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# Sidetracking with Whipstocks: An Efficient Method for Increasing Your Operational and Asset Value

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Flowjacket Oilfield Services  
SPE Strategic Solutions



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# Agenda

## What is Sidetracking

## Evolution of Sidetracking

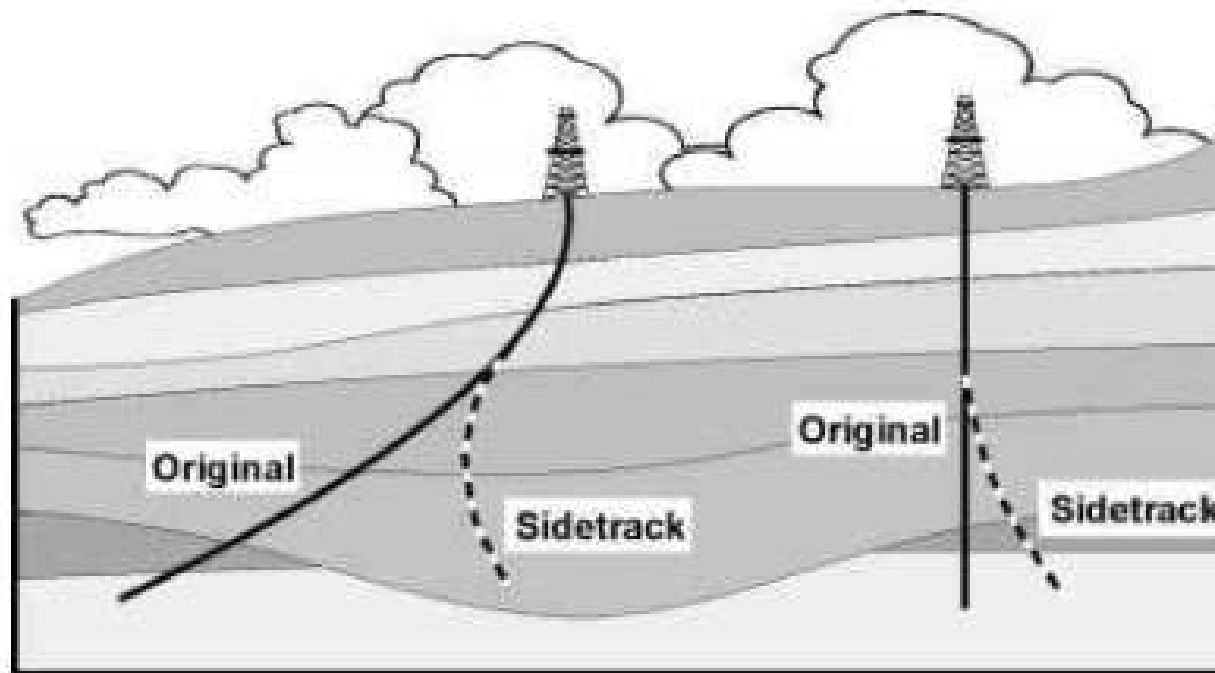
- Efficiency changes
- New Technology
- Case History

## Contingency Scenario

- Fishing vs Sidetracking
- Ideology shift
- Case History

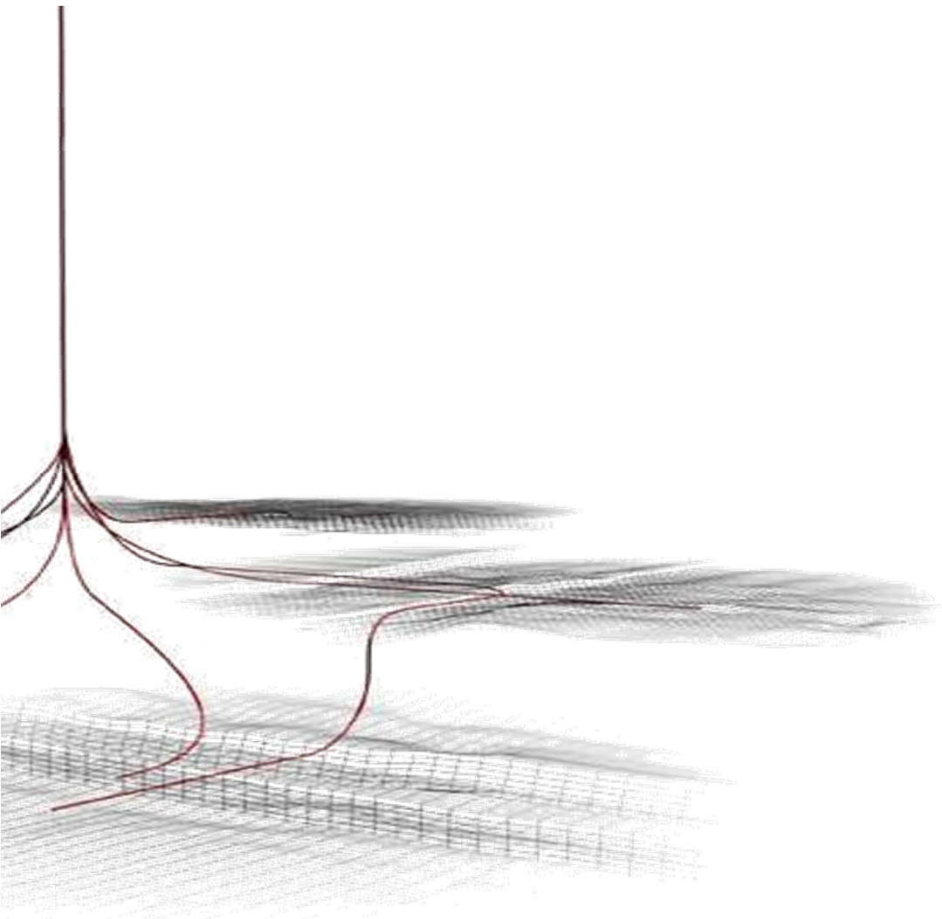
# Definition of Sidetracking

A secondary wellbore drilled away from the original hole. It is possible to have multiple sidetracks, each of which might be drilled for a different reason. *(Oilfield Glossary)*



Sidetrack examples

# Industry Drivers for Sidetracking



- Stranded reserves
- Maximize reservoir exposure
- Surface limitation
- Reduced carbon footprint
- Main bore impasse
- Pilot well / Exploration
- Slot recovery
- Geothermal
- Regulatory

# Whipstocks – A Simple Solution

## Milling Assembly

- Single mill to four mills used to cut window
- Mechanically or hydraulically released from whipstock
- Carbide, diamond, polycrystalline diamond compact (PDC)

## Whipstock – deflector /wedge

- Degrees of face angle i.e., 1-1/2 to 4 deg

## Anchor

- Mechanically or hydraulically set
- Retrievable or permanent
- Options provide isolation



Whipstock layout

# Alternatives to Whipstocks

- Section milling – removing casing section and pumping cement kick off plug
  - Large volume metal
  - Time to mill, cement, kick off
  - Risk with cement kick off
- Drill new well
  - Cost and time to get to kick off point
  - Surface footprint

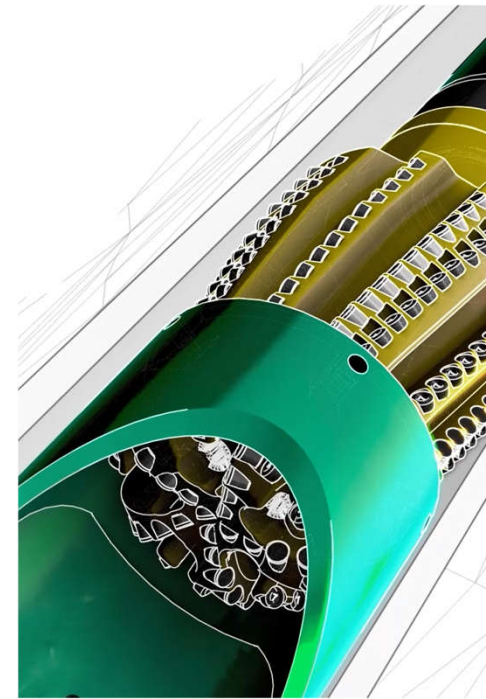


Section Mill – Courtesy  
of DrillStar

# Evolution of Sidetracking

- From unreliable contingency to critical step during well planning
  - Limited sizes → Majority of casing sizes
  - Time consuming → Single trip defined risk profiles
  - Part of fishing toolbox → Stand alone technology
  - Tribal knowledge → Real time data driving analytics for efficiencies

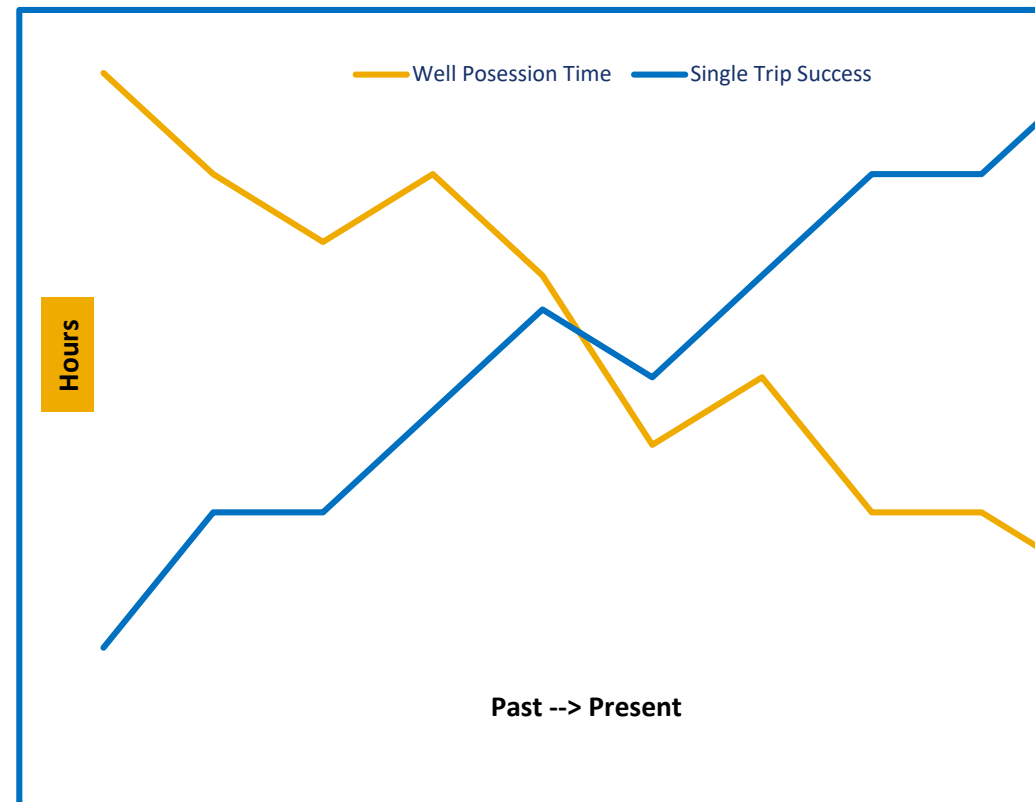
Multi-trip system  
with casing weight  
dependent anchor -  
courtesy of Eaton Oil  
Tools



Next Generation  
whipstock system -  
Courtesy of Baker  
Hughes

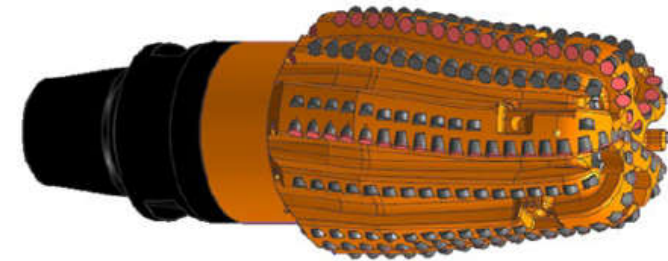
# Reliability Equals Savings

...s of thousands of runs industry  
...le  
...Known risk profiles for applications  
...ustry accepted best practices  
...jority of installations less time  
...3-1/2 days per install and less than 10  
...hours per window / rat hole with  
...95+% single trip success  
...anned sidetrack operations for  
...hat if” scenarios



# Technology to Drive Efficiency

cutting structure designs increase success rates  
while decreasing milling time  
real time down hole data collection and software  
feedback for more efficient operation  
evolution of systems further reduce trip count  
and lower well possession times  
improved utilization for cutting structure dull grading



New Generation Mill - Courtesy of Baker Hughes



New Generation System - Courtesy of Weatherford

# Wellbore Preparation Run and Slow Trip Times Eliminated, Offshore Europe (SPE 209564)

## Objective:

Combine clean up run with whipstock installation

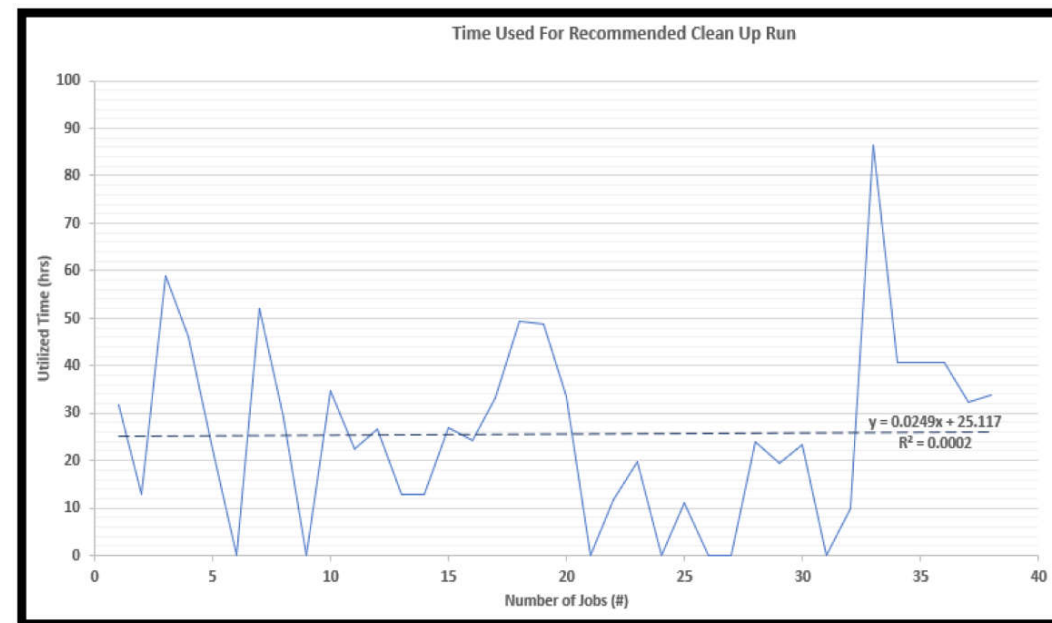
Increase efficiency of whipstock operation

## Result:

Level non-weight dependent milling  
A release

Lower BHA below anchor to prepare  
working area and avoid dedicated run

17% floor make up reduction by 17%, 25  
hours saved on clean up, trip speed 2-  
times faster



Trip Time Associated With Clean Up Run - Courtesy of Baker Hughes

# 30 Hours of Rig Time Saved With Hydraulic Release Whipstock, Kuwait

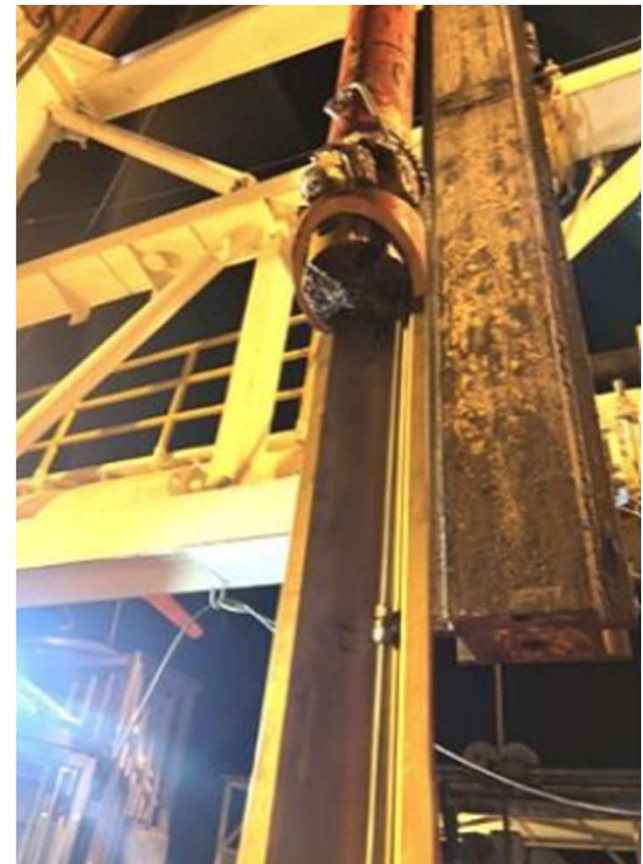
## Objective:

Perform single run 9-5/8-in 45.5# casing  
t operation in a vertical well at 6,100-ft  
Combine clean out run with whipstock run  
Provide secondary abandonment barrier

