Real Time Slickline: Unlocking Additional Production With Reduced Uncertainties in Limited Space Platforms

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Abstract

Platforms with limited crane capacities and restricted space in which to set up the necessary well intervention equipment are challenges that the industry is facing increasingly in offshore environments. Operators are having to either compromise on operational efficiency and certainty through the use of memory based slickline conveyance applications (e.g. slickline perforating without real time correlation) or are having to rely on more costly solutions utilizing a multitude of equipment and leveraging workover rigs in order to accomplish their intervention campaigns.

Real time slickline’s light, minimal foot print and modular make up coupled with its digital telemetry enablement allows operators to access wells and perform conventional slickline operations, plus perforating, plug setting and production logging, all with downhole in-situ information available on surface in real time, bringing huge operational efficiencies as well as reducing considerably the risks and uncertainties of the intervention programs being undertaken.

Interventions executed using real time slickline have proven to be a safer, more efficient and more cost effective way to conduct operations by having full realtime control of its downhole tools and periphery sensors. It reduces the associated risks of having to mobilize and switch between electric line and slickline units, equipment and personnel in the cases where the scope of the intervention programs can be fully covered by real time slickline’s capabilities. Furthermore, its minimal weight and footprint enables intervention operations where space and crane capacities make slickline the only choice of conveyance.

Introduction

The offshore industry globally is facing multiple challenges when it comes to the planning and execution of well interventions in small and/or limited space and crane capacity platforms. The number of small platforms is clearly increasing in many regions around the world, since the size of recent discoveries and future field development plans converge with this as the most optimal cost effective solution for field development. As the wells and the reservoirs they are draining age, the need for intervention whether it be for diagnostic, repair, maintenance or remedial purposes, is increasing exponentially. Final intervention as part of a Plug and Abandonment campaign is also on the increase.

Size limitations can be related to either horizontal space lay out, specifically related to the equipment foot print and the area that it will cover to perform the operation, or height limitations when the intervention equipment needs to be placed on a lower deck. Well intervention programs commonly include multiple scopes of work with a multitude of services scheduled. In many cases expensive logistical arrangements are needed often including the use of support boats for moving equipment in and out of the platform as the interventions program evolves and/or for providing catenary operations from a service barge. Often multiple crews are needed increasing the amount of people on board requirements and the cost and risk exposure associated costs to this. Finally such complex logistics often result in unnecessary production delays.
Platform size limitations can also be related to vertical space in order to rig up the required pressure control equipment in order to run the tools to accomplish the intervention plan. In some regions, well interventions under the rig floor have become a standard approach. Vertical limitations can also be related to placement of physical obstacles after the drilling rig has moved out of the platform (helideck, production facilities, accommodation facilities, etc. As per Fig 1. ZEDP-E Platform). Space limitations will either imply expensive and complex platform modifications (depending on the specific conditions) or may result in a limited number of operations that can be performed in the well.

![Fig 1. ZEDP-E Platform.](image)

Platform limitations can also be related to weight of equipment to be brought on board. This is more common in old platforms as aging necessitates the downgrading of crane capacities reaching their Safe Working Load levels below two Ton which often result in more expensive logistics (the need of support boats or cranes) in order to mobilize the equipment on board.

Standard electric line (eline) equipment is normally above those levels. As a result in many cases, operators have been forced to adjust and compromise their programs in order to work within these limitations and stay within the intervention budget.

The most common approach for conveyance in small and/or limited space platforms has been slickline- Given its minimum footprint and its modular characteristics it is suitable for these kinds of environments. The feature of not requiring grease injection for well control also reduces the vertical space needed in comparison with eline. The compromise with slickline conveyance is that it does not allow real time communications with the down hole tools hence all decisions are taken based only on the surface tension behavior and a rather inaccurate mechanical depth counter. Uncertainty in depth control will also be present in slickline and in many cases will demand additional correlation runs with memory tools and line tagging.

Memory tools have been in the industry for decades now and have become the low cost solution by excellence when it comes to acquiring pressure and temperature surveys and in many cases complete production logs. Unfortunately real time decisions are not possible with memory surveys and there are situations where either the data is corrupted or part of the information is missing because of improper correlations.
Specific to perforating, a number of technologies have been developed in the industry in order to perform such operations with slickline. These range from simple timers to more complex sequence arming triggers but all depending on a previous correlation run and physical tagging on the line. Furthermore these systems offer no means of shooting confirmation other than feedback via change in the surface tension meter (which does not happen in all instances).

For decades there has been very little innovation on slickline technologies until the recent development of real time slickline, a technology that is bridging the gap between a slickline unit applications and the real time e line capabilities, enabling operators to have real time information while performing any conventional slickline operation and also enabling the acquisition of production logs in real time and allowing perforating operations with the same capabilities as e line related to real time Gamma ray – CCL correlation, on command from surface trigger activation and real time information from the wide range of sensors that provide shooting confirmation through changes in downhole pressure, temperature, head tension, and through an accelerometer that will identify a shock downhole.

