



# The qualitative risk assessment of MINI, MIDI and MAXI horizontal directional drilling projects



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## ABSTRACT

The differences between uncertainty, risk and hazard in horizontal directional drilling (HDD) technology were described in this paper. Various types of uncertainty in HDD technology were shown on the chosen examples. Due to the increasing complexity of HDD projects, the continuous development in HDD technology, the optional possibility of applying various tools and machines and the diversity in the installation size (MINI, MIDI and MAXI), it was needed to consider the additional risks in HDD projects, as well as identify those risks which have not been considered in previous works. Literature study, scenario analysis, risk interviews with HDD contractors, manufacturers of HDD equipment and mud services, risk brainstorm sessions, expert surveys among HDD contractors and own observations of HDD installations supported the risk identification process. Various types of risks connected with the carrying out of HDD installations were presented. The feedback from expert surveys from 5940 HDD projects carried out in 5 countries, allowed to assess the frequency of occurrence and the influence on project failure of 38 risks in HDD technology and, therefore, proved the need to include them in the risk assessment. Additionally, the survey results allowed to assess the frequency of the occurrence of various types of problems with: the product pipe installation, rig failures, drill pipe failures, the importance of the reasons of drill rig failures and drill pipe failures. The survey results were a basis for the qualitative risk assessment, which was carried out applying Ishikawa diagram.

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## 1. Introduction

Typical risk management consists of 6 main processes: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, risk monitoring and control (Project Management Institute Standards Committee, 2000). This paper focuses mainly on the risk identification and the qualitative risk assessment in HDD projects.

In this work various methods were used during the HDD risk identification process: literature study, scenario analysis, risk interviews with HDD contractors, manufacturers of HDD equipment and mud services, expert surveys, risk brainstorm sessions among HDD contractors and own observations of HDD installations. It was not easy to find many publications describing the HDD installations which failed, as many contractors were afraid that the description of problems in HDD could be bad publicity for the company rather than a lesson learned for other contractors. However, some authors, e.g. Allen et al. (2007), Anders (2001), Burnam et al. (2002), Francis et al. (2005) and Staheli and Ramos

(2007) decided to describe various problems which occurred during HDD installations, which is a significant contribution into the risk identification process. In (Ariaratnam et al., 1998; Kuliczowski and Gierczak, 2011; Osbak et al., 2012; Woodroffe and Ariaratnam, 2008) some important risk factors in HDD projects were identified. However, due to the increasing complexity of the HDD projects, the continuous development in HDD technology, the optional possibility of applying various tools and machines and the diversity in the installation size (MINI, MIDI and MAXI), it was needed to consider the additional risks in the HDD projects, as well as identify those risks, which have not been considered in previous works. In this work feedback from 5940 HDD from 5 various countries was analyzed. The analysis of the expert survey results (the frequency of the occurrence of the various problems in the HDD and their influence on HDD failure) aimed to prove the need to consider them in the qualitative and quantitative risk assessment in the HDD projects and, as a result, increase the number of foreseeable risks in HDD projects. Additionally, the frequency of the occurrence of the various types of problems with: the product pipe installation, drill rig failures, drill pipe failure, the importance of the reasons of drill rig failures, and drill pipe failures were a subject of the expert surveys. The survey results were a basis for the

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qualitative risk assessment, which was carried out applying Ishikawa diagram.

## 2. The differences between uncertainty, risk and hazard in HDD projects

The proper understanding and unified interpretation of the terms: risk, uncertainty and hazard plays a significant role in risk management planning. As the risk theory developed, many risk definitions were available and the term 'risk' started to have a multifaceted and wildcard character. However, it is important to distinguish between the terms 'uncertainty', 'risk' and 'hazards' in HDD projects.

In the case of HDD projects, the term 'uncertainty' is connected with a lack of information about the considered trenchless pipe laying project applying HDD technology. It is present even when the information is considered to be complete (van Staveren, 2007). It is important to distinguish the 3 types of uncertainty: randomness, fuzziness and incompleteness (Blockney and Godfrey, 2000). All 3 types of uncertainty are to be considered for each HDD project. Randomness is defined as an absence of individual parameters or variables (van Staveren, 2007). In the case of HDD projects, it is encountered e.g. when the probability-density functions for particular ground parameters or quality geological evidence are not available, which is widely common in geologically complex areas (with various types of subsequent deposition, erosion, glaciations, etc). Fuzziness is connected with the imprecision of definition or concept (van Staveren, 2007). It can be easily noticed in geotechnical reports for HDD, e.g. the various classification systems for soil in many countries or the statements 'hard rock' or 'good ground conditions' for HDD is fuzzy as the words 'hard' and 'good' are imprecise and can be interpreted in many ways. Incompleteness is connected with the lack of complete data or information (van Staveren, 2007). In the case of HDD projects, it is important to be aware of the 2 types of incompleteness – foreseeable and unforeseeable incompleteness. The first type concerns missing information, about which we are aware. In the case of HDD projects, it is often encountered in geotechnical reports, e.g. the statement that 'sands are present along the bore path' indicates the type of ground but does not indicate the precise ground parameters. The second type concerns the incompleteness of information, which is not identified. It can be easily noticed in the case of carrying out HDD under a river, where there is geotechnical data available only from 2 boreholes situated on separate river banks and the characteristic of the ground under the river is not known. Another example is when there is total unawareness of the need of carrying out certain ground tests for HDD.

