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Research Article

Implementation of Positive Train Control (PTC) or ETC (European Train Control System) in Bangladesh Railways: A Sustainable Approach

Nafis Al Imran*

Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh

Abstract

Bangladesh Railways, nowadays faces noticeable challenging issues in safety and efficiency as well as capacity due to backdated signaling and train control systems. This research evaluates the feasibility of the implementation of Positive Train Control (PTC) or the European Train Control System (ETCS) to give a modern solution to Bangladesh Railway operations. A multi-criteria analysis compares economic, technical, and operational factors while case studies from the USA (PTC), Europe (ETCS), and India (Kavach) provide benchmarks. The study identifies Dhaka-Chittagong as the optimal pilot corridor and proposes a phased implementation strategy that includes cost-benefit projections. Result indicates that ETCS level to is more applicable for Bangladesh Railway because of its interoperability with future regional networks. On the other hand, PTC offers a cost-effective solution for the high- density routes. This paper concludes by giving a roadmap for adoption, working on training challenges, and addressing funds. This research mainly focuses on the feasibility of implementing PTC or ETCS to modernize Bangladesh Railway operations. A multi-criteria analysis compares economic, technical, and operational factors was made form the studies from USA (PTC), Europe (ETCS), and India (Kavach) provide benchmarks. Through multi-criteria analysis assessing economic viability, technical adaptability, and operational impact- supplemented by global benchmarks like PTC in the USA, ETCS in Europe, and India's Kavach, the research identifies ETCS level 2 as the optimal choice for Bangladesh. The recommendation prioritizes its regional compatibility, automated safety features and scalability. While PTC remains a nice option for high-density routes, the Dhaka-Chittagong corridor (handling 60% of national rail traffic) is selected for the pilot phase due to its economic importance and existing semi-automated infrastructure.

Keywords

Railway Safety, PTC, ETCS, Bangladesh Railways, Signaling Modernization, Smart Transportation

1. Introduction

1.1. Background and Context

Bangladesh Railways operates near about 3, 200 km of track that serves millions of passengers yearly [17]. However, frequent accidents, delays, and slackness underscore the importance for modern signaling and the train controlling system. PTC which is used in U.S.A and ETCS which is used in European standard that are advanced train protection systems that

*Corresponding author: nafisalimrandgbhs2017@gmail.com (Nafis Al Imran)

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increase safety by the automation of speed enforcement, collision avoidance, and real-time observation. In recent years it has been observed that multiple deadly train accidents and derailments, often attributed to error caused by human and lack of safety system which is automated. For example, in 2019 a collision occurred in Dhaka-Tangail [17, 27] rail route which resulted in numerous casualties that highlighted the urgent need for modernization. After this the government of Bangladesh has expressed intertest in adopting advance train control technologies like Positive Train Control (PTC) and the European Train Control System (ETCS), for enhancing the safety [1, 5], and operational efficiency.

1.2. Problem Statement

The signaling system of Bangladesh Railways relies on manual and semi-automated block signaling that is prone to errors and lacks real-time monitoring [15, 16] capabilities. Some key challenges including:

1) The rates of high accidents due to over speed vehicles, signal violations [10, 17], and miscommunication.
2) Lack of interoperability with modern rail system [8].
3) Infrastructure issues that facing problems to meet the growing demand [18].

For addressing these issues, automated train control systems which is known as ATCS. Some automated train control system like PTC (used in the U.S.A) and ETCS (European standard) which offer regulation of automated speed, collision prevention, and the centralized traffic system management. But implementing such system in Bangladesh requires careful consideration of cost, technical feasibility, and readiness of infrastructure.

1.3. Objectives of This Study

This research aims to on the following point:

1) Evaluation of the suitability of PTC and ETCS for adopting in Bangladesh [7, 20].
2) Comparison of the economic and technical aspects of both systems [4, 6].
3) Identification of the challenges in implementation like financial, workforce related, and infrastructure [15, 19].
4) Proposal of a strategic for phased adoption [21].
5) This study ensures a holistic approach for the implementation of PTC or ETCS in Bangladesh Railways.

1.4. Significance of This Study

1) Assisting policymakers in making significant decision on the modernization of rail [22].
2) Increasing safety and efficiency by the reduction of human caused errors [10].
3) Supporting long-term expansion of rail network [18].
4) Giving a contribution to Bangladesh's Vision 2024 by the improvement of the transportation infrastructure [16].

