SPE-208116-MS

Wireless Coiled Tubing Disrupts the Industry by Enabling Use of Conventional Coil Tubing for Access and Matrix Acidizing of Multilaterals and Extended Reach Carbonate Reservoirs

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This paper was prepared for presentation at the Abu Dhabi International Petroleum Exhibition & Conference to be held in Abu Dhabi, UAE, 15 – 18 November 2021. The official proceedings were published online on 9 December 2021.

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Abstract

As the number of Extended Reach Wells (ERW) with multilaterals and restricted access due to electric submersible pumps (ESP) increases, so does the challenge to enable access and stimulation to these wells to maintain production rates. This paper describes a Slim Access and Stimulation System (SASS) development program launched to develop a game changing technology to give operators the ability to maintain high production rates in unconventional developments. There is available technology today to accurately access extended reach lateral wells, even with restricted access. But the technology is limited to logging only, as the tools and/or control wire are not acid resistant and would limit the pump rate through the coil tubing for pumping acid. The new system would require a tool suite which was acid resistant, enable slim access to the laterals, and have the ability to perform multiple stimulation jobs in one run, with monitoring and control from surface without a wire inside the coiled tubing. The SASS development program gave birth to three separate and revolutionary new technologies: two-way wireless communication and energy harvesting with integrated production logging suite, slim and high-power open hole tractor with a wire bypass to power the tool string, and semi-autonomous lateral access sub, which finds, enters, and confirms the lateral access. The three game changing technologies have application as standalone products, however the real value occurs when they combined as a Slim Access and Stimulation System, run on conventional coiled tubing. The paper will describe working methods and technology incorporated to provide access to restricted extended reach laterals and perform multiple stimulation jobs in a single run. The SASS development program is a testament of how the industry can tackle complex challenges, introducing new technologies across in multiple domains while still adapting to conventional methods. The paper highlights the full system design approach method used to understand and combine features of downhole tools, surface equipment, and operational and handling routines to achieve the overall design goal.

Background

Operating Oil and Gas companies has a long history in the construction of Maximum Reservoir Contact (MRC) wells in tight carbonate formations using Technology Advancement of MultiLaterals (TAML) Level One and Level Two junctions (Petrowiki 2021; Salerni 2003; Nughaimish 2004). With their increased

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popularity, MRC wells were next proliferated into more difficult fields containing sandstone formations and heavy oil types requiring Electrical Submersible Pumps (ESP) and periodic acid treatments (Hembling 2007; Al-Mulhim 2009; Arukhe 2014). With the combination of horizontal, extended reach, and ESP wye tool restrictions, a problem arose with interventions to log and acid treat these wells all the way to total depth (TD). In many cases only 60% of the horizontal producing wellbore could be accessed using coiled tubing (CT) before lock-up would occur. Evaluations were made of agitator tools and friction reducers to improve reach, but none gave more than an incremental benefit (Saeed 2018).

Conventional Applications

Oil and Gas companies considered working over the wells, removing the ESPs, conducting acid treatments on drill pipe, and then recompleting. Since the acid treatment would be needed on an annual basis, this solution was deemed both expensive and impractical. In 2013 a challenge was submitted to the industry to develop new slimline intervention products to increase multilateral window access and increase horizontal reach in wells with severe restrictions caused by ESP wye tools. Several responded to the call and improvements were made for 1) smart lateral access for logging capability with an electric tractor on wireline (Abdelaziz 2016), and 2) extended reach for acid treating with a hydraulic tractor on coiled tubing (Saeed 2018). But these were two separate solutions and were not designed to be integrated into a single bottom hole assembly (BHA). Separate trips had to be conducted in order to reliably complete these two functions. This paper will detail development and testing of slimline coiled tubing tools designed to integrate these functions. Downhole power generation bidirectional pressure pulse telemetry and are the key technologies employed to create "Wireless CT" make the tools smart and provide large pump volumes needed for effective treating.

The Challenge

The challenge was to enable access and stimulation capability by conveying a CT into the producing zones of the long horizontal laterals.

The title of the project would later be known as "Slim Access and Stimulation System" (SASS), as the challenge was increased to also pass thru ESP wye tool restrictions in multilateral wells.

The SASS development program was condensed into 4 major new technology achievements; 1) downscaling 'sthe hydraulic logging tractor to a 2.125″ max outer diameter (OD) while still being able to convey the tool string to the toe of the open hole wellbore, be acid and debris resistant, and facilitate a wired feed thru to connect a lateral search and entry tool to the front end of the tractor ((Saeed 2018, SPE-192301-MS) 2) downscale WINS's core technology, downhole power generation and wireless communication technology to a 2.125″ max OD tool, while still providing high pump rates for acid stimulation by developing and integrating an electric high flow rate circulation valve, 3) design and develop a novel new tool for providing autonomous access to lateral wells, with an unquestionable confirmation and high success rate, by use of the limited bandwidth wireless communication between downhole and the surface crew, 4) design the SASS system such that all 3 components, power & communication and valve sub, hydraulic tractor, lateral access sub, works flawlessly together while also providing individual standalone applications.

Development of SASS

The team's 'sapproach for developing any new product, method or process is to invest heavily in drafting the Design Objectives and Requirement Specification Document (RSD). This was done by completing a large market study within the middle east oil and gas fields in the need of stimulation and several interviews with service companies involved. Upstream Research Group facilitated several comprehensive and productive workshops with proponents from multiple fields. Similarly, field experience from service providers was also included to learn how SASS can best be implemented in the standard job routines of acid stimulation jobs.

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The outcome of this first phase of the development program was a comprehensive and thorough list of Design Goals and a RSD for SASS, to guide the team of engineers and researchers to conceptualize, design, build, test and iterate, the various components and systems of SASS.

SASS is made of several new and innovative technologies, which in many cases will be a "world's first", and it was early on decided to separate the design goals and requirement in two categories; Initial and Ultimate. The idea behind was to get an early working system tested and gain field experience, fail early, and further develop and optimize the specifications of SASS to cover a larger market share and provide more value to its users.

One of the early identified challenges was to select the correct technology for enabling autonomous access to lateral wells and providing an unquestionable confirmation and high success rate. The technology for sensing and detecting the lateral windows and even the laterals are highly dependent on the type of well architecture. Therefore, a study was initiated to find the
distribution of well architecture known as, Technology Advancement of Multi-Laterals (TAML), among the applicable candidates for SASS.

The selection criteria for SASS candidate wells are the following; the wells needs to be slim access, i.e. ESP wye tools restrictions (2.441″), and have multiple wellbores, i.e. multilateral wells and not mono bore.

