Digitalization of Interlocking System to Optimize Logistics in Railway Transportation

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ABSTRACT

Effective logistics management plays a crucial role in the railway industry for transporting goods and people. There is a need to improve the railway infrastructure to meet today’s increasing demand for railway transportation. Digitalising the railways help improve the old dilapidated infrastructure which could cause train delays in railway logistics. Interlocking testing is a priority, requiring stringent procedures guided by rail safety regulations. Historically interlocking testing required significant protocols and effort resulting in expensive resource allocation in the form of personnel, equipment, and time. This study examines modernised technology that presents the new configuration setup and improves processes that can potentially replace traditional methods. The findings of this study prove that the use of this new technology in railways can significantly reduce the amount of time spent on this process, increase the reliability, and save on human resources.

KEYWORDS

Authentication Of Interlocking FAT Tests, Automated Testing, Digital, Interlocking System Configuration, Logistics

INTRODUCTION

The first public railway in South Africa was built in the early 1860s and ran from Durban point harbour to Durban market square according to (Cottrell & Michael, 2010). This rail was primarily for service industries such as blacksmithing, carpentry, and the sugar industry. The first steam train was built on the 26th of June 1860 in South Africa (Cottrell & Michael, 2010) The extension then later spread to Umgeni for transportation of stone. The increased use of rail necessitated the improvement of safe movement of trains guided by principles and philosophy thus railway signalling is obligatory. The elevated demand for railway transportation services has resulted in a spotlight on safety and reliability, this calls for stricter guidelines and improved methods for signalling.

Signalling originates from the need of safety in the railway industry, safety standards and procedures are imperative and are used as measures to guide the signalling philosophy. Signalling uses interlocking which guides signalling elements through an arrangement of tracks, points, and signals to prevent prohibited train movement. Before a train station is commissioned, there need to be a validation test for the interlocking system. These tests are analysed during FAT testing and allow for the safety of the system as well as train movement to be tested in a controlled environment. These systems use a fail-safe system that is meant to ensure the components are reliable, and the trains do not collide with one another.

DOI: 10.4018/IJBAN.2020010102
Interlocking backdates to as early as the 1840s when the block system was introduced, this introduction eliminated lots of difficulties involved in the older system (King & Edgar, 1921). Power interlocking presented track circuits and some improvements were made better and automatic block systems were perfected (King & Edgar, 1921). There are different types of interlocking systems currently used (Nathoo, 2015) these consists of the mechanical, electro-mechanical, relay and electronic-based interlocking. Mechanical interlocking uses a simple concept of wire pulling system using levers to control signalling elements. Electro-mechanical systems use the combination of the mechanical element and relay-based interlocking (Nathoo, 2015). Relay interlocking replaces the mechanical structure with the relay controlling the signalling elements using a virtual display unit (VDU) technology (Nathoo, 2015). Modern interlocking systems use Programmable Logic Controllers (PLC) or Microprocessors which are based on electronic systems and monitor instructions issued through computer VDUs.

These elements optimise safety and when connected form an interlocked system which is a fail-safe. Elements configuration is associated with the setup of the station to pool the components together and make a complete system. The setup is evaluated on the shipment of the complete product to the installation site.

When these elements are interlocked such as signalling lights (Vanit-Anunchai, 2010), points and track circuits, the train movement is initiated in the control centre (Dincel, Eris, & Kurtulan, 2013) by a system feedback loop that causes elements on a particular route to form a safety path for train movement, these routes are categorised and differentiated by classes (Weerakody & Don, 2012) these classes are:

- The main route: is permitted on main lines, these routes are also used in the block sections to cross over to the train station. Main routes require overlap, the main route should also be protected by a joining junction deflecting any running wagons or trains from the main line. The main route also requires that points, overlap, and flank must be locked and detected before routes can be operated.
- Shunt routes are used for shunting the movement of trains, shunting movement is done using shunt signals for train movement. Shunt routes require track vacancy and berth track to be occupied before the operation.

During FAT tests these route classes are tested for operational functionality and safety using standardised guidelines through control tables (Tombs, Robinson, & Nikandros, 2002). A Control table is an organised tabular presentation of rules that are used to guide and specify the signal interlocking (Table 1). These guidelines are derived from the procedures and principles that are applied in the railway industry and used to test different routes that are tabulated for that particular station (Tombs, Robinson, & Nikandros, 2002), the control table prescribe the test standards against FAT testing (Bonacchi & Fantechi, 2014).

Figure 1 above illustrates, the control table displays the following: route numbers, signal elements, destination signals, tracks and points/switches which are affected on that particular route. Recently new forms of testing processes have been introduced to decrease the test time of the interlocking tests. New techniques for testing interlocking system, where applicable, such as the method of generating test cases with the help of Satisfiability Modulo Theories (SMT) Solver output (Li, Liu, Sun, Zhou, & Sun, 2017) These programmes can predict possible accidents on train routes, and simulate train movements (Sriram & Sheerazuddin, 2016).

Modern systems have been introduced like the European Railway Traffic Management system (ERTMS) (Durmuş, Yıldırım, & Söylemez, 2013) which are integrated with software validation processes. Validation is of vital importance in the signalling environment and could determine the safety-critical systems (Lecomte & Mottin, 2016) the process is complex and tools which are practised in today industrial are expensive for small companies (Fantechi, Fokkink, & Morzenti, 2012). In order to cut down costs introduction of some methods and tools for validation is introduced, Petri Nets
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