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WITH THE CONTINUOUS CITIES EXPANSION AND POPULATION GROWTH, THE EXTENSION OF EXISTING METRO LINES IS BECOMING MORE AND MORE NECESSARY FOR SERVING THE TRANSPORTATION NEEDS. UNLIKE NEW METRO LINES CONSTRUCTIONS, EXISTING LINES EXTENSION IS SUBJECT TO SERIOUS CHALLENGES INCLUDING INTEROPERABILITY, MIGRATION, AND NON-DISRUPTION OF THE EXISTING NETWORK OPERATION. THIS PAPER PROVIDES KEY HINTS FOR LOCAL AUTHORITIES WILLING TO BUILD A STRATEGY FOR EXTENDING THEIR EXISTING METRO LINES WHEN ALREADY OPERATED WITH A CBTC SYSTEM.

During the last decade, the Communications-Based Train Control (CBTC) system has emerged as the main signalling system for urban railway applications, offering optimized headway performance, enhanced operation flexibility, and improved availability and safety. Today, a large number of worldwide CBTC lines are subject to on-going or future extensions to cope with the cities' demographic expansion.

For each extension project, a specific case study needs to be carried out in the preparatory stages of the project. Engineering Companies can provide a significant support to the local authorities in defining their extension strategy, taking into account the context and particular characteristics of the line.

Requirements and expectations

For an optimum operation, the CBTC system design of the extension should ensure full interoperability with the existing track section and existing trains of the metro line. This means that trains should be able to run on both existing main line and extension, with full transparency for the operation and the passengers.

The operation, safety and RAM performances of the extension are generally expected to be at least equal to the ones of the main line. A particular attention should be given to the extension border where seamless operation is expected. Trains running on the main line should not stop or reduce speed once arrived at the extension border.

For projects with long line extensions, additional trains are often required to maintain the headway performance on the whole line. Both new and existing trains are expected to be interoperable on the whole network.

Furthermore, the construction of the extension should be done without disrupting the daily operation of the main line at any phase of the project. To do so, a judicious migration strategy should be built and followed along the project execution. SYSTRA, which has a strong background in CBTC migrations worldwide, can offer a substantial support in this field to the local authorities and contractors.

Future extensions to be anticipated

Among the CBTC metro lines requiring an extension today, some have been able to anticipate future extensions from the initial CBTC design of the main line. However, this is not always possible, which leads to increased extension complexity and requires a careful extension strategy.

It is highly recommended when possible to anticipate future extensions from the early stages of the CBTC design of the main line. For instance, when the connection location of the future extension is predefined, the signalling design of the extension border can be optimized to ensure safe and flexible migration when connecting the extension to the main line. Besides, locations for installing extension trackside equipment, such as beacons, signals and optical fibers, on the bordering track sections of the main line, can be reserved. The CBTC backbone network can be designed such as to ensure sufficient bandwidth spare for the extension and allow an easy connection to a new backbone loop for the extension. CBTC and OCC systems can be dimensioned with enough margin, allowing the addition of the extension's new equipment without saturating the main line equipment (e.g., calculators, servers and displays).

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Proposed procurement strategies and recommendations

The main procurement scenarios that are generally envisaged for a new extension are listed below.

1. Same CBTC system for the extension as the existing one for the main line

This scenario consists in proposing for the extension the same CBTC system, and thus the same CBTC supplier, as the existing one on the main line. This implies that the supplier is maintaining the corresponding CBTC product line.

With this scenario, the interoperability is guaranteed since the system, architecture and protocols are the same on the whole line. As the upgrades on the existing track and trains are limited, the cost and execution time are reasonable, and the risk of disrupting the current daily operation is low. In addition, modifications on the existing internal/external CBTC interfaces and existing maintenance and operational procedures are limited.

However, this solution does not allow for an open tender which therefore limits the negotiations, and the extension would not benefit from the newest CBTC techniques on the market.

This solution is the most common. It is recommended when the main line is relatively new with no major obsolescence issues, and when the extension project schedule and cost are tight. Note that, although the same CBTC system is used for the extension, a newer CBTC software and/or hardware release could be envisaged for the extension as long as the compatibility with the main line system release is preserved. It is also recommended to perform an overall performance and obsolescence study on the whole line to ensure that the consequent life cycle duration meets expectations.

2. New CBTC system for the extension, existing CBTC system maintained for the main line

This scenario allows for an open tender and a new CBTC system for the extension only, while maintaining the existing CBTC system on the main line, and thus limiting modifications on the existing track.

Today, CBTC systems from different suppliers are proprietary and not inter-compatible by default, which increases the risk of non-interoperability between the extension and the main line and not reaching the performance targets. This scenario requires a dedicated interoperability development program that is technically risky and expensive in time and cost. Besides, dual CBTC systems would be needed on-board which is space consuming, in addition to the need of dual maintenance and training procedures, and to an increase of the internal/external CBTC interfaces complexity.

