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

Tom Emelander
Weatherford

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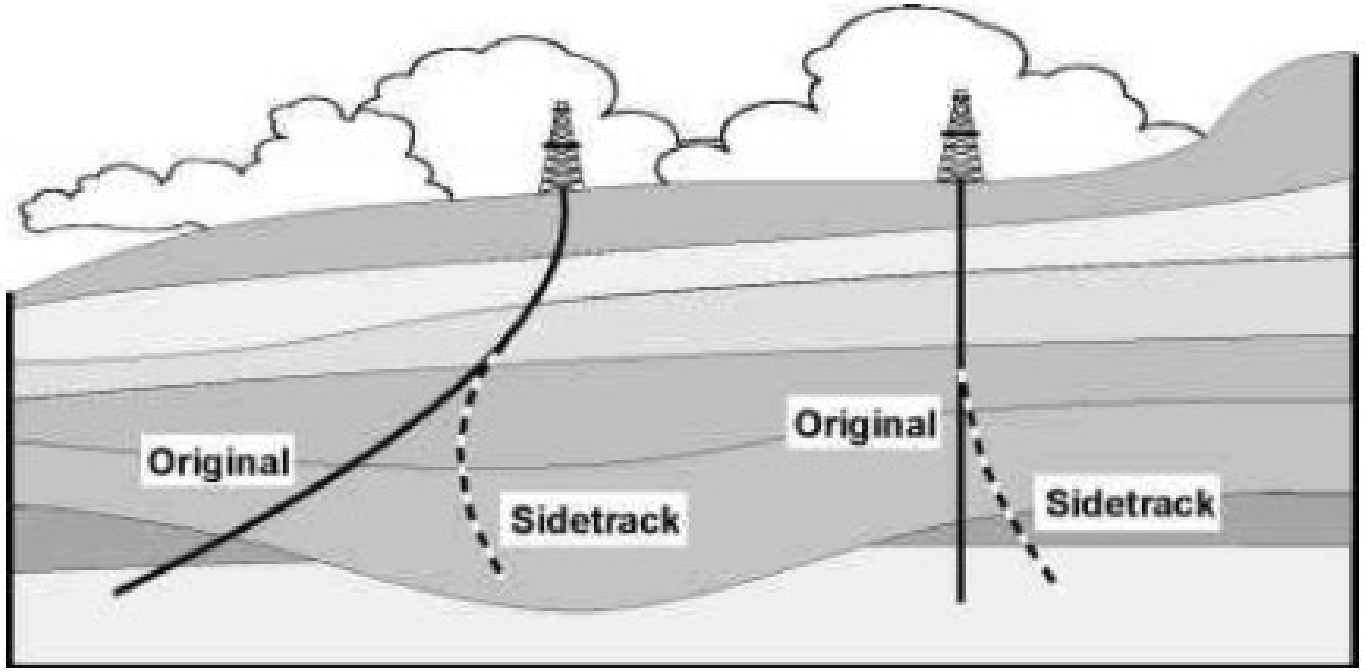
Agenda

- Sidetracking
  - Defined
  - Reasons
  - Whipstock – process / anatomy
  - Alternatives
- Evolution of Sidetracking
- Contingency Scenario
- Multilaterals / Re-entry
- Open Hole Sidetracking

