWIS*

The current offerings across IRS and RLWI are:

AKOFS Offshore - 7 3/8" Intervention Riser System with Riserless capabilities. 10k psi rating

Baker - 3 1/16" Riserless (3.0), 3 1/16" Riserless Lite (3.1), 4 1/16" Riser based system (4.1), 7 1/16" Riserless (7.0), 7 3/8" Subsea Riserless Intervention System (7.1 & 7.2) - Both Riser and Riserless options available for the SRIS. 10k psi ratings

Enovate Systems Ltd - P&A lightweight well intervention system with Riser and Riserless ability. 10k psi ratings

Expro Group - 7 3/8" Intervention Riser System (IRS), 7 3/8" Riserless Well Intervention System (RWIS). 10k psi ratings

Halliburton – 6 3/8” Light Riser Intervention System (LRIS), Riser and Riserless capabilities, 15k psi ratings

Helix Energy Solutions - 7 3/8" Intervention Riser System (IRS), 5 1/8", 7 1/16", & 7 3/8" Subsea Intervention Lubricator (SIL). 10k psi ratings & 15k psi ratings (IRS)

Oceaneering - 7 1/16" Interchangeable Riserless Intervention System (IRIS), 7 1/16" Blue Ocean Riserless Intervention System (BORIS). 10k psi ratings

Sapura Energy Well Services - 7 3/8" Subsea Intervention Device (SID), Riserless system. 10k psi ratings

TechnipFMC - 5 1/8" - 7 1/16" Completion & Workover Riser (CWOR), 7 1/16" Riserless Light Well Intervention (RLWI). 10k psi rating for 7 1/16" stacks with 5 1/8" riser package having 15k psi rating

Trendsetter Engineering – 5 1/8”, 6 3/8”, & 7 3/8” Trident Intervention System - Riser based and RLWI functionality, 10k, 15k, & 20k psi rating

Worldwide Oilfield Machine (WOM) - 6 3/8" & 7 3/8" Deepwater Riser System (DRS), 7 3/8" Riser-less Light Well Intervention (RLWI). 10k psi rating for 7 3/8" and 15k psi rating for 6 3/8" system

The differences in the packages as you can see are nominal bore ID's and pressure ratings. There are also differences in depth ratings per package.

So now that you are clued in on vessel classifications and general setup, looking more towards planning your Subsea Well Operations, what questions might you ask yourself?

- What is the scope of work being considered & what are the goals? Is it simply a wireline scope or are there additional types of operations to be considered such as coiled tubing (that require a riser)?

- What are the risks and benefits of a riser based vs riserless setup? Is one ruled out, meaning can everything be done riserless or is there a requirement for large fluid circulations indicating the need for a riser based system.

- How much deck space do you need taking into consideration equipment spread required and what is the load strength (and weight distribution) vs equipment spread required?

- What is the maximum load required (crane size needed) to deploy and what is deployment depth of subsea equipment? The main crane should be Active Heave Compensated (AHC).

- Do you require a moonpool or can you safely deploy over the side?

- Can you perform your scope with a lighter Wireline Mast or is a Module Handling Tower (MHT) preferred for heavier scopes?

- What options do you have within the specific region you are in? Is a fully kitted WIU or LWIV an option or do you need to piece everything together?

- If you require fluids for pumping operations, what is the total volume required? Is there storage below deck or will it go on deck? what is the size/weight?

Once you have asked yourself these questions you should have identified whether a RLWI System or an Intervention Riser System is to be utilized. If you are using a RLWI system let's discuss the standard deployment options. Those options are:

1) Deployment through moonpool with the use of a MHT with an Active Heave Compensated (AHC) winch

2) Deployment over the side with the use of an AHC crane

With the first method mentioned, MHT are typically found on specialized Light Well Intervention Vessels (LWIV), though smaller versions may be present on some Subsea Equipment Support Vessels (SESV) & Construction Vessels (CSV). The MHT is situated over a moonpool area, and that is where the majority of subsea equipment is deployed. They allow for more bulky lifts as equipment can be stacked up prior to deployment, MHT can be likened to a Drilling Rigs derrick.