The market study of the received candidate shows the following distribution of wells

Table 1—TAML Distribution among Candidate Wells

Well	Well Type	Minimum ID	Restriction Type	TAML	Number of Laterals	Casing Size @ KOP	Inclination @ KOP	Mother Bore Open Hole Size	Lateral Open Hole Size	Comments
1	FDHL OIL (DRY) PRODUCER	2.813″ @ 230.05'	DSV?	2	2	7″ #26	90 °	6.125″	6.125″	Slim Access Multilateral
2	ARBD OIL (WET) PRODUCER	2.812″ @ 5139.15'	3 1/2″ NIPPLE 'X'	2	2	7″ #26	90 °	PLUGGED	6.125″	Slim Access Multilateral
3	ARBD OIL (WET) PRODUCER	2.441″ @ 4664.96'	3 1/2 ESP	2	2	9 5/8″ #40	90 °	8 1/2″	6.125″	Slim Access Multilateral
4	ARBD OIL (WET) PRODUCER	2.812″ @ 5116.24'	3 1/2″ NIPPLE 'X'	2	2	7″ #26	90 °	8 1/2″	6.125″	Slim Access Multilateral
5	LFDL OIL (DRY) PRODUCER	2.441″ @ 5621.39'	Y-BLOCK / ESP	2	2	9 5/8″ #40	90 °	8 1/2″	8 1/2″	Slim Access Multilateral
6	ARBD OIL (WET) PRODUCER	2.812 @ 10,409.94'	3 1/2 ICV	2	1	7″ Liner	85 °	8 1/2″	6.125″	Slim Access Multilateral
7	ARBA STANDING OIL PRODUCER	2.441″ @ 5259.37'	Y-BLOCK / ESP	1	4	N/A	90 °	8 1/2″	8 1/2″	Slim Access Multilateral
8	ARBD OIL (WET) PRODUCER	2.347″ @ 4832.57'	Y-BLOCK / ESP	1	2	N/A	90 °	8 1/2″	8 1/2″	Slim Access Multilateral

Based on the collected information and studies conducted in the first phase of SASS development program, the following design goals were set.

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Table 2—SASS Design Goals

DG#	Design Goals	Initial	Ultimate
1	Designed for Coiled Tubing	X	
2	Max tool OD 2.125″	X	
3	Locating lateral windows CH-OH (TAML 2)	X	
4	Locating lateral windows OH-OH (TAML 1)		X
5	Access to laterals CH-OH (TAML 2)	X	
6	Access to laterals OH-OH (TAML 1)		X
7	Stop/Start function of hydraulic tractor	X	
8	Facilitate acid stimulation	X	
9	Multicycle circulation valve	X	
10	Provide downhole data from BHA during operation	X	
11	Provide data communication for 3rd party logging tools	X	
12	Provide power to 3rd party logging tools	X	
13	Wellbore imaging capability		X
14	Temperature profile while POOH	X	
15	Onboard logging of downhole data (WiCCS)	X	
16	Onboard logging of downhole data (ALADIN)	X	

The following requirements were set

Table 3—SASS Requirements

R#	Requirement	Initial		Ultimate		Unit
		Min Value	Max Value	Min alue	Max Value	
1	Operational time in the well	R(5) = 95%		R(10) = 95%		MTF(days)
2	Data package refresh rate - DH to surface		5		0,5	minutes
3	Data package refresh rate - Surface to DH		5		0,5	minutes
4	Environment Temperature Rating Downhole Equipment	20	125		177	°C
5	Environment Temperature Rating Surface Equipment	0	55			°C
6	Hydrostatic Pressure Rating _ Downhole Equipment	0	7500			Psia
7	Hydrostatic Pressure Rating _ Surface Equipment	0	5000			Psia
8	Circulation flow range for RIH and tractor operation	0,8	1,4			bl/min
9	Circulation flow for acid stimulation	2	4			bl/min
10	Acid Type and concentration	<30% inhibited HCL				%
11	Exposure time during stimulation		48			Hours
12	Circulation fluid	Fresh water, diesel				-
13	CT OD	1 3/4	2 3/8			Inch
14	CT wall thickness	Tapered 0.204 - 0.156				Inch
15	CT length	22,000	30,000			ft
16	BHA Tool connections	1.5 AMMT				-

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R#	Requirement	Initial		Ultimate		Unit
		Min Value	Max Value	Min alue	Max Value	
17	Lubricator length	40	70 (90)			ft
18	Min BHA length available for ALADIN and WiCCS	23				ft
19	Production tubing type (OD and weight class)	2-7/8″#6.5	5.5″#15.5			Inch/lbs/ft
20	Minimum Restriction	Y-tool (2.441″)				Inch
21	Dog Leg Severity		12			Deg/100ft
22	Motherbore Length	~15,000	~30,000			ft
23	Lateral length	~2,000	~10,000			ft
24	Lateral window length (Cased Hole)	7	15			ft
25	Lateral window length (Open Hole)	10	50			ft
26	Casing size and diameter, Motherbore (@KOP)	7″#26	9 5/8″ #40			Inch/lbs/ft
27	Open-hole diameter, Motherbore	6.125″	8.5″			Inch
28	Open-hole diameter, Lateral	6.125″	8.5″			Inch

SASS Overview

SASS is a complete tool string system for well stimulations, consisting of 3 main products, see Figure 1. The Wireless Cablehead and Circulation Sub, ™ the Slim Logging Tractor, and the Autonomous Lateral Access for Downhole Intervention (ALADIN™).

Figure 1—SASS tool string

WiCCS will provide power and data communication to the tool string when downhole from the circulation fluids. The surface unit WiCOM™, has a wireless connection to a PC which enables the surface crew direct control and monitoring of the SASS tool string. The live data can also be shared over secure cloud solutions, connecting remote stakeholders directly to the job site.

All 3 products have standardized threaded interfaces and can easily be made up in the field during rig up. In the standard SASS configuration, the order will be; WiCCS – Slim Logging Tractor – ALADIN, see Figure 1. However, all 3 products have multiple standalone configuration as well.

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Figure 2—SASS Overview

SASS Configurations

SASS tools can also be used in many other configurations where a few is presented in the Figure 3 below. Some variations will also require the use of the Slim Battery Sub (SBS™) and the Slim Telemetry Sub (STS™) depending on the application.