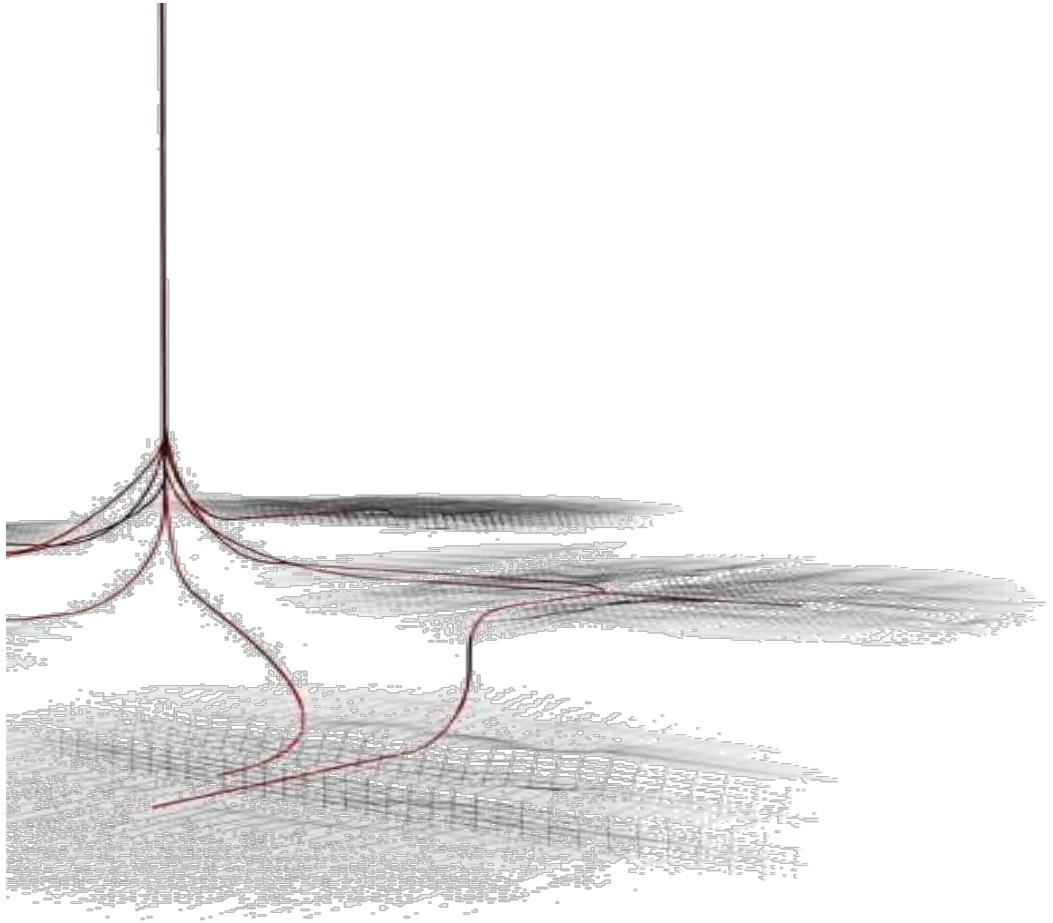
Definition of Sidetracking

- 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 Mill – Courtesy of DrillStar

- 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

Evolution of Sidetracking

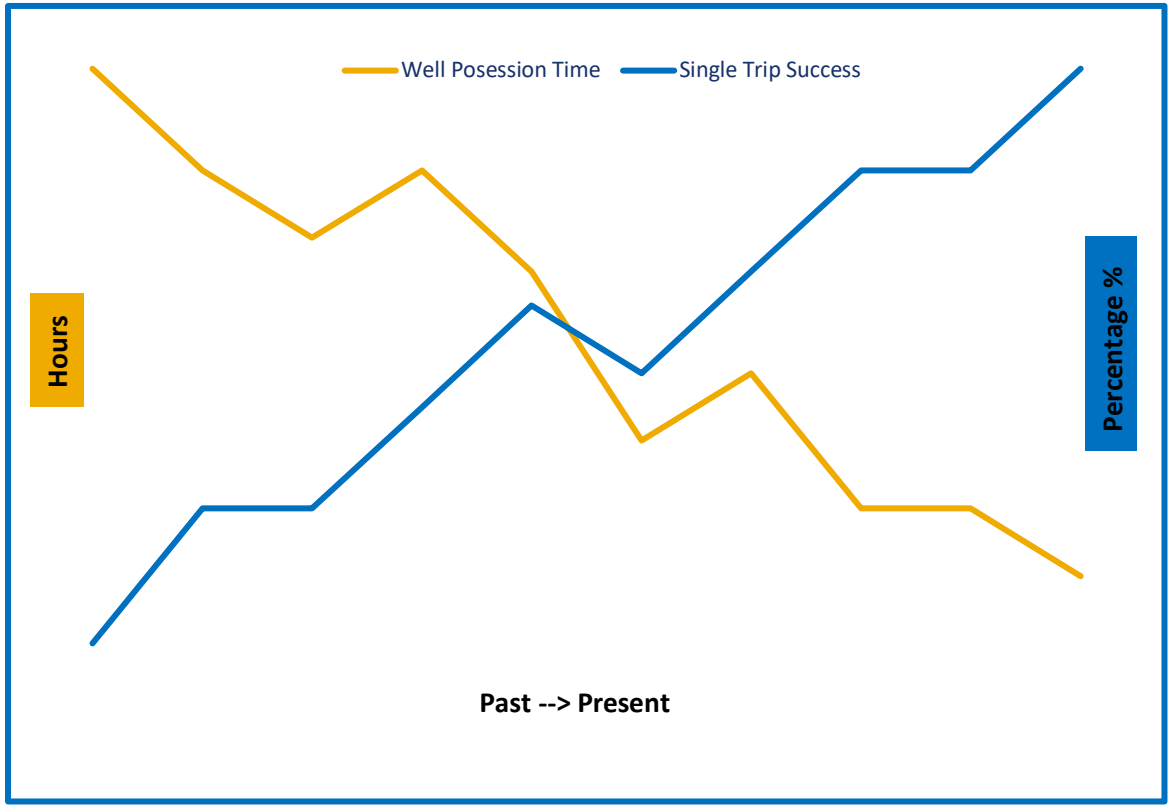
Multi-trip system with casing weight dependent anchor - Courtesy of Eaton Oil Tools