## Result:

Draper BHA below anchor to prepare  
cutting area and avoid dedicated run  
Hydraulic release of milling BHA enables  
faster trip time

Total of 30 hours of rig time saved vs  
conventional operations



Hydraulic Release Milling BHA attached to Whipstock  
Courtesy of Weatherford

# Super Heavy Wall Exit, GOM (OTC 31245)

## Objective:

Retrack around liner integrity issue through 1-1/4-in 134# casing at 22,500-ft while maintaining well design

Industry first for 1-1/8-in thick SY130

## It:

Window / rat hole cut in single trip with no deviation from planned well design

Production re-established on critical well

Step change on field development with reliable contingency option available



# Industry First 100 Consecutive Single Trip Sidetracks, California (SPE-209318)

## Objective:

Sidetrack wells less than 2,500-ft efficiently and consistently

Overcome limited torque and weight challenges

## Result:

Improvement in cutting structure and increase torque to above 3,000-ft/lb

100 consecutive sidetracks comparison from 2016/17 versus 2018-2021

0% to 100% single trip success

Overall time average decrease by 35%



Cutting Structure Advancements -  
Courtesy of WFRD

# Planned Contingency

Increased reliability in whipstock sidetracks has revolutionized aspects of the oilfield

Drilling BHAs and tubulars optimization vs fishing friendly

Decrease contingency cost when utilizing unique casing / liner sizes

Increasing drilling rate of penetration (ROP) make sidetracking more desirable

# Fishing Limited Technology

torque pipe used to increase drilling ROP and lateral  
with

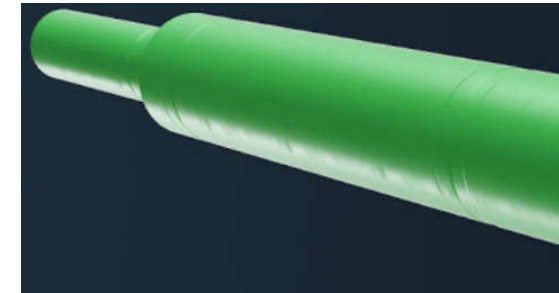
connections too large to OD fish

most prohibitive measures must be taken in order to get past the  
tool joint and fish the tube

Rotary Steerable (RSS) assemblies can also provide very  
challenging fishing scenarios

agitator in conjunction with the RSS that has no ID for wireline

Must perform manual back-off or an outside back-off which can  
be problematic or impossible

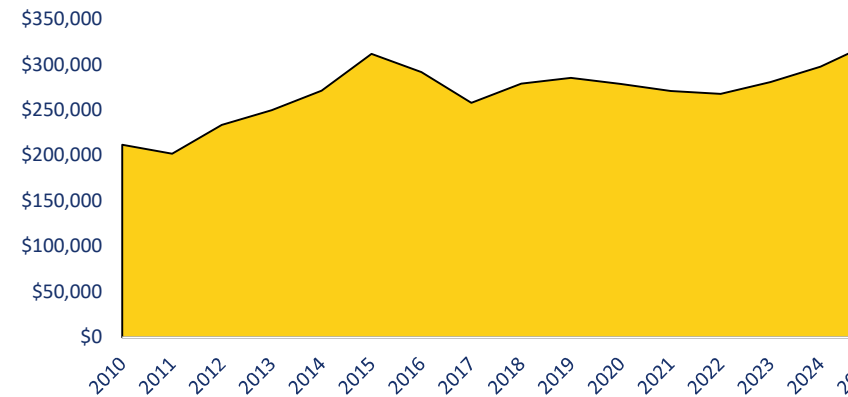


Standard 150 overshot

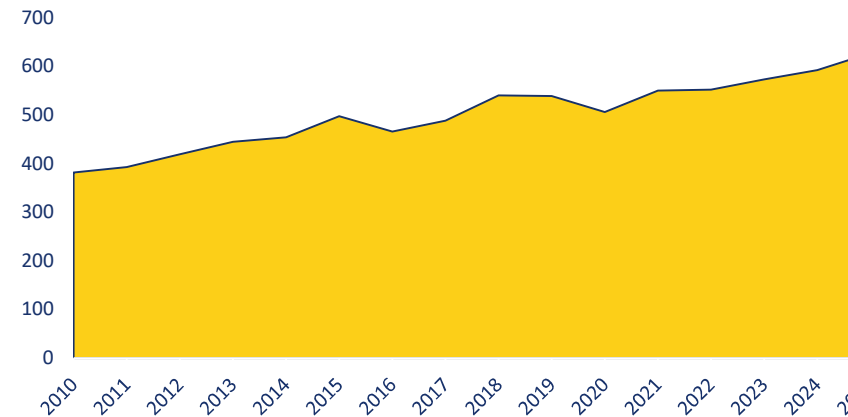
# Fishing vs Sidetracking

- Increase in total cost of sidetrack
- Efficient sidetrack operation
- Equipment costs down 35% in last decade (Evercore)
- Footage drilled per day increased (Spears)
- Increase in cost of fishing
- Cost of spread increasing (Spears)
- Potential cost of fish decreasing
- Work profile and time for sidetrack can often be better defined compared to fishing operations
- Number of days to justify fishing decreasing

AVERAGE DAILY SPEND PER RIG (USD)



AVERAGE DAILY FOOTAGE PER RIG (FT)



# Cemented Pipe and Short Time Frame, Louisiana

## Objective:

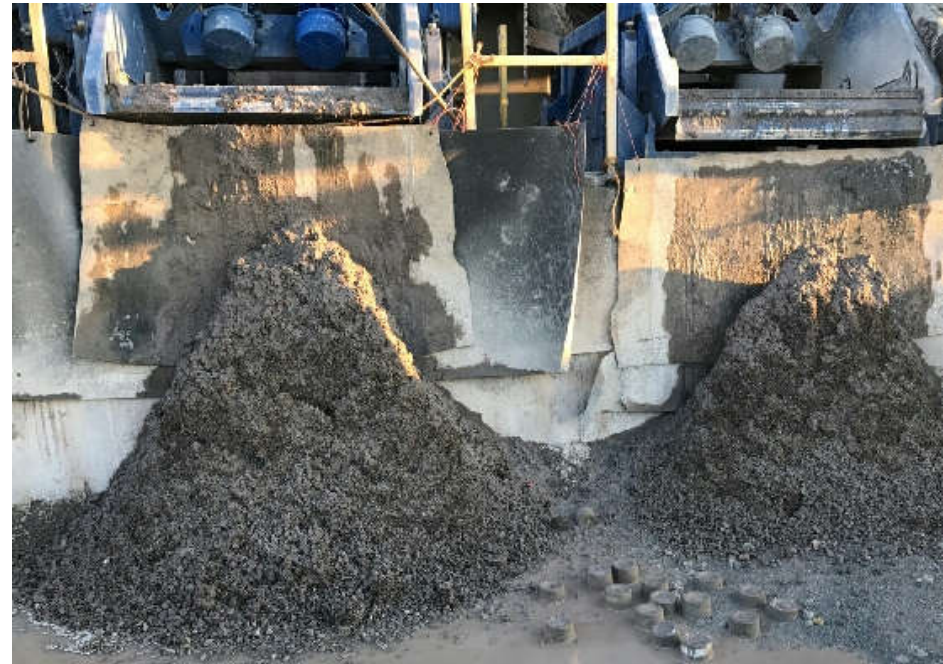
3/4-inch casing exit installation during  
drilling operation after cementing pipe in  
the hole

Case obligation made fishing operations  
re-drill options undesirable

## Result:

7/8-inch window achieved and drilling  
continued

Well construction finalized prior to hard  
deadline



Swarf collected at surface from casing exit

# 13-3/8-in Expandable Liner Exit, GOM (SPE 204082)

## Objective:

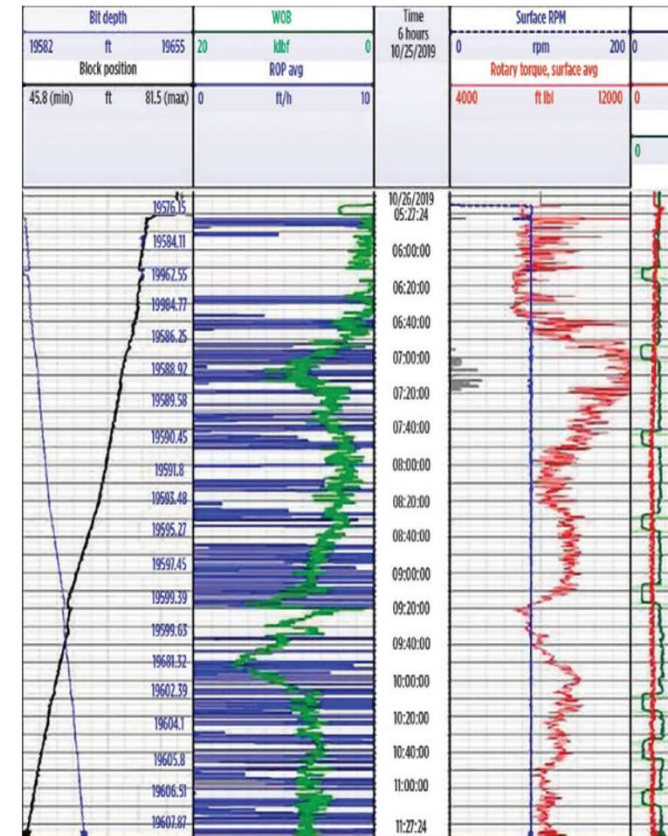
Retrack collapsed section of expandable liner with  
of 13.6-in

Avoid collapsing the thin wall liner and issues that  
come with poor cement job

## It:

1/2-in window achieved in three planned tapered  
drilling BHAs

Saved ten days and cost associated with sidetracking  
hole



Milling Parameters for 13-3/8-in Exi

# Key Take-Aways

Whipstock are reliable options in majority of wells  
New Technology is further decreasing sidetrack times  
Industry shift from Fishing to Sidetracking in majority of  
applications in Drilling  
Efficient whipstock operations change ideology in drilling  
operation

# Your Feedback is Important

Enter your section in the DL Evaluation Contest by  
completing the evaluation form for this presentation

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# Backup Slides



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# Challenging Exit Possible With Newer Technology, Australia

## Objective:

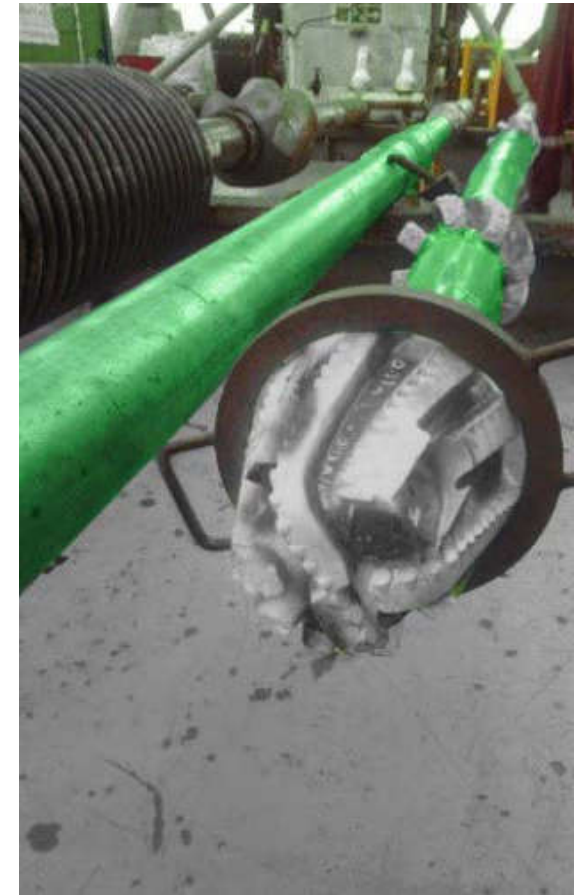
Retrack low-side in 10-3/4-in 66.7# HS110  
4,757-m with steel centralizer at KOP

## Result:

6-m Window / 6-m of rat hole cut in single  
trip in 11 hours utilizing three mill BHA

Reduced drilling time vs conventional  
high-side exit and avoiding centralizer

Well construction per plan



Milling BHA – Courtesy of WIS

# Advanced Dual Casing Exit Success, Offshore India

## Objective:

Retracking through uncemented 13-3/8-in and 20-in casing at 276-m

Minimize well possession time of operation

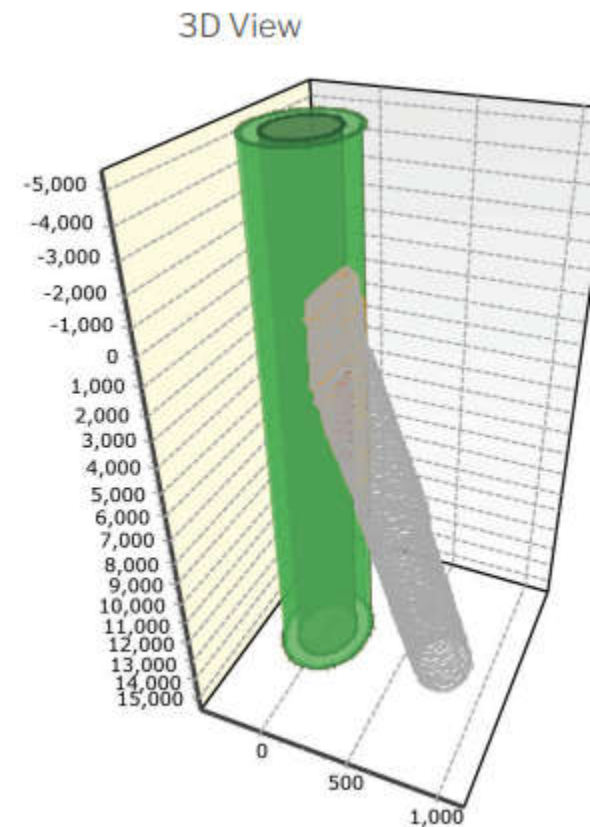
## Result:

Single trip system with bi-mill BHA

Window and rat hole achieved in one

trip, 11-1/2 hours

Drilling BHA gauge loss negligible



Window Modeling – Courtesy of WIS

# Low Dog Leg Junction to Increase Production, Qatar

## Objective:

Retrack 9-5/8-in casing to access production

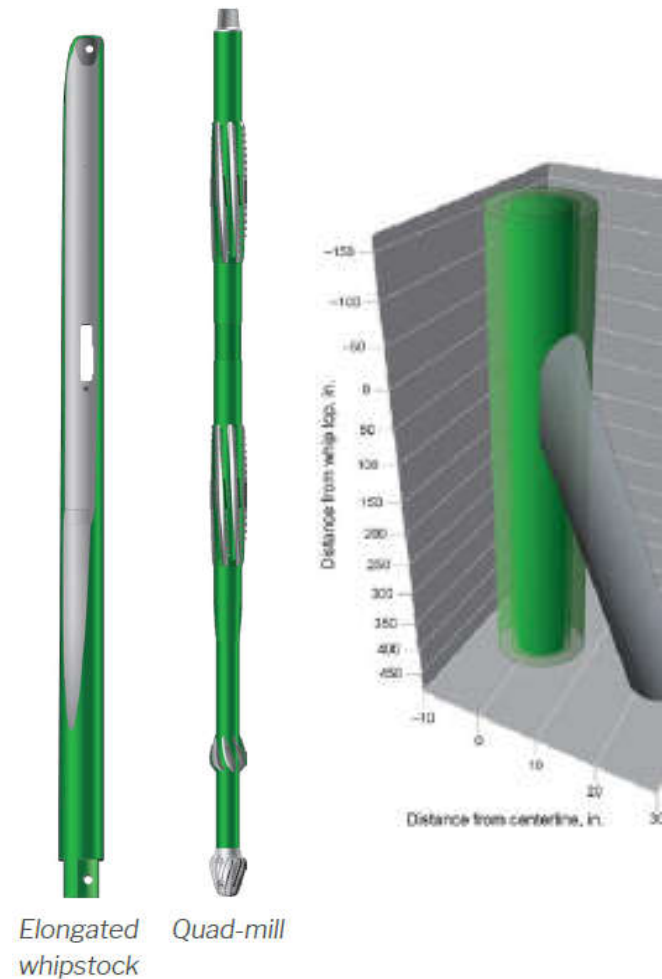
Low dog leg at junction to avoid limiting lateral length

## Result:

Single trip system with quad-mill assembly achieve 40% longer window (7-m)

Avoid extra trip to elongate

100-m lateral cut to maximize production



Low Dog Leg System - Courtesy of WIS

# New Low-Pressure Packer Anchor Technology, Kuwait

## Objective:

Establish barrier in main bore for liner cement  
separation

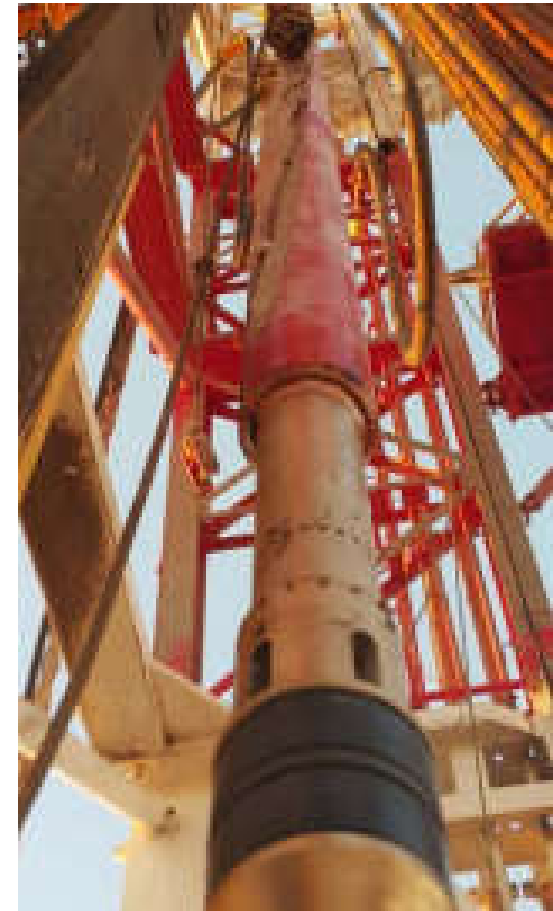
Validate pressure integrity of system post set

## Result:

Hydraulic whipstock set at 1,870-meter in 9-5/8-in  
 casing, single trip

2-Mpa pressure test for 10 minutes

Cost reduction vs traditional isolation methods



Low-Pressure Isolation Anchor - Courtesy of W

# Low Side Re-entry to Target Behind Pipe Reserves , Colombia

## Objective:

Retrack existing well through 9-5/8-in casing at 1090-m and 11 deg.