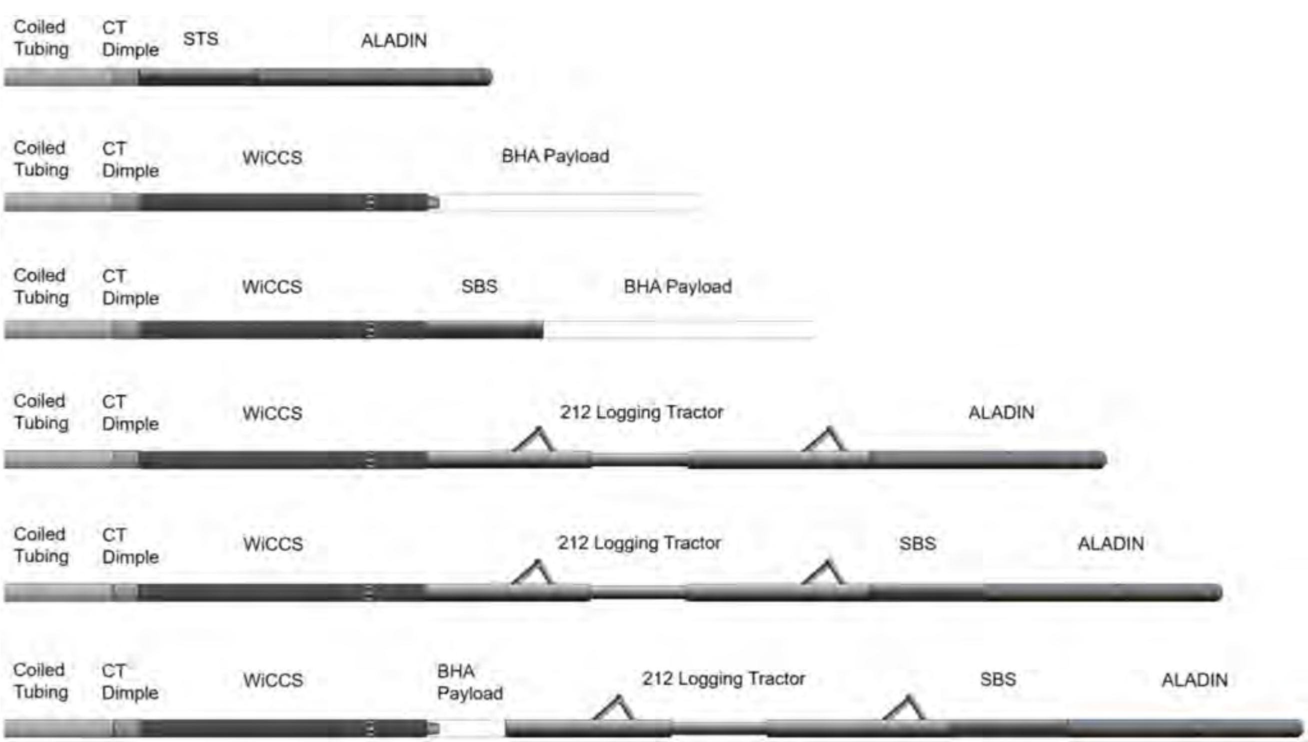

Figure 3—SASS configurations

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Third party integrations

WiCCS is designed with an open power and communication protocol, Wireless Control and Network (WiCAN™). WiCAN provides a 4 wire electric connection where 24 VDC and RS 485 serial communication is used to interrogate measurements, status and even setting states (for control of the tools). WiCAN will be open to the public, providing details of communication protocols, power schemes, pin outs on the connector and sourcing of the connector and mechanical interfacing.

WiCAN will enable any 3rd party Production Logging Tool (PLT) to be integrated on the SASS tool string and connected to WiCCS. WiCAN will provide electric power and a 2 way data connection, which enables the PLT to be monitored and controlled from surface even without any control wires inside the coiled tubing. This unique feature of WiCCS will provide all the same benefits of having a control wire inside the coiled tubing, without any of the limitations conventional control wire possess.

WiCCS - Wireless Coiled Tubing

One of the first challenges in the design and development of SASS was how to remove the impractical control wire from the coiled tubing, while still providing the same benefits and features the control wire facilitates. These features are essentially electric power, and data communication between downhole and surface. There is a number of ways to communicate wireless data from one location to another (Bouldin 2021), and similarly there is several available technologies for generating downhole power (Ahmad 2015; Arsalan 2018; Noui-Mehidi 2019). WINS has wireless communication technology which is very applicable for coiled tubing wireless communication and can be adapted for use in SASS. Furthermore, WINS has specialized on downhole turbines for electric power generation for many years and can produce several hundred watts of downhole conditioned electric power.

WINS designed and developed WiCCS for use in the SASS application which includes a turbine electric generator, and essential part of providing downhole electric power and wireless communication. WiCCS is the downhole portion of the system, and WiCOM is the surface portion of the system. WiCOM is connected between the steel pipes between the circulation pump and the coiled tubing reel. WICOM has a wireless connection (WiFi) to the surface crew PC for control and monitoring of the SASS toolstring while in hole.

WiCCS is designed to be like conventional tool sub's and has standard tool connections, pin and box at each end, where the box connection will be connected to the CT dimple connector, see Figure 1. On the pin side of WiCCS, an electric line connector is integrated which enables the WiCAN connection between WiCCS any other tool in the tool string. The WiCCS sub has the following main parts; tool connections, turbine generator, electronics compartment, sensor hub and the circulation sub as seen in Figure 5 below.

WiCCS is powered from the circulation of fluids and will booth up when pump rate exceeds 0.8 barrel per minute (bbl/m) according to Table 3 SASS Requirements. WiCCS will start to transmit and receive data packages from the surface located WiCOM, and also provide power on WiCAN to operate other tools connected on the string, like ALADIN and 3rd party logging tools. WiCCS is controlled by the user via a Graphical User Interface (GUI) run on a small tablet or laptop PC in WIFI range of WiCOM.