- 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

Single trip system with isolation anchor - Courtesy of Weatherford

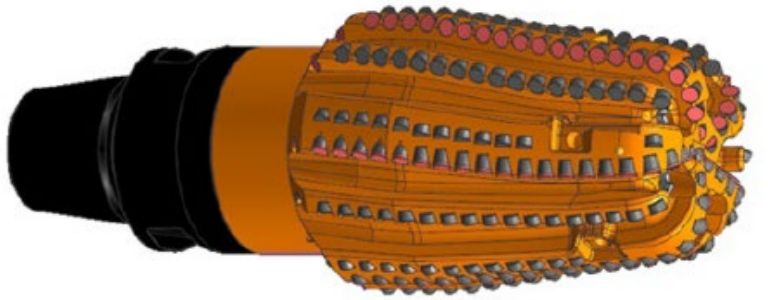
Reliability Equals Savings

- Tens of thousands of runs industry wide
  - Known risk profiles for applications
- Industry accepted best practices
- Majority of installations less time
  - 3.6 days per install and 6.8 hours per window / rat hole with 97% single trip success
- Planned sidetrack operations for “what if” scenarios

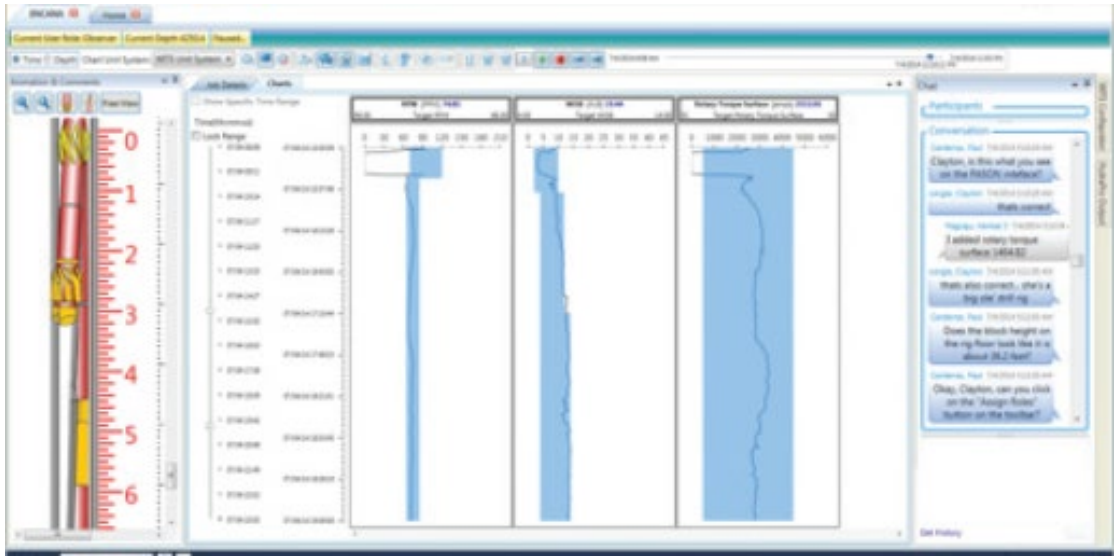


Technology to Drive Efficiency

- 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



New Generation - Courtesy of Baker Hughes



Data Acquisition / Remote Field Support - Courtesy of Weatherford

Challenging Exit Possible With Newer Technology, Australia

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Objective:

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

Result:

- 5-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

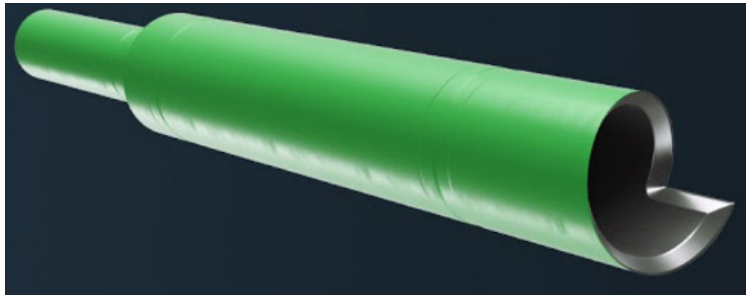
Milling BHA – Courtesy of WIS

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

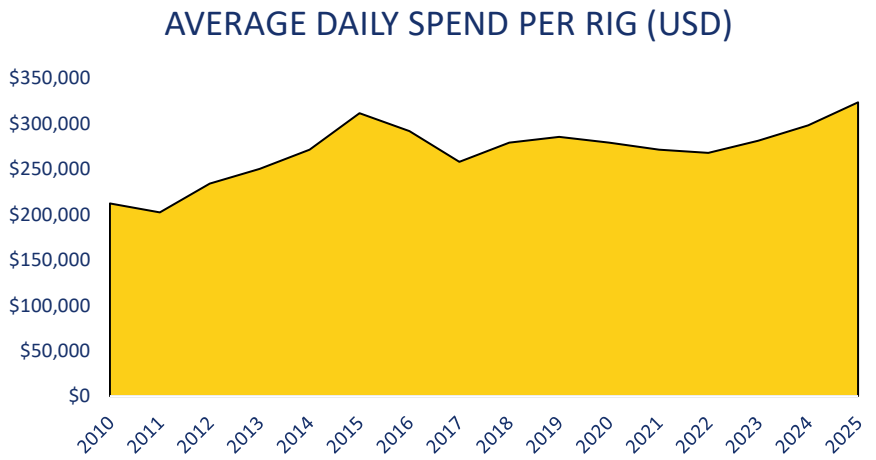
- High torque pipe used to increase drilling ROP and lateral length
  - Connections too large to OD fish
  - Cost prohibitive measures must be taken in order to get past the tool joint and fish the tube
- Rotary Steerable (RSS) assemblies can also provide very challenging fishing scenarios
  - Agitator 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

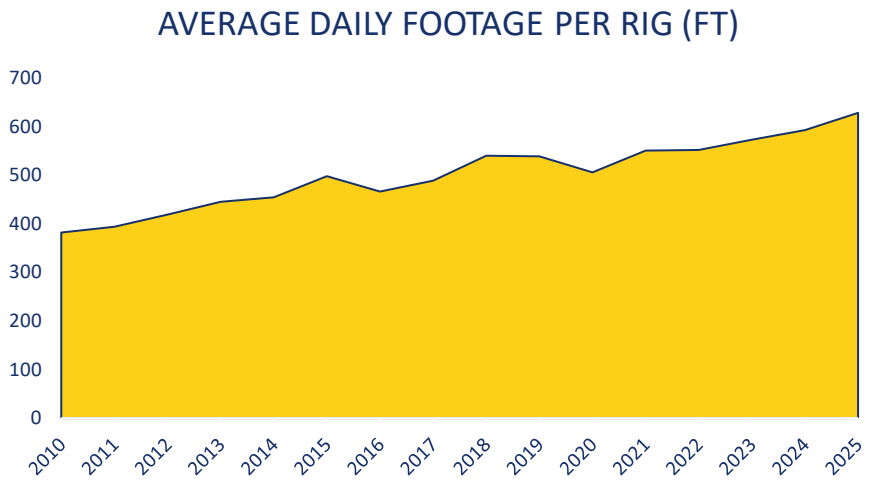


Standard 150 overshot

Fishing vs Sidetracking

- Decrease in total cost of sidetrack
  - Efficient sidetrack operation
  - Equipment costs down 35% since 2014 (Evercore 10/20)
  - Footage drilled per day increased (Spears 02/21)
- Increase in cost of fishing
  - Cost of spread increasing (Spears 02/21)
  - Potential cost of fish decreasing
- Risk profile and time for sidetrack can often be well defined compared to fishing operations
- Number to days to justify fishing decreasing





Super Heavy Wall Exit, GOM (OTC 31245)

Objective:

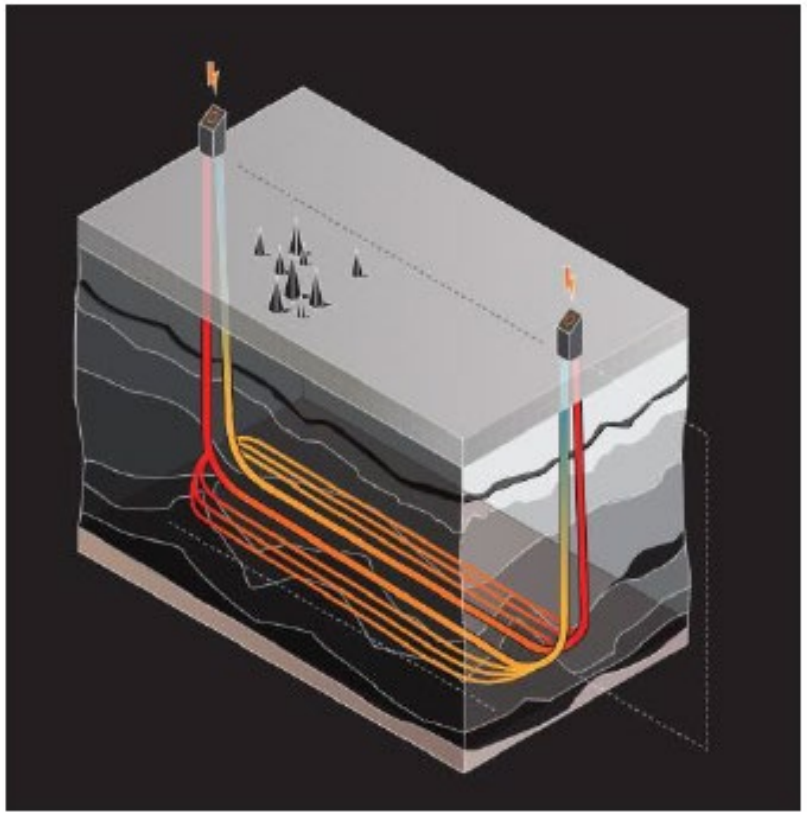
- Sidetrack around liner integrity issue through 12-1/4-in 134#casing at 6,858-m while maintaining well design
- Industry first for 1-1/8-in thick SY130

Result:

- 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

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 (TAML-1997)
- Sidetracking 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 Eavor

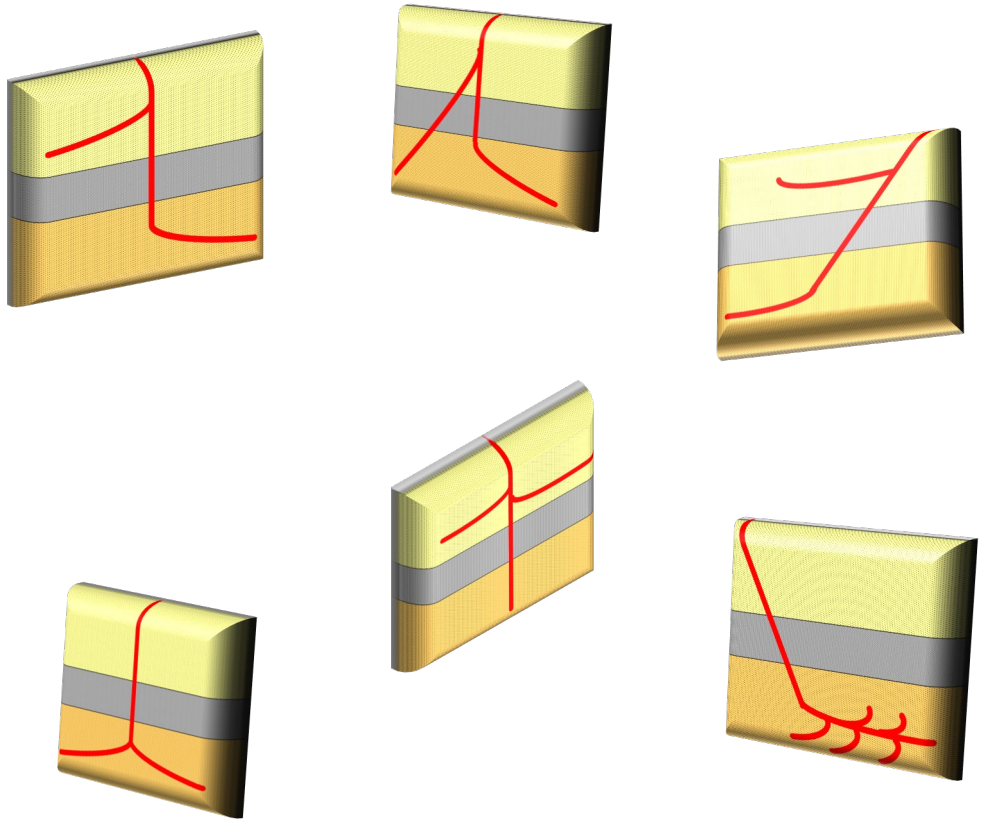
Existing Wells for Lower Cost Production

- Well construction down to KOP is typically between 50-60% of total well construction cost and time regardless of basin (Major Operators)
- Stranded reserves more economical to recover with new technology
- Re-establish production on mature wells without intensive workover operations
  - Maintain current production if economical

