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D6.2 Report of possible drilling, completion and well stimulation problematic scenarios

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EXECUTIVE SUMMARY

In order to realize the drilling advisory system that is to be developed within the OptiDrill project the building of an extensive drilling database that covers all the available data from geothermal wells to oil and gas drilling data is a fundamental and crucial step.

The drilling advisory system that is being developed highly relies on high quality data for any kind of application planned within the project. For the specific application that the databases and scenarios elaborated in this, and the previous report are planned for, which is the automatic detection of problematic drilling incidents, the quality of the data provided, and definitions of the scenarios described will be even more important. The challenge to be faced will be the prediction of rather complex and diverse scenarios based on real drilling data. The better and more extensive the data and the accompanying documentation provided the better will be the performance of the systems that can be expected for this particular task.

This deliverable builds on the outcomes presented in task 6.1 report where a list of possible drilling scenarios was elaborated based on the inputs from the OptiDrill project partners and also through research in previous publications. In this deliverable, based on the scenarios included in the previously created drilling scenarios list, a new set of scenarios included in a list is derived based on identification and inclusion of scenarios that are categorized as problematic during the drilling process. The main and most common problematic scenarios, which are also planned to be researched, include what-if scenarios, bit wear, low ROP, stick slip vibrations, pipe failures, loss of circulation, excessive torque and drag, and wellbore instability.

1. INTRODUCTION

The tasks reported on in this deliverable focuses on the creation of a list that contains the drilling scenarios which can be categorized as problematic during the drilling operations. This report directly builds up on the previous report on deliverable 6.1. Within the deliverable 6.1 report, an extensive list was created with the inclusion of various types of possible drilling scenarios. The drilling scenarios that can be found in the latter mentioned list were taken from the inputs that the OptiDrill project partners provided in the form of end of well reports, daily drilling reports, and lists which were specifically created for this task containing any kinds of incidents that occurred during the completed projects for which data was provided. This list will now be further analyzed and reduced to those drilling scenarios that can be categorized as problematic.

A problematic drilling scenario is defined as an incident that occurs during the drilling operation which can lead to non-productive time (NPT) and can be categorized as a lost time incident (LTI). These kinds of incidents have a direct and negative impact of the whole drilling project and lead to additional costs, failing to meet targets set in the project plan, and can cause significant delays. All in all, these incidents categorized as problematic drilling scenarios can result in a significant amount of time and cost and subsequently should be avoided to the most possible extent.

The main problematic drilling scenarios that are planned to be included within this list are:

- Bit wear
- Low rate of penetration (ROP)
- Stick slip vibrations
- Pipe failures
- Loss of circulation
- Excessive torque and drag
- Wellbore instability

These are some of the main problematic drilling incidents that are firstly commonly occur in drilling operations and are known to cause significant delays and additional cost. A worn-down bit for example will slow down the drilling progress and can also lead to unwanted deviations in the wellbore. Low rates of penetration that can be a consequence of wear but can also have many different other causes like hard geological formations, unoptimized drilling process parameters, unoptimized drill bit type, etc. Wellbore instability that can be caused by either natural, uncontrollable like formation properties or controllable factors such as drilling fluid properties or inclination and azimuth can subsequently lead to high torque and drag, stuck pipe incidents, or even a collapse of the wellbore.

Apart from these particular drilling incidents, there exist many other possible problematic drilling scenarios which will also be added to the list as more progress is made. It should be noted that the problematic drilling scenario list is an evolving live document which needs to be updated as more progress is made in either the data acquisition or drilling data analysis aspects.

2. PROBLEMATIC DRILLING SCENARIOS

Based on the data gathered from the OptiDrill project partners and extensive research on publication and other research studies, another list containing only problematic drilling scenarios building on the lists created in the previous task was elaborated. Drilling scenarios that are no direct threat to the success of the drilling operation and do not cause non-productive time or additional expenses were excluded according to the definition of problematic scenarios described in the previous section. In a similar manner, the scenarios whose causes were not directly related to the drilling process, such as harsh weather conditions causing a delay or not having water available, have also been removed, accordingly.

