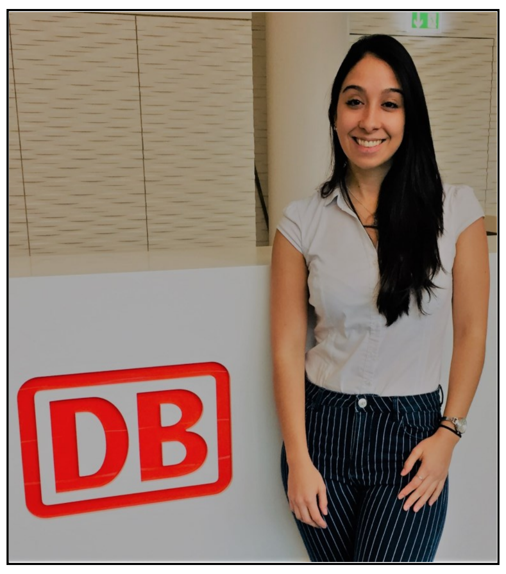
Master Thesis

Deutsche Bahn regulations for tunnel construction

Creating a decision-making model to help evaluate and prioritize single-track and double-track tunnel design alternatives in the context of urban planning demands.

Summary

The worldwide trend is urbanization: more people live in cities than ever before. Unprecedented urbanization rates and the rapid development of metropolitan areas lead to the saturation of the existing infrastructure and superficial spaces as well as increasing demands on the transportation system. In pursuit of sustainable growth, many European cities are exploring possibilities of better utilizing underground space. This is especially relevant in terms of public rail transportation, which plays a critical role in the day to day life of city inhabitants. In Germany, the technical guideline that regulates the design, construction, and maintenance of railway tunnels fundamentally recommends the implementation of parallel single-track tunnels. Therefore, dual-track transverse sections, which usually present a lower impact on urban surface areas, are often neglected.



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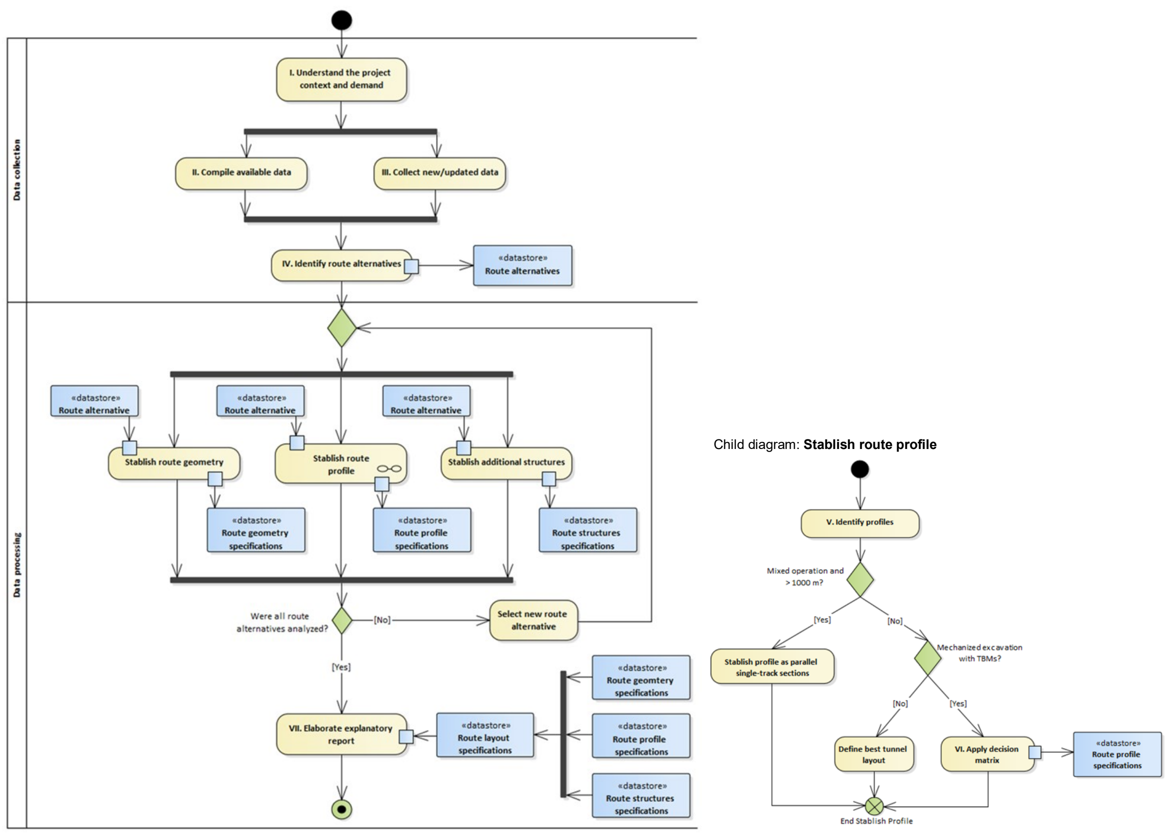
In order to encourage the consideration of both tunnel layouts during project planning phases, this study took into account particular advantages and disadvantages of each profile(1), regulatory technical standards and their influence on recent tunnel projects(2), as well as expert opinions from representatives of Deutsche Bahn AG to develop a decision model(3).