The RLWI package is typically stored in close proximity to the MHT, assembled and tested, on a skid trolley in a parked position, thus saving rig-up time offshore. These towers typically have an AHC subsea winch and a series of smaller winches mounted up top (pod and guide wire winches); some to stabilize movement of load (by use of guide wires), winches (and sheaves) for umbilical, and tie off points for wireline sheaves, etc. There could be some type of "cursor/tension frame", an upper & lower frame which supports the Well Control Package entering and exiting the moonpool until landed out on a 150T skid trolley and secured.

From the skid trolley, the RLWI package is transferred to a position above the moonpool where the assembly is lifted and lowered through the splash zone by two cursor frames. If applicable, four guide wires are utilized preventing unintended movement of the package. Active heave compensation allows the winches to effect a controlled and secure landing, and disconnection.

Next, "Over the Side" deployment where AHC crane deploys Well Control Package over the side. Typically this method is utilized when a Vessel of Opportunity (VOO) is being used and a MHT is not present, and there may or may not be a moonpool to deploy equipment packages through.

The Well Control Package (WCP) will be deployed, landed, latched, and then typically the Wireline Sheave is hung off on the fast line and Lubricator Section (LS) is hung off on the main line, of the AHC crane. Wireline tools will be made up horizontally and pulled up into the LS for deployment or deployed alone through open water with ROV assistance depending on method utilized. When work is complete the well is secured and the LS is unlatched from the WCP and retrieved back to surface.

As with any other vessel there will be tank storage either below or above deck for storage of brines, freshwater, chemicals, etc with piping and transfer pumps to move fluid to your downhole pumping equipment. High pressure pumping equipment is then mounted above deck with high pressure line sea fastened and permanently plumbed into manifold and connected to the downline reels.

Depending on the type of operations to be done, a wireline unit with the ability to perform mechanical operations (slickline/braided line) and the ability to run electric wireline tools is usually present. Dual drum units are handy for this purpose, where one drum holds slickline and the other holds electric line. Digital Slickline Units can be a good choice as you can do with one unit what 2 units did in the past

(depending on services to be run). A variety of downhole tools will be present, again depending on application.

To aid in pumping Coiled Tubing reels with Coiled Tubing, Flexible Hose, or even TCP can be used for downlines. In my personal experience, over the side injectors were used on a sliding plate which then allowed the downlines to extend out over the port side of the vessel, though conduit through the moonpool with powered reels are also common. Some type of high pressure hose or jumper is then used at or near the seabed to run between the CT downlines and the pump-in location on the WCP mounted with Emergency Quick Disconnects (EQD) in the case of an emergency and the need to disconnect while operations underway.

With vessels that deploy IRS such as Helix Q4000, Q5000, Q7000, SH1, SH2, and FTAI Offshore MV Pride, a Coiled Tubing unit can also be utilized and set up as it would be on a drillship or semi-sub, in a conventional way with Coiled Tubing Lift Frame (CTLF). Advances are also being made to deploy Riserless Coiled Tubing (RLCT) and could have Injectors at the surface and subsea to make sure tension is held between the 2 points; Coiled Tubing has also been deployed successfully multiple times Riserless from LWIV.

If you are utilizing a Well Intervention Unit (or vessel for that matter) with an Intervention Riser System, deployment will mimic standard deepwater rig deployment, though since IRS is smaller and lighter, deployment is easier and faster.

Going into the actual well operations themselves, in addition to wireline work, you might be considering Hydraulic Intervention or even Decommissioning. Lets touch on those now.

Regarding wireline work, what can be done? Everything from Production Logging, Water shut off, Sand clean out, Scale milling, Shifting sleeves, Gas Lift Valve change out, Nipple milling and restriction removal, perforating, setting plugs, Logging, etc. Anything with wireline that can be done conventionally can also be done riserless.

