IRSE INTERNATIONAL TECHNICAL COMMITTEE

WHAT CAN SIGNALLING DO TO ENHANCE RAIL OPERATIONS? A VISION FOR SIGNALLING AND TRAIN CONTROL FOR METROS AND MAINLINE RAILWAYS

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Any rail transportation infrastructure, whether metros or mainline railways, represents a tremendous capital investment in terms of the right-of-way and stations, with significant on-going life-cycle costs to maintain the infrastructure in a state-of good repair. This investment is justified on the basis that the infrastructure provides the foundation for the movement of passengers and freight within the network covered by the infrastructure.

The actual safe movement of passengers and freight on this infrastructure is however only possible through the implementation of signalling and train control systems. Indeed, it is the signalling/train control systems that enable the return on the infrastructure investment to be realized.

While signalling/train control systems are the enabler of rail/transit operations, they can also impose a constraint on operations for example by constraining the achievable line capacity or by limiting the flexibility of train movements while, in addition, incurring substantial ongoing maintenance costs.

The goal of future signalling/train control systems therefore can be stated as to maximize (optimize) the utilization of the rail transportation infrastructure and to remove the signalling system as a constraint on rail system operations, while still providing for the high level of safety of train movements expected by the passengers. This would be achieved by maximizing line capacity (limited only by the infrastructure and rolling stock performance), providing for high system availability (with degraded modes of operation in the event of equipment failure), and permitting flexible train movements i.e. any train movement that is supported by the infrastructure should be safely permitted by the signalling/train control systems - all with a system design that minimizes life cycle costs.

Many rail transportation authorities have demonstrated the business case for re-signalling with a modern signalling system on the basis that the only other alternative would be to construct additional rail lines to accommodate the required capacity, which would be orders-of magnitude more expensive.

So, looking to the future, we can expect the priority for signal and train control engineers to be increasingly focused on optimizing the movement of passengers and freight, by maximizing the utilization of the available rail infrastructure and by enhancing rail/transit operations, in addition to ensuring the safety of train movements.

The key elements of any signalling and train control system will continue to be:

a) A method to safely and reliably locate the position of every train operating within the network within an accuracy and precision to meet both the safety and operational requirements.

b) A method to safely and reliable communicate status and command information between central, wayside and train-borne equipment where the data communications infrastructure has sufficient bandwidth and exhibits sufficiently low latency to support both the safety and operational requirements with a protocol structure that supports timely and secure delivery of train control messages.

c) A method to establish limits of movement authority for every train operating in the network and a method to enforce compliance with these authorities.

d) A method to manage and regulate train movements utilizing optimization algorithms and decision support systems to ensure stability of network operations even in cases of operations at the capacity limit.

e) An ability to integrate seamlessly with other operating elements of a metro or railway system to include traction power systems, tunnel and station ventilation systems, passenger information systems, etc. in a manner that exploits the operation and safety capabilities of the signalling and train control system, such as:

- Real-time availability of precise location, speed, and operational status of each train.
- Ability to communicate train health status and other system alarms to a central control location.
- Real-time ability to restrict train movements in response to detected hazardous or other conditions.
- Inherent bidirectional capability and ability to reroute and reverse train movements either automatically or in response to user inputs.
- Ability to predict train arrival times at downstream stations for schedule regulation and other purposes.
- Ability to coordinate multiple train movements for junction management and/or energy optimization purposes.

While the signalling systems will continue to provide the safety functions, and the train control systems will continue to provide the operational functions to optimize the performance of the railway within the constraints imposed by the signalling system, and while these two components may continue to be comprised of physically separate elements, from an overall systems architecture perspective the signalling and train control systems will increasingly be viewed as an integrated “train control and train management system” with capabilities to:

1) Maintain the highest practical levels of safety, not only during normal operations but also during degraded and emergency operations. While fail-safe design principles will continue to be the foundation of signalling system designs, increased emphasis will also be placed on providing an ability to continue to move trains safely in the event of equipment failure through designs that support degraded modes of operation with minimum reliance on adherence to operating rules and procedures.

2) Provide for increased levels of system availability by ensuring that components and materials are selected and appropriate standards of quality control and test procedures are employed to ensure the lowest practical hardware failure rates for individual items of signalling and train control equipment. In addition, unless non-redundant equipment is sufficiently reliable to satisfy the overall system availability requirements, appropriate levels of equipment redundancy will be employed such that the failure of a single component, processor, or device will not render the signalling or train control system unavailable or an operationally critical function non-operative. The trend seems that all track-based signalling/train control equipment will be eliminated to the maximum extent practical in order to minimize equipment/component access and track maintenance requirements and signalling/train control equipment will increasingly be train-borne and located in readily accessible wayside or central equipment rooms.

3) Provide for improved maintenance and diagnostic capabilities to detect and react to signalling and train control equipment failures, including remote diagnostics capabilities as well as local built-in test equipment and other fault displays for troubleshooting, and the timely identification of failed components and functions. Data logging capabilities will also be provided in wayside and train-borne equipment to permit the recreation of a sequence of events to allow maintenance personnel to identify the cause of any failure and/or mis-operation of equipment that cannot be identified by the in-built diagnostics of the equipment.

4) Support increased levels of automation (with fully automatic (unattended) train operations increasingly becoming the standard for metro rail transit operations), with close-loop control to increase the precision of control, and to optimize capacity and trip times on all key routes.

5) Support signalling principles based on a “moving-block” train control philosophy that will become the standard, replacing “fixed block” train control with no

reduction in safety levels but providing increased operational capability and flexibility. Another way of achieving the same objective would be to reduce the length of the fixed blocks to, e.g., tens of meters.

6) Utilize "information technology" based on a data communications networks that provided for high capacity, reliable and timely communication of control and status information between wayside signalling/train control devices, between wayside and train-borne devices (utilizing radios as the communications medium), and between train-borne devices within a train.

7) Provide for the integration of all control functions onboard the train, and provide for the integration of all control functions at central and station-level control centres including support to a wide range of wayside and train-borne external interfaces designed to enhance passenger safety and comfort, and to minimize passenger journey times.

8) Be of modular design to permit application to a wide-range of operational requirements without requiring extensive re-certification of standard safety functions and to be responsive to changing requirements.

9) Require minimum field testing after installation by utilizing integrated factory test facilities that accurately simulate the actual operating environment.

10) Comply with international (rather than solely national or railway-specific) standards that support interoperability and interchangeability between trains and trackside to reduce the cost between equipment providers.

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