

Introduction to debate on the theme:

What are the limitations in TBM technology?

Panel; Brad Grothen, Robbins; Werner Burger, Herrenknecht; Bruno Combe, Bouygues; Amund Bruland, NTNU.

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What are the limitations in TBM technology?



Is 'Innovation' a Dirty Word in Tunneling?

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It's well known in our industry that a certain billionaire entrepreneur named Elon Musk is now in the tunneling business. Through his venture The Boring Company, Musk aims to revolutionize tunnel boring. Some of Musk's plans include a

10-fold improvement in the cost per mile of tunneling, and a more than 10-fold increase in TBM advance rates, to be achieved by decreasing the tunnel diameter, and creating a high-powered, continuous tunneling and lining machine, among other

things. In a statement on The Boring Company's website, "... there is virtually no investment in tunneling Research and Development [in the United States]. Thus, the construction industry is one of the only sectors in our economy that has not improved its productivity in the last 50 years." A harsh statement to be sure, but is it true? And if it is, why? As The Boring Company was not available for comment, NATJ asked representatives from different segments of the industry to weigh in on the state of innovation.

“...there is virtually no investment in tunneling Research and Development [in the United States]. Thus, the construction industry is one of the only sectors in our economy that has not improved its productivity in the last 50 years.”

Elon Musk

What are the limitations in TBM technology?

Elon Musk states: How are we (the tunnel boring company) reducing the cost of tunneling? He claimed to include 10-fold improvement in cost, and > 10 -fold increase in TBM advance rates.

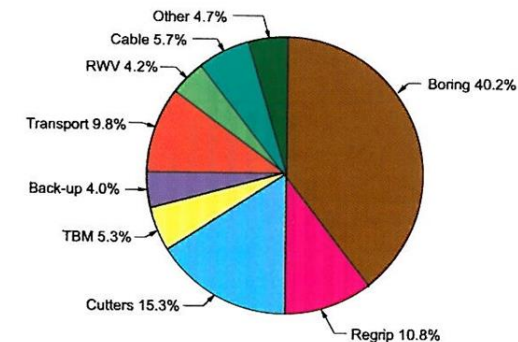
- First, we reduced the tunnel diameter. The current standard for a one-lane tunnel is approximately 28 feet. By using electric autonomous vehicles with alignment wheels, the diameter can be reduced to less than 14 feet. Reducing the diameter in half reduces tunneling costs by 3-4 times.
- Second, we're working to significantly increase the speed of the Tunnel Boring Machine (TBM). TBMs are super slow. A snail is effectively 14 times faster than a soft-soil TBM. Our goal is to defeat the snail in a race. Ways to increase TBM speed:



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Musk continues:

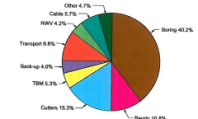
- Increase TBM power. The machine's power output can be tripled (coupled with the appropriate upgrades in cooling systems).
- Continuously tunnel. When building a tunnel, current soft-soil machines tunnel for 50% of the time and erect tunnel support structures the other 50%. This is inefficient. Existing technology can be modified to support continuous tunneling activity.
- Automate the TBM. While smaller diameter tunneling machines are automated, larger ones currently require multiple human operators. By automating the larger TBMs, both safety and efficiency are increased.
- Go electric. Current tunnel operations often include diesel locomotives. These have been replaced by electric locomotives.



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What do we see in the future for TBM-tunneling?

- One machine to every possible ground conditions, no need to distinguish between different types of machines!
- Fully remote operated without any human beings at the tunnel face whilst in tunnelling modus!
- Fully capable of doing all sorts of pre-grouting and rock support all the way around
- Faster machines and non-circular profiles or mega-size > 20m
- What about the cutter technology?
- TBM's to explore oil and gas development offshore?
- What can be done to increase the average machine utilization?



What are the limitations in TBM technology?

This leaves for the panel to debate the following:

1. What are the limitations in TBM technology?
2. Are we able to reach the 90 % cost reduction as Musk proclaimed or the 10-fold improved advance, HOW?
3. Are there any possibilities in assisting the cutters in breaking the rock?
4. Can TBM's be made more multi-functional – i.e. one machine fits all ground conditions