In addition, the scenarios taken from the previously elaborated list with all possible drilling scenarios were condensed and categorized. The main categories available in the list are bit wear, low ROP, excessive torque and drag, stick slip vibrations, pipe failures, circulation loss, wellbore instability, pipe sticking, and cementing problems. Table 1 shows the current state of the list with the problematic drilling scenarios. Besides the included categories, Table 1 also contains a number of common, possible causes and their respective consequences of each problematic scenario.

Table 1: Problematic Drilling Scenarios

Category	Causes	Consequences
Bit wear	Material fatigue	Low ROP
	Unfavourable bit selection	Wellbore deviation
	Formation properties	Additional tripping time
	Unfavorable choice of drilling process parameters	Higher expenses for equipment
Low ROP	Unfavourable bit selection	Project objectives are not achieved
	Hard formations	Inefficient drilling
	Poor hole cleaning	Higher total expenses
	Unfavorable choice of drilling process parameters	
	Bit wear	
	Excessive torque and drag	
Excessive torque and drag	Formation properties	Low ROP
	Poor hole cleaning	Increased wear
	Unintended deviations in the wellbore	Pipe failures

	Wellbore instability	
Stick slip vibrations	Drill string-borehole interaction	Low ROP
	Bit-rock interaction	Equipment failure
	Unbalance of curvature of the drill string	
	Variation of drilling parameters	
Pipe failures	Excessive torque	Pipe twist off
	Excessive drag	Pipe burst and collapse
	Material fatigue	Pipe fatigue
	Improper storing, transporting, and installing	Pipe parting
		Drill string Washout
Circulation loss	Drilling fluid exceeds fracture pressure	Accumulated cuttings in the annulus
	Natural fractures and faults	Pipe sticking
	High formation permeability	Low hydrostatic pressure
	Rapid movements of the drill string	Wellbore instability
	Excessive ROP and other events causing high ECD	Kicking
	Unfavourable drilling fluid properties	
Wellbore instability	Naturally fractured or faulted formations	High torque and drag
	Tectonically stressed formations	Hanging up of drill string, casing, or coiled tubing
	High in-situ stress	Increased circulation pressure
	Mobile formations	Stuck pipe

	Unconsolidated formations	Excessive drill string vibrations
	Bottom hole pressure	Drill string failure
	Inclination and azimuth	Deviation control problems
	Transient pore pressure	Inability to run logs
	Physical / chemical rock-fluid interactions	Poor logging response
	Drill string vibrations	Keyhole seating
	Erosion	Doglegs
	Temperature	Oversized hole
	Water absorption, swelling, dispersion	Under gauge hole
		Excessive volume of cuttings
		Hole fill after tripping
		Excessive cement volume required
		Wellbore collapse on the drill string
Pipe Sticking	High differential between wellbore and formation	Increasing torque and drag
	Thick mud cake	Inability to reciprocate drill string
	Low lubricity mud cake	Uninterrupted drilling fluid circulation
Cementing Problems	Lost circulation	Bad protection of the wellbore
	Poor pumpability	Bad sealing of the wellbore
	Fluid influx	
	Wet shoe track	
	Gas flow	
	Poor displacement Efficiency	

	Cement Failure	
	Zonal Communication	

The table does not have any claim to completeness regarding the categories listed and the causes and consequences provided for each category. Once one takes a closer look at the table it quickly becomes clear that many of the problematic scenarios listed in the column category are interrelated and favor or trigger one another.

Wellbore instability for example might lead to excessive torque and drag on the drill string, which again might lead to a lowered rate of penetration, stuck pipe incidents or even pipe failures. Circulations losses might lead to pipe sticking, which again will lead to excessive torque and drag and thus result in a low rate of penetration. The figure below illustrates theses interrelationships in a simple manner for drilling operations scenarios