2. Literature Review

2.1. Positive Train Control

Its PTC which is a GPS-based system that is used primarily in the United States to prevent train to train collision and fatal rail accidents [1, 2] and unauthorized incursions. It indicates the following points which is very important in railway communication system:

1) GPS tracking system
2) Wireless communication system
3) Centralized railway traffic control system

2.2. European Train Control System (ETCS)

It is a part of the European Rail Traffic Management System (ERTMS) which features a different level of automation:

1) ETCS Level 1: Balise-based control [5].
2) ETCS Level 2: Continuous wireless control via GSM-R [5, 9, 24]
3) ETCS Level 3: Movement by block signaling which is fully an automated system [6].

3. Current State of Bangladesh Railways

3.1. Recent Example of Train Control System in Bangladesh

3.1.1. Dhaka Metro Rail (MRT Line-6)- ETCS Level 1 Signaling System [5, 8]

1) For safety operation Dhaka Metro Rail (MRT Line-6) uses ETCS level 1 with Automatic Train Protection (ATP) for safe operations as it's not a part of Bangladesh Railways.
2) This process ensures speed control, prevention of control and automatic braking system.
3) The success of this system could encourage Bangladesh Railways to adopt similar standards of ETCS.
4) The success of this system could encourage Bangladesh Railways to adopt similar standards of ETCS, though interoperability challenges with legacy systems must be addressed [23].

3.1.2. Bangabandhu Sheikh Mujib Railway Bridge- Modern Signaling & Control Systems [16]

1) The new rail bridge is featuring modern signaling system and train control systems like ETCS- technologies.
2) It improves safety and allows higher-speed train operations.

Figure 1. *Bhairab Train Collision incident (October, 2023).*

3.2. Train Accidents Analysis in Bangladesh (Recent Years)

3.2.1. Bhairab Train Collision (October 23, 2023) [17]

1) *Location:* Bhairab, Kishoreganj
2) *Incident:* A train collided with Turna Nishita Express from behind.
3) *Casualties:* At least 18 killed over 100 injured.
4) Post-accident investigations highlighted systemic failures in signal enforcement and underscored gaps in safety management systems [14].

3.2.2. Kalurghat Train Collision (June 05, 2025) [17]

1) *Location:* Kalurghat, Chattogram
2) *Incident:* The train entered the bridge at high speed without stopping at the dead stop signal after pa ssing Gomdondi station.
3) *Casualties:* 2 people died and approximately 22 injured.
4) Similar PTC-related failures were documented in U.S. NTSB reports [3], emphasizing the need for automated controls.

Figure 2. *Kalurghat Train Collision (June 05, 2025).*

3.3.3. Mirsorai Train Collision (July 30, 2022) [17]

1) *Location:* Mirsorai, Chattogram
2) *Incident:* Train collided with a microbus.
3) *Casualties:* 11 people died.

Figure 3.. *Mirsorai Train Collision (July 30, 2022).*

3.3. Existing Signaling and Control Systems

Aging electro-mechanical systems lack resilience against modern operational demands [11].

3.3.1. Manual Blocking Signaling System [15]

It is a manual blocking system in railways where train movements into a block section are fully controlled by the railway staffs by ensuring that only one train can take a block section at the same time.

3.3.2. Electro-mechanical Interlocking [16]

It is a safety system, preventing the confliction of train movements by ensuring that signals and routes are set in a way that avoids the collisions. A combination of electrical and mechanical components that are used to achieve, with electrical signal controlling and mechanical locking mechanism.

3.3.3. Limited Automatic Signaling (Only in Dhaka-Chittagong Route)

Bangladesh Railways relies on the manual and also electro-mechanical signaling systems, which are outdated now because of human error. Moreover, the route of Dhaka-Chittagong mainline stands out as one of the few routes that are adopted with limited automatic signaling and make is the most advance rail corridor in Bangladesh.

3.4. Major Safety Concerns

1) Human errors (65% of accidents) [10, 17]
2) Violation of signal
3) Lack of real-time monitoring

3.5. Current System on Dhaka-Chittagong Route

1) Automatic Block Signaling (ABS)

2) Color-Light Signals

3.6. Why Only on Dhaka-Chittagong Route

1) *High Density of Traffic:* This route connects two largest cities of Bangladesh the handles over 60% of freight and passengers also.
2) *Economic Importance:* It's a critical route for trade and business level for in Chittagong port.

3.7. Limitations of the Current System

1) Not fully automated
2) No advanced train control system
3) Implementations of patchwork

3.8. Comparison with Global Standards [6, 12]

Best practices for signaling upgrades stress modular compatibility [23], a gap in Bangladesh's current approach.

Table 1. Key Differences Between Current and ETCS Level 2 Railway Signaling.