Low side exit to minimize drilling operations and maintain low doglegs

## It:

Single trip installation with window / rat hole drilled in 6 hours

Reduced drilling cost avoiding conventional high side exit

Low-cost production established from up hole reservoir



Lead Mill Made Up to Hydraulic Whipstock - Courtesy of

# Consecutive Single Trip Installs Highlight, Ecuador

## Objective:

Retrack wells for various operators /  
Application successfully

## Result:

• consecutive installs for 6 operators -  
100% planned  
100% single trip  
1000-m to 3000-m  
Average mill time 5.5 hours



# Best in Class Milling Time, Malaysia

## Objective:

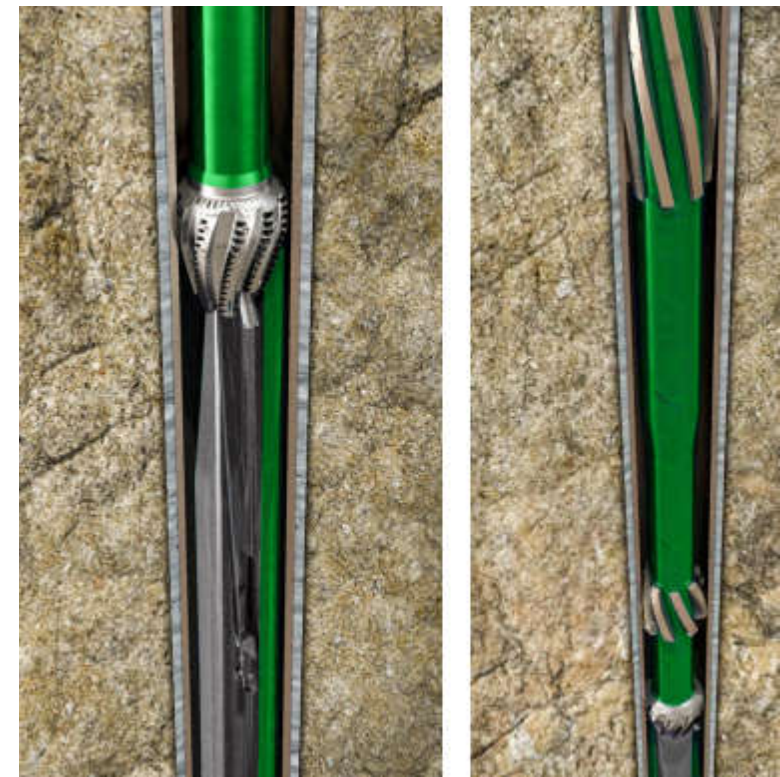
Re-track existing depleted well through  
5/8-in casing  
Centralizer at junction point  
Extended rat hole

## It:

Single trip installation with window / rat  
hole milled in 2.5 hours

No issue passing future BHAs or  
completions

Low-cost production established with  
milling operation setting standard for  
similar application



Tri-Mill Hydraulic Whipstock System - Courtesy of

# Unprecedented Thick Wall Exit, Mexico

## Objective:

Mill a window in 10-1/8-in 79.2# TAC110 casing at 4,801-m and 42 deg.

Minimize well possession time of sidetrack

## Result:

Hydraulic whipstock set and 8-1/2-in window and rat hole in single trip

Benchmark efficiency for casing size/weight

Well construction risk reduction in similar application



Milling BHA - Courtesy of Weatherford

# First Regional S13 CR Exit, UAE (SPE 177852)

## Objective:

Retrack deep in 177.8-mm Super  
Drome 13 casing to allow for  
Super pump

Avoid cost/time associated with  
drilling hole section involved  
with “standard” 244.5-mm exit

## Result:

Single trip junction –regional first  
Saved 5.5 days vs up hole exit  
Production increase of 58%



New Technology Carbide Milling BHA- Courtesy of Baker Hughes

# Uncemented Dual String Exit, Iraq

## Objective:

Smooth junction through 244.5-mm and 199.7-mm casing with no cement in either annulus

Bring well back into production

## Result:

Successful single trip window/rat hole at 283-m in 12.5 hours, weight limited to avoid jump off

Completed in 3 days vs offset application - \$230,000

Result:

Well back onto production as planned



Mill Gauge in Tolerance After Dual String Unsupported Exit - Co

# Three String Exit Offshore Well, KSA

## Objective:

Retrack existing wellbore through 177.8-  
mm, 244.5-mm and 339.7-mm casing

Minimize well possession time for install

## Result:

Single trip install through all three strings in  
hours

No issue passing following BHA or  
completions

Days/times saved vs historic three string  
installs in region



Three String Concentric Layout - Courtesy of WFL

# Whipstock Technology for Unsupported Low-Side Exits, United Kingdom (SPE 149625)

## Objective:

Retrack in mature field low side with no cement in casing annulus  
Avoid junction formation integrity issues previously experienced

## Result:

Successful deployment of modified whipstock system that forces top back after anchor engagement

Single trip installations success from 35% to 100% in same application



Modified Whipstock System for Low Side Exits - Courtesy of

# New Thru Tubing Whipstock Technology

(SPE 194290)

## Objective:

Re-track in existing wells using coil tubing  
utilize high expansion whipstock system in  
application (177.8-mm and 129.7-mm )

## Result:

Successful development and trials on new  
whipstock system  
Whipstock access to previously inaccessible  
production similar application worldwide  
Cost / time saved drilling new well down to  
work off point



TT high expandable anchor - Courtesy of Northern Sol

# Cemented Pipe and Short Time Frame, Algeria

## Objective:

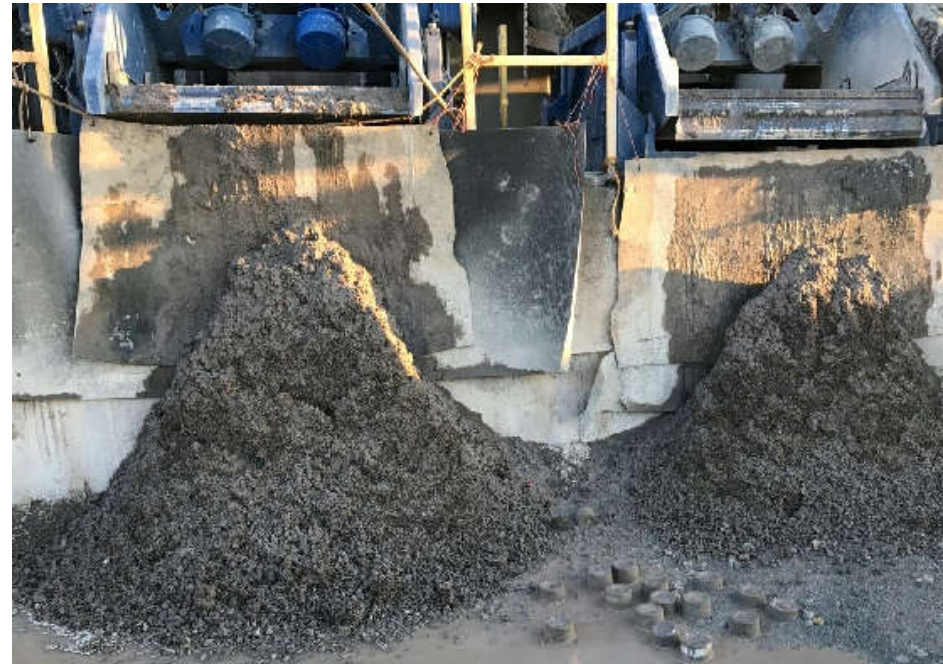
20-in casing exit installation during  
drilling operation after cementing pipe in  
the hole

and sale obligation made fishing  
operations or re-drill options undesirable

## Result:

20-in window achieved and drilling  
continued

Well construction finalized prior to hard  
deadline



Swarf collected at surface from 20-in exit

# Stuck BHA and Restriction in Casing, Permian

## Objective:

7-3/8-inch casing exit installation during  
drilling operation after stuck BHA  
internal casing patch resulting in  
restriction up hole

## Result:

Custom 7-3/8-inch mills ran through  
restriction

System anchored in standard pipe

Window achieved and drilling continued



7-3/8-in OD Mill after window cut

# al String Exit to Avoid Complex Intervention, Malaysia



## Objective:

Retrack 244.5-mm and 339.7-mm casing to avoid time/cost associated intervention

## It:

Hydraulic set whipstock system with hard formation mill was set at 2,050-m

al string exit milled in 7 hours and 12-m of hole in 1 hour

5M USD saved relative to offset application

illions USD saved vs cut/pull and casing lining



Hard Formation Milling BHA - Courtesy of Baker Hughes

# Sidetrack on Semi-Submersible to Bypass Stuck BHA, Philippines



## Objective:

Sidetrack 9-5/8-in casing to avoid time/cost of continued milling operations

Minimize time of sidetrack due to risk of ongoing tide changes

## Result:

1/2-in window and rat hole in single trip with hydraulic whipstock at 2,430-m

12 hours total well possession time

Expense of additional NPT avoided

All construction continued as planned



Milling BHA Made Up to Hydraulic Whipstock

# Bypassing Fish Saves USD1M, KSA

## Objective:

Designing exit in 18-5/8-in to bypass abandoned BHA and salvage current well

## Result:

System install creating 17-1/2-in window in one trip, allowing continued well construction without issue

72-meter saved in two-day operation

Operator saves USD1M in construction of new cellar and re-drilling / casing top hole section



Lifting operation of 18-5/8-in system

# al String Exit to Avoid Complex Intervention, Malaysia

## Objective:

Retrack 9-5/8-in and 13-3/8-in casing to avoid time/cost associated intervention

## It:

Hydraulic set whipstock system with hard formation mill was set at 2,050-m

al string exit milled in 7 hours and 12-m of hole in 1 hour

5M USD saved relative to offset application

illions USD saved vs cut/pull and casing lining



Hard Formation Milling BHA - Courtesy of Baker Hughes

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Lifting operation of 18-5/8-in system

# Dual String Exit to Avoid Intervention and New Drill, Iraq

## Objective:

Bypass cemented pipe and sidetrack through 339.7-mm and 473.1-mm casing 1,586-m

## Result:

1,586-m long window/rat hole milled in 5 hours

Production schedule met

Well construction and intervention avoided at \$500,000 USD / day



12-1/4-in OD Mill on Location for to Bypass Obstruction – Courtesy of W

# Dual-String Bypass of Cemented Pipe, KSA

(SPE-204881)

## Objective:

13-3/8-in X 13-3/8-in casing exit installation

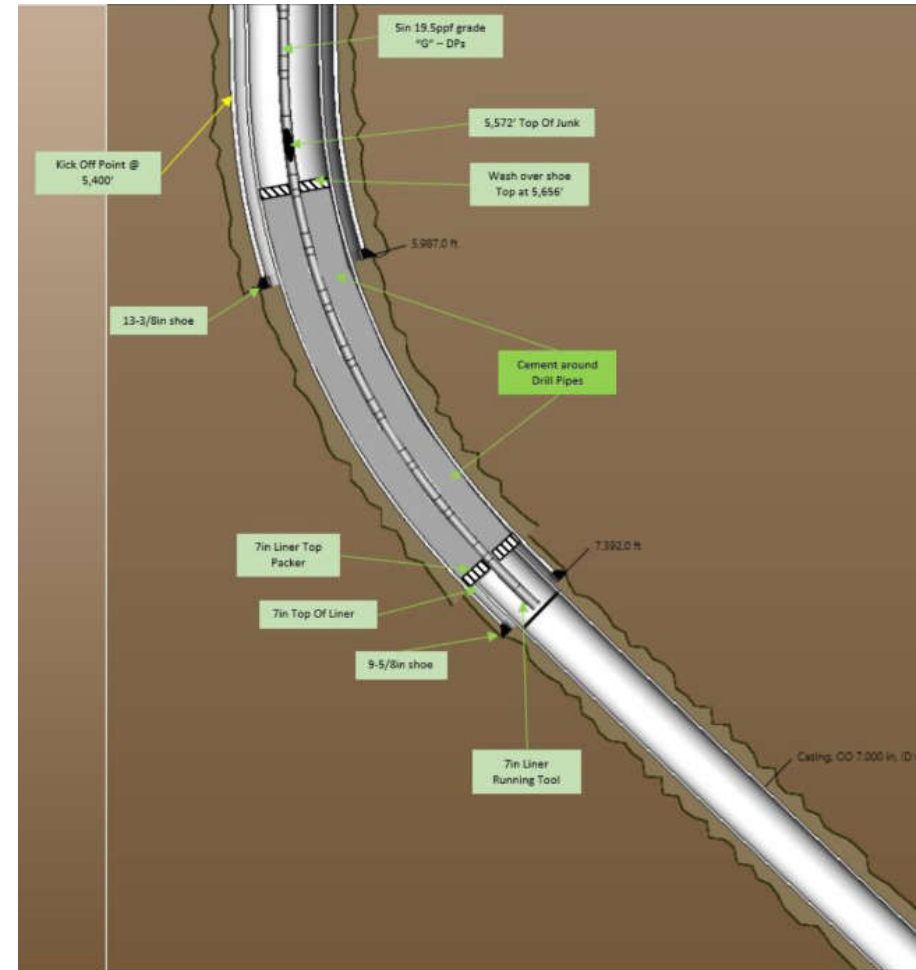
Avoid reducing production hole size

## Result:

Single trip 8-1/2-in window achieved through  
two strings

Inner string set at original 13-3/8-in casing  
exit and 6-in hole drilled to TD

Avoided cost/time associated with fishing



Wellbore Layout of Application Pre-window – Courtesy of SPE

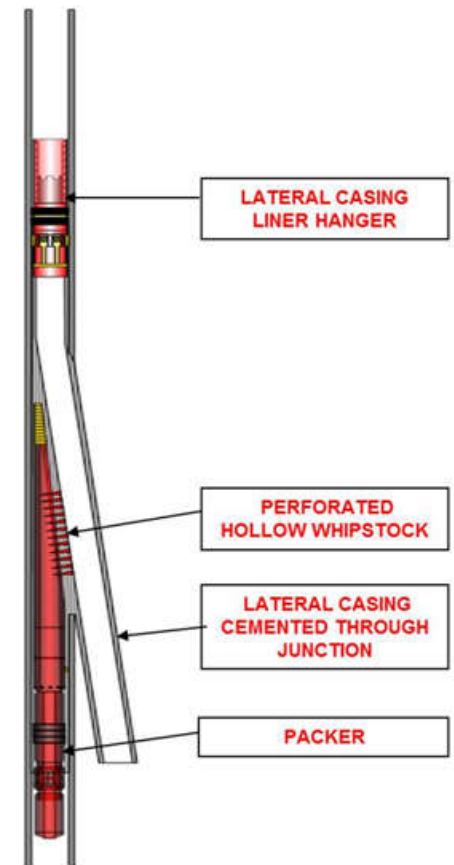
# Extend Well Life and Increase Reserves, Thailand (OTC - 26418)

## Objective:

- 4.5-m X 177.8-mm junction
- Completion only required during well construction
- Production not on production
- Lower production from main bore required

## Key:

- Junctions installed in single trip 980 – 1,400-m
- 50 – 73-degree inclination
- Conventional completions equipment used after standard well construction
- Utilization of existing platforms
- Low trip count / low risk solution to extend well



