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An Innovative Approach to Railway Signalling in Sri Lanka: Appraisal of Technical and Economic Rationale

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1. Introduction

The objective of a railway signalling system is to provide a safe and efficient passage of trains. Railway signalling systems are designed as failsafe to avoid the emittance of erroneous signals to trains due to equipment failure [1]. At a time of signal failure, trains have to be operated using manual signals in accordance with established rules and regulations. These manual operations carry a much higher risk, entail unnecessary delays and need to be avoided as much as possible. Therefore safety, reliability and ease of maintaining a railway signalling system is of paramount importance for the safe and efficient operation of trains [2].

According to an analysis by the signal department of train delays caused by signal failures in year 2017, there were approximately seven signal breakdowns per day causing an average delay of 43 minutes a day. This calls to question the reliability of the existing system and highlights the need for either the introduction of a new system or an upgrade of the available system.

This paper therefore presents a summary of the innovative research undertaken to design, construct and implement a signalling system for the Sri Lanka Railways.

2. Background and lessons learned from the past

The signalling systems have evolved from initial mechanical systems through multiple aspect colour light signalling system (MAS) to communication based train control. MAS, which was adapted in 1923 in Great Britain, is the leading method of operation throughout the world today. In this system unsafe situations are prevented by an arrangement of tracks and junctions by a signal apparatus (interlocking) in a way that conflicting movements are barred.

The mechanical signalling system introduced during the British era is still operational in most of the railway network today and relies totally on manpower. With increasing traffic densities delays due to inefficiency and human errors are unavoidable.

MAS was first introduced to Sri Lanka Railway in 1950s. That relay based MAS is currently in operation in Colombo and suburbs. Relays used for these systems were manufactured by a company called Eriksson from Sweden, which unfortunately does not manufacture these relays anymore.

A processor based MAS replaced mechanical signalling in the costal line from Kalutara North to Galle in year 2000. Fifteen years after installation it was noted that installed versions of electronic interlocking cards are no longer in production and newer available versions are not compatible with the existing system. To make matters worse due to the complexity of the system a contractor's assistance was required to carry out modifications amounting to an enormous cost and significant delay.

With this background it was imperative to introduce a standardised new signalling system to replace obsolete relay based systems and mechanical systems.

3. Literature review and market assay

The planning and construction division of Sri Lanka Railways looked into available options for upgrading the existing system. The first option considered was a processor based MAS system which is currently widely used in the world. An initial market survey mainly through vendor web sites revealed a number of processor based MAS systems from different manufacturers such as VPI (General Railway signals, now Alstom), Micro lock (General Railway Signals, now Ansaldo STS), West lock and Wes trace (Invensys rail, now Siemens), and Smart lock (Alstom) MEI 633 (Medha), K5B series (kyosan) and E132FA (Nippon signalling).

However, there are many constrains to adopting this system. The most important factor that needs to be taken into account is the fact that these systems are rapidly evolving. Upgrading or replacement of the system installed needs money and expertise for either [3]. For example, Nock (1985) notes that the 'first generation processor based MAS systems developed with the collaboration of British railway, GEC-general signal and Westinghouse signals in the 1980s under the brand name of Solid State Interlocking' are no longer being manufactured [4]. Also, the current processor based MAS system located in the coastal line from Kalutara North to Galle has to be upgraded to a newer version with the older version no longer being manufactured.

The second factor was related to the installation and maintenance of the system, as although a certain brand would be selected based on the available procurement guidelines there is no guarantee that the same manufacturer would be selected for replacement or extension of the existing system. Due to the diversity of vendor specific programming applications and programming idiosyncrasies it is not feasible or sustainable to have systems supplied by different manufactures.

The second option considered was relay based MAS systems. Similar to processor based MAS systems there are number of available relay based MAS systems in the market according to vender websites can be given as Siemen's relays, B-style relays used in USA, N. S1 relays based on French standard (SNCF), Arteche auxiliary relays and Q-type relays.

The relay based MAS system in operation in Sri Lanka railways (Erickson) is no longer available in the market today.