In many cases, a real time slickline unit will be sufficient to cover the whole expected scope of work programmed, without needing to switch back and forth between conveyance methods (e line and Slickline), and with the entire operation performed by a single crew on board.

**Description and Application of Equipment.**

A real time slickline unit will have the same footprint and specifications as a slickline unit (Fig 2. Surface setup). Its only differences in terms of surface equipment are that it requires a surface acquisition system and also a special cable coated that will enable real time telemetry communications with the downhole tools (Fig 3. Real time slickline cable) as well as sending commands from surface (such as shooting a gun).
The downhole tools that can be run in combination will vary according to the specific scope of work needed. For the particular application referred to in the following case study, the bottomhole assembly was formed by:

1) Digital Correlation Cartridge: The digital correlation cartridge provides a digital CCL as well as natural GR detection to enable real-time depth correlation with openhole or cased-hole reference logs. The robust GR detector means this tool can also be used during slickline jarring or perforating operations.

2) Basic Measurement Cartridge: The basic measurement cartridge provides the power to all the sensors, as well as the telemetry to send the data from each sensor to the surface at the proper rate. In addition, it receives control signals from the surface transceiver.

3) Digital Pressure Gauge: The digital pressure gauge is equipped with robust sensors to measure the well pressure and temperature during slickline operations, including jarring and perforating.

4) Digital Trigger: The digital trigger device enables activation of perforating guns, cutters, and samplers, when a command is sent from surface. This device incorporates safety features that ensure that the triggering of explosive devices cannot occur without positive action from the operator and complies with API RP 67, Recommended Practice for Oilfield Explosives Safety.

The complete tool string in each perforating run (Fig 4. Downhole tools) had a total length of 26.9 ft (including the 10 ft gun) and a weight in air of 101 lb.

Case Study

Z Field (ZEDP-E) located at Bintulu, Sarawak offshore, has 14 conductor slot, with a total of 22 strings, and total production of about 4900 bopd. The well T-41 from PETRONAS Carigali Sdn Bhd in Offshore Sarawak was intervened in July 2013 using real time slickline. The scope of the intervention included a correlation log (GR-CCL), seven runs of perforating guns (2” HSD), the deployment of a sand screen and finally the setting of the well subsurface safety valve.

The platform had the helideck built on top of the well decks including the one to be intervened (Fig 5) leaving a vertical rig up available length of only 28 ft (Fig 6). In addition the platform crane had a limited safe working load (Fig 7).
The entire scope of work was accomplished using a single unit and crew. Gamma ray and CCL correlation information was acquired in real time during a correlation run and during all the perforating runs for accurate depth control. Every run was combined with a pressure and temperature gauge to monitor the well conditions during the perforating job and also while tripping in and out of the well.

Shot detection was very clear with the sensors available, (pressure, temperature, head tension and toolstring shock). As demonstrated in Fig 5. (and during every run) head tension, pressure, temperature and shock gave a precise indication and a record of the gun initiation for this perforating operation and also gave additional valuable information about the immediate response of the formation to the perforating operation.

Immediate pressure changes denote either depleted or overpressured zones (compared to the well conditions before perforating). A designed underbalanced or overbalanced condition can be verified before executing the operations if needed.

Furthermore the temperature response can provide a qualitative indication of the type of fluids initially flowing, a warm up like the one in Fig 8 could be related to liquids production while with gas we would expect a cool down effect due to the Joule Thompson expansion considering the particular well conditions.

Fig 8. First perforating run in well T-41

The fact of having a full survey of pressure and temperature in every trip in the well can help to understand the dynamic well conditions between runs and get a very close idea of the pressure and temperature dynamic gradients. Fig 9 shows one of the perforating guns run in hole with full acquisition of pressure and temperature. A fluid contact can clearly be seen at 1260 m through the pressure gradient change and also can be corroborated by the head tension change. All this was seen and acquired in real time.
The perforating runs were initiated utilizing the on command digital trigger device that enables accuracy and precision during gun detonation.

The sand screen was set in the well using similar tool configuration permitting monitoring of the downhole head tension during the jarring operation. Finally the well subsurface safety valve was also set with the real time slickline unit.

**Conclusions**

Using real time slickline the operation was accomplished successfully despite the constraint which prevented the use of an e-line unit.

A single unit performed a multiple scope of work that under normal conditions would have required two units and twice the amount of people on board plus elimination of the associated inefficiencies of having to switch units back and forth and the related production delay.

Depth control certainty and shot detection which are of paramount importance in such operations was achieved.

An additional margin of safety was possible by monitoring the downhole tools conditions (especially head tension) during all the operations including the ones that are normally done with slickline.

Additional information (pressure and temperature) continuously during the real time slickline operations proved an important feature in providing important feedback on the immediate well response during each perforating run as well as the dynamic well conditions in-between runs.