TAML 4 junction layout – Courtesy of WFRD

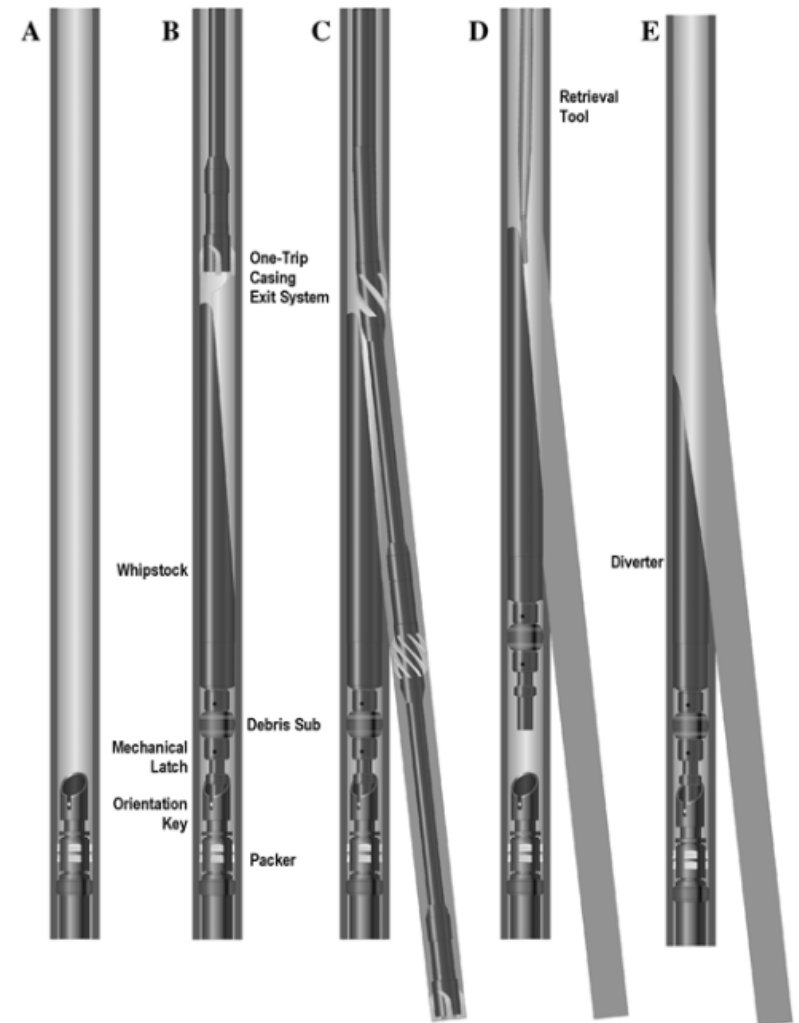
# Simple TAML 2 Selective Re-entry System Adds Production, United Kingdom (SPE-68512)

## Objective:

Increase production utilizing off-the-shelf cost-effective equipment  
Low risk installation – reserves under wildlife sanctuary / recreational area

## It:

Two wells with two additional laterals from 7-in casing  
Economic production increase from all laterals and one main bore  
Re-entry capability to all laterals



# TAML 5 Multilateral Step Change for Production Gains, Australia (SPE 202359)

## Objective:

Drill a vertical 9-5/8-in main well to maximize reservoir exposure, 1,700-m average completion  
1,700-m average completion  
1,700-m average completion  
Access to all laterals post well construction

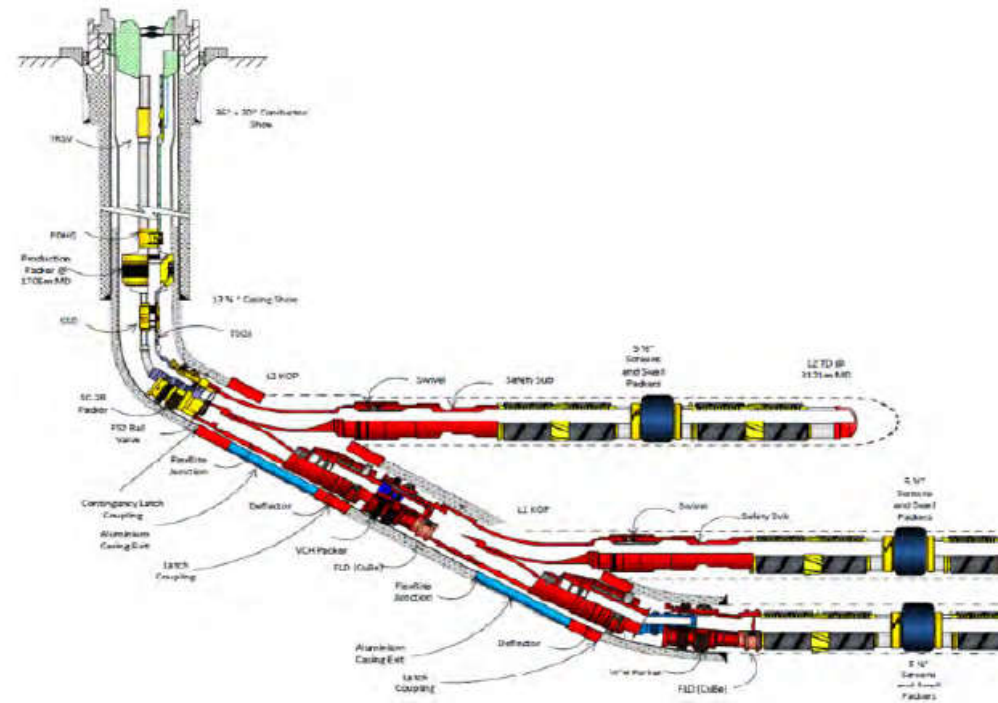
## Key:

Industry first TAML 5 for 800-m water  
Multiple industry improvements for application

30% faster for production, 50% decrease cost per barrel

24% reduction in field well construction time, 24% reduction in capex average

30% faster than offset MLs



TAML 5 Tri-lateral Layout – Courtesy of Halliburton

# Dual String Exit Slot Recovery, Cambay

Basin India (SPE 194677)

## Objective:

Re-track shallow through 9-5/8-inch and 13-inch casing targeting stranded reserve

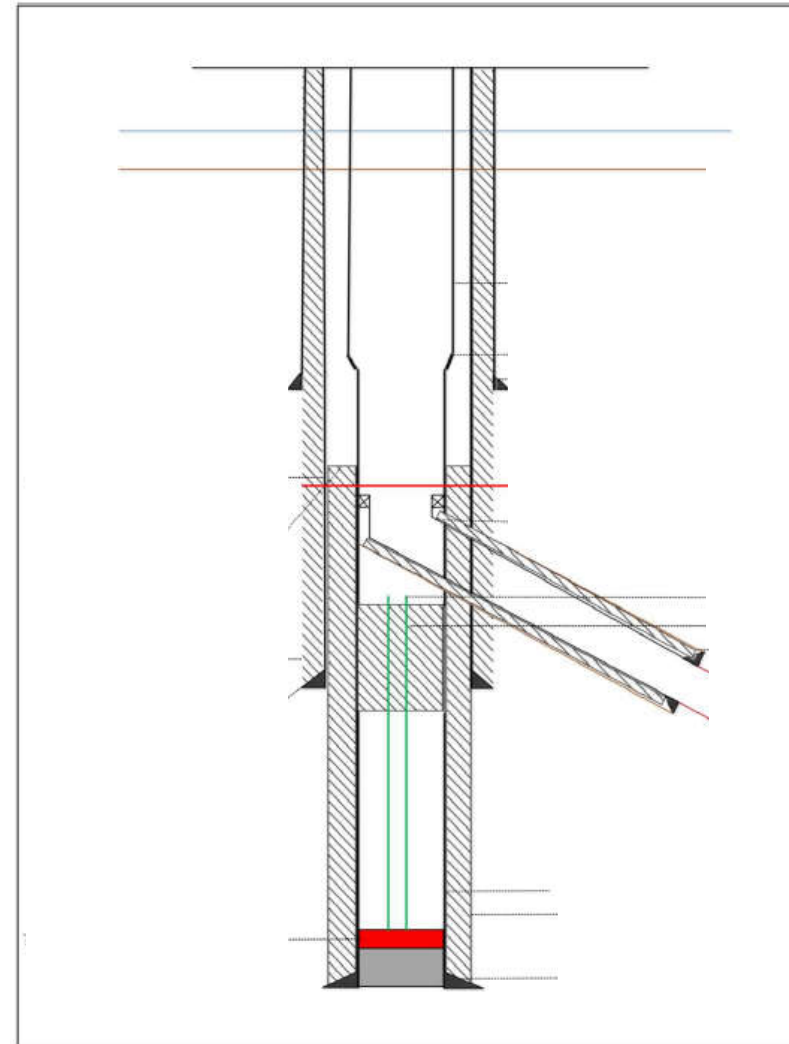
Utilized existing infrastructure while avoiding the need to move to increase production in mature field

## Key:

Single trip junction with no deviation from planned well design

Reduced time / cost associated with section drilling equated to thirteen days

Environmental impact minimized



# Avoiding New Well Construction and Future Abandonment Obligations, Nigeria

(SPE-184259)

## Objective:

Utilize existing wells to avoid well construction/abandonment cost

## Result:

1) re-entries with 7-in and 9-8-in main bore  
 2) hydraulic systems ran, all single trip with less than 7-hour window/rat hole  
 3) renewed production on previously abandoned wells

	Well A	Well B	Well C
Casing Description	9 5/8" N-80 47ppf	7" N-80 29ppf	9 5/8" N-80 47ppf
Casing Age	4 years		5 years
Whipstock Deployed	Hydraulic		
Casing Window Depth	3,113 ft TVD @ 75°	3,295 ft TVD @ 77°	3,493 ft TVD @ 81°
Old Heel Depth	3,737 ft TVD	3,509 ft TVD	3,711 ft TVD
New Heel Depth	3,715 ft TVD	3,494 ft TVD	3,713 ft TVD
Milling Duration	1.25 hrs	2.3 hrs	1.25 hrs
Mud Weight	11 ppg	11 ppg	10 ppg
Plastic Viscosity	52 cP	47 cP	42 cP
Yield Point	24	20	17

	Well D	Well E
Casing Description	9 5/8" N-80 47ppf	13 5/8" K-55 68ppf
Casing Age	5 years	9 years
Whipstock Deployed	Hydraulic	
Casing Window Depth	5,369 ft TVD @ 21°	4,063 ft TVD @ 16°
Old Heel Depth	9,255 ft TVD	7,330 ft TVD
New Heel Depth	6,469 ft TVD	7,355 ft TVD
Milling Duration	7 hrs	6 hrs
Mud Weight	10 ppg	9.8 ppg
Plastic Viscosity	30 cP	29 cP
Yield Point	22	19

	Well F	Well G
Casing Description	9 5/8" N-80 47ppf	9 5/8" N-80 47ppf
Casing Age	12 years	13 years
Whipstock Deployed	Hydraulic	
Casing Window Depth	4,570 ft TVD @ 37°	3,193 ft TVD @ 27°
Old Heel Depth	6,203 ft TVD	6,189 ft TVD
New Heel Depth	6,157 ft TVD	6,115 ft TVD
Milling Duration	3 hrs	1 hr
Mud Weight	11 ppg	11 ppg
Plastic Viscosity	32 cP	47 cP
Yield Point	16	22

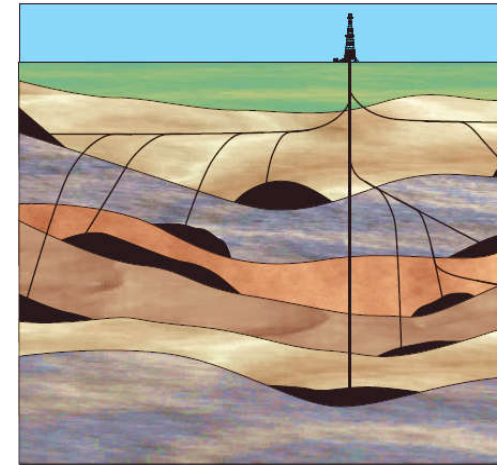
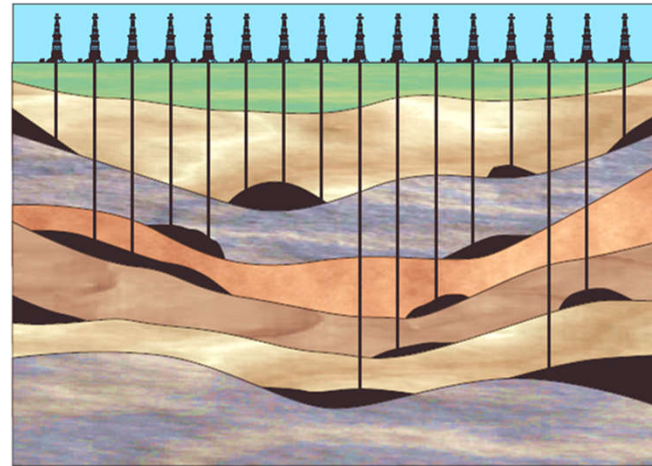
# Simple TAML 2 System Adds Production, Canada

**Objective:**

- Increase reservoir exposure utilizing off-shelf equipment
- Direct entry access into all laterals
- Economical for low margin coal bed methane

**Key:**

- Hundreds of 7-in installs, 2-3 per well, the reservoir
- Economical production increase relative to new construction
- Retrievable isolation anchor technology with redress capability
- Test project in UK, India, Eastern Australia, China and US



Retrievable Isolation Anchored System with Bi-Mill BHA - Courtesy of Weatherford

# Novel TAML 4 Junction Results in Highest Field Producer, Venezuela

## Objective:

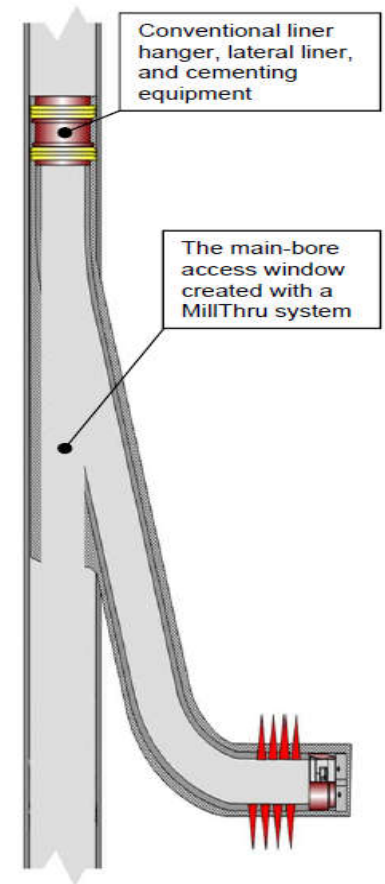
TAML 4 9-5/8-in x 7-in junction at 1,036-m and 45 deg.