Q-type relays based on BS 930 standard is widely available around the world. This is due to the fact that there is BR 930 specifications and number of variations catering to different applications leading to universality and versatility unlike others which are region specific. Also, the carbon to carbon relay contacts in Q-type relays reduce the probability of contact welding than in Ericson relays which use metal to metal contacts improving the safety of the system. Furthermore, Q-type relays have a competitive price advantage due to the high demand and availability of large number of manufacturers. According to IRSE (2013) in year 2013 demand in UK for Q-type relays was 50,000 [5]. Q-type relays are being manufactured by multiple manufactures based in India, Australia, United Kingdom, Netherlands and USA.

4. Designing of new system

After taking the above factors into consideration it was concluded that Q-type relay based MAS system would be the best option for the upgrading of existing railway signal system of Sri Lanka as it is the most economical, easy to maintain and sustainable system available in the market.

When designing the system several factors pertaining both to the relay type and positioning of signals were taken into consideration.

The Q-type relays are available in both latch and non-latch types. British relay interlocking design approach developed by Indian railways and its suppliers have refrained from utilizing latch type relays for their designs. This non-use of latching relays necessitates availability of a very reliable power supply arrangement as power failure can result in loss of memory of previous operations. Also, by using latch relays, safety interlocking is achieved with less number of relays in comparison to Indian British relay interlocking approach.

Therefore, the new design incorporated latch type relays to take advantage of these factors.

Provision of overlap protection: that is the length of the track beyond a stop signal, that proved to be clear of vehicles in the controls of the previous signal, as a safety margin, which was somewhat overlooked in the numerous modification stages of the existing Ericson system was improved based on signalling principles.

Centralized traffic control (CTC) which enables consolidation of train routing decisions carried out by local signal operators improves the efficiency of the system and minimises man power necessary to maintain the system. As an initial step in facilitating CTC, programmable logic controller (PLC) was incorporated as the interface between relay interlocking and operator panel (human machine interphase (HMI). This gave the added advantage of system event logging for trouble shooting and incident investigations. Furthermore, it enabled the introduction of a graphical user interface for high level process supervisory management (supervisory control and data acquisition - SCADA).

To improve the visibility and reliability, LED signals were used instead of incandescent bulbs.

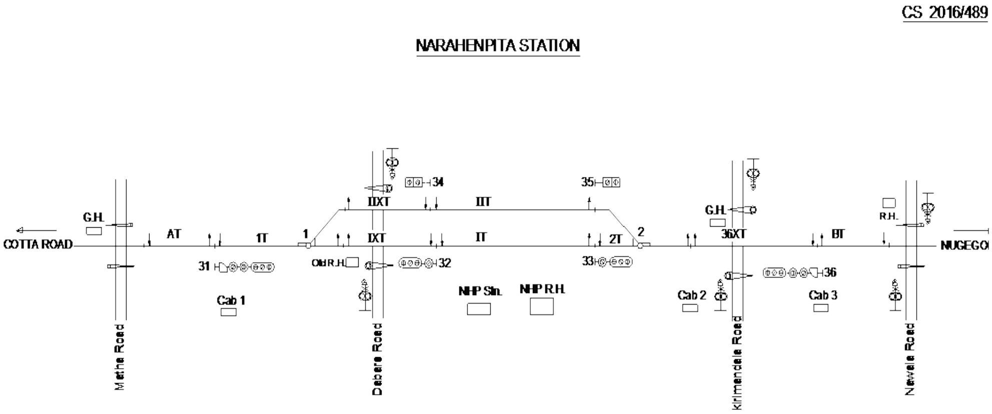

Figure 1: Narahenpita station signal arrangement.