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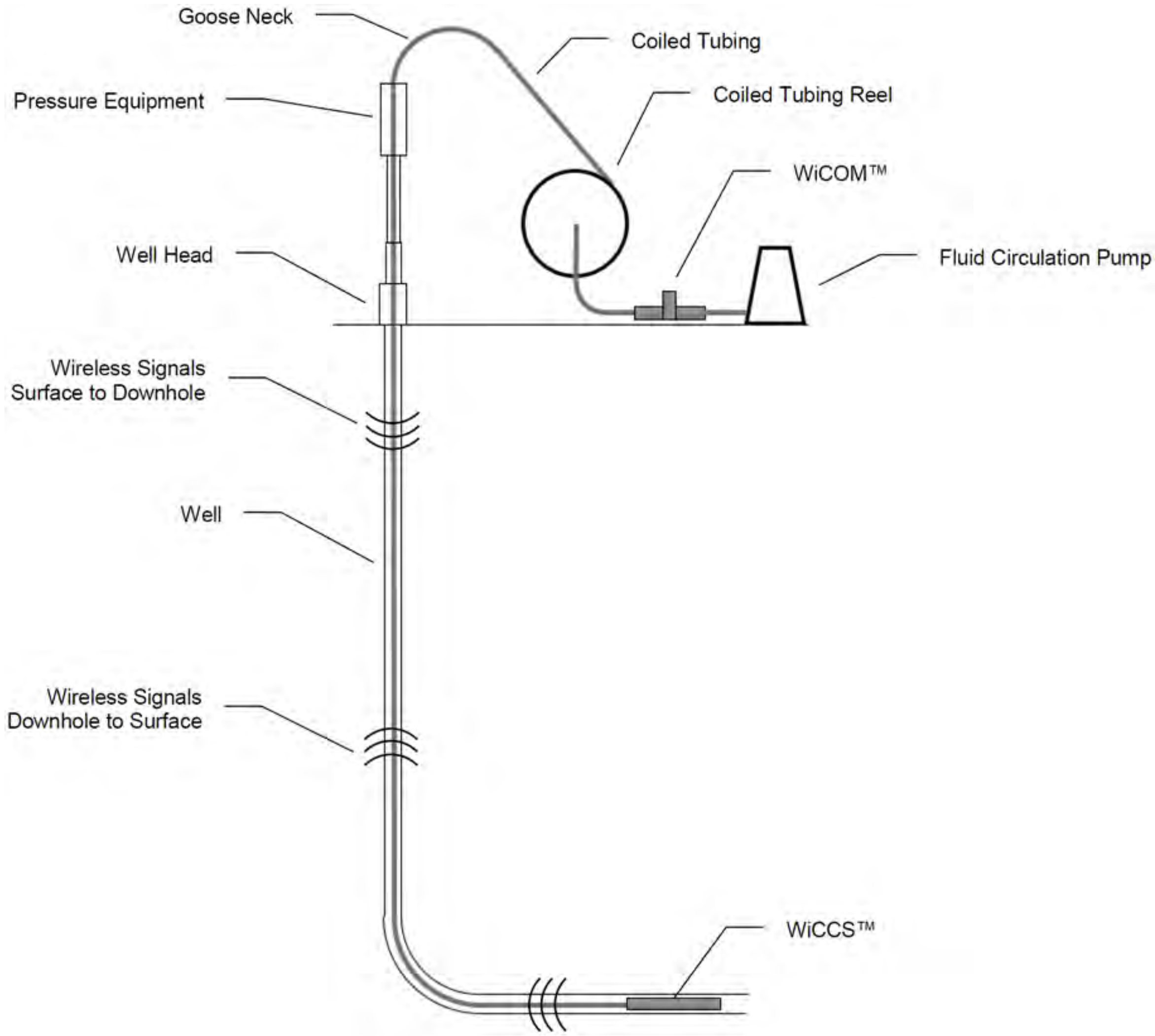

Figure 4—WiCCS system overview

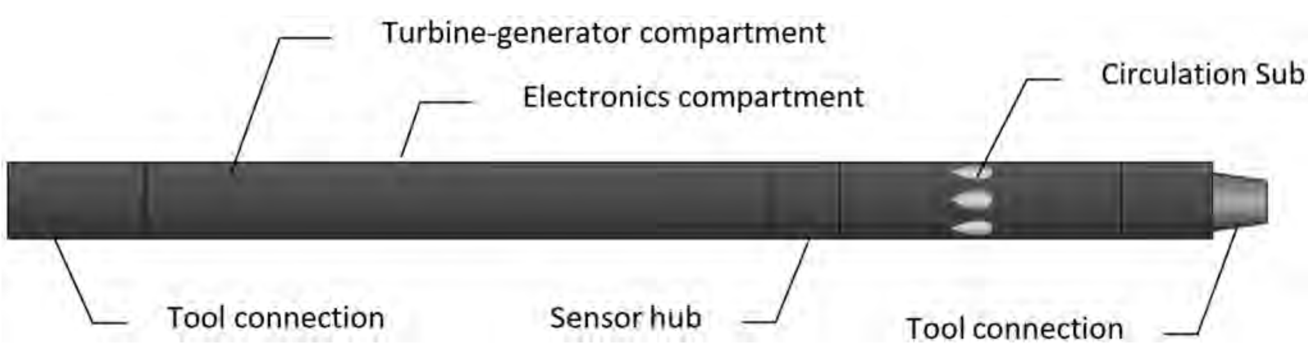

Figure 5—WiCCS overview

The GUI is as a touch-based tablet app which displays the downhole data in an easy to understand setup. Both WiCCS and ALADIN tools is operated directly from the GUI, with fail-safe buttons to avoid any unintentional instructions being sent downhole to the toolstring. The GUI will be the main interaction between the user and WiCCS, and all commands necessary to operate and control the tool string will be monitored and controlled through this system.

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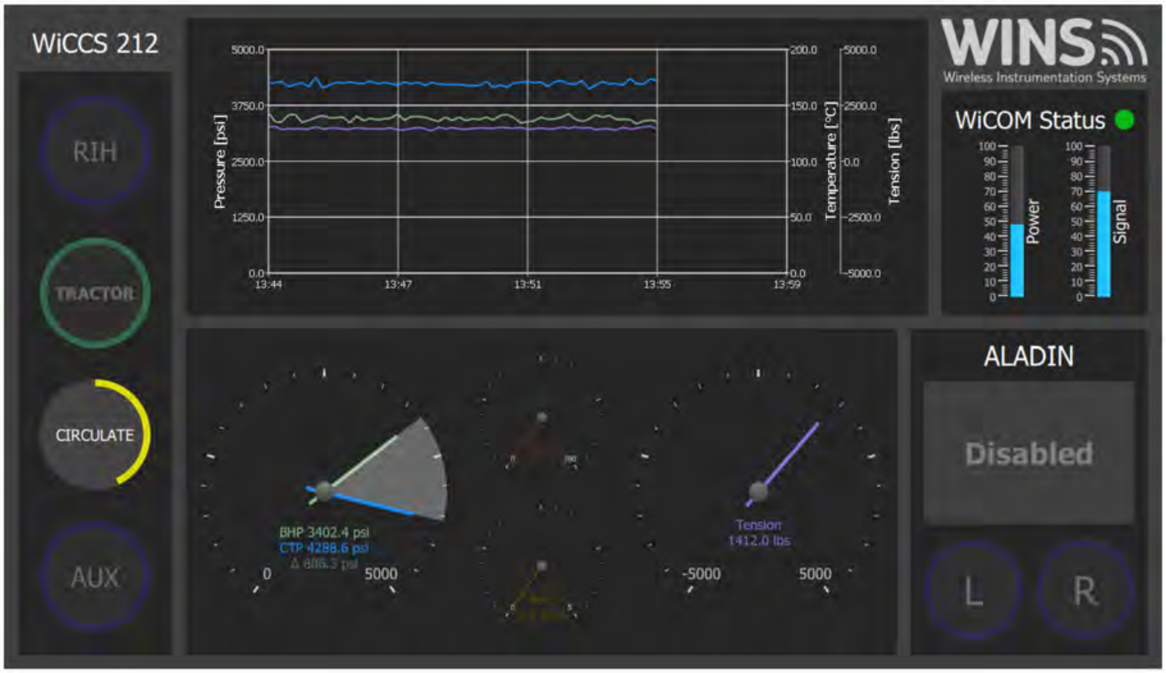

Figure 6—GUI

The user can at any time during the operation set WiCCS in different modes depending on the job program and execution. Each mode is selected by holding down the mode button for 3 seconds until the yellow progress indicator surrounds the button rim. Whenever a mode is selected, the button will be flashing yellow while the command is transmitted downhole to WiCCS. The selected button will turn solid green when the GUI receives confirmation from WiCCS that the mode is successfully entered.