Avoid time/risk associated with previous multilateral installs

## It:

Novel technique junction with mechanical / cement integrity resulted in best production in field of the five successful junctions out of seven attempts

Full entry capability into both main bore and lateral made this technology primary choice for future multilaterals



TAML 4 Junction- Courtesy of WFR

# Multilateral Production vs Cost, Middle East

(Journal of Petroleum Exploration and Production Technology, Volume 9 2019)

## Objective:

Multilateral wells to increase production and decrease cost BOE

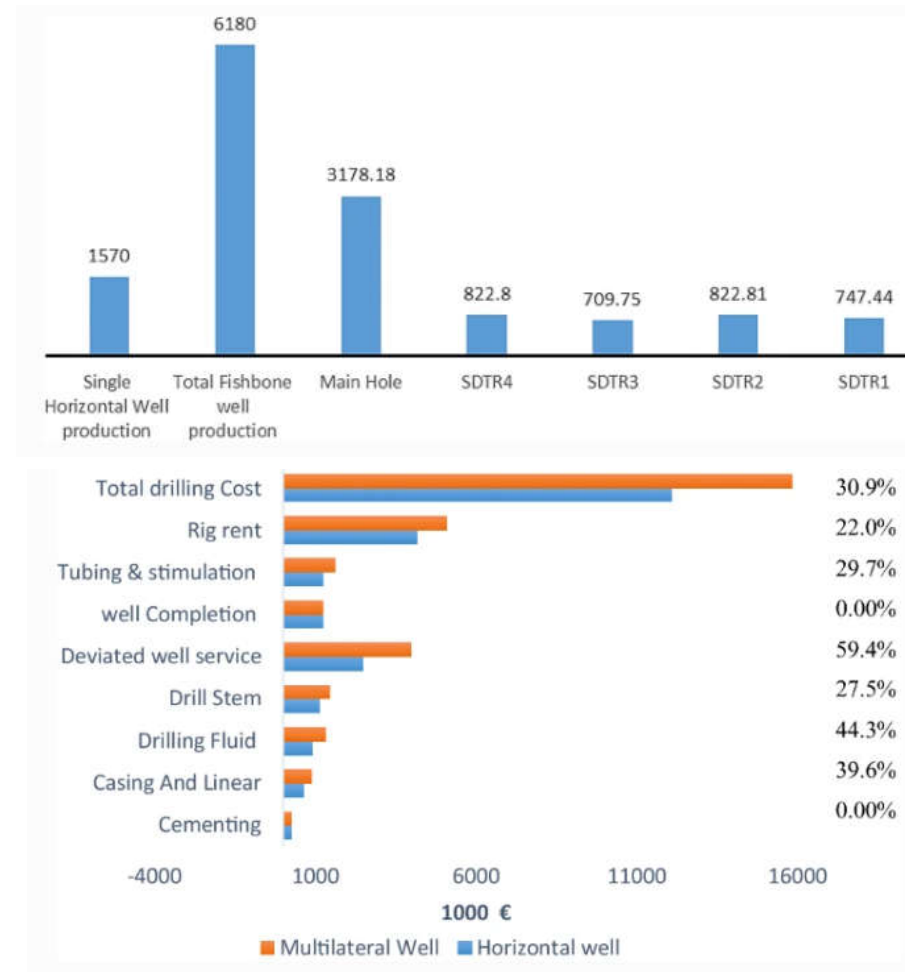
## Result:

ML 2 wells fishbone wells

3% increase on total production when four laterals drilled

5% increase on well construction cost

No additional environmental footprint associated with new pad and top hole



# Dual String Exit Slot Recovery, India

(SPE 194677)

## Objective:

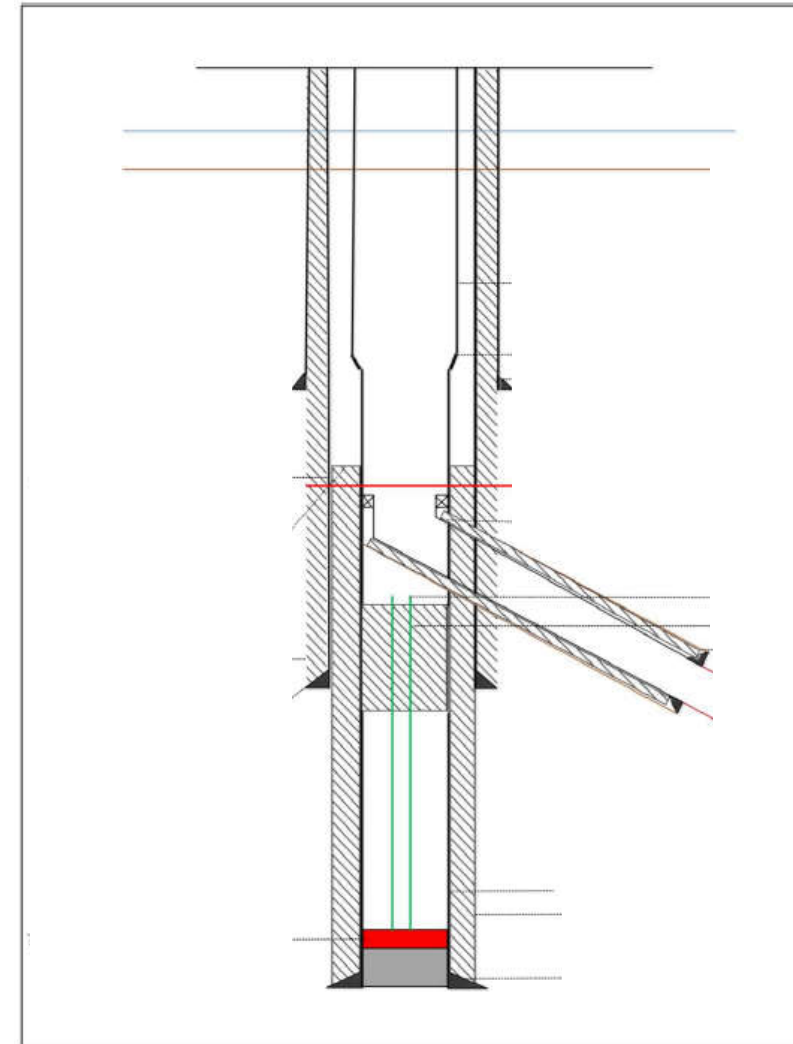
Retrack shallow through 9-5/8-inch and 7-1/8-inch casing targeting stranded reserve utilizing existing infrastructure while avoiding rig move to increase production in mature field

## It:

Single trip junction with no deviation from planned well design

Reduced time / cost associated with section drilling equated to thirteen days

Environmental impact minimized



# Worlds First TAML 6 Multilateral, Malaysia

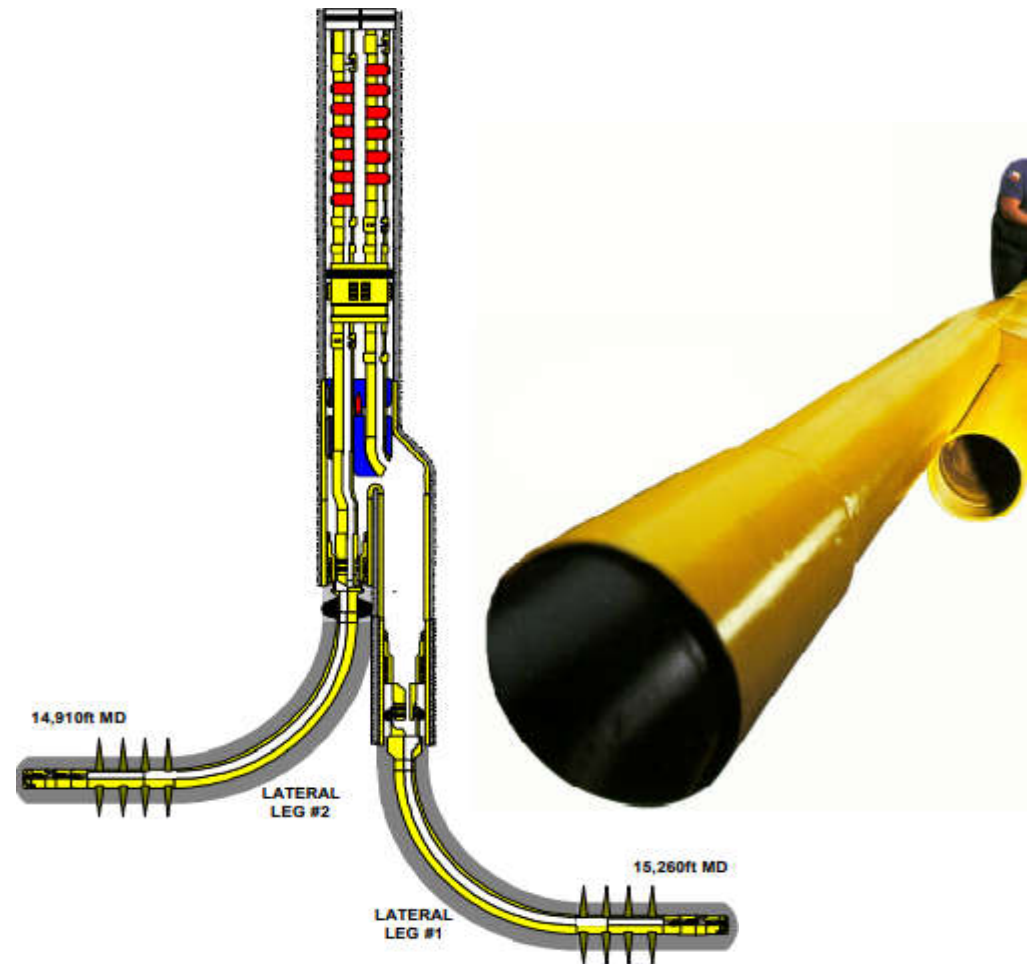
(SPE-68729)

## Objective:

Pre-made junction of 244.5-mm trunk with (2) 177.8-mm branches able to pass through 339.7-mm casing  
Isolation at junction and each lateral  
Independent thru-tubing access to both laterals

## Result:

TAML 6 junction ran into 431.8-mm under reamed hole and formed downhole using swedging operation  
Well construction, completion and stimulation as planned  
Avoid milling operation for TAML 5



TAML 6 junction layout – Courtesy of Baker Hughes

# Multilateral Geothermal Well Reduces Cost, Philippines



**Objective:**

Multilateral wells to decrease cost and increase KPH

**Cost:**

8-5/8-in main bore with 9-7/8-in lateral, 8-5/8-in slotted liner dropped outside level 2 junction

15% increase on well construction cost

25% increase on steam

10% increase on surface footprint, rig moves, more “deep steam” reduces decline

||

Well Type	Cost (\$MM)		Steam Deliverability (kph)		\$/kph	
	Estimated	Actual	Estimated	Actual	Estimated	Actual
Standard	3.0	3.56	200	175	15,000	20,340
Multi-lateral	4.2	3.78	300	320	14,000	11,810

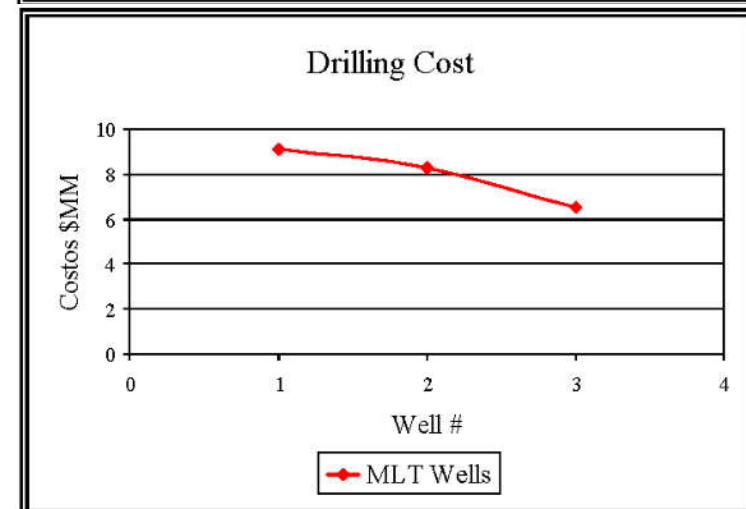
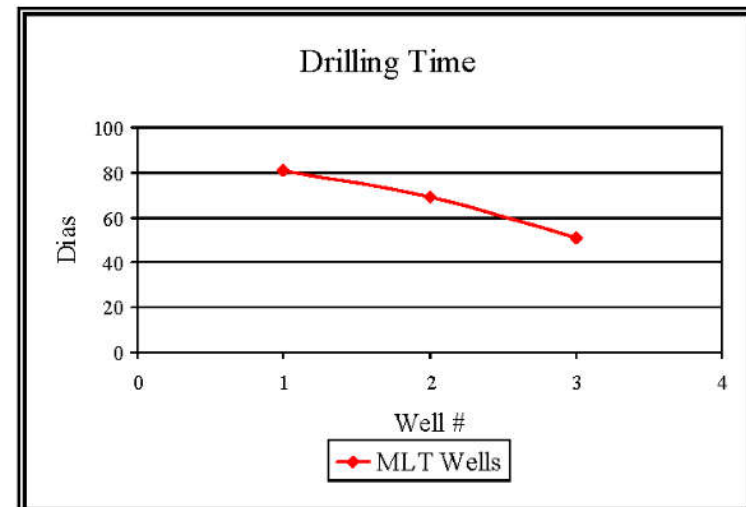
# Multilaterals Reduce Water Coning and Save Construction Time/Cost, Colombia (SPE-119458)

## Objective:

Replace three dual lateral ML wells to replace nine conventional wells  
Decrease cost/time of well construction  
Install 3 X 4-1/2-in TAML 4 junction with screens

## Result:

Average oil production declination 3.25% vs 5% per month  
2 month increase in production time  
0.7M USD save in total cost  
0.6M additional bbl. oil recovery



# HWU Re-entry Sidetracks Extend Well Life, New Zealand (IADC/SPE-170487)

## Objective:

Low-cost re-entry solution that avoids use of platform rig  
Sidetrack 4 well out of 244.5-mm casing using HWU  
Access behind pipe reserves

## Result:

Well junctions achieved using less than optimal milling parameters  
Well construction as planned  
Established production from target reserves while avoid cost / time associated with platform rig

Table 1—Milling parameter and result summary

	Well #1	Well #2	Well #3	Well #4
Project Date	August 2011	March 2012	June 2012	September 2012
Casing Size	9 5/8" 47ppf, L80	9 5/8" 43.5ppf, L80 × 13 3/8" 54.5ppf, K55	9 5/8" 47ppf, L80	9 5/8" 47ppf, L80
Whipstock Face (°)	3	3	3	3
Accchor Type	Hydraulic	Hydraulic	Hydraulic	Hydraulic
Attachment Bolt (lbs)	40,000	40,000	40,000	40,000
Setting Depth (m)	2067	1987	2410	2100
Well Inclination @ Setting Depth	24.21	0.06	30	7.5
Orientation Method	MWD	Gyro	MWD	MWD
Toolface Orientation (°)	13 Left	159	63 Right	30
High Side/Low Side Exit	High Side	High Side	High Side	High Side
Setting Fluid	SBM	Water	Water	Water
Setting Flow Rate (GPM)	340	350	330	250
Setting Pressure (psi)	2700	1800	1800	1500
Mill Size (in)	8 1/2"	8 1/2"	8 1/2"	8 1/2"
Window Length (m)	4	4	4	4
Milling Fluid	SBM	SBM	SBM	SBM
Weight on Mill (lbs)	17,000	22,000	10,000	20,000
Rotary Speed (RPM)	80	70	50	70
Free Torque (ft-lb)	8,500	6,000	10,000	6,000
Milling Torque (ft-lb)	16,000	10,000	14,000	12,000
Milling Flow Rate (GPM)	265	310	230	250
Milling Pressure (psi)	1800	1600	1400	1500
Average ROP (m/hr)	1.33	0.70	0.47	1.0
Milling Time	3:00hr	5:40hr	8:30hr	3:40hr
Milling Trip	1	1	2	1
Rathole Length (m)	3	3	3	3
Formation	Shale	Shale	Shale	Shale
Mill Wear (in)	1/16"	1/16"	Negligible	Negligible

Sidetrack Campaign Details – Courtesy of WFRD

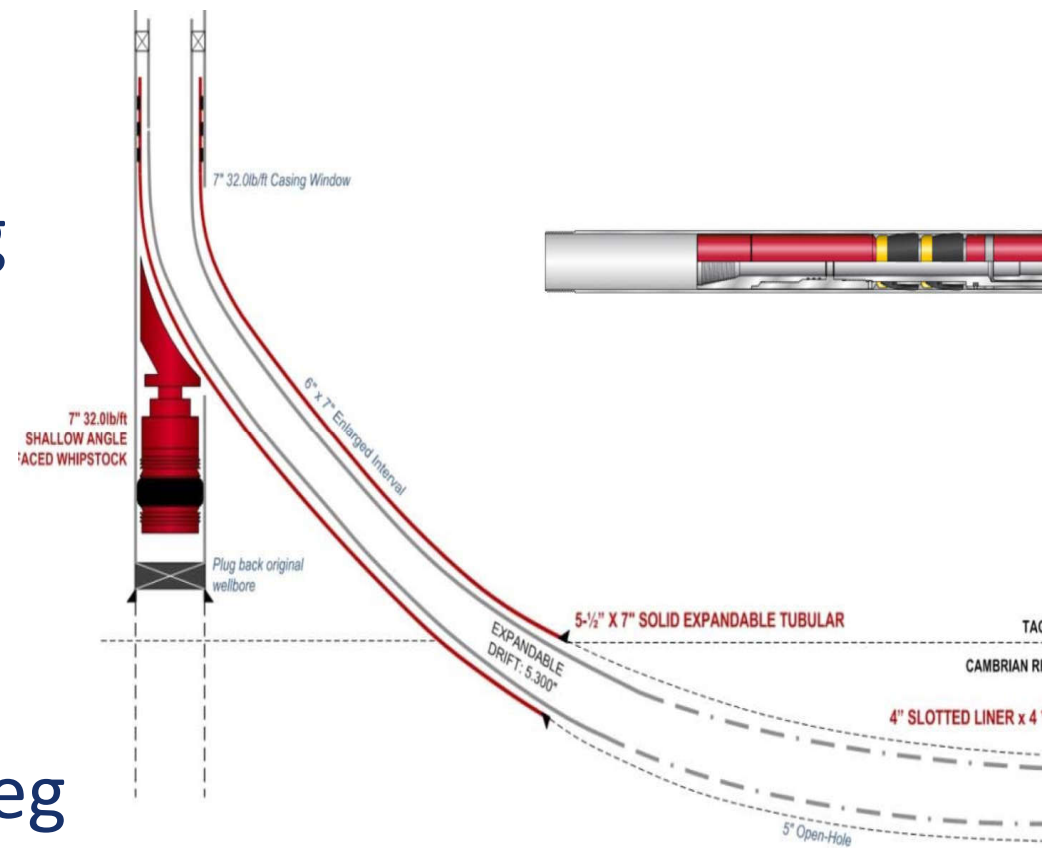
# New Life to Dead Wells, Algeria (SPE-160839)

