# RISK-BASED ENGINEERING FOR TRENCHLESS INSTALLATION PROJECTS

## *More than Just a Line on a Piece of Paper*

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The design and construction of projects using one or more trenchless installation methods is more than just a line on a piece of paper. It does not require just a good survey plan, it requires an understanding of the geological conditions, an understanding of exactly how the selected trenchless method excavates and removes the ground and installs the pipe, and knowledge of the required equipment within a specific work zone. It also requires an understanding of existing "other issues" such as: contaminated ground, how to identify and plan for its handling and disposal, realizing that former and existing building foundations exist and can be impacted by the project or impact the project, knowing location and type of other utilities in the ground, traffic volumes on surface streets, and the all-important egress/ingress points to local commercial, public and private properties. Add to this the often overlooked but just as important local social issues and stakeholder management.

**Drive Cost Down And To The Left**

| PROBABILITY | MINIMAL EFFECT | MODERATE EFFECT | SIGNIFICANT EFFECT | SEVERE EFFECT |
|---|---|---|---|---|
| WILL HAPPEN | Low To Moderate Cost | Moderate To High Cost | High Cost | High Cost |
| WILL PROBABLY HAPPEN | Low To Moderate Cost | Moderate To High Cost | Moderate To High Cost | High Cost |
| COULD HAPPEN | Low To Moderate Cost | Low To Moderate Cost | Moderate To High Cost | Moderate To High Cost |
| UNLIKELY TO HAPPEN | Low Cost | Low To Moderate Cost | Low To Moderate Cost | Low To Moderate Cost |
| HIGHLY UNLIKELY | Low Cost | Low Cost | Low Cost | Low Cost |

IMPACT OF RISK EVENT

*Figure 1. Driving risk down*

**IN ESSENCE, RISK-BASED ENGINEERING FOR TRENCHLESS PROJECTS IS AN ACCOUNTING SYSTEM BASED ON REAL RISK TO THE PROJECT.**

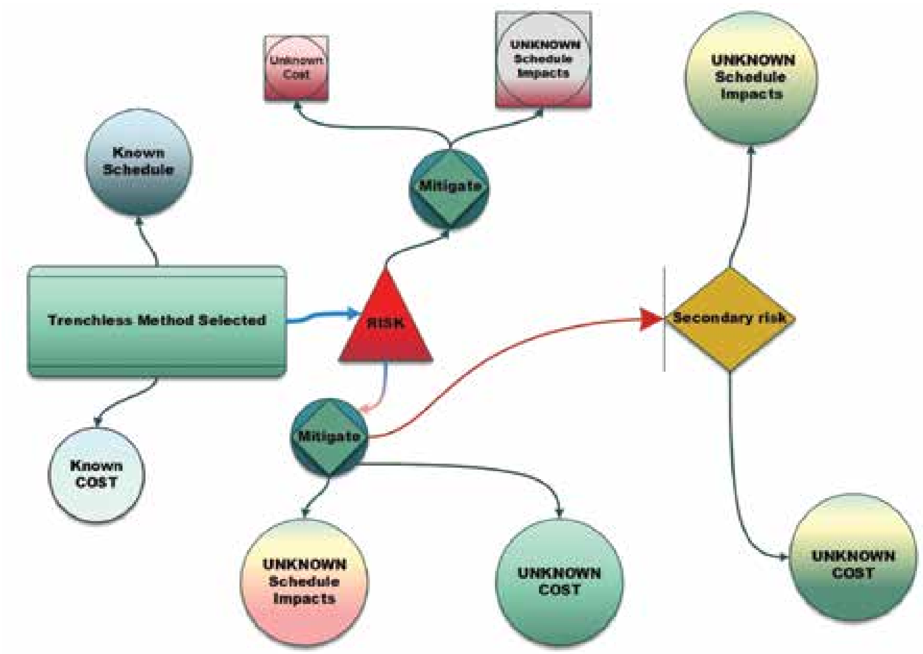



*Figure 2. Trenchless methods cost, risk, mitigation, cost of mitigation and cost of risk*

Design and construction of trenchless projects also requires an understanding that there are risks, and that not all risks are equal. The cause and effect, or trigger, of a risk event occurring with a specific trenchless method is dependent upon engineering and human error from operations in engineering and construction. These can be controlled through changes in the design and/or construction operations. Risk events in trenchless projects can include ground settlement, ground heaving, creating large voids, movement of sensitive buildings, inadvertent returns, changed ground conditions, broken downhole tooling, damage to third party property, damage to other utilities and structures, and even loss of life. So, risk needs to be managed.