(1)

Single-track double tunnels	Double-track single tunnels
+ Independent unidirectional traffic: reduced probability of collisions and interferences on the parallel track; + Cross-passages enable the adjacent, unaffected tunnel to be employed as a safe area, in emergency cases; - Less space for evacuation and rescue operations inside the affected tunnel; - Larger exploration area of the underground space (in extension and width); + Island platform stations, favored by the tracks layout, provide more comfortable and convenient transfer conditions; + Tunnel boring machines with smaller diameter have lower rental costs; - Doubled tunneling work fronts usually require more complex logistics and longer execution times; - Higher pressure fluctuations acting on tunnel walls and equipment, trains and passengers; + Uninterrupted operation during maintenance services and other track-blockage events; - Greater impact extension on the surface (higher potential ground settlement).	- Bidirectional confined traffic: higher probability of collisions and interferences on the parallel track; - Provision and accessibility requirements to safe areas might increase rescue concept and project design complexity (specially in dense urban areas); + More space for smoke/gases to spread (more time for evacuation and rescue operations under acceptable conditions); + Smaller exploration area of the underground space; - Island platforms in double-track tunnels, increase station project cost and complexity; - Large-diameter boring machines are considerably heavier, presenting higher rental costs; + Single excavation face leads to less complex logistics and faster execution; + Reduced probability of noise and vibration radiation at the tunnel portal (micro-wave pressures effects); - Operation has to be interrupted in both directions during maintenance services and other track-blockage events; + Shorter potential impact extension on the surface building and structures.

(2)

(3)



The proposed process consists of seven stages, among them a decision matrix(4), and has been applied to the current project of underground rail network expansion in Hamburg(5).

(4)

