

Use Case 16: Machine Guidance and Control

Purpose

Tunnel construction using a TBM (Tunnel Boring Machine) has become a common method of construction nowadays: controlling and navigating a TBM requires the utmost precision along the entire alignment until the final breakthrough. Alignment control is important in drill-and-blast tunnelling as well, where computerized systems help jumbo/rig operator to respect tolerances imposed by functional cross-section and install bolts/shotcrete in correct way.



Figure 1: Example of software for automatic drilling with jumbo rig

Therefore, it is essential that the actual position of the machine in relation to the as-designed tunnel alignment is continuously present and displayed, for any type of machine involved in tunnelling:

- for TBMs and roadheaders
- for excavators/drilling jumbos/shotcrete & bolt rigs/dump trucks etc.
- shaft boring machine (SBM) or VSM (vertical sinking machine)

A guidance system is equivalent to a navigation system and it regulates all procedures that has an influence on alignment control, i.e. steering cylinders stroke, keystone position (TBM tunnelling), borehole direction, rig positioning and driving while drilling (conventional tunnelling). It provides information for starting a control or course correction, usually by software owned by machine manufacturers themselves.

The alignment provides the most important source of information for machine control, which is provided from the designer. For steering the machine (TBM tunnelling) or positioning and drilling boreholes (D&B tunnelling), it is important to have precise as-built information, as usually there are deviations between the as-designed and the as-built alignment. Accordingly, in-process corrections are required.

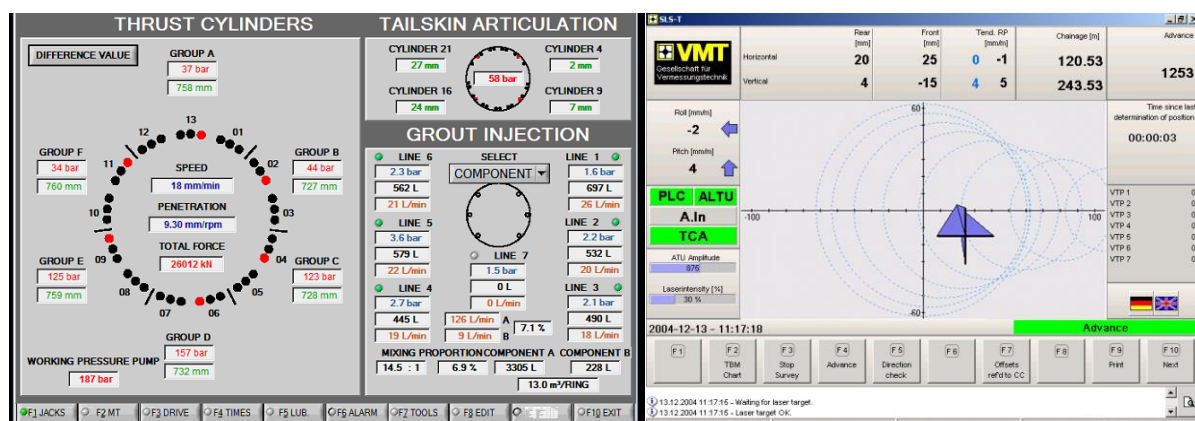


Figure 2: Machine control in TBM tunnelling, example of software for machine guidance

The objective of this use case is primarily to guarantee the geometrical tolerances and the compliance between theoretical (as-designed) and actual (as-built) tunnel alignment. As a consequence, the purpose of this use-case is to increase safety during tunnelling, to improve the quality of the tunnel structure, with complementary systems for monitoring and automating process sequences, and to standardise the information flow coming from actors involved in the process.

The IFC exchange scenario has to take into account:

- Design application to machine guidance software
- Machine guidance and on-field applications to design software and AIM-solutions (as-built)

Machine guidance involves a more complex information flow from the machine to the steering software, and further on to the design application (for as-built modelling) and the asset management application. This flow on information will involve also georeferenced as-built data from TBM/jumbo while drilling (key-segment position, TBM pressure/thrust/torque/injection, jumbo rigs direction/advance rate/torque, MWD data) that could be important to understand why a deviation occurred and how to design countermeasures.

This use case is linked with following ones:

- Input data → UC 15b and 15c - Geological documentation and Scanning during construction; UC 3 – Exchange of alignment and major road/railway parameters
- Output data → UC 17 - Damages recording, and UC 18 - Settlement monitoring

Requirements for IFC-Tunnel:

- Alignment (as-designed / as-built)
- Tunnel itself
- Terrain

Coordinate Systems:

Particular attention must be paid to the question how geo-referenced coordinate systems are handled. Whereas some BIM systems provide 1:1 modeling, BIM for Infrastructure and professional GIS systems operate in projected coordinate system. For some specific project (Alpine tunnels), transformation to single project coordinate systems to standard ones has to be developed. Thus, a transformation is necessary, and all required parameters must be provided by the IFC format.

Geometry:

Precise description of the alignment, both as-designed and as-built, as well as the allowable tolerances. For drilling and blasting, the tunnel cross-section geometry shifts along the tunnel: interpolation between these shifting cross-section is a challenge in practice that must be addressed. A clear cross-section definition and interpolation rules are important issues to be addressed for conventional tunnel production. For mechanized tunnelling, geometrical characteristics derived from construction sequence should be added (location of the key segment, machine data). Particular attention must be paid to the interface with GIS systems.

Semantics:

All existing entities must be described with appropriate semantics. Interface between huge amount of data (machine parameters, MWD data, laser-scanner, typological classes...) and entities should be investigated deeply. All information previously described are basically linked with each construction unit with significative information (round / ring).