## Objective:

- Utilize existing wells
- Target lower reservoir while casing over depleted zone
- Maximize completion size

## Result:

- One re-entries with 7-in main bore and 5-1/2-in expandable liner
- 15 deg. system used minimize dog leg
- Thin slotted liner for production



Re-entry Well Example

# Dual String Exit Slot Recovery, India

(SPE 194677)

## Objective:

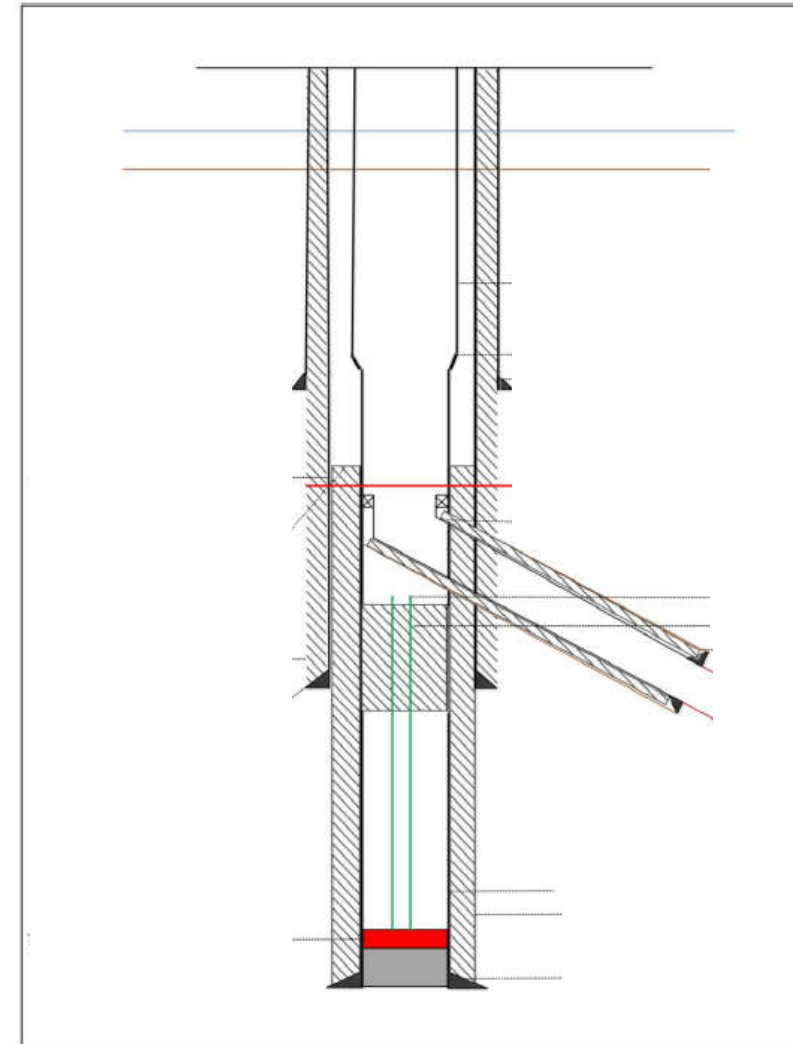
Retrack shallow through 9-5/8-inch and 7-1/8-inch casing targeting stranded reserve utilizing existing infrastructure while avoiding rig move to increase production in mature field

## It:

Single trip junction with no deviation from planned well design

Reduced time / cost associated with section drilling equated to thirteen days

Environmental impact minimized



# Extending Production Life of Mature Fields, Norway (SPE-68512)

## Objective:

Utilize existing assets in field to avoid well construction cost and environmental impact associated

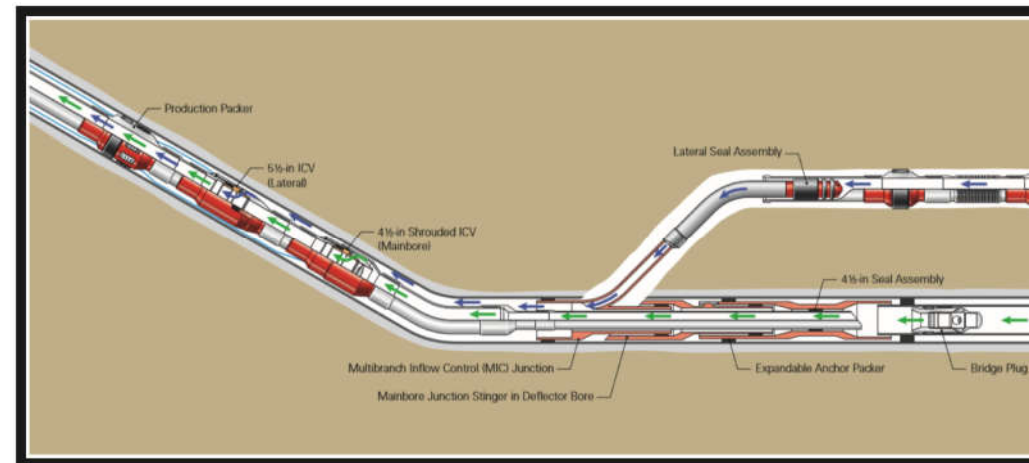
## It:

4.5-mm main bore junction utilizing new expandable anchor technology

New target completed with 139.4-m screens while maintain production from existing completion  
Significant reduction in cost per barrel of oil produced



TAML 5 Multilateral Junction Using Expandable Anchor – Courtesy of Haliburton



Final Production Path From Multilateral Well – Courtesy of Haliburton

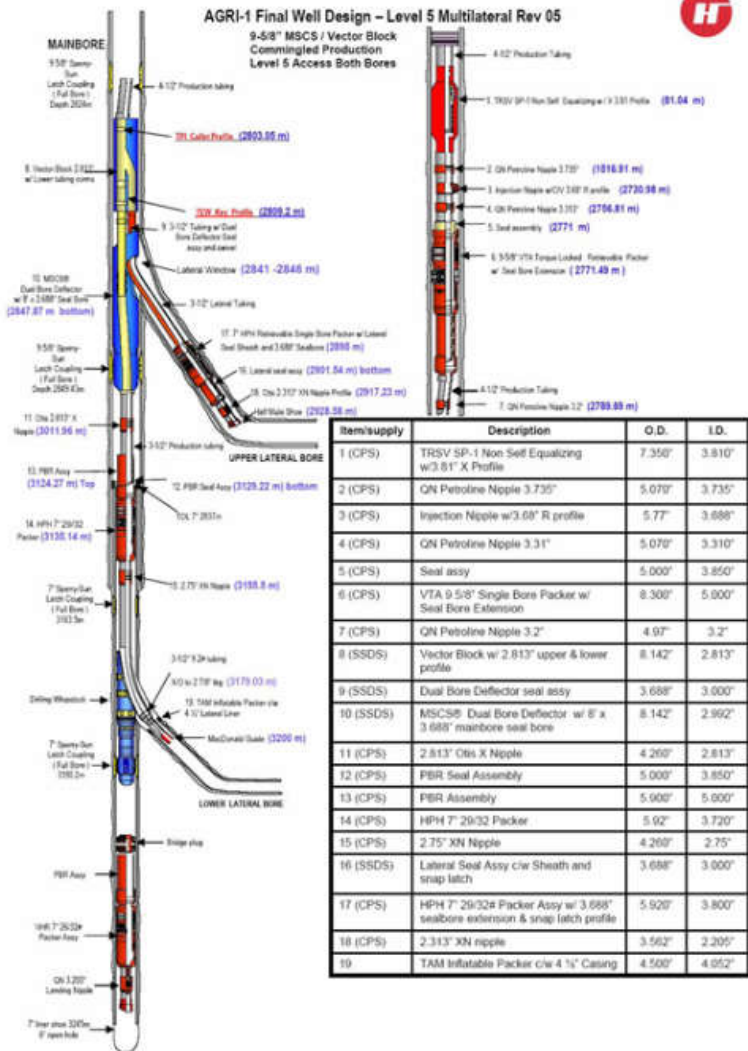
# Multilateral Technology Increases Production in Environmentally Sensitive Area, Italy (SPE-107603)

**Objective:**

- Plug and abandon the existing main bore
- Install a Level 4 junction from the 244.5-mm latch coupling
- Install a TAML Level 5 Incoloy 925 completion to isolate the junction and provide through-tubing access to all bores

**Constraint:**

- Meet national park regulations by minimizing vibrations
- Use latch couplings and multilateral allow accessibility to additional reserves (all wells moving forward)
- Meet production targets while meeting park regulations



# TAML 4 Junction Improves Production, Kuwait

## Objective:

- Increase reservoir exposure utilizing existing wellbores
- Enable entry access into both legs
- Prevent cement at junction to avoid sand-off

## Result:

- Two wells 244.5-mm X 177.8-mm
- Economical production increase
- Well life increase from clean out capability and junction integrity



Dual-Lateral Well Design and Photo of Junction - Courtesy of Weatherford

# Multilateral Well for Sustainability and Self Sufficiency, United Kingdom

## Objective:

Operational lateral well in coal bed methane  
University toward energy  
independence

## It:

Two exits in 5-1/2-in at 54 deg.  
inclination with 605-m and 646-m  
laterals

Retrieved whipstocks without issue  
Production established, cleaner energy  
source for the campus



Geometric Drilling Rig HH55

# TAML 3 Junction Reduces Well Cost, Permian

## Objective:

Maximize lateral footage  
Well construction to allow for all wells  
to commingle production eventually  
Full entry capability into each lateral

## It:

Two or three laterals 7-inch X 9-5/8-inch  
10,000 psi rating on junctions  
10% / BBL reduction in break even oil  
price and \$500,000+ saved in lifting cost



Tri-Lateral Well

# Dual Lateral Well in Extreme Environment, UAE

## Objective:

7.8-mm exit in 23 to 27% chrome casing  
3,066-m and 60 deg.

Establish more reservoir exposure without risk  
surface collision

## Result:

4.5-m window and 4.5-m of rat hole in 3 hours  
Chipstock retrieved without issue after lateral  
of 1,524-m drilled using RSS

Production increase and full-bore access to  
both laterals for future intervention



Dual Lateral Wells in 25% H<sub>2</sub>S – Courtesy of Al Hosn Gas

# Increase Production and Extend Reserves, Bare Field Venezuela

## Objective:

Draw down existing reserves in mature field  
without drilling new wells

Identify and address formation integrity issues at KOP

Enable full-bore access into all laterals for clean out

## Result:

5/8-inch x 7-inch junction created

Full-bore access into each lateral

Multilateral well resulted in field leading production



Level 4 junction with  
access to each lateral

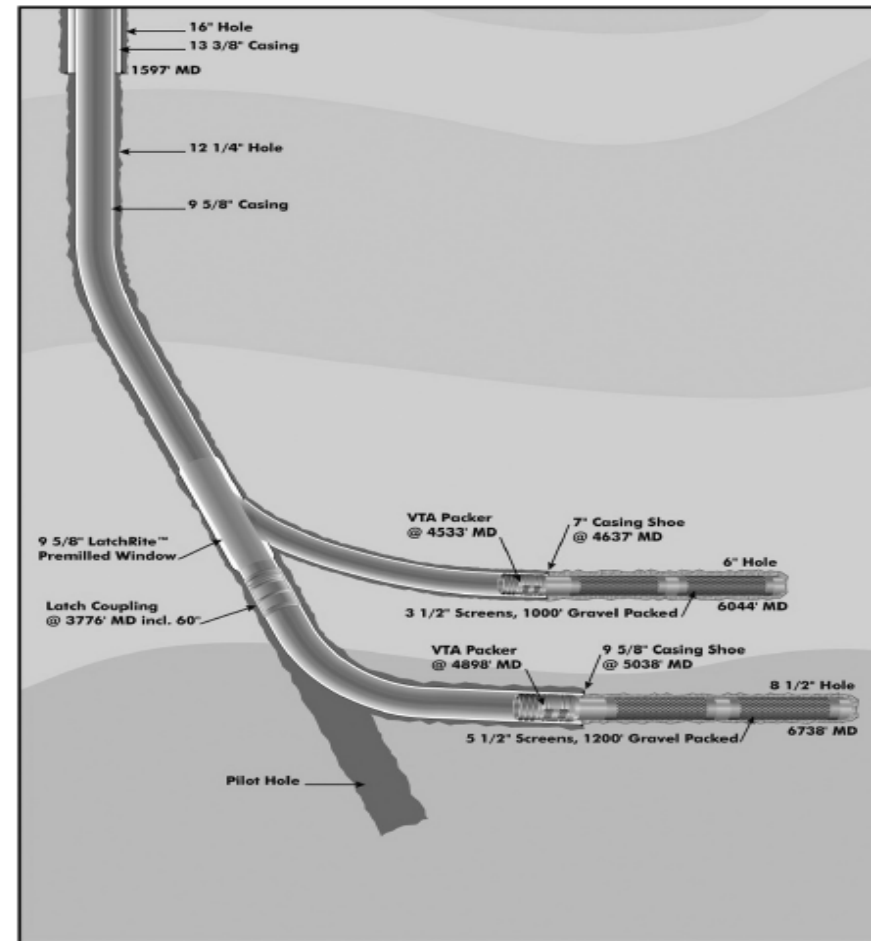
# Country First Multilateral Well, Trinidad (OTC-16244)

## Objective:

Completion for sand control  
Permanent / cased junction with access to  
all laterals  
Utilize one well to maximize production

## It:

5/8-in X 7-in level 4 junction using  
composite wrapped pre-milled window  
Gravel pack completion in each lateral  
Initial production was 5X offset wells  
Cost / time associated with well  
Construction reduced



Multilateral Well With Gravel Pack

# Dual String Slot Recovery, Kuwait

## Objective:

Retrack through 244.5-mm and 339.7-mm casing in carbonate formation

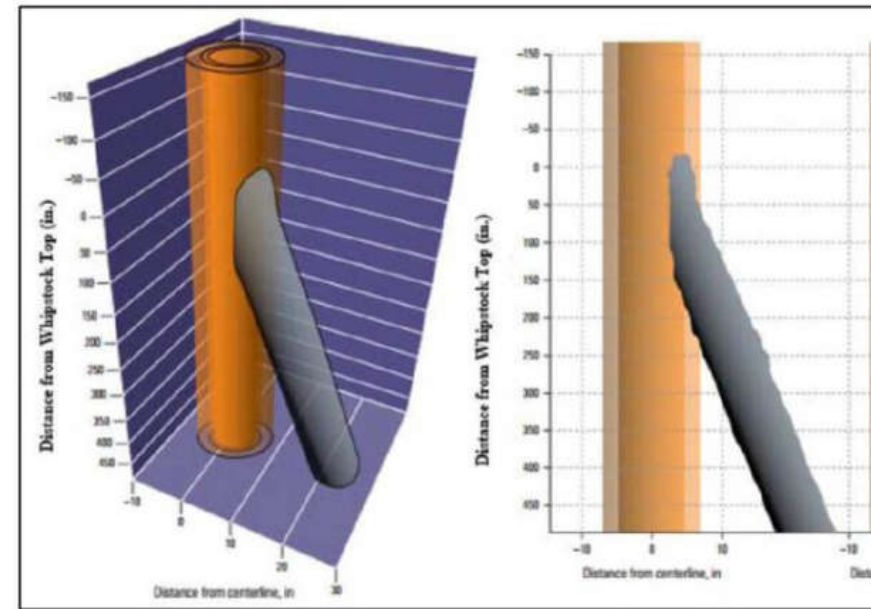
Establish increased production in mature field

## It:

Window / rat hole cut in single trip with minimal deviation from planned well design

Reduced trips which reduced risk of wellbore damage relative to previous case history

Step change on field development in mature asset application



Simulated junction through two strings of casing - SLB

# Multilateral Technology Reduces Risk for Additional Production, KSA (SPE-208103)

## Objective:

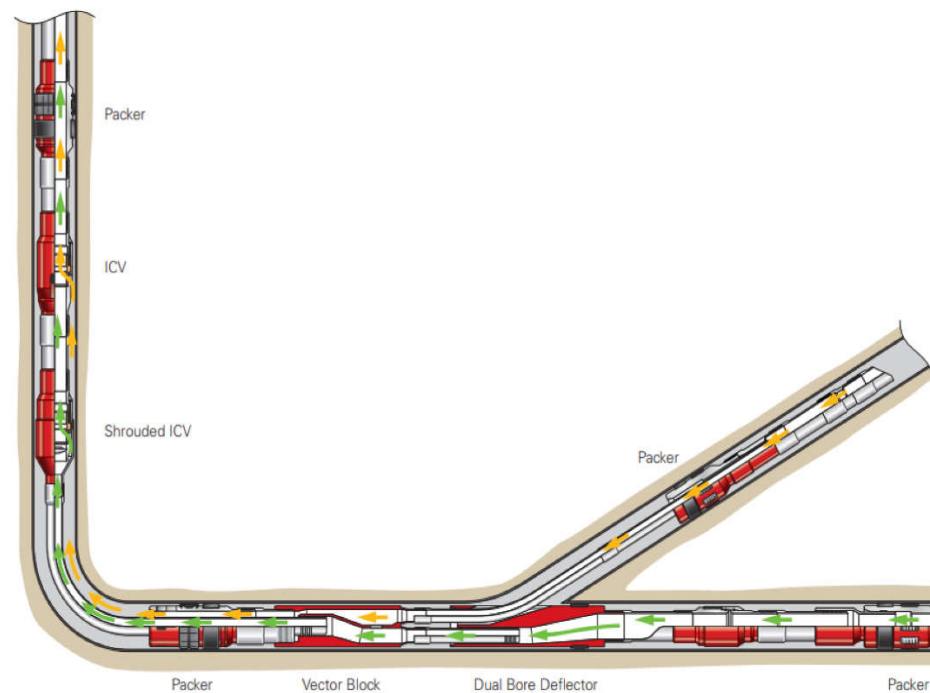
Convert TAML 4 and TAML 5 wells to increase production using existing infrastructure  
Maintain ability for intervention work on main bore or coil into laterals