If you are looking at boosting production with stimulation, there are subsea modules made available for hydraulic intervention such as Baker Hughes 10k Fluid Intervention System, Caltex Oil Tools Rigless Stimulation Tool (RST), Enpro Subsea Flow Intervention Service (FIS), Oceaneering Well Stimulation Tool (WST) & Rapid Access Tool (RAT), Trendsetter Engineering Subsea Tree Injection Module (STIM), TechnipFMC Subsea Injection Module (SIM), and OneSubsea SMIS (Subsea Modular Injection System) with MARS (Multiple Application Reinjection System).

As well as modular subsea systems, if proper planning has been done in the early design stages, subsea access points where downlines can be connected for pumping will be available on your PLET/PLEM/XT. SECC Oil and Gas offer such connectors in their Hot Make Hot Break line of connectors.

With Hydraulic Intervention there is a requirement for Emergency Quick Disconnect (EQD) connectors on your downlines/hardware in the case of vessel drift or drive off. If you are familiar with the emergency disconnect for a coflex hose on a stimulation vessel, these subsea connectors are similar in their purpose, allowing disconnect during vessel drift or drive off.

There are a range of connectors from passive to active in nature. So, who offers these connectors and what is available?

Blue Logic - Auto Release System, Large Bore Hot Stab

Flint Subsea Ltd - Mid Line Weak Link EQD, Well Kill Connector, EQD Skid

SECC Oil & Gas - Hot Make Hot Break Connector, Hot Make Hot Break Gimbal System, Mid Line Weak Link Connector

Enpro Subsea also provide a passive Mid Line Weak Link system in addition to the active and passive EQD located on their Subsea Safety Module.

There are a number of ways to perform stimulation and these are some of your options:

- Mobilize LWIV with Pumping/Fluids/Chemicals including Hydraulic Intervention kit

- Mobilize multiple vessels LWIV including Hydraulic Intervention kit with including Stim Vessel (or MSV to carry Fluid/Chemicals)

- Mobilize Vessel of Opportunity (provided it has subsea crane abilities) including Pumping equipment & Hydraulic Intervention kit.

- Any of these options above without Hydraulic Intervention Kit provided proper planning has been done by having a pre-installed connection point on your Subsea Manifold/PLET/PLEM; then its as as simple as tying into that access/injection point and pumping.

Fast forward to plug and abandonment – decommissioning workscopes, as the situation is now, it is not economically sustainable for operators to perform P&A operations conventionally from Drilling Rigs. The best way for P&A operations to become more economically viable is through advances in technology and once approved by regulatory bodies, they enable P&A to be completed with electric wireline tools and coiled tubing services alone, enabling lighter vessels to perform the full scope of work.

LWIV's are typically monohull, flexible, extremely cost-efficient, and can be used for single or multi-well campaigns of subsea wells. Purpose built Abandonment Rigs and Well Intervention Units are also continued interest.

The P&A of subsea wells is a major issue, so there is considerable interest in how to utilize these vessels, rigs, units most effectively in Decommissioning operations. The future goal is to perform full permanent abandonment of subsea wells with smaller vessels.

In abandonment, no two wells will be the same. Thinking must be dynamic as the challenges faced could be many. These challenges range from high temperatures, unconsolidated formations, formation strength changes due to reservoir depletion, uncertain reservoir pressure post abandonment, formation permeability, formation shear stress/subsidence, sustained casing pressure, lack of data, deep section milling requirements, & cement verification behind multiple casing strings.

Let us digest some general information on abandonment types and phases.

What Abandonment types are there? In general, these can be broken down into three categories and can be defined as follows:

1. Suspended

2. Temporary
3. Permanent

A suspended abandonment is where well control equipment remains intact, and the wells operations are suspended. This could be due to many reasons such as waiting on weather, workover of other wells, postponed while waiting on equipment delivery, the rig has been skidded performing work on adjacent wells, or construction activities are ongoing in the field.

A temporarily abandoned (long-term suspension) well has been abandoned, and the well control equipment is removed with the intention of later re-entry or to abandon permanently. Temporary abandonment could be due to various reasons such as an extended shutdown, waiting on a workover, waiting on field development, re-development, etc.