It is said that after assigning the probability to uncertainty, it becomes a risk (Carlsson et al., 2005). Other definitions define risk as the probability of the undesired event with its consequences (losses). There are 3 factors which decide the risk character: the event, the probability and the severity (Pritchard, 2002). Under the term of 'an event', there is understood the description of the circumstances under which the risk event occurs. After describing the circumstances which accompany the risk event in the HDD it is needed to assess the probability of that event and its severity. When all of those 3 factors are assessed, then the final risk level of the HDD project can be estimated.

There are 4 main risk types that can be distinguished: pure and speculative risk, foreseen and unforeseen risk, information and interpretation risk, direct and indirect risk. Pure risk is connected with hazards or undesired events, which always cause unwanted effect. It is advised to eliminate this type of risk as quickly as possible (van Staveren, 2007). Speculative risk can have desirable and undesirable effects, which is easily noticed in the Chinese risk

symbol, which is a connection of the words crisis and opportunity. It is important to note that it is not advisable to focus only on risk reduction, as it also minimizes the chances of success, e.g. the reduction of the risk connected with the changes of the actual rate of return on the investment in comparison to the expected, even when the score is positive (Damodaran, 2009).

The second distinction is between foreseen and unforeseen risk. Foreseen risks result from the unwanted events that can be identified during the risk identification process (e.g. equipment breakdown, unfavorable weather conditions), whereas unforeseen risks are connected with the unwanted events that are not anticipated during the risk identification process (e.g. unexpected market fluctuations, rapid changes in the political situation that can severely impact the HDD installation price). The unforeseen risk can be further divided into the apparent unforeseen risk and the real unforeseen risk (van Staveren, 2007). The apparent unforeseen risk is, in fact, possible to foresee, but its probability of occurrence and the consequences are difficult to assess. Real unforeseen risk remains unforeseen during the stage of the project risk identification.

The third distinction is between the information and interpretation risks. The information risks are the objective risks including the uncertainties of randomness and incompleteness (Blockney and Godfrey, 2000). They are connected with false and incomplete factual data, e.g. in the case of HDD projects, human errors, such as wrong or incomplete geotechnical data. Interpretation risk is connected with the subjective interpretation of the factual data. The differences in the interpretation can be caused by different views on the variety of geotechnical conditions along the bore alignment. This type of risk aligns with the fuzzy type of uncertainty and it is difficult to reduce because there are many sources of the fuzziness (van Staveren, 2007).

The last distinction is between the direct and indirect risk. Direct risk is connected with the hazards which arise inside the system (in the case of an HDD project it could be an equipment failure during the installation). Indirect risk is connected with the hazards which arise in the system environment and have an undesired effect on the system functioning (in the case of HDD projects, it could be economic and legal problems).

It is important to note that risk in HDD projects has a dynamic character and is dependent on time, the changing circumstances (the factor connected with the objective assessment of the factual data) and the changing human perception (the factor connected with the many different ways of interpretation and subjective assessment of the factual data).

## 3. Risk identification methods

In this work 38 various problems which may occur during the carrying out of various sizes of HDD project were identified thanks to literature study, scenario analysis, risk interviews with HDD contractors, manufacturers of HDD equipment and mud services, expert surveys, risk brainstorm sessions among HDD contractors and own observations of HDD installations. Thanks to asking the question "what if" in the scenario analysis it was possible to look

**Table 1**  
The number of surveys and HDD installations from various countries.

| Country         | The number of the surveys | The number of HDD installations |
|-----------------|---------------------------|---------------------------------|
| Poland          | 6                         | 1870                            |
| France          | 1                         | 1700                            |
| The Netherlands | 2                         | 1400                            |
| USA             | 3                         | 900                             |
| Germany         | 2                         | 70                              |

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