

Two-Lane Rail Line Design, Parallel Double-Track Expansion

Digital rail technology empowers freight trains and cargo wagons to operate without stopping or waiting in front of signal box systems. It provides the technological base to commute autonomously between metropolises, cities, and logistic hubs and transport cargo at high-speed coast-to-coast to the benefit of industry, society, and the entire nation. To operate digital trains safely, accelerate, decelerate, avoid oncoming trains, and overtake slower traveling trains ahead by changing tracks, parallel rail tracks (aka. parallel double-tracks) are required and a prerequisite for digital train operation.

Operators of digital railways benefit from faster train frequencies and a higher number of trains traveling simultaneously. Precise train positioning is key when securing minimum braking distances between trains. Transponders (aka. balises) installed in the track sleepers are the basis, signaling train positioning to onboard computers and supporting digital imaging of the train as a moving block. Fully implemented, the digital double-track can transport additional billions of dollars in freight capacity and cargo value securely and efficiently.

The Digital Switch, Digital Interlocking

Under consideration of programmable train movement authorities, the decentralized operating digital switch calculates real-time optimal train priorities, routes, and speed levels while syncing with the centralized monitoring unit, managing redundant backup processes such as train control and emergency braking. The digital interlockings comprise most of the digital computing power and rail track intelligence and are the key to a fast, autonomous, and secure train traffic flow. A digital interlocking comprises the following three main components:

- 1) The Electronic Interlocking (EI): to operate and position the switch and secure the train on the double-track
- 2) The Radio-Block-Center (RBC): a control and safety system for calculating movement authorities, real-time
- 3) The Signaling Antenna (GSM-R): for continuous data transfer between the digital switch and the moving train.

Digital Standards for Train Control, Satellite Technology, Digital Diagnostics, AI/Algorithm, Rail Cyber Security

Harmonized, digital standards, e.g., ETCS are key for secure train operation. It enables digital imaging of trains as moving blocks and forms the basis for other standards, such as ATO-Go (aka. autonomous train operation). To enable fully automatic train operation and autonomous movement of individual rail transport units, expansion stage GoA 4 is required. Digital technologies also support the following fields of rail transportation:

- A) Maintenance, e.g., Digital Diagnostics, Ultrasonic Technology for inspection of brake discs, wheel materials
- B) Maintenance, e.g., Asset Monitoring, AI/Algorithms for identifying damage patterns on equipment, tracks
- C) Train Safety, e.g., Train Positioning, Safety Distances, real-time comparison of movement<>satellite data
- D) Rail Cyber Security, e.g., Data encryption and coding, IT/OT Convergence, Digital Rail Network Monitoring

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