Feature	Dhaka-Chittagong (Current)	ETCS Level 2 (Recommended)
Automation Level	Semi-automatic	Automated
Train Detection	Track circuits	Continuous monitoring by GSM-R
Collision Prevention	Limited	Automatic braking
Real-Time Updates	Partial	Full

4. Comparative Analysis: PTC vs. ETCS for Bangladesh

Table 2. Key Differences Between PTC and ETCS Train Control Systems.

Characteristics	PTC	ETCS
Technology Base	Wireless and GPS	GSM-R Balises
Automation Level	Semi-automatic	Automatic fully
Implementation Cost	High (US- based)	Moderate (EU-based)
Compatibility	Limited global use	Widely use in Asia and Europe
Maintenance	Complex	Modular

Recommendation: ETCS (Level 2) is more applicable and acceptable due to its scalability, adoption and effectiveness.

5. Implementation Strategy

5.1. Phased Approach

A. Expansion to Important Routes
   1) Integration of GSM-R communication system
   2) Deploying ETCS level 2.
B. Pilot Project (Dhaka-Chittagong route)
   1) Training of the staffs and test system
   2) Installation of ETCS level 1
   3) Adoption of ETCS must integrate energy-efficient protocols to align with sustainability goals [25, 26].
C. Network Coverage
   1) AI based predictive maintenance
   2) Adoption of ETCS

5.2. Financial Considerations

1) Approximate Cost: $2-$2.5 billion [7, 19]
2) Funding Sources:
   a) Public-private partnership [19, 22]
   b) ADB loans [19, 22]

5.3. Financial Considerations

1) Approximate Cost: $2-$2.5 billion [7, 19] with potential long-term energy savings [26].
2) Economic models confirm ROI from automation-driven efficiency gains [28].

6. Challenges and Mitigation

Table 3. Common Rail Modernization Challenges and Recommended Solutions.

Challenges	Solutions
Infrastructure limitations	Consequent upgrades alongside new projects [23]
Lack of technical expertise	Training programs
High cost	Fundings and international acceptance
Resistance to automation	Stakeholder engagement and SMS frameworks [14]

7. Result and Discussion

7.1. Key Findings

1. System Suitability:

ETCS Level 2 emerged as the optimal solution for Bangladesh Railways due to:

1) *Higher automation* (fully automated vs. PTC's semi automation) [5, 7, 8].
2) *Interoperability* with Asian/Europe network (critical for future regional connectivity).
3) *Moderate cost* compared to PTC (EU- based supply chains reduce expenses).

2. Pilot Corridor Identification:

The Dhaka-Chittagong route was selected for the pilot phase due to:

1) *Economic significance* (handles >60% of national rail freight/passengers).
2) *Existing semi-automated infrastructure* (e.g., Automated Block Signaling), enabling smoother ETCS integration.

3. Implementation Roadmap:

1) *Phase 1 (Pilot):* Deploy ETCS level 1 on Dhaka-Chittagong; train staff; test GSM-R.
2) *Phase 2:* Upgrade to ETCS Level 2; expand to high-density routes (e.g., Dhaka-Khulna).
3) *Phase 3:* Network-wide rollout with AI- driven predictive maintenance.
4) Predictive maintenance using AI [13] must comply with safety standards [11, 14]

7.2. Critical Challenges

1) *Financial Barriers:* High upfront costs (mitigated via PPPS and ADB loans) [19].
2) *Technical Gaps:* Lack of skilled workforce (addressed through specialized training programs) [15].
3) *Infrastructure Limitations:* Aging tracks and signaling (requires phased upgrades alongside ETCS) [16].

7.3. Limitations and Future Work

1) Cost projections assume stable foreign exchange rates [19].
2) Workforce training requires international partnership
3) Future models (e.g., ETCS + Kavach) for cost optimization [21].
4) Energy efficiency metrics [26] and regional sustainability benchmarks [25] should be integrated.
5) OECD economic models [28] can refine cost projections.

8. Conclusion

ETCS adoption supports UNESCAP's sustainable transport goals [25] and unlocks economic benefits quantified in OECD studies [28]. The application of ETCS Level 2 in Bangladesh Railways is attainable and important to modernize applications, reduce fatal accidents, and increase safety [5, 8, 20]. With the adoption of ETCS, Bangladesh Railways can attain global safety standards, better efficiency which will support the country's economic growth by the reliable railway transportation [16, 18].

Abbreviations

ETCS	European Train Control System
PTC	Positive Train Control System

Author Contributions

Nafis Al Imran is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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