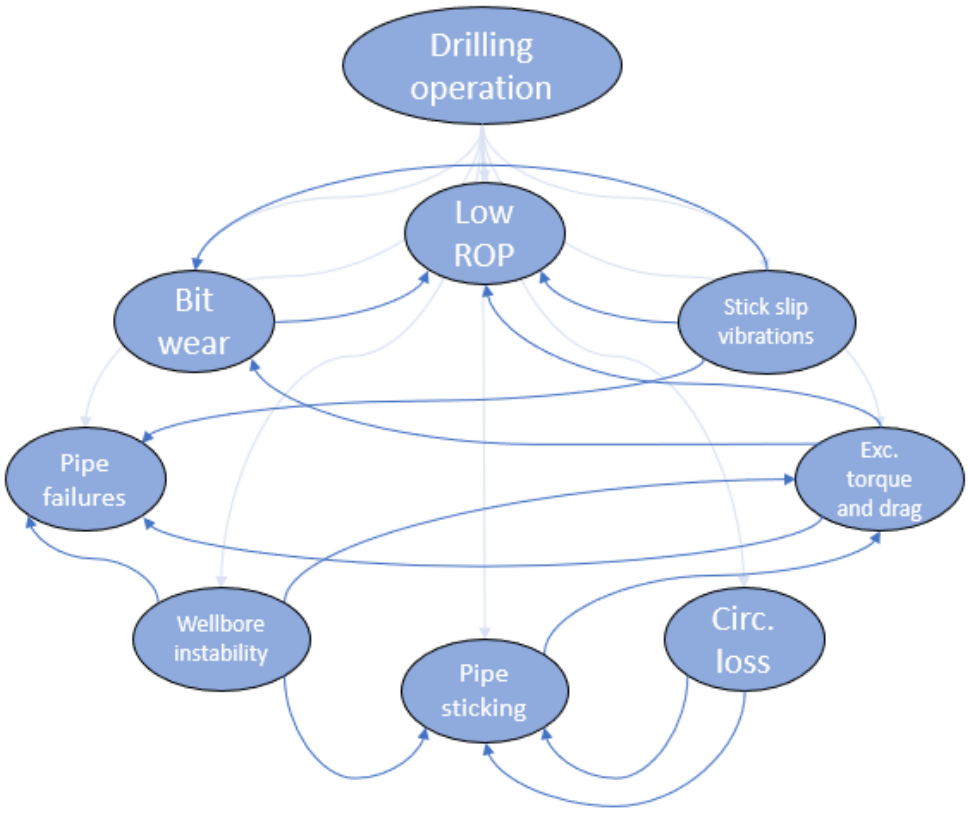

Figure 1: Interrelationships of problematic scenarios in drilling operations

3. CONCLUSION

The list with the most common problematic drilling scenarios elaborated within the task reported in this deliverable contains a good foundation for further developments and as a live and dynamic document, it will be continuously updated with further details and scenarios during the progress of the OptiDrill project.

Table 1 shows that most of the main categories of scenarios are quite complex in terms of their causes and the consequences resulting from the scenarios. Each scenario can be favored and triggered by a number of different factors, which can be caused by natural, environmental influences, or by faulty decisions of the drilling crew, for example with regard to the choice of equipment or drilling parameters.

Also, the importance of the interrelationships of the listed scenarios should definitely be considered as shown in Figure 1. The challenge in later stages of the project will be to transfer this knowledge to the data analysis and artificial intelligence applications and to enable the developed models being capable of detecting the listed scenarios within real drilling data.

REFERENCES

Pašić, B., Gaurina Međimurec, N., & Matanović, D. (2007). Wellbore instability: causes and consequences. *Rudarsko-geološko-naftni zbornik*, *19*(1), 87-98.

DeBruijn, G. Common Well Cementing Problems and Solutions.

Hassan, Z. (2018), Drilling Well Problems

Tang, L., Guo, B., Zhu, X., Shi, C., & Zhou, Y. (2020). Stick–slip vibrations in oil well drillstring: A review. Journal of Low Frequency Noise, Vibration and Active Control, 39(4), 885-907.

Feng, Y., & Gray, K. E. (2017). Review of fundamental studies on lost circulation and wellbore strengthening. Journal of Petroleum Science and Engineering, 152, 511-522.

Muqeem, M. A., Weekse, A. E., & Al-Hajji, A. A. (2012, April). Stuck Pipe Best Practices–A Challenging Approach to Reducing Stuck Pipe Costs. In SPE Saudi Arabia Section Technical Symposium and Exhibition. OnePetro.

Zamani, S. M., Hassanzadeh-Tabrizi, S. A., & Sharifi, H. (2016). Failure analysis of drill pipe: A review. Engineering Failure Analysis, 59, 605-623.

Mitchell, R., & Miska, S. (2011). Fundamentals of drilling engineering. Society of Petroleum Engineers.

Lavrov, A. (2016). *Lost circulation: mechanisms and solutions*. Gulf professional publishing.