Someone has to pay for the risk. The risk to the owner to pay for legitimate change orders due to defective designs or changed conditions; the risk to the contractor of financial losses caused by defective work, or by underestimating production rates, or by use of incorrect tooling for the ground conditions; and the risk to third parties caused by settlements of pavements or rails, the movement of ground under or near sensitive structures, or even the loss of life. Not all planned capital construction and administrative costs to the owner include the cost of risk. This could double the cost of the project if not controlled. It really comes down to "Pay me now or pay me later". It has to be asked - which is more expensive?

Risk is defined as the chance or probability of an event occurring that exposes something or someone to a specific level of danger and peril. For each risk event, there is a cost associated with it. These costs can be monetary, can affect the schedule, or affect the finished product - in project management terms: cost, schedule, and scope.

Engineering is defined as using the knowledge of science and technology to construct or modify the environment for the benefit of society. In the case of trenchless technologies, it can be the knowledge of the chemicals in a rehabilitation process, or optimal temperature control during a curing process, or long term stress-strain relationships for rehabilitation methods. For new trenchless installations, the focus of this article, it is a deep understanding of geology, geotechnical engineering, material science, management of contaminated ground, spatial relationships, and program management; all of which are required for a successful project. Eliminating all risk is almost impossible, but it is possible to limit the cost of the risk event by purposefully lowering the probability of the event from occurring.

Therefore Risk-based Engineering, considers the risk involved, the probability of a risk event occurring when using a specific engineering and construction method, and potential cost, if the risk event occurs. For each potential risk, there is a cost and also a probability factor that a risk event will happen. The costs are either monetary or time but may be both. The probability factor ranges from it will not happen to it will happen or someplace in between such as it may happen. Assignment of risk cost and probability can be subjective and are best assessed by experienced engineers, managers, and construction experts in a brain storming session.

And there can be a multitude of secondary risks stemming from the mitigation methods selected to lower the cost and probability of the original risk, and each of these secondary risks have their own additional cost and probability factor. Trenchless engineering is an iterative process. When you first begin the project, the project is full of risk and uncertainty. As more knowledge is gained through the design process, the risk profile changes. These changes can be in the severity of a


*Figure 3. Risk, risk mitigation and secondary risk*



risk event or the probability of such a risk event occurring. Should a risk event occur, there will be a definitive cost and schedule impact assigned to the event. The intent of Risk-based Engineering is to drive risk cost down as well as the probability of the risk event occurring.

Still, not all risk can be eliminated. Risks, both original and secondary are distinct, like project management work packets. The difference is that each risk event has cost and probability, whereas a work packet has cost and schedule. For a risk event, the cost incurred is affected by the probability that the event will occur. For example, if the cost that would be incurred is estimated to be $5M for the settlement of a busy intersection, and the probability it will happen is 70 percent, then the estimated cost of that event entered into the ledger of total project cost is $3.5M. If changing the construction design to another trenchless method, simply going deeper, or considering ground modification, reduces the probability of the risk event occurring to a 10 percent chance, then the cost of the risk event added to the project cost ledger would only be $500,000, plus mitigation costs.

However, the costs of secondary risks may also need to be considered. A secondary risk is a result of changes in design or construction that have a distinct set of their own risks. There is also the cost of implementing risk mitigation measures such as ground modification as well as the cost of secondary risk. Please note in the above example that the $5M cost of risk would include such things as pavement reconstruction, utility replacement, the cost of lost revenue to the local store that has to shut down for a period of time during construction, and impacts to people traveling through the area having to make long detours around the construction site. These are otherwise known as direct, indirect, and social costs.