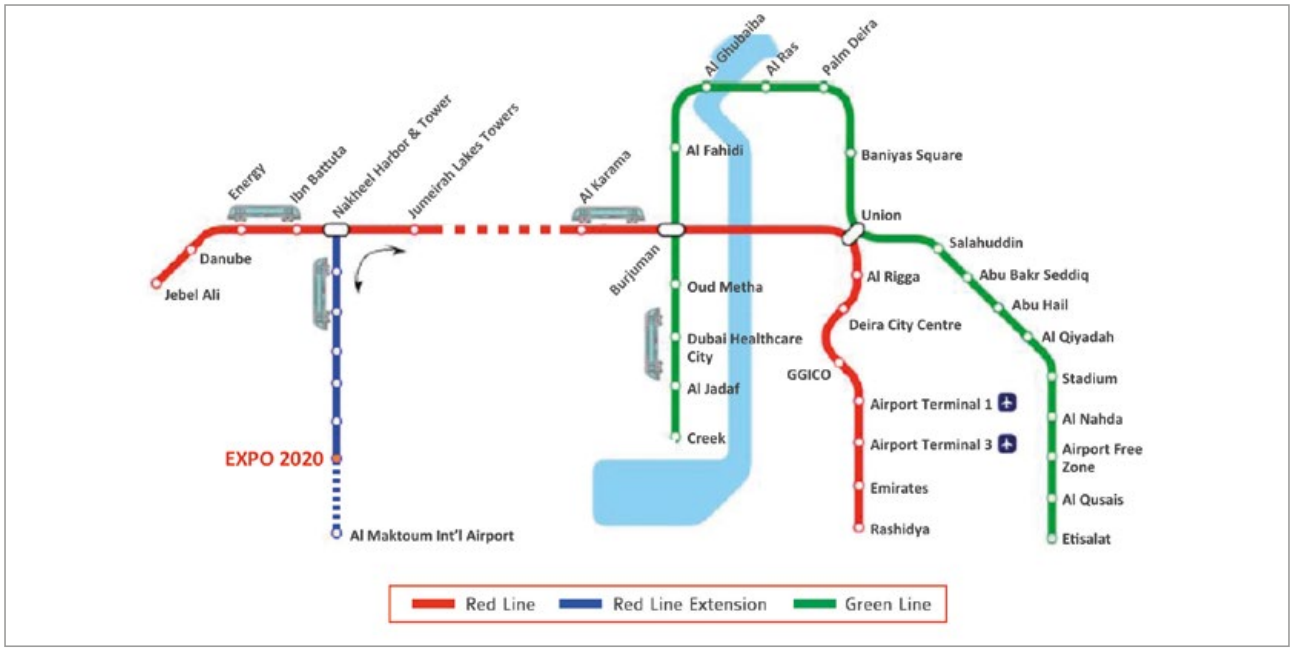
Due to its complexity, this scenario is recommended only in particular cases such as when numerous extensions within the same network are under study, or when the operator would like to connect several lines using different CBTC systems together.

3. New CBTC system for both the extension and the main line

This scenario consists in refurbishing the main line with a new CBTC system and implementing this system on the extension, which extends the CBTC life cycle of the whole line and potentially improves the overall system performance. In addition, the interoperability is guaranteed thanks to the use of a single system.

However, retrofitting the whole line and trains leads to high cost, time and risk of disrupting the current daily operation, and requires a judicious migration strategy.

This solution is recommended when the main line CBTC system is at its life cycle's end or is not meeting the major operational performance requirements, and the project execution time is not a constraint.



CASE STUDY

Dubai Red Line extension to EXPO 2020

The Roads and Transport Authority's (RTA) Dubai Metro project is one of the major flagship projects in the city of Dubai and has become part of the city's worldwide recognition. The Dubai Red Line and Green Line form the world's longest fully automated UTO metro network (75 km). This project was entirely led by SYSTRA/PARSONS JV, as "The Engineer" (FIDIC frame), from its feasibility study to its revenue service phase. The Dubai Metro has contributed to reducing traffic congestion in Dubai and has been a key catalyst to fast-track development and economic growth in the city.

Within the preparation of the World EXPO event that will be held in Dubai in the year 2020, a key project connecting the existing Red Line to the EXPO 2020 site is on-going, with a tight total execution duration of less than 4 years. Continuing on the success of the Dubai Metro, the aim of this extension project, also led by SYSTRA/PARSONS JV as "The Consultant" today, and "The Engineer" later, is to contribute to the enhancement of the public transport facilities in line with RTA vision for providing an effective and integrated transport system to the residents of Dubai during and after the prestigious EXPO event.

The extension consists of a new indoor and outdoor section of 14.5 km creating a junction in the middle of the Red Line and including 7 new stations, in addition to the insertion of 40 new trains. The CBTC system should ensure optimum reliability, availability and full interoperability on the whole metro network, i.e. existing and new trains should be able to run on both the main line and the extension with full transparency for the operation and the passengers. The CBTC system should be capable of operating trains in UTO mode with a maximum speed of 90 km/h and a headway of 90 seconds between trains.

Taking into account that the existing line is relatively new (in service since 09/09/2009), the tight project schedule to meet EXPO event and the interoperability concerns, the recommended procurement strategy for the extension is the one of *Scenario 1*, i.e. the implementation of the same CBTC system as the one existing on the Red Line, provided that the cost proposed by the CBTC supplier is reasonable. A newer software and hardware release is also foreseen for the extension, in addition to a wise selection of non-complex upgrades that will enhance the overall system operation and maintenance, without compromising interoperability.

Conclusion

For every metro line's extension project, procurement strategy and feasibility assessment need to be carried out from the early stages of the project. Engineering Companies such as SYSTRA play a crucial role in helping local authorities build the best procurement strategy, and subsequent tender and contract packages, taking into account short-term and long-term cost, time and performance requirements as well as obsolescence and operation continuity constraints. Whenever possible, future extensions should be anticipated from the initial design of the main line.

On the other hand, extending a line is not always the best solution to counteract the city demographic growth. When the system performance reaches its limitations, building a new independent metro line should also be considered.