Temporarily abandoned status comes into effect when the main reservoir has been fully isolated from the well bore and may last from days up to several years.

A permanently abandoned well is one in which the well or part of the well, has been permanently plugged and abandoned with the intention of never being re-used or re-entered.

During well abandonment, there are three main phases: (4 actually, as pre-planning is phase 0)

0. Pre-planning

1. Reservoir abandonment

2. Intermediate abandonment

3. Wellhead and conductor removal & the setting of Surface Environmental Barriers (if required)

Reservoir abandonment starts primarily by inspecting the wellhead, followed by rigging up a wireline unit. The wireline unit is utilized to gauge wellbore access by drifting and evaluating the tubing condition by performing a caliper log. Also, at this point, waste handling systems are established for liquid and solid phases of the operations. This phase follows with an injection test to examine well integrity. If integrity is maintained, cement slurry is bullheaded to plug the main reservoir, and once the cement plug is deemed to have the strength required, its quality is determined by pressure testing.

The intermediate abandonment phase includes milling, retrieving casing, setting barriers to isolate intermediate hydrocarbon or water-bearing permeable zones, and installing an environmental plug. The production tubing may partly be retrieved if it has not been retrieved in the first phase. The second phase is complete when all the potentials for flow are secured.

In the final phase, the conductor and wellhead are cut below the surface or seabed and retrieved. The reason for this is so to avoid any future incident with other marine activities such as fishing activities.

Now that we know the types and phases of abandonment, one of the major deciding factors in the scope of work are the type of Xmas trees (XT) utilized.

XMT types can be broken up into two categories:

1. Vertical XT (VXT) – The valves are in a vertical arrangement with the tubing being landed in the wellhead itself, and then VXT is landed and locked onto the wellhead.

With a VXT, to get to the tubing, the tree would first have to be removed, whereas, with an HXT, tubing is pulled with the HXT still locked onto the wellhead.

2. Horizontal XT (HXT) – The valves are in a horizontal arrangement, and the tubing is landed in the XT, which has already been landed and locked onto the wellhead.

During a subsea abandonment, the Well Control Package or BOP is positioned above the HXT and tubing is retrieved without nippling down the XT, leading to more efficiencies and time savings.

So, knowing what levels and phases a P&A consists of and the types of subsea XT involved, what is it that an LWIV of today's standards can perform in the scope of work?

In summary an LWIV (and WIU) typically accommodate a wireline unit (electric wireline & slickline), a coiled tubing unit, and high pressure pumping unit utilized for fluid injection or cementing operations. Operations can be performed to include logging and perforating, setting plugs, fluid and/or cement injection with coiled tubing, wellhead cut and removal with additional cut and retrieval assemblies, & tubing retrieval with pipe handling units. Some units also accommodate saturation diving spreads when required.

Yes, there can be limitations to what an LWIV can do, but the capabilities are increasing. Those are limited pull capacity, weather limitations, & perhaps limited deck space area (depending on vessel chosen). This is also where a Cat B or WIU comes in as those limitations are lessened.

In recent years, there have been systems developed for giving the ability to retrieve tubing in open water with a shut off device so that dual barrier philosophy is intact, such as OneSubsea/Helix ROAM, TechnipFMC Subsea Shutoff Device (SSOD), Trendsetter Engineering Mudline Closure Device (MCD), and the Oceaneering OSPAT concept.

For added safety and less exposure due to decreased handling, vessel skidding systems and automated handling systems have been developed to avoid manual lifting & handling with minimal personnel. There are also automated deployment systems to avoid manual handling and pipe handling systems suited for vessel based tubing retrieval.

Some of the benefits of a fully integrated vessel are shorter mobilization & demobilization times, higher operational efficiency, continued performance improvements with the same crew, and better agility than larger drilling units, giving them flexibility.