In case of a unsuccessful mode shift, i.e. no confirmation received from WiCCS, the button will turn solid red and the currently active mode button will remain green.

The GUI is fully customizable for any application, and the default modes are the following:

RIH Mode - This mode is used during run in hole. This mode has an open circulation valve, and a selected set of sensor values is transmitted to surface at specified data rate.

TRACTOR Mode - This mode starts the tractor by shifting the circulation valve to closed and divert the fluid flow into the tractor. A selected set of sensor values necessary to operate the tractor is transmitted to surface at a specified data rate.

CIRCULATE Mode – This mode opens the circulation valve fully, enabling high pump rates at low pressure drop. A selected set of sensor values necessary to perform stimulation is transmitted to surface at a specified data rate

AUX Mode – This is an optional mode, where additional modes can be implemented, ie operating 3rd party tools.

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WiCCS removes the need to run the impractical control wire inside the coiled tubing, as all the same benefits and features the control wire is provided by its integrated downhole power generation and wireless communication. WiCCS also provides real time downhole measurements like tension, compression, coiled tubing pressure, bore hole pressure and differential pressure, temperature and circulation rate, which can be key downhole data to safely and efficiently operate a downhole tool string in varying applications.

ALADIN - Autonomous search and Entry of Laterals

The challenge of accurately locating and entering lateral wells has been successfully demonstrated with other developed tools like the Steerable Access Sub, developed by Saudi Aramco Upstream Research Group and Welltec.(Saeed 2018, SPE-182996-MS) However, this tool requires a high bandwidth electrical connection to surface in order to stream data between downhole and surface, enabling a tool specialist to interpret and steer the tool's arm into the lateral window manually. However, the SASS development program possessed one unique challenge, which was to remove the wire inside the coiled tubing in order to pump stimulation fluids at a high rate, (preferably 4 bbl/min). WiCCS was introduced as the tool to substitute the control wire, however the data communication rate is much lower with wireless technology, compared to conventional wired solutions. Given the limited communication bandwidth between downhole and surface, a novel new autonomous method of searching, entering and confirming laterals was developed for ALADIN.

ALADIN has the following main parts; tool connection, inductive sensor, electronics compartment, a swivel connection and pivot joint with an electric actuated arm, as seen in Figure 7 below.

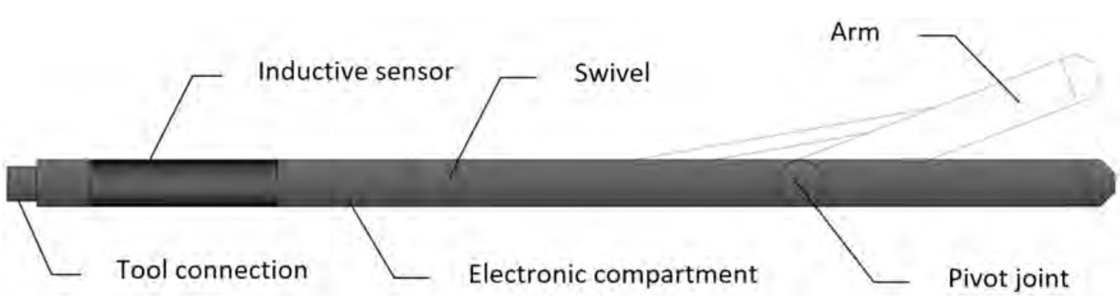

Figure 7—ALADIN overview

The working principle of ALADIN is that the tool will be activated from the surface when the SASS tool string is located a certain depth above the kick off point (KOP) of the desired lateral. After activation,

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ALADIN will run a condition test algorithm, where five consecutive tests will be conducted and the state and condition of ALADIN will be determined consecutively.

In Figure 8, a flow chart shows the condition test algorithm, where a number of tests with certain parameters is executed in a consecutive order. A detailed description of each step follows in section Detailed Description of ALADIN Conditions Test Algorithm.