TAML level 2 multilateral

Multilateral by Design

- Acreage 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

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

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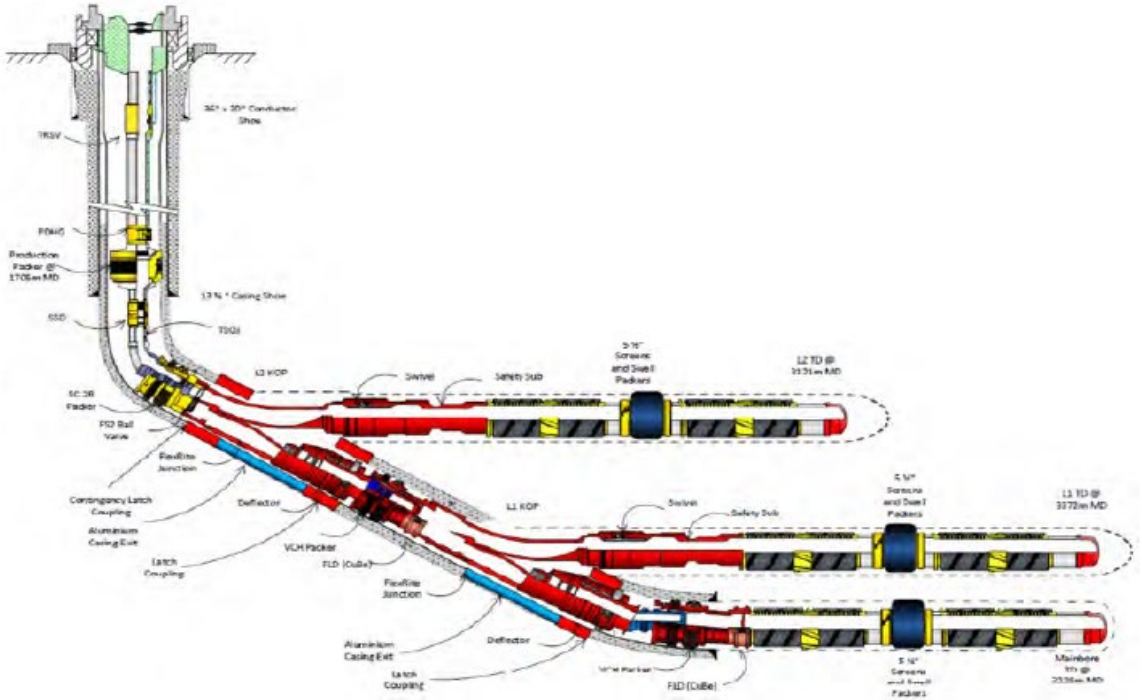
Objective:

- Tri-lateral 9-5/8-in main well to maximize reservoir exposure, 1,700-m average
- 5-1/2-in screen completion
- Access to all laterals post well construction

Result:

- Industry first TAML 5 for 800-m water
- Multiple industry improvements for application
- Top performers for production, 50% decrease in cost per barrel
- Best in field well construction time, 24% reduction in capex average
- 15-30% faster than offset MLs