## It:

Convert TAML 4 wells – 9 wells / TAML 5 – 1 well  
Use a TAML 5 style junction with interventions

Avoid time/cost/risk associated with pulling upper completion

Use acid simulation and breaking of ceramic discs through main bore



TAML 5 Junction with Comingled Production - Haliburton

# Open Hole Whipstock Solution for Missed Production Target, Canada

## Objective:

Retrack high side in 155.5-mm lateral section after unintentional deviation from directional plan  
Avoid drilling new lateral

## It:

Logging tool deployed whipstock at 67 degrees inclination without issue  
Directional BHA kick off to achieve base plan well design  
Days saved vs new lateral



Hydraulic expandable anchored single trip whipstock - Cou

# Record Distance for Open Hole Whipstock Installation in Lateral, KSA (IPTC-20239)

## Objective:

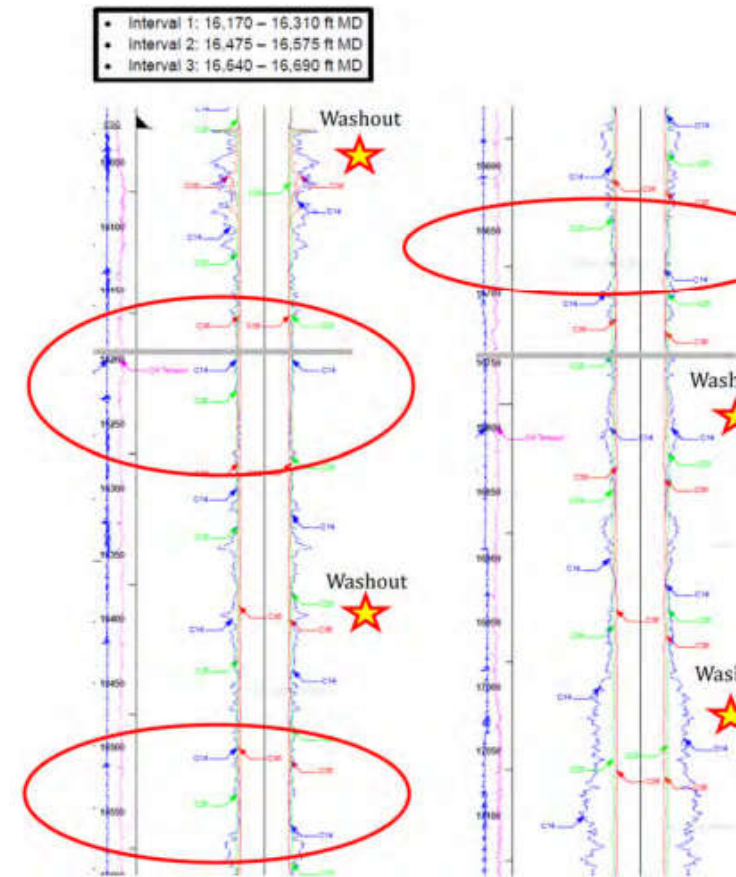
Pass stuck drilling BHA in 149.2-mm hole  
Avoid time and cost of re-drilling hole section

## It:

Single trip hydraulic whipstock system  
Installed 194-meters outside the casing shoe

Days saved vs cased hole exit and  
drilling section

Low-risk well construction process in  
contingency scenario



Three potential setting depths to avoid hole problematic open hole conditions - Courtesy of S

# Large Wellbore at a Diamond Mine, Botswana

## Objective:

Pass fish and continue coring operations in Diamond Mine

## Result:

Used hole system set in open hole application: 310-MPa dolomite formation, 6-3/4-in hole at 47 degrees inclination  
Single trip install at 1,200-M  
\$1M saved in 900 hours of rig time, drilling fluid and bits



Rig for Coring Application in Diamond Mine

# Open Hole Whipstock Solution to Bypass Radioactive Source, USA

## Objective:

Bypass stuck drilling BHA in 222.2-mm hole  
Avoid setting multiple cement plugs in hard  
formation

## It:

Hard cement job, whipstock set and kick off in  
single trip

Three days vs cement plug

Operator flagged the install as “best  
practice” in similar open hole contingency  
scenarios



Hydraulic Inflatable Single Trip Whipstock - Courtesy of WFP

# Open Hole Whipstock Solution in Fluid Loss Zone, Kuwait (SPE-192646)

## Objective:

Pass stuck drilling BHA in 12-1/4-in hole  
without setting multiple cement plugs in  
problematic formation

## Result:

Single trip whipstock system installed  
without issue saving six days vs cement plug  
Well completed on time and without  
fundamental design change  
Operator flagged the install as “best  
practice” in similar contingency scenarios



Hydraulic expandable anchored single trip whipstock - Cou

# Whipstock on Offshore Rig to Bypass Fish in Open Hole, Brazil

## Objective:

Whipstock around fish in 8-1/2-in hole section at 33-m

Avoid time consuming / risky cement plug operations

## Result:

Single trip hydraulic whipstock deployed on cutting structure

Reduced 36 hours vs running tool deployed system in high spread rate environment

Reduced NPT associated with continued fishing operations



# Simple Open Hole Whipstock Bypass Fish in Geothermal Well, Mexico

## Objective:

Bypass stuck fish in 8-1/2-in volcanic formation at 1,357-m

Avoid cement due to 290 C degree environment

## It:

Run OD open hole whipstock ran on running tool was anchored to the stuck fish

Directional BHA with rock bit used to retrack

Avoid alternative operations that would have been troublesome at high temp



Geothermal Well in Los Humeros Field

# Short Interval Sidetrack Below Shoe, Oman

## Objective:

Open hole sidetrack in 15-m section between fish and 6-in casing shoe  
Casing exit not desirable due to depleted zone left behind pipe  
Limited room for conventional sidetrack operation

## Result:

System with custom 5-m long anchor cemented in place on running tool  
Successful kick off and sidetrack of well with drilling  
A  
Weeks of time saved over alternative to re-drill well down to 4,267-m

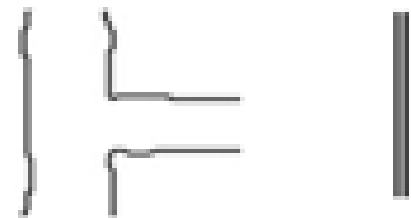


Running tool and tail pipe - Courtesy of

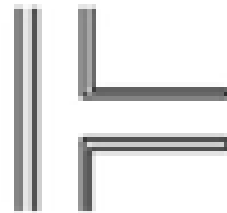
# Window the New Wellhead

Function depends on formation at KOP  
and completion requirements  
Multiple laterals on same well  
Whipstocked or produced separately  
Feasibility of whipstock retrieval increases  
Flexibility of options  
Side-entry into some or all laterals for  
Future clean out

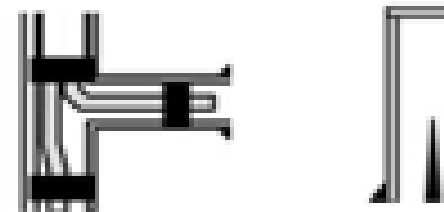
Level 1 & 2:



Level 3 & 4:



Level 5 & 6:



# You Can Create a Window In It

Normal application range includes majority of sizes

All sizes, grades, weights

Multi-string, expandable liner, through restriction and mixed strings

TT Exits – economical method in smaller casing sizes

Using coil with motors to mill windows

Specialty bottom hole assemblies (BHA)

## Recovery

Driving conductors with large  
whipstocks preassembled

Anchoring whipstock in existing  
conductor



Slot recover whipstock to anchors in conductor  
stub - Courtesy of Acteon



Coil Tubing Casing Exit Operations- Courtesy of

# Whipstocks – A Simple Solution

## Milling Assembly

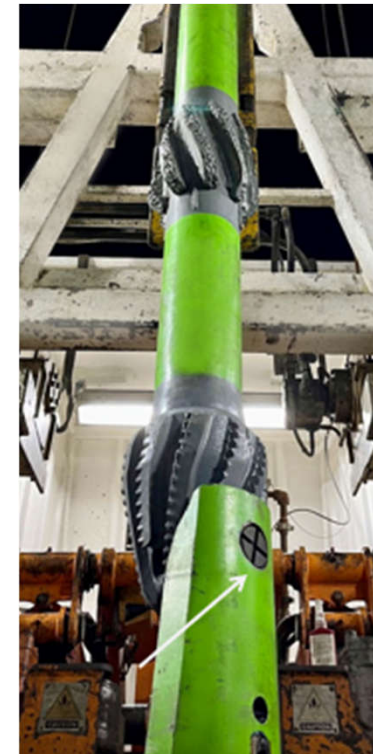
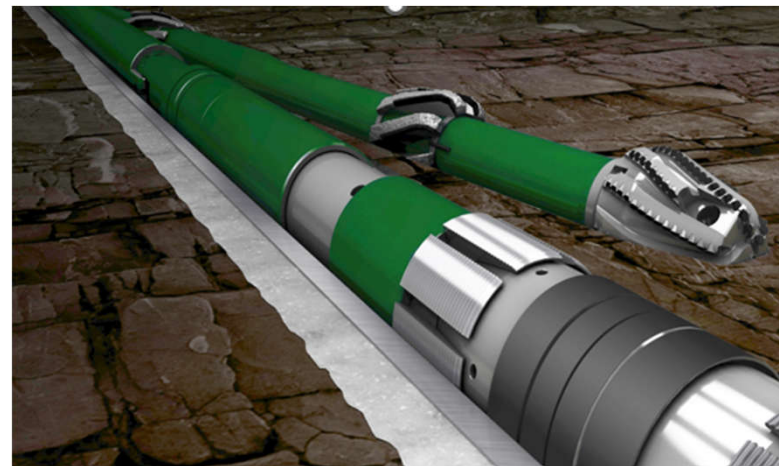
- Single mill to four mills used to cut window
- Mechanically or hydraulically released from whipstock
- Carbide, diamond, polycrystalline diamond compact (PDC)

## Whipstock – deflector /wedge

- Degrees of face angle i.e., 1-1/2 to 4 deg


## Anchor

- Mechanically or hydraulically set
- Retrievable or permanent
- Options provide isolation




# Evolution of Sidetracking

- From unreliable contingency to critical step during well planning
  - Limited sizes → Majority of casing sizes
  - Time consuming → Single trip defined risk profiles
  - Part of fishing toolbox → Stand alone technology
  - Tribal knowledge → Real time data driving analytics for efficiencies



Multi-trip system  
with casing weight  
independent anchor -  
courtesy of Eaton Oil  
Tools



Single trip system with  
isolation anchor -  
Courtesy of Weatherford

# Combining Operations Decreases Well Possession Time

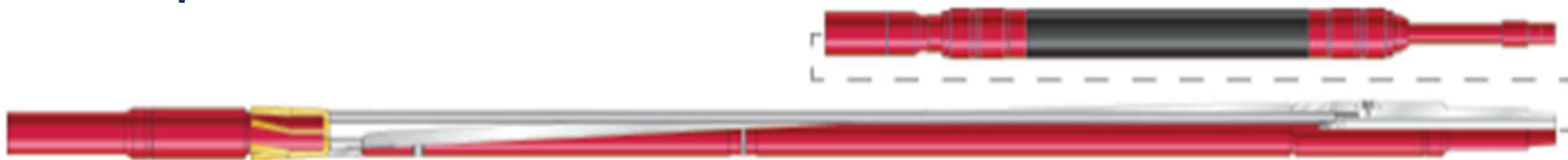
Use new technology to minimize trip count

Cementing and drilling off in same trip

Allows for any drill ahead BHA to be run without risk

With isolation

Pilot hole scenarios where cementing over lower producing zones required



Open Hole Whipstock - Courtesy of Weatherford

# Agenda

- What is Sidetracking
- Evolution of Sidetracking
- Contingency Scenario
- Multilaterals / Re-entry
- Open Hole Sidetracking

# Multilaterals / Re-entries to Minimize Cost of Reservoir Exposure

A multilateral well is one in which there is more than one horizontal or near horizontal lateral well drilled from a single main bore and connected back to that main bore (SPE, 1997)

Retracking existing wells to access more production

Saves cost / time of well down to kick off point (KOP)

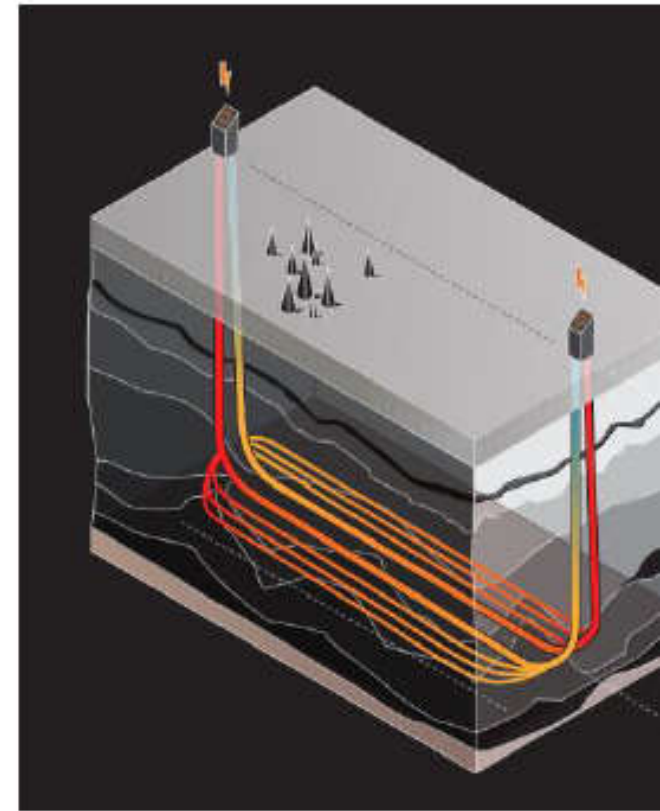
Reduced surface and carbon footprint

Utilize existing infrastructure in place

Planned multilaterals

Cost per foot of reservoir exposure reduced

Well geometry and acreage specific for multiple laterals



Geothermal Loop Multilateral Design – Courtesy of [unintelligible]

# Existing Wells for Lower Cost Production

Well construction down to KOP is typically between 50-60% of total well construction cost and time regardless of basin (Major Operators)

Grand reserves more economical to cover with new technology

-establish production on mature wells without intensive workover operations

Maintain current production if economical



TAML level 2 multilateral

# Multilateral by Design

Increase layout to maximize reservoir exposure

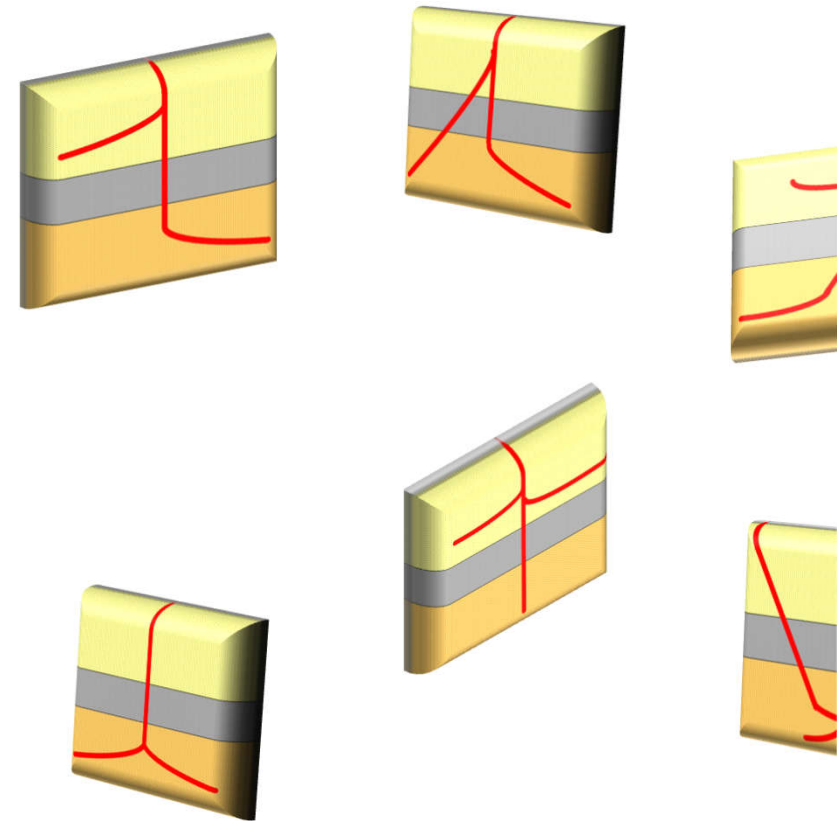
Pre-planning on well geometry and lift scenarios