Factors & Criterias	Weight (%)	2 x single track	1 x double track
		[Weighted arithmetic mean]	[Weighted arithmetic mean]
1. Urban and social impacts	[%]	*Arithmetic mean*	*Arithmetic mean*
1.1 Extension of surface impact			
1.2 Level of implementation			
1.3 Intervention time (execution period)			
1.4 Allocation of tunnel portals		*Score*	*Score*
2. Safety performance	[%]	*Arithmetic mean*	*Arithmetic mean*
2.1 Operational speed		*Score*	*Score*
2.2 Trains frequency			*Score*
2.3 Evacuation conditions			*Score*
2.4 Rescue conditions (external services)		*Score*	*Score*
3. Operational conditions	[%]	*Arithmetic mean*	*Arithmetic mean*
3.1 Pressures waves		*Score*	*Score*
3.2 Tunnel climate (natural ventilation)		*Score*	*Score*
3.3 In case of track blockage		*Score*	*Score*
4. Infrastructure complexity	[%]	*Arithmetic mean*	*Arithmetic mean*
4.1 Deviating from existing underground structures			*Score*
4.2 Influence of bad soil conditions			*Score*
4.3 Installation of switch points			*Score*
4.4 Implementation of central platform stations		*Score*	*Score*
4.5 Implementation of safety structures		*Score*	*Score*
4.6 Disposal of excavated materials		*Score*	*Score*
5. Execution costs	[%]	*Arithmetic mean*	*Arithmetic mean*
5.1 Concrete volumes (sealing and leveling)		*Score*	*Score*
5.2 Tunnel boring machines rental		*Score*	*Score*
5.3 Infrastructure complexity		*Score*	*Score*

Factors

Criteria

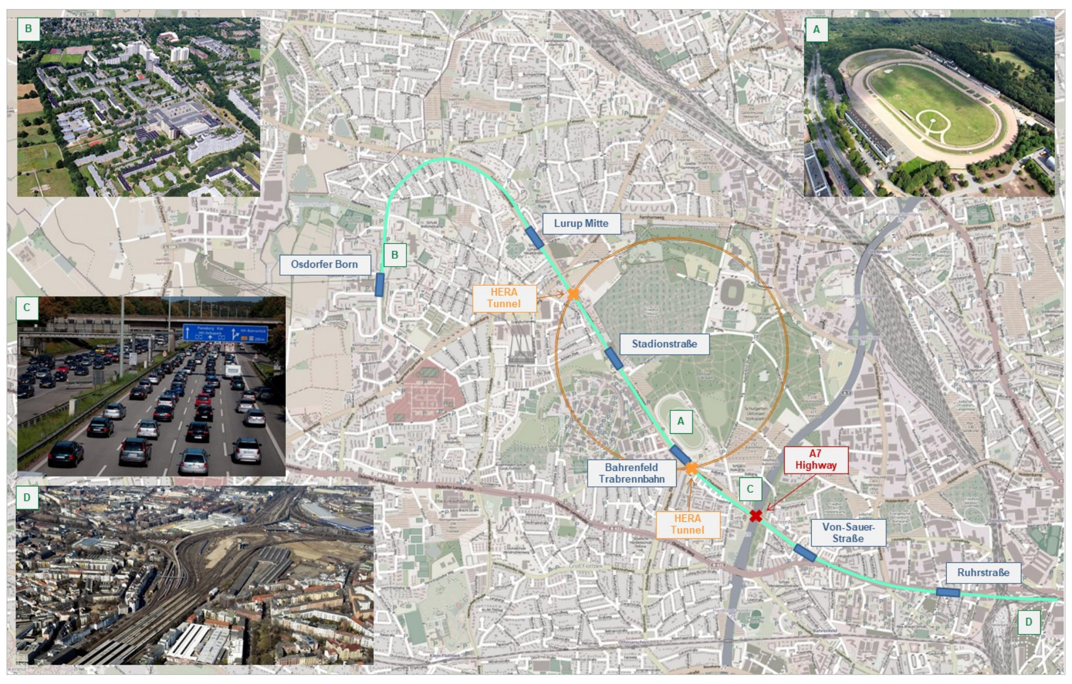
Is the weighted average of the five scores arithmetic means, considering the respective percentage weights. The best alternative is defined by the highest value.

Average of factor-related criteria scores

Reflect the importance of each factor. The total weighting of the 5 factors should add up to 100%.

Criteria scores (vary from 1 - 5)

(5)



2 x single track	1 x double track
3,13	2,73

Finally, it has been proved that the model not only efficiently helps evaluating and prioritizing tunnel profile alternatives, but the contemplation and comparative analysis of both layout sections, furthermore, favors the identification of potential project performance improvements.

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