TAML 5 Tri-lateral Layout – Courtesy of Haliburton

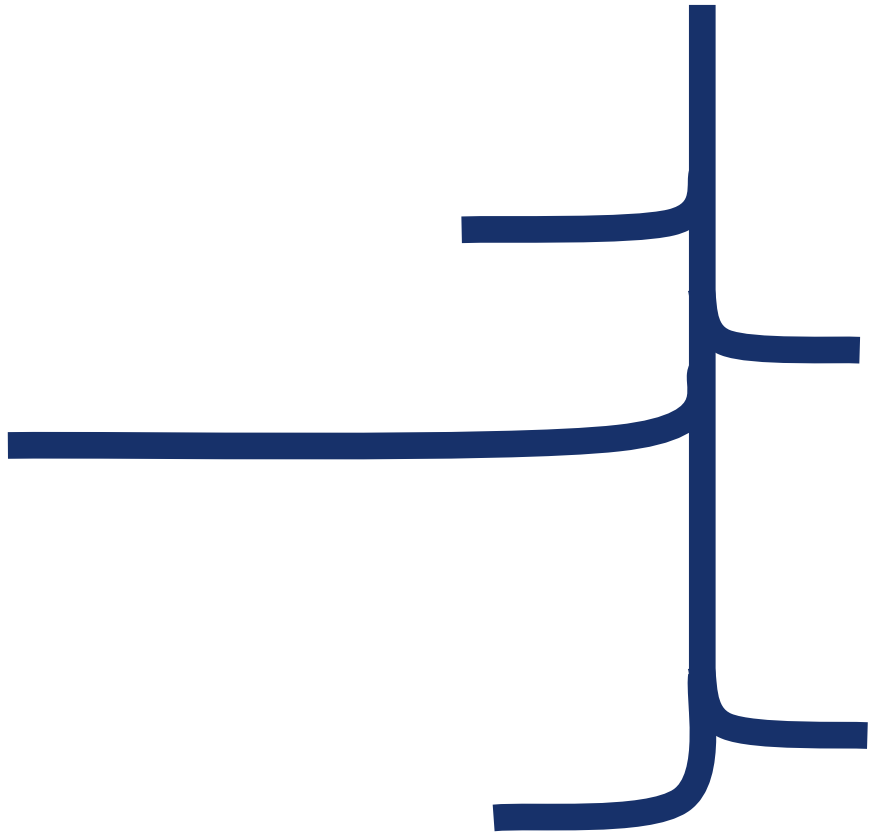
18,000-Meter+ of Lateral per Well, USA

Objective:

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

Result:

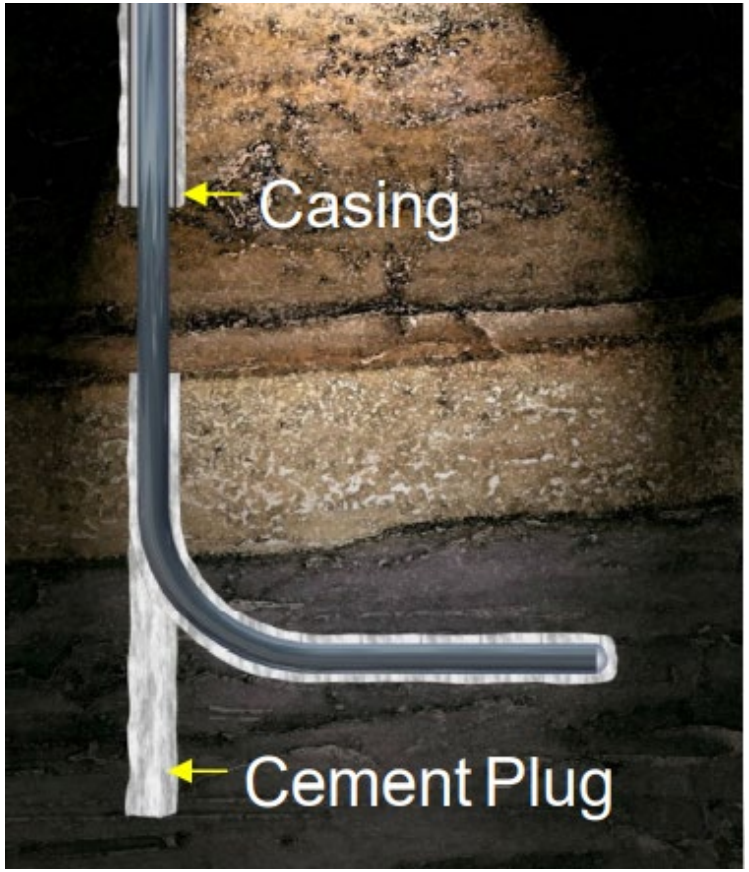
- Two to eight laterals both 5-1/2-mm and 7-in main bore
- Retrieved whipstocks with additional laterals in open hole
- 12-15 MMCF / day



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
- Cement through capabilities
- Deployed on running tools or mills
- Hole condition dependent
- Advantages
  - Sidetrack time reduction
  - Known kick off depth and direction