Low front-end impact with back-end value

Multiple laterals on same well commingled or produced separately

Well construction all at once or in stages depending on completion requirement

Re-entry into some or all laterals for future clean out



Example multilateral well designs

# Field Re-entry Project Reduces Cost of Accessing Production, US Land

## Objective:

Utilize existing wells to access reserves

Retrack 5-1/2-in and 7-in production casing with workover efficiently

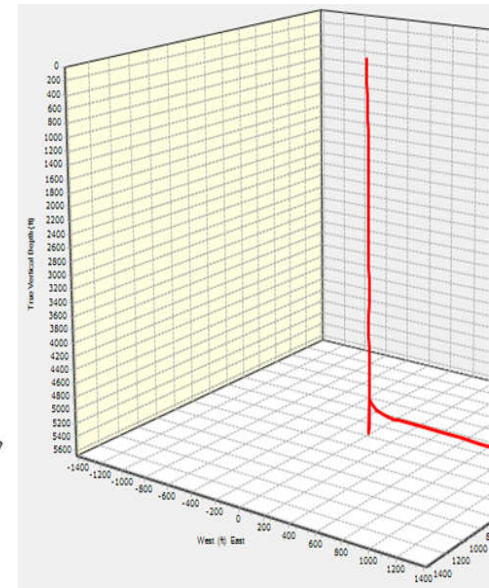
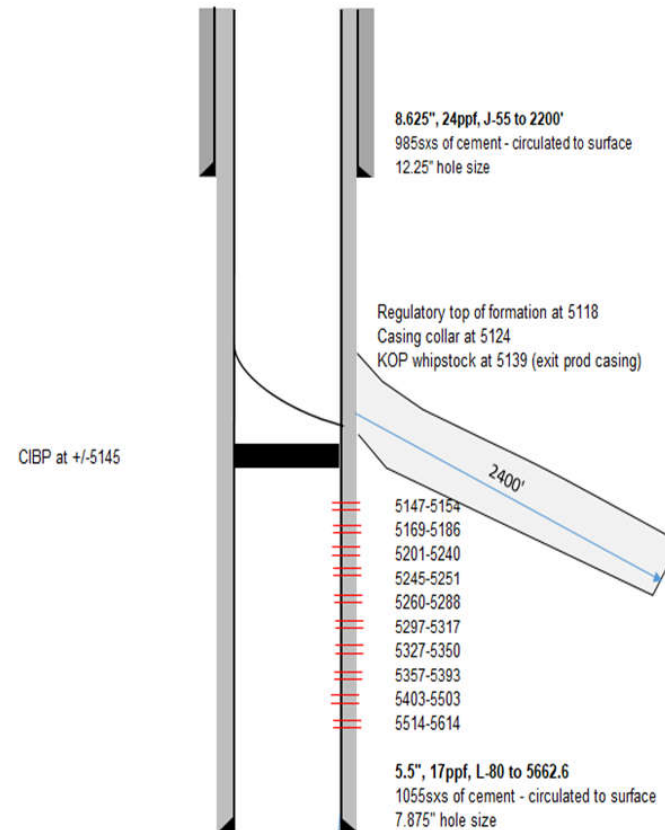
Access to lateral and main bore

## Key:

Multiple single trip installations with various Operators

Retrievals as desired

Savings in well construction cost down to KOP and utilization of current surface footprint



Example of Re-entry Well

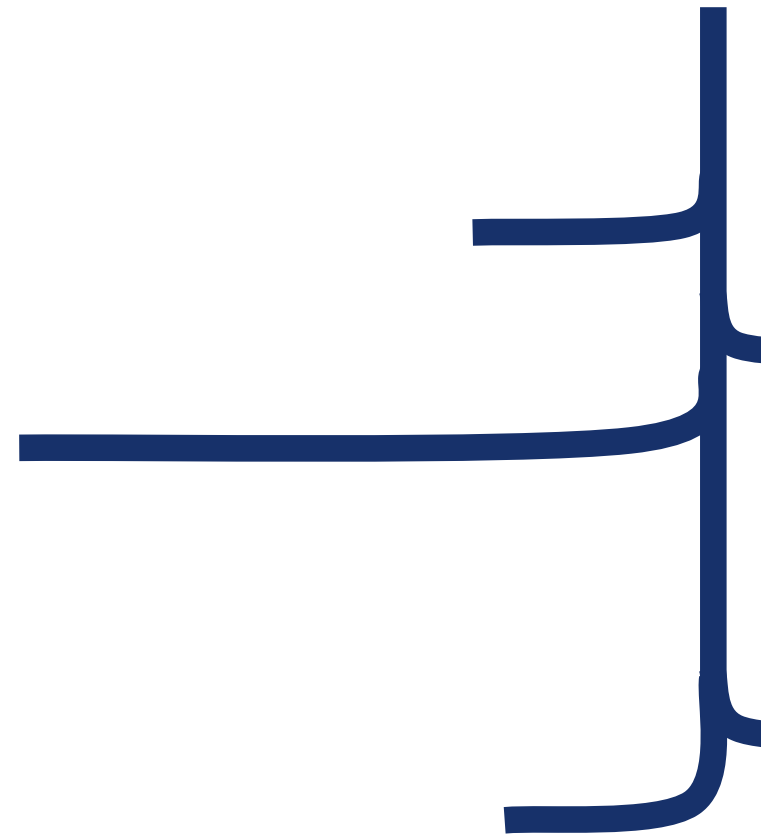
# 60,000-ft+ of Lateral per Well, USA

## Objective:

- Maximize lateral footage
- Well geometry to allow for all laterals to commingle production
- Full entry capability into each lateral

## Result:

- Two to eight laterals both 5-1/2-in and 7-in main bore
- Retrieved whipstocks with additional laterals in open hole
- 10-15 MMCF / day



Five lateral well

# Application Specific Alternative for Open Hole Sidetracking

Directional sidetrack without cement

Cement plug kick off

- Wait on cement and time drilling
- Larger hole sizes, oil-based mud and hard formation can be problematic

Open hole whipstock

- Hole condition dependent
- Cementable options

Come back into casing



# Open Hole Whipstock Options

Anchor with isolation

Deployment through capabilities

Deployed on running tools or mills

Condition dependent

Advantages

Sidetrack time reduction

Known kick off depth and direction



Inflatable anchor - Courtesy of Weatherford



Hydraulic expandable anchor - Courtesy of Weatherford



Milling BHA attached to whipstock - Courtesy of Weatherford

# Cement Plug vs Whipstock Time Savings

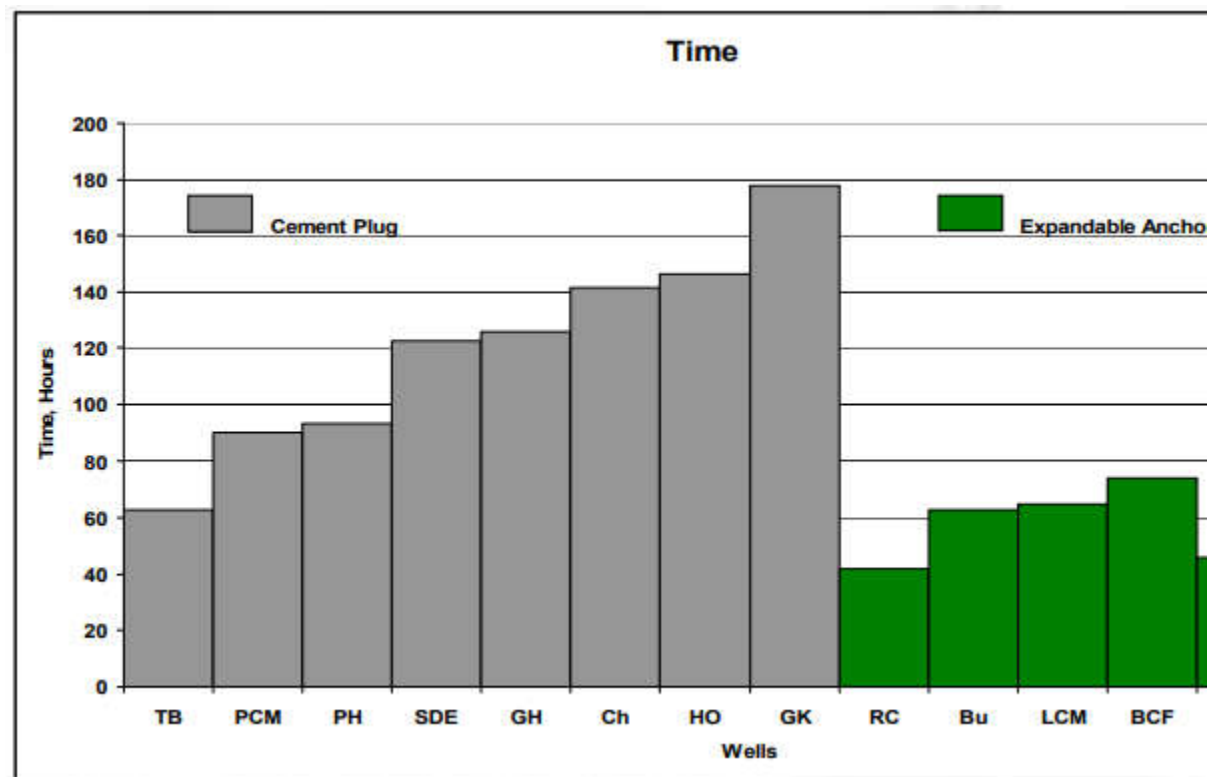
Most savings in total time spent  
retracking

On average 2-1/2 days saved

Reliability of cement plugs  
dependent on formation, hole size,  
and properties

Repeat cement plug inefficiency or  
longer wait times

Extended sidetrack operations can  
result in further open hole issues



Cement plug and whipstock sidetrack case study - Petroleum and Coal, Ma

# Combining Operations Decreases Well Possession Time



Technology to minimize trip count

Anchoring and drilling off in same trip

Allows for any drill ahead BHA to be ran without risk

Pilot hole scenarios where cementing over lower producing zones required

PDC cutting structure

Flexibility to set in casing as well in some cases



Open Hole Whipstock - Courtesy of WIS

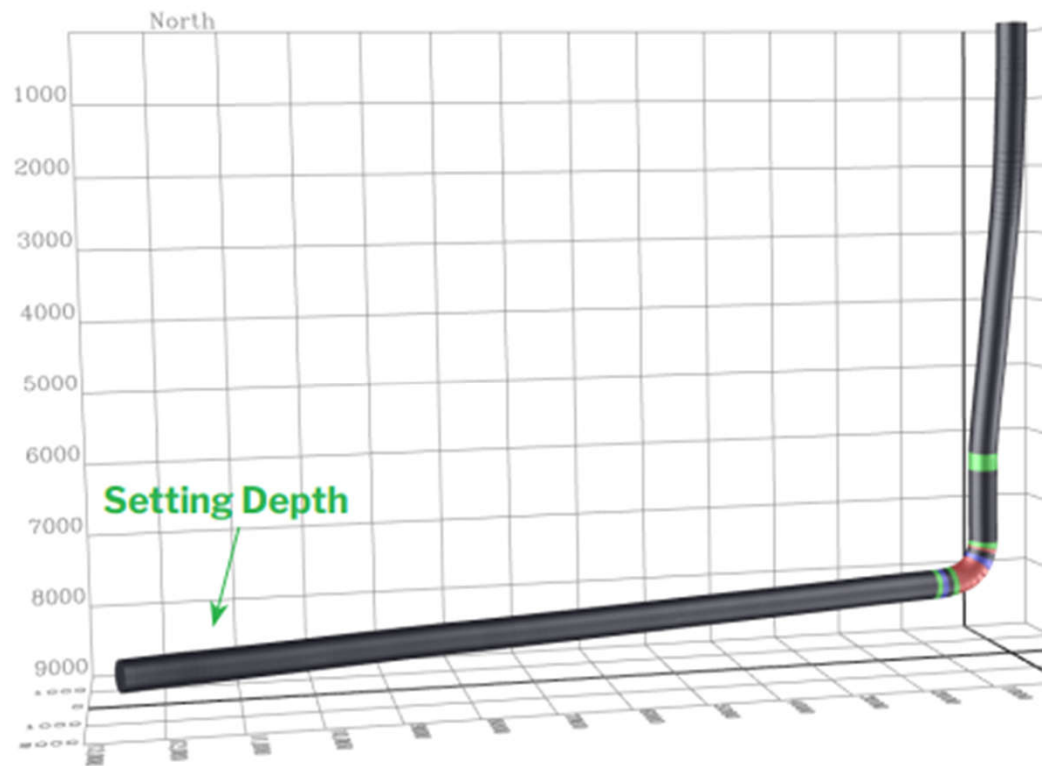
# 8,900-ft of Lateral Recovered, United States

## Objective:

Pass fish in 6-3/4-inch hole  
Planning tool installation deep in  
lateral for flexibility of higher dog  
leg severity of 12.9 deg

## Result:

Whipstock set at 17,000-ft  
Measured depth / 8,900-ft in  
lateral  
Significant time saved redrilling  
lateral



Well profile - Courtesy of WIS

# Open Hole Whipstock for Intersect and Abandonment, California (OTC-32508)

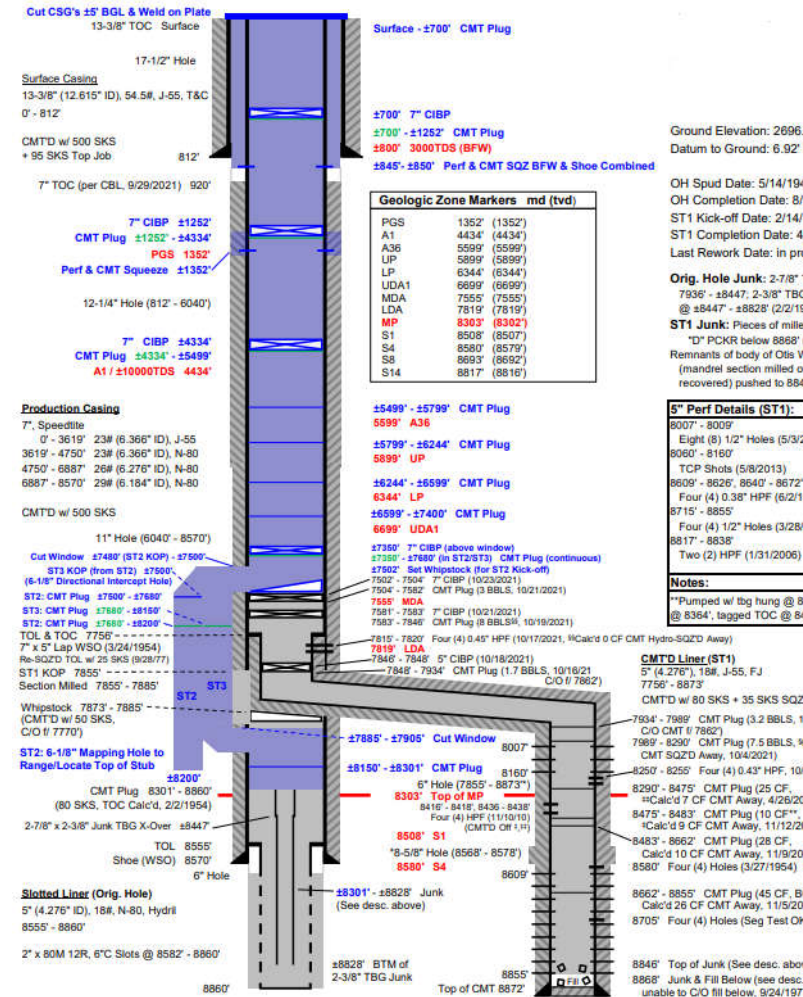


**Objective:**

- Intersect existing 7-in casing to abandon lower wellbore for regulatory requirements
- Reduce time/cost associated with conventional sectional intersect

**Well:**

- Segment type open hole whipstock oriented to intersect existing casing
- Use specific milling BHAs used to intersect to allow for cement abandonment
- Reduce 55-days versus 44-day initial conventional cement
- Optimized operation and using lessons learned to further improve operation to 6 days or less



# Key Take-Aways

- Whipstock are reliable options in majority of wells
- Efficient whipstock operations change ideology in drilling operation
- Re-entries and planned multilateral can decrease cost of accessing production
- Open hole whipstocks may be more economical than other detracking methods