Sometimes, risk is caused by the good will attempt of the project owner to appease third party stakeholders. Agreements to appease stakeholders can and often do have effects on technical risk. An example of this is having to move a jacking shaft for microtunnel operations into a busy urban intersection in order to appease a local social/political group whose desire to minimize the impact that construction operations would have on a school is a good cause. The movement of the jacking shaft then has many secondary risks that are a direct result of this move. The cost of these secondary risks may far outweigh the original cost of a risk event at the school because the control on the probability of occurrence of these secondary risks cannot be as effective. A solution to reduce the probability of the risk event occurring at the school would be to conduct work at the jacking shaft when school is not in session such as over the summer vacation, introducing extra safety measures, and educating and involving not only the students at the school, but also the local social/political group being appeased. All of this does require a good stakeholder management program with costs, but these costs have certainty whereas moving the jacking shaft to the intersection may not.

In essence, Risk-based Engineering for trenchless projects is an accounting system based on real risk to the project. The risk arises due to the technical limitations of a specific trenchless method or material used, geological conditions not being

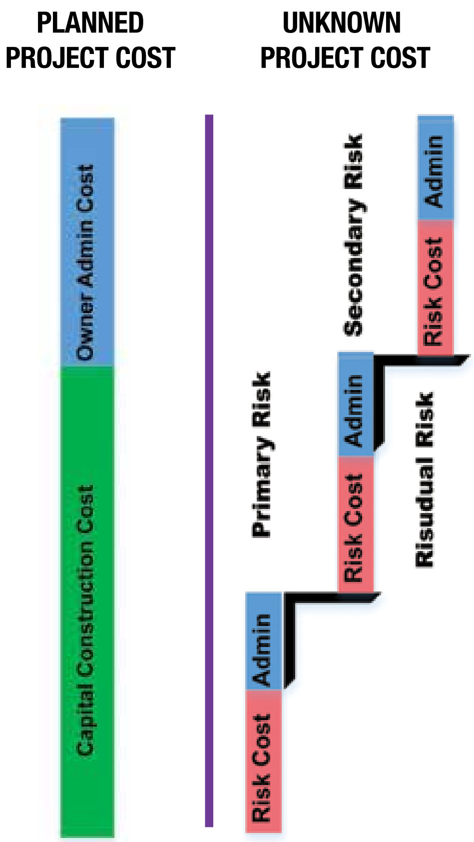


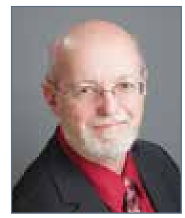

*Figure 4. True cost of a project including cost of risk*

accurately characterized, sensitive nearby structures and underground utilities that can move and cause damage, impacts to traffic, etc. The risk may also arise due to stakeholder demands. In the end, there is a cost to these risks, including administrative costs.

Most trenchless projects are relatively simple and do not require Risk-based Engineering methods. Each project should be considered based on total dollar value, when competing stakeholder demands drive erratic and sometimes uncontrollable risks, or when work is being conducted in an area with high value such as real estate, institutions, commercial districts, medical campuses, and other major critical infrastructure such as highways and railroads.

It is important to remember that not all risks have negative impacts or costs. Mitigating the risk may have positive effects such as reducing overall project cost or schedule. Using Risk-based Engineering methods does require a detailed level of understanding of all trenchless methods, how they work and their specific limitations. All of this requires an attitude of designing to manage risk and not just drawing a line on a piece of paper.

**ABOUT THE AUTHOR:**



***Dennis J Doherty*** *is a Senior Consultant and the National Practice Leader for Trenchless Technologies at Haley & Aldrich, applying a total trenchless approach on microtunneling, HDD and other trenchless method projects for private sector energy clients. An ardent proponent of the benefits and value of trenchless methods, Dennis has a unique understanding of risk management as it relates to trenchless design, having worked on a number of innovative projects across the US. He serves on the NASTT No-Dig Show Program Committee and is an instructor for NASTT's HDD Good practices Course. Dennis is proud to be Chair of the new NASTT-NE Chapter.*