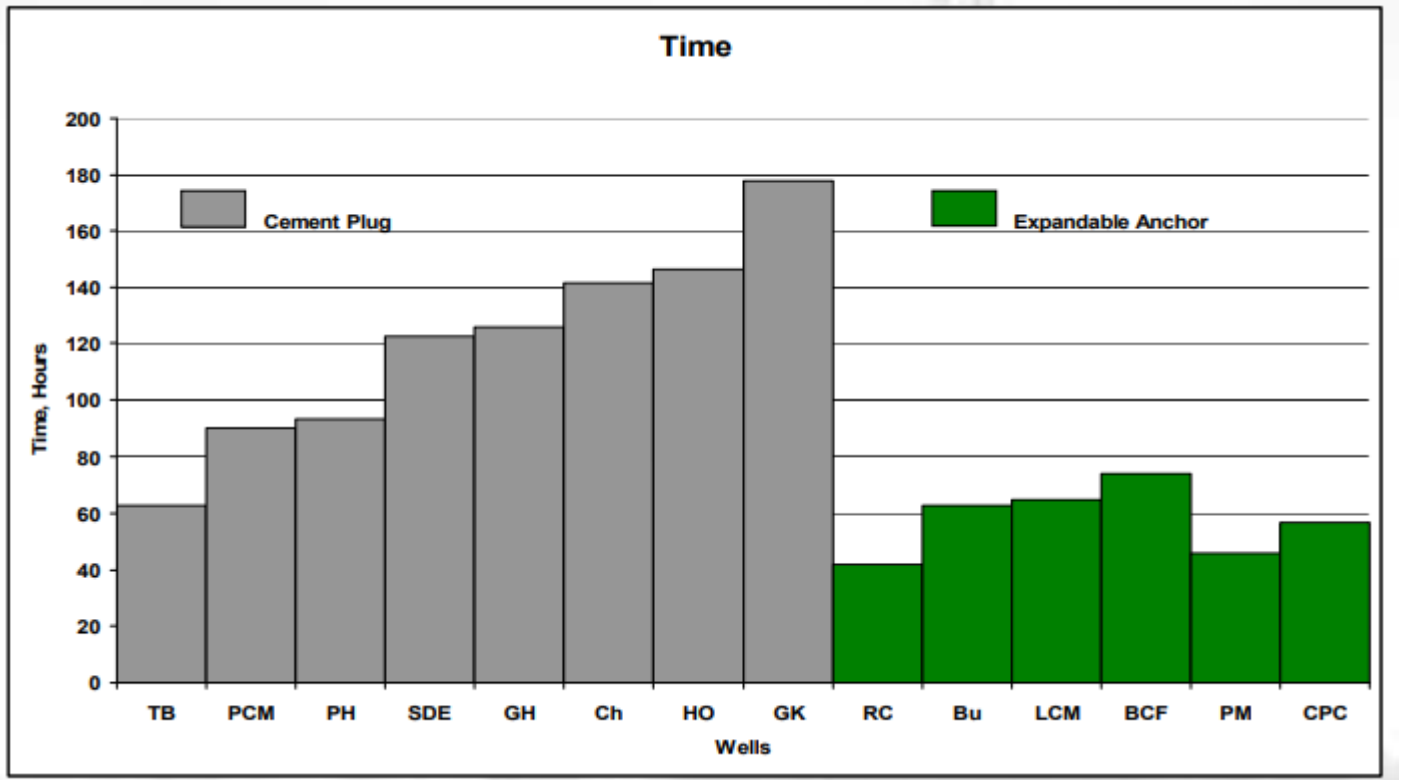
Isolation anchor - Courtesy of Weatherford

Hydraulic expandable anchor - Courtesy of WIS

Milling BHA attached to whipstock - Courtesy of WildCat

Cement Plug vs Whipstock Time Savings

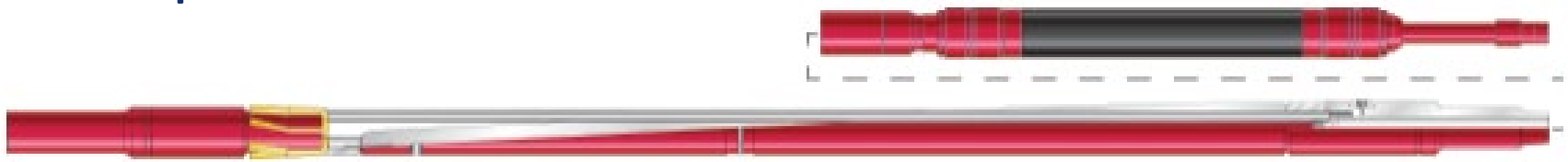
- Cost savings in total time spent sidetracking
  - On average 2-1/2 days saved (AADE Tulsa Symposium Jan 2010 / SPE 123577)
- Reliability of cement plugs dependent on formation, hole size, mud properties
  - Repeat cement plug inefficiency or longer wait times
  - Extended sidetrack operations can result in further open hole issues



Cement plug and whipstock sidetrack case study - Petroleum and Coal, May 2017

Combining Operation Decreases Well Possession Time

- New technology to minimize trip count
  - Cementing and drilling off in same trip
  - Allows for any drill ahead BHA to be ran without risk
  - With isolation
  - Pilot hole scenarios where cementing over lower producing zones required



Open Hole Whipstock - Courtesy of Weatherford

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

Result:

- 8-in OD open hole whipstock ran on running tool was anchored to the stuck fish
- Directional BHA with rock bit used to sidetrack
- Avoid alternative operations that would have been troublesome at high temp

Geothermal Well in Los Humeros Field

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 sidetracking methods

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