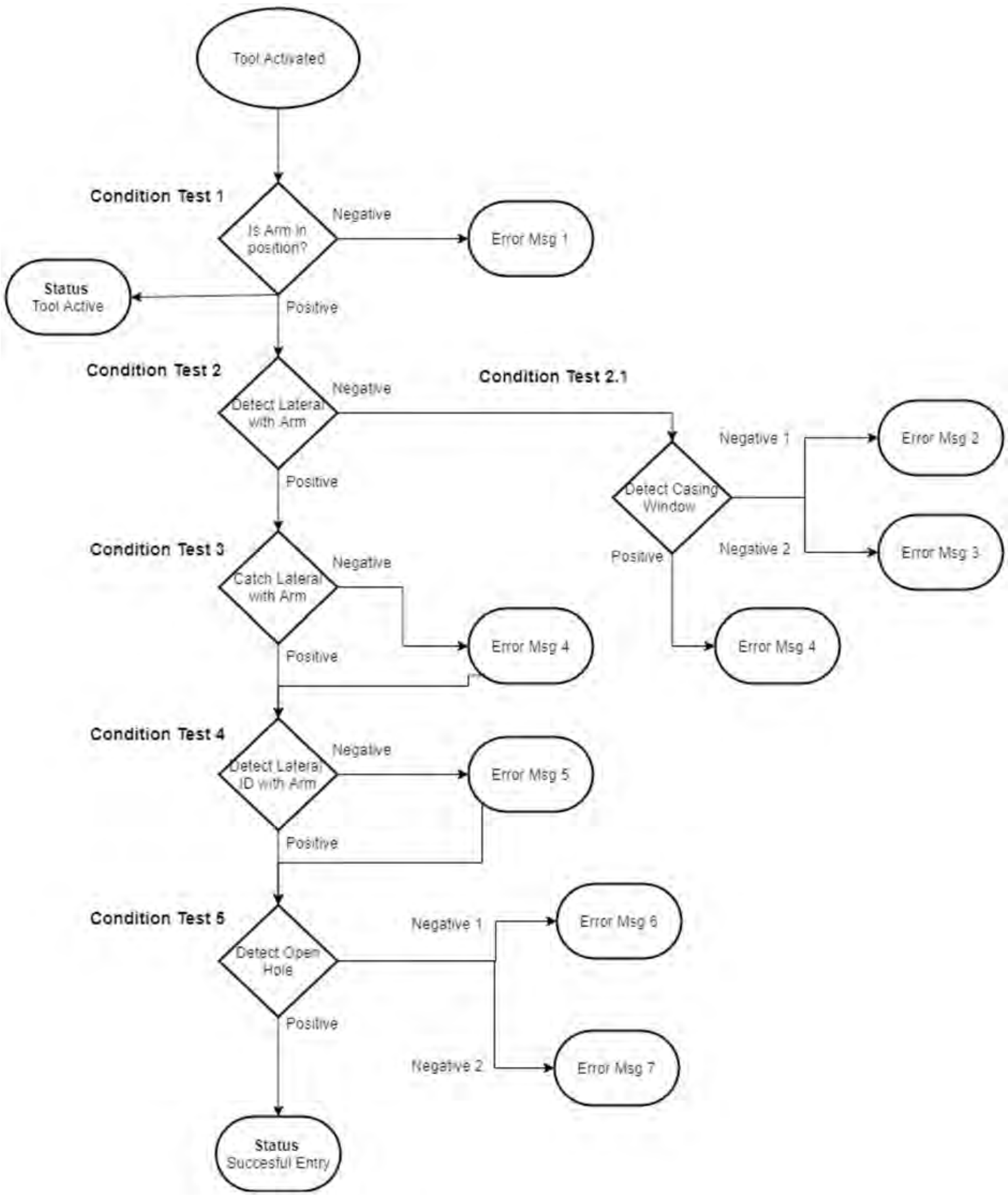

Figure 8—ALADIN algorithm flow chart

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Detailed Description of ALADIN Conditions Test Algorithm

Below is a detailed description of all the steps the surface crew will perform while operating the ALADIN tool (in bold text), and all steps that ALADIN executes as conditional tests to determine its surroundings and state. Note that various distances and speeds in this detailed description is denoted as *X, Y, Z* values, as the real value will be job and application specific.

1. **When tool string BHA is "X" ft above the desired lateral window, Activate ALADIN with the GUI and wait until confirmation of ALADIN activation is received.**

   Figure 9 represents a view from top, where ALADIN lays low side inside a horizontal, cased portion of the mother bore in a multilateral well.

   When the activation command is sent from the surface crew, ALADIN will be activated with commands relayed over WiCAN from WiCCS. The activation command sent from the surface crew will also include the instructions either Right Hand "R" or Left Hand "L" as seen in Figure 1. This information is available to the surface crew from the directional survey and the well plan. ALADIN has an integrated Inertial Motion Unit (IMU), which enables ALADIN to measure its relative position and attitude in the wellbore based on the gravity vector and the tool face vector. ALADIN will use the IMU measurements to position and control the roll azimuth angle of the arm.

   Condition test 1 includes the following steps:
2. Measuring and calculating the orientation of the tool calculated from the gravity vector and tool face vector.
3. Homing (zero setting) of the rotational position of the arm (roll azimuth angle).
4. ALADIN rotates the swivel joint of the arm to the direction R or L (relative to tool face and gravity vector measured by IMU) to the set roll azimuth angle.
5. ALADIN bends the arm towards casing Internal Diameter (ID) and the bend angle is measured when a predetermined force is detected on the arm, preventing the arm to fully bend. The measured bend angle on the arm will be given the notation α (partially bent).
6. ALADIN will compare the measured angle α to a predetermined value range which corresponds to the casing size and weight class ID. If angle α is within the range, condition test 1 will be positive. If outside, condition test 1 will be negative.
7. If condition test 1 is negative, ALADIN will straighten the arm, deactivate, and send a status message to surface confirming the tool has been deactivated with a corresponding error message.
8. When condition test 1 is positive, a status message confirming "Tool Active" is sent to surface, and the next condition test (Condition test 2) is started.
9. **When the status message "Tool Active" appears on the surface crew GUI, the CT crew is instructed to run the CT downhole at "Y" ft/min to a "Z" ft distance below the location of the lateral window.**

   The SASS tool string will move downhole and towards the location of the lateral window, while the arm is pushed against the casing ID with a predetermined force, and the bend angle α of the arm is monitored.
10. The arm is pushed against the casing ID, and when the lateral window appears, the arm is able to fully bend to a new bend angle β (fully bent) extending inside the lateral window, see Figure 12.
11. ALADIN will compare the measured angle β to a predetermined value range which is larger than the corresponding casing size and weight class ID. If angle β is above this range, condition test 2 will be positive. If angle β is under this range, <u>and</u> a predetermined timer runs out, condition test 2 will be negative.
12. If condition test 2 is negative, condition test 2.1 is started. Condition test 2.1 will be using the inductivity sensor (see Figure 7) to sense if the lateral window will pass by ALADIN as the SASS

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tool string is run deeper into the well. This is achieved by comparing the inductivity measurements over a predetermined time interval, see Figure 13.

