CBTC FOR TRAM: TOWARDS HIGHER LEVELS OF AUTOMATION

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**Introduction**

CBTC versatility enables its boundaries to fluctuate not only in terms of functions, but also in terms of transit systems applications. Indeed, CBTC scope may nowadays legitimately englobe subsystem functions traditionally allocated to “external” systems such as ATS, SCADA, Traction Power control, Fire Alarm systems... as these systems do impact the train service in one way or another. In terms of applications, the range of transit systems relying on CBTC, whether driverless or not, extends from heavy duty transit systems down to LRTs, in some cases, possibly APMs (Automatic People Mover).

By LRT here, we mean the kind of LRT that needs both train spacing protection and that is running in a dedicated track, not interfering with road traffic. Recently, a new CBTC application was born and made operational with Dubai Tram that was successfully commissioned on 12 November 2014, paving the way for a new standard of tram operation. SYSTRA played a central role as the main consultant (The Engineer) in this project, which was delivered 45 days ahead of schedule.

CBTC is a significant investment in relation with systems usually found in a tramway system: the benefits of equipping a tram system should undergo a detailed feasibility study. This article presents how CBTC functions can assist in upgrading the capabilities and performances of a tram system, and highlights some of the associated challenges.

**Classic Tram Operation reminders**

The driving concept behind tram signalling is the drive-on-sight operational procedure. The driver is responsible for enforcing safe tram separation from other trams, road vehicles and pedestrians.

The driver is also responsible for respecting the wayside signaling that is protecting the track shunting areas, as well as other signals protecting particular areas such as tight curves with low visibility, tunnel parts (if any) etc.

Finally, the driver must adapt his speed to surrounding conditions and abide by the permanent and temporary speed restrictions.

**Tram operation design upgrade with a CBTC system**

The first obvious benefit of CBTC integration by an overlay to tram operation is the ATP function: passing signals at danger and overspeeding are prevented. However, in Dubai, this excludes road traffic signals which are not considered as shunting railway signals and therefore the question of controlling SPADs (Signals Passed at Danger) arises for road crossings signals.

GOA1 as per CBTC standard IEC 62290 includes safe train separation of the trains: in this respect, a tram without this function would only qualify as a “GOA+”. In Dubai, the choice was to rely on the driver for safe train separation whereas for more operationally demanding systems (higher max speed, shorter headways, in the future) this function may be taken over by CBTC.

The ATP function also contributes to the safe management of the Platform Screen Doors fitted on Dubai Tram stations.

The goal of CBTC is not all about safety: it is also meant to improve the line capacity by reducing headway within
the ATP safety net. This performance can be met either by efficient cabsignal HMI ("in cabin signal") and/or ATO assistance. When it comes down to tram applications where trams are able to get very close to each other during passenger service, this is too much of a challenge for the current ATP performances, and would require the introduction of a speed control release threshold as in ETCS/ERTMS control mode, under which the ATP would ignore the tram obstacle.

The second benefit would be the use of the ATO function to control the train movement. ATO does not spring to mind when designing a signaling system for tram operation, essentially because as the tram is often operating in non-reserved track, being then subject to all kind of external events and obstacles (pedestrians, cars, etc.) The driver, capable of analyzing these events in real time should have the hand over the braking control and acceleration. However, this principle is not required for part of tracks reserved for tram operation: in this case the ATO advantages stand out and can help optimizing the tram running time, as well as ensuring a certain level of passenger comfort by limiting jerk. Nevertheless, the driver should always have the priority through a manual braking command. The ATO can also be used to provide an efficient stopping accuracy in stations: in Dubai, where stations are fitted with Platform Screen Doors for station air conditioning purpose, a stopping accuracy of a few centimeters is needed. It is ok to run in ATO in this part as the stations configuration, equipped with Platform screen Doors and pedestrian signage makes it similar to a reserved track. The ATO does also enable the door synchronization between train and platform doors.

CBTC availability in Tram systems does not need to be that high in comparison with metro systems since this is a system that is not only permanently operated by drivers, but also for which the driver is managing safe tram separation. The driver is also able to pass signals at danger on short notice, therefore limiting impact on line traffic. Therefore, in order to limit capital expenditures, redundancy is not an essential feat for the CBTC architecture. However, this should not be detrimental to the system availability to avoid resorting to a potentially cumbersome manual operation of the Platform Screen Doors through alternative devices available to the driver during onboard CBTC failure (e.g. portable hard-wire as done in Dubai or wireless).

The third benefit of CBTC is its capacity to provide an integrated tram tracking and supervision function to the Operation Control center, relying on the CBTC localization function and an Automatic Train Supervision (ATS) system. In Dubai, the choice was not to perform this supervision function by CBTC but by an independent traffic control system, commonly used in classic tram projects. In addition to having the operator familiar with this tram traffic supervision tool, this would allow the operation to carry on based on rules and procedures, in case of CBTC failure.

The Dubai Tram was not only the first tram to be equipped with a CBTC but the projected design had to take other technical innovations into account, such as ground-based traction power (i.e. no overhead contact line), and Platform Screen Door management, all these developed within a harsh local environment (temperature, humidity, salinity, dust.)

Mid-height pedestrian fencing and road crash barriers are installed along the track alignment. Therefore, crossroads
and pedestrian crossings excepted, the tram is operated in a dedicated corridor, although it cannot strictly be considered as a reserved track when compared to metro systems.

Tram priority request and intersection clearing are performed by means of inductive loops in Dubai tram. Another potential upgrade would be to use the CBTC localization system to perform the same function. Here again, there is a compromise to be made between CBTC availability targets and the possibility to continue nominal operation at cross roads regardless of CBTC failures.

CBTC interest in tram application becomes more profitable for tram applications when some sections or branches of the line require higher running performance targets closer to LRTs: these higher targets can only be achieved with reserved tracks. In some cases, these applications can be referred to as “tram trains”. CBTC may enforce limited constraints on the road traffic or pedestrian shared tracks where driving on sight is the rule, as in Dubai operation mode, and then switch to a more “metro-like” GoA1 mode of operation on other sections of the line.

Depending on the track map and operational constraints, CBTC may even be adapted to the required level of tram control by alternating sections of the line ranging from:
- continuous track to train control,
- spot track to train transmission from switchable beacons,
- on-sight driving with fixed speed limitation, assistance in road crossing management.

One challenge based on the lessons learnt in Dubai is CBTC management of road crossings: how to provide CBTC protection without impacting the running performance of the line? In Dubai, road crossings are not equipped with barriers for road vehicles: the risk of passing a signal at danger is quite different between a signalling railway signal and a tram road traffic signal.

**The future**

Driving a tram equipped with CBTC represents a challenge as the driver must pay attention to the cabsignal HMI and to the external events bound to non-reserved tracks. Future development in tram could consist in the use of additional trainborne detection devices comparable to driverless road vehicles already on trial on some roads in the USA or Sweden. Such “driver assistance system” based on stereovision cameras recently received a certification for Tram application in Germany. Another interesting development could focus on the driver HMI by providing heads-up display (HUD) in order to ease the task of the driver in non-reserved tracks. Trainborne devices could complete the range of functions provided by CBTC systems to offer an efficient signalling package customized to every client’s future tram operation need.

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