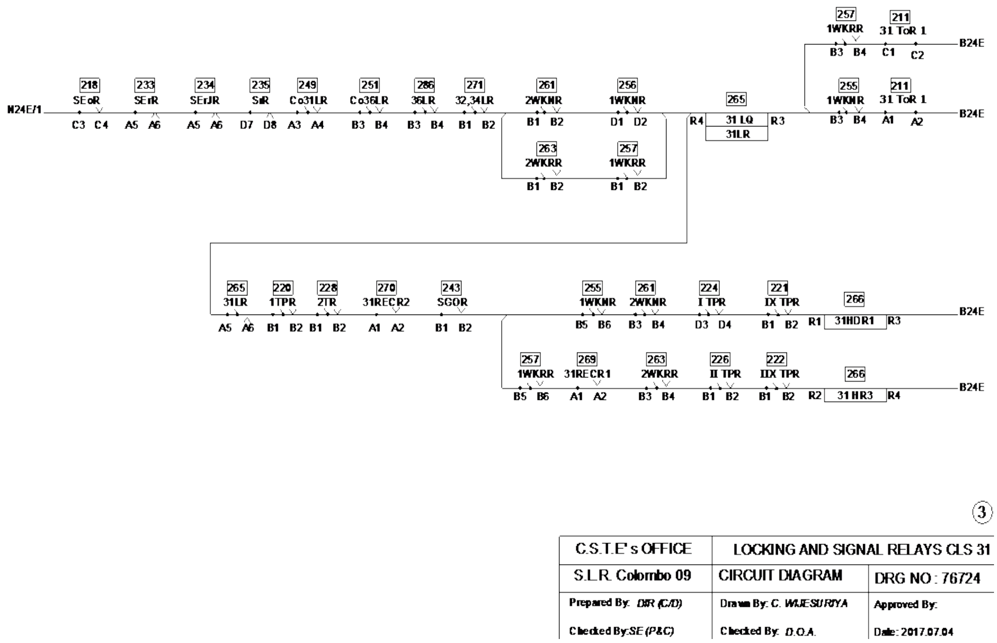

Figure 2: Relay design diagrams

5. Implementation of new system

It was decided to implement the designed system at a single loop station as the first step in standardizing the signalling in Sri Lanka Railways.

Narahenpita railway station was selected to implement newly designed signalling systems due to its close proximity to Colombo and for ease of monitoring and implementation. The earlier signalling system at Narahenpita consisted of C type mechanical signalling system, where points for track deviations were hand operated and trains were admitted by the station master.

Later Nugegoda station was also provided with a similar colour light system

Figure 3: Relay interlocking

Figure 4: New Signalling system at Narahenpita

6. Results and benefits

As per the mechanical yard signalling arrangement which earlier existed at the Narahenpita station only entry signals were provided at both ends. Other than presentation of giving both entry signals at the same time, no other safety measures were adopted by the system. Diversion between tracks at the station was done by manual operation of diversion points by the pointsman who would then show the green flag for the train driver until the train passes the point. Then again, he has to go to the other end of the loop line to do the same. As these manual operations are no longer necessary the newly implemented system has markedly improved the efficiency of the system cutting down operational delay time by around two minutes.

It has also improved the safety which was hitherto given by the station master guided by the railway rules and regulations. Also due to automation of point operation, station cadre has been made redundant and can now be used elsewhere: thereby reducing the operational cost at the station.

The total cost of one such installation was found to be only Rs. 15 million. If one to consider recent procurements of similar signalling systems by Sri Lanka Railways, which came with hefty price tags totalling more than Rs 300 million per station, this innovative approach by Sri Lanka Railways signal sub department has resulted in savings of around 285 million per station.

7. Conclusions

This innovative approach taken by signal sub department has resulted in saving Rs. 285 million per station. This shows the huge potential of money saving and advancement make possible by research and development (R&D) in railway signalling. This is a good example to showcase the effect of innovation in railway signalling and the contribution it can make to the development of our nation. While creating wealth for the nation by gaining a cost advantage, knowledge generated by R&D could facilitate further expansion into railway signalling solutions and related areas.

In comparison with the metal to metal contacts used in Ericson relays, carbon to carbon contacts used in Q type relays for the Narahenpita colour light system has shown higher failure rate. Also, poor track condition at station yards has created higher number of signal failures due to track circuit defects.

Based on the Sri Lanka Railway experience, relay signalling systems are robust, durable, and easier to maintain in comparison with processor based signalling systems. But relay based systems tend to consume more power and require more space to install.

8. Future

Before the end of year 2018 the Maharagama station will be converted to relay based MAS signalling, and then all three stations would be connected to central control at Maradana for efficient operations.

Through the motivation, dedication, the knowledge and skills obtained with this experience, the upgrade of the Sri Lanka Railway signal system will not end up a mere dream.

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