13. If the inductivity increases above a predetermined threshold for a predetermined duration, and then returns to the same level of inductivity, condition test 2.1 will be positive as ALADIN has detected a passing of the lateral casing window and that the tool is still in the cased hole (metallic environment is still surrounding the tool).
14. If the inductivity increases above a predetermined threshold for more than a predetermined duration, condition test 2.1 will be negative 1 as ALADIN has detected a successful entry into an open hole environment, however with a malfunctioning condition test (Condition test 2).
15. If the inductivity does not increase above a predetermined threshold for a predetermined duration of time, condition test 2.1 will be negative 2 as ALADIN has detected no lateral window present.
16. If condition test 2.1 is Positive, Negative 1 or 2, ALADIN will straighten the arm, deactivate and send a status message to surface confirming the tool has been deactivated with the corresponding error message, see Figure 13 and Figure 8.
17. If condition test 2 is positive, ALADIN will reposition the arm to a shallower bend angle (<β), not fully bent, and condition test 3 is started.
18. If the arm catches the edge of the lateral window, the arm will be pushed back to the fully bent angle β position. If the monitored shallow angle (<β) increases to the fully bent angle β within a predetermined time duration, condition test 3 will be positive, and if not, condition test 3 will be negative.
19. If condition test 3 is negative, ALADIN will continue on to the next condition test as explained in the below step and send a corresponding error message to surface.
20. If condition test 3 is positive, ALADIN will reposition the arm to the fully bent angle β and hold this position with a predetermined force, and the next condition test (Condition test 4) is started.
21. The arm is positioned and monitored with a predetermined force at the fully bent angle β while the SASS tool string is run deeper into the lateral well. When the arm is straightened, i.e., prevented to hold the fully bent angle β for longer than a predetermined time duration, condition test 4 will be positive. If the arm position is maintained at the fully bent angle β longer than a predetermined time duration, condition test 4 will be negative.
22. If condition test 4 is negative, ALADIN will continue to the next condition test as explained in the step 24 and send a corresponding error message to surface.
23. If condition test 4 is positive, ALADIN will straighten the arm and the next condition test (Condition test 5) is started.
24. The SASS tool string is run deeper into the lateral and the inductive sensor monitors the inductivity measurements from its surroundings, see Figure 16.
25. If the inductivity increases above a predetermined threshold for a predetermined duration, and then returns to the same level of inductivity, condition test 5 will be negative 1 as ALADIN has detected a passing of the lateral window and has stated that ALADIN is still in the cased hole environment, see Figure 17.
26. If condition test 5 is negative 1, ALADIN will deactivate and send a status message to surface confirming the tool has been deactivated with the corresponding error message.
27. If the inductivity does not increase above a predetermined threshold for a predetermined duration of time, condition test 5 will be negative 2 as ALADIN has detected no lateral window present. If condition test 5 is negative 2, ALADIN will deactivate, and send a status message to surface confirming the tool has been deactivated with a corresponding error message.
28. If the inductivity increases above a predetermined threshold for a predetermined duration, condition test 5 will be positive as the lateral window locator and entering sub has detected a successful entry into an open hole environment.

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29. If condition test 5 is positive, ALADIN will deactivate and send a status message to surface confirming "**successful entry**".

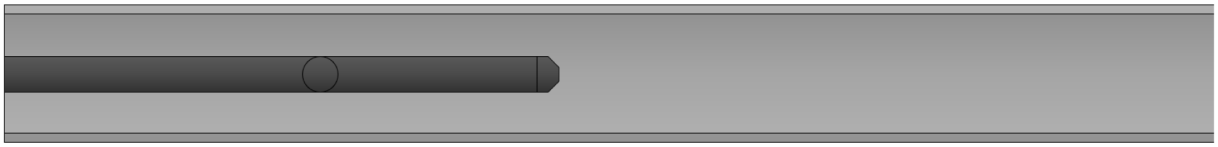

Figure 9—ALADIN seen from above, laying low side a cased well

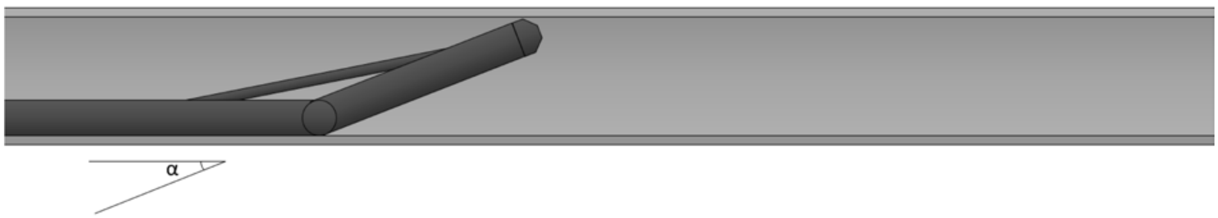

Figure 10—ALADIN activated inside the cased well bore

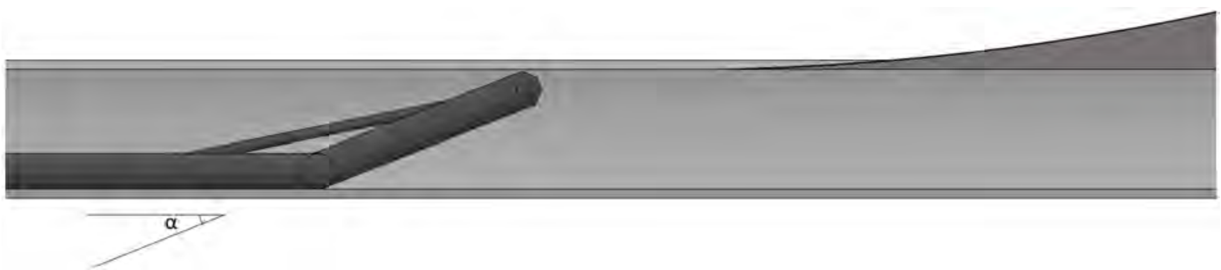

Figure 11—ALADIN moves toward the location of the lateral window

Figure 12—ALADIN arm extends inside the lateral window

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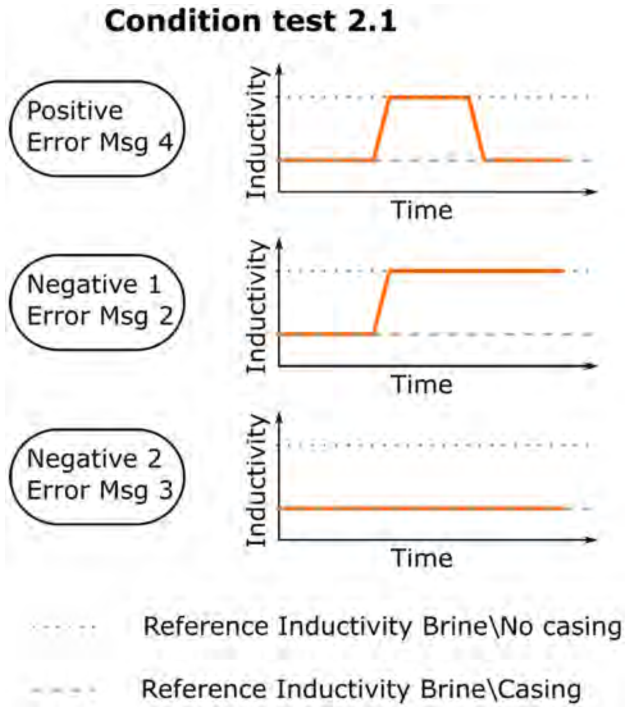