An LWIV or WIU can come in and perform all phases of reservoir abandonment (depending on degree of work involved), and a Vessel of Opportunity (provided it has a rated crane) can perform the later phases thereby saving costs. Some of the intermediate abandonment phases can also be performed with LWIV or WIU, though dependent on a well by well, case by case basis; the limitations of the intermediate phase being the requirement to perform section milling and casing removal, if those are required.

Just to quickly touch on new Wireline Decommissioning technologies available, a number of niche companies are developing thermite and alloy fusion technologies to be able to leave tubing in place in cases where its not necessary for complete removal.

The companies involved in this space are:

- BISN (Perf & Melt)
- Isol8 (Fusion Tubing Plug, Fusion Annulus Barrier)
- Interwell (RockSolid)
- WellStrøm (Bizmuth Alloy tech)

Then companies such as WACORP have developed their K-WAT tools to allow for wireline-only multi-zone abandonments by simultaneously setting and pressure testing the bridge plug on wireline. The K-WAT tool sets and pressure tests the bridge plug, eliminating the costly tubing run.

Last, but not least, cut and retrieval, with a quick summary on what is currently in the market, specifically vessel deployed single trip systems. Yes, there are more systems available, but they aren't single trip or they require a rig with drillpipe to deploy.

- Acteon Multi-String Cutting Tool/Multi-Wellhead Retrieval Tool
- Baker Hughes Terminator
- James Fisher Decommissioning Internal Cut and Lift Tool (ILCT)
- Oceaneering Wellhead Picker (WHP)
- Sapura Energy Well Services AXE Cutting System.

What are the similarities in these tools? They are all single trip cut and retrieve, and all vessel capable, so they don't require a rig on location.

What are the differences in these systems? The differences are the way that they cut whether that be abrasive waterjet or mechanical powered by hydraulics.

Here are the systems listed below:

1. Acteon (Claxton) Multi-String Cutting Tool & Multi-Wellhead Retrieval Tool. The MSC is a proven and reliable cutting method that can sever all strings in one deployment; ranging from 7 inch inner casing up to 30 inch. Combined with the multi-wellhead retrieval tool the ability to perform recovery directly after cutting is possible.
2. Baker Hughes Terminator - Mechanical Hercules™ cutter with hydraulic motor including wellhead connector. Terminator has no depth limitations, system footprint is small so can be mobilized quickly, and it only requires two personnel to operate. Once the Terminator is deployed subsea, there is no more equipment remaining on deck. The cutting time is less than an hour for single cuts and within a few hours for multi-casing cuts.
3. James Fisher Decommissioning ICLT - Collaboration with First Subsea has led to the development of a one-component system, Internal Cut and Lift Technology (ICLT), which merges market-leading cutting and lifting tooling, optimized with Ballgrab gripping technology, to provide a simple, flexible and quick mechanism to remove retired subsea assets and tubulars.

ICLT offers a simple solution that streamlines the number of contractors, operations and personnel required on offshore platform operations.

4. Oceaneering Subsea Wellhead Picker - Abrasive Waterjet cutter, Internal Multistring Cutting Tools (IMCT) including wellhead connector. The Subsea Wellhead Picker is a combination of a connector that latches onto the wellhead and the Internal Multistring Cutting Tool (IMCT). The IMCT uses the extremely effective Abrasive Waterjet Cutting method to sever all the layers of casing in one go. It can cut from 7 - 36 inches.
5. Sapura Energy Well Services AXE Cutting System - Abrasive Waterjet cutter, Multistring Cutter including wellhead connector. The AXE uses entrained grit water, at 10,000 - 14,000 psi system pressure, as a cutting medium. The standard cutting tool is capable of entering and cutting wellheads with 7 inch, or larger, casing and severing through multiple casings of 7, 9⅝, 13⅜, 20 and 36 inches in a single pass cut. An optional four inch cutting tool is able to provide a solution for smaller bore applications.

What does the future hold? Considering the value of Well Intervention including Hydraulic Stimulation to unlock new reservoir value vs. drilling new wells, and considering a large percentage of Plug and Abandonment/Decommissioning can be performed from lighter assets, equalling less footprint and emissions, I think we will also see more utilization across the space.