Figure 13—Condition Test 2.1

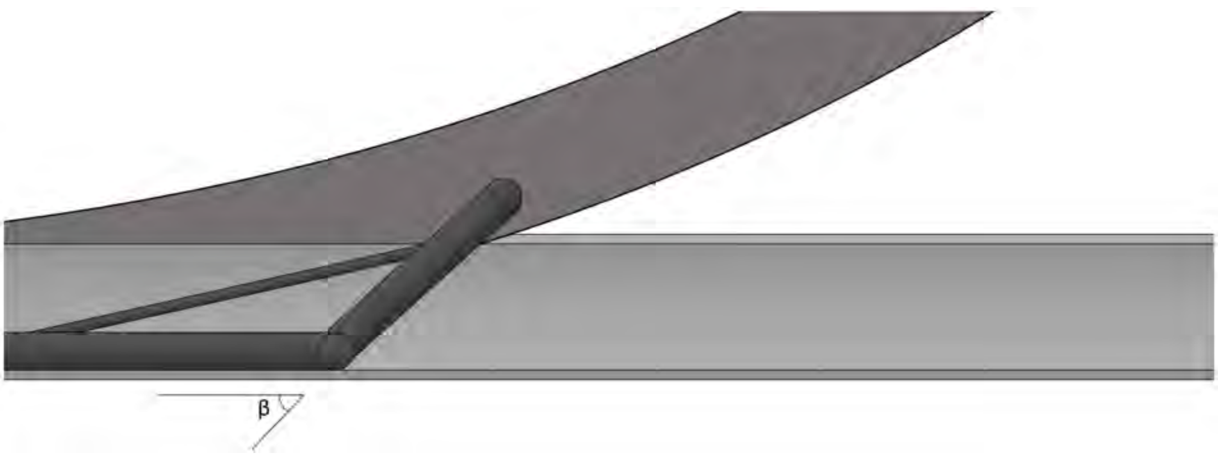

Figure 14—ALADIN catches the edge of the lateral window

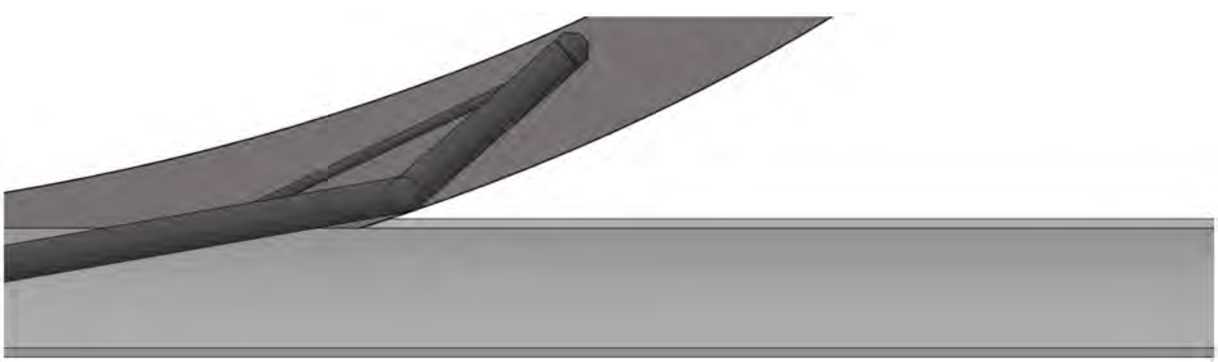

Figure 15—ALADIN enters the lateral

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Figure 16—ALADIN's inductive sensor senses the open hole environment

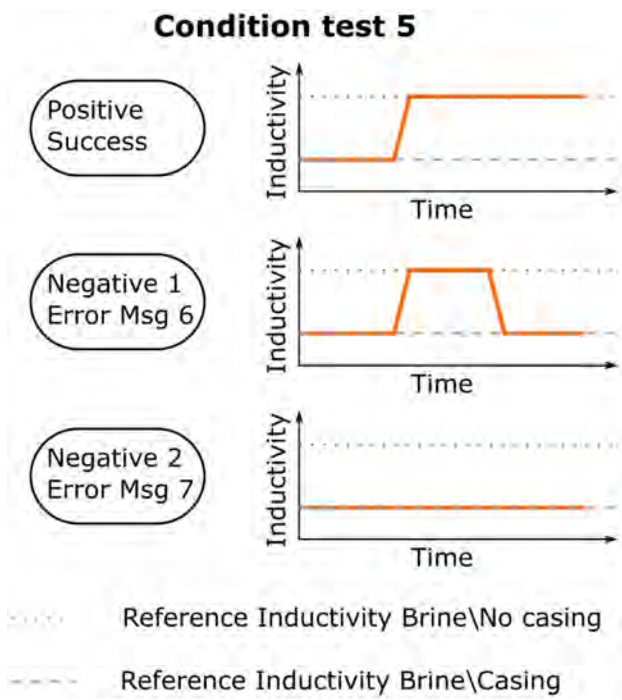

Figure 17—Condition test 5

ALADIN is a world first easy to use, autonomous lateral access tool, which does not require a tool specialist to operate. ALADIN combined with WiCCS completes the SASS tool string, by enabling access into open hole multilaterals for coiled tubing conveyed tool strings with high a success rate and confidence.

Why Wireless CT is a Game Changer

The industry has for decades trended toward better process control, monitoring of operations and generally more data generation, also for downhole operations, and this need for data is expected to continuously increase. This is often solved by running a control wire inside the coiled tubing. However, as many of the wellbore intervention jobs involve pumping large quantities of acid stimulation fluid, the control wire simply cannot be used. This results in that service companies are forced to have two coiled tubing reels onsite, one with a control wire for logging purposes and one without for stimulation, which involves significant HSE risks, time delay and larger expenses. Wireless CT will revolutionize the industry by enabling production logging and stimulation all in the same run. And by including ALADIN on the tool string, full access to stimulate open hole multilaterals is finally granted.

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Conclusion

This paper describes the process and the results of the SASS development program. The SASS development program is a testament of how the industry can tackle complex challenges, introducing new technologies across multi-disciplinary platforms and adapting to the conventional methods and processes.

SASS will be a game changer in the industry by enabling access to open hole multilateral, even thru small restrictions like wye tools, to provide real time production logging and stimulation of multiple- zones and laterals, all in one run.

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Abbreviations

ALADIN	Autonomous Lateral Access for Downhole INtervention
AUX	Auxiliary
BHA	Bottom Hole Assembly
CT	Coiled Tubing
ERW	Extended Reach Well
ESP	Electrical Submersible Pump
GUI	Graphical User Interface
ID	Inner Diameter
MRC	Maximum Reservoir Contact
OD	Outer Diameter
PFCOM	Perturbated Flow Communication
PLT	Production Logging Tool
RIH	Run In Hole
RSD	Requirement Specification Document
SASS	Slim Access and Stimulation System
SBS	Slim Battery Sub
STS	Slim Telemetry Sub
TAML	Technology Advancement of Multi Laterals
TD	Total Depth
WiCAN	Wireless Control And Network
WiCCS	Wireless Cablehead and Circulation Sub
WINS	Wireless Instrumetation Systems AS

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