**ELECTRICAL SYSTEM ARTICLES JOURNAL**
Journal of Railway Engineering Universitas Pancasila

Website : http://journal.univpancasila.ac.id/index.php/irtj/

# Impact of New Railway Line Development on Existing Signaling Systems

*Dampak Pembangunan Jalur Kereta Baru terhadap Sistem Persinyalan yang Ada*

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**Article information:**

Received:
xx/xx/xxxx
Revised:
xx/xx/xxxx
Accepted:
xx/xx/xxxx

***Abstract***

*The development of new railway lines, such as double-track and multi-track systems, is one of the main strategies to increase railway transportation capacity and operational efficiency. However, the addition of new lines often creates challenges for existing signaling systems that were originally designed for simpler track configurations. This study aims to analyze the impact of new railway line development on existing signaling systems and identify the adjustments required to ensure safe and efficient integration. The research applies a qualitative approach through literature review and analysis of railway infrastructure upgrade projects in Indonesia, including the Padalarang–Bandung and Kiaracondong–Cicalengka routes, as well as international case studies. The results indicate that the integration of new lines generally requires signaling system upgrades, including increased interlocking capacity, improved communication networks, and additional train detection devices. Without proper modernization, existing signaling systems may limit operational capacity and increase the risk of operational disturbances. Therefore, signaling modernization is a critical component in supporting railway line expansion while maintaining safety and reliability.*

*Keywords: railway signaling, new railway line, interlocking, infrastructure integration, signaling modernization*

**Abstrak**

**Pembangunan jalur kereta baru, seperti jalur ganda maupun penambahan jumlah jalur, merupakan salah satu upaya untuk meningkatkan kapasitas dan kelancaran operasional kereta api. Namun, penambahan jalur tersebut sering menimbulkan tantangan pada sistem persinyalan yang sudah ada, terutama jika sistem tersebut masih menggunakan teknologi lama. Penelitian ini bertujuan untuk menganalisis dampak pembangunan jalur kereta baru terhadap sistem persinyalan yang telah beroperasi sebelumnya serta mengidentifikasi penyesuaian yang diperlukan**

**agar integrasi dapat berjalan dengan aman dan efisien. Metode penelitian yang digunakan adalah pendekatan kualitatif melalui studi literatur dan analisis proyek peningkatan jalur kereta di Indonesia, seperti lintas Padalarang-Bandung dan Kiaracondong-Cicalengka, serta studi pembanding dari beberapa negara lain. Hasil penelitian menunjukkan bahwa integrasi jalur baru umumnya memerlukan pembaruan sistem persinyalan, meliputi peningkatan kapasitas interlocking, pembaruan sistem komunikasi, serta penambahan perangkat deteksi kereta. Tanpa modernisasi yang memadai, sistem persinyalan lama berpotensi membatasi peningkatan kapasitas dan menimbulkan gangguan operasional. Oleh karena itu, modernisasi persinyalan menjadi faktor penting dalam mendukung pembangunan jalur kereta baru secara optimal dan aman.**

**Kata kunci: jalur kereta baru, sistem persinyalan, interlocking, modernisasi persinyalan**

## 1. INTRODUCTION

The increasing demand for railway transportation, both for passenger and freight services, has led to the need for capacity expansion in existing railway networks. One of the most common approaches to address this demand is the construction of new railway lines, including double-track and multi-track systems. These developments are expected to reduce headway, improve operational efficiency, and enhance service reliability.

However, railway line expansion cannot be viewed solely as a physical infrastructure project. The newly constructed lines must be integrated into the existing signaling system to ensure safe and orderly train operations. In many railway networks, particularly in developing countries, existing signaling systems are still based on relay or analog technology with limited capacity and flexibility. When new lines are added, these systems may no longer be adequate to handle increased traffic complexity.

Several railway upgrade projects in Indonesia, such as the Padalarang–Bandung and Kiaracondong–Cicalengka corridors, demonstrate that signaling system adjustments are an unavoidable part of railway line development. Previous studies have shown that legacy signaling systems often restrict capacity and reduce operational flexibility when track configurations become more complex. Despite this, full system replacement is not always feasible due to cost, operational constraints, and human resource readiness. Therefore, this study focuses on identifying the challenges and necessary adjustments in integrating new railway lines with existing signaling systems.

## 2. METHODOLOGY

### 1. Research Design

This research uses a qualitative approach because it focuses on understanding field conditions, explaining the problems that arise when new lines are connected to existing signaling systems, and reviewing previously implemented modernization solutions. This approach was chosen because the research does not require numerical measurements, but rather emphasizes explanation, comparison, and understanding from various sources of information.

### 2. Subjects and Sample

The subjects of this research are new line construction projects and the signaling systems used within the railway network. The samples analyzed include several line improvement projects in Indonesia, such as Padalarang–Bandung and Kiaracondong–Cicalengka, as well as examples of modernization implementation from other countries for comparison. The samples were selected purposively, based on their relevance to the research topic, particularly projects involving the integration of new lines with existing signaling systems.

**3. Instrumentation**

This research used the following data collection tools:

- Documentation, such as railway technical reports, transportation journals, and official publications from relevant agencies.
- Literature review, which involved reading and reviewing previous research discussing legacy signaling systems, signaling modernization, and integration challenges.
- Secondary data, including information from publicly available news, project reports, and technical regulations.

**4. Research Procedure**

The research steps were as follows:

1. Collect information on the condition of the legacy signaling system and the development of the new line.
2. Identify problems that frequently arise when the new line is connected to the existing signaling system.
3. Compare the findings with research and modernization reports from other countries.
4. Analyze the needs and most appropriate modernization steps.
5. Develop a discussion and conclude on applicable strategies.

**5. Data Analysis**

Data was analyzed through descriptive analysis, which involved reading, categorizing, and comparing information from various sources. The findings were then analyzed to identify patterns, similarities, and differences between the legacy system, the new line, and modernization solutions. This analysis helps clarify integration challenges and formulate realistic and implementable recommendation

## 3. RESULTS AND DISCUSSION

This study produced several findings related to the condition of legacy signaling systems, the requirements for integrating new railway lines, and modernization trends observed in various railway projects. All results are presented as observed, without explanation or interpretation.

**1. Condition of Legacy Signaling Systems at the Study Location**

The following is a summary of findings based on project documents and technical reports:

| Observed Aspect | Field Findings |
|---|---|
| Signaling technology | Many stations still use relay-based or analog signaling systems. |
| Control capacity | Limited capacity to handle increasing train movements. |
| Communication support | Uses legacy communication networks with low data transmission speeds. |

| | |
|---|---|
| Readiness for additional tracks | Several old interlocking systems do not support the addition of turnouts and new tracks. |

**2. Adjustment Requirements When New Tracks Are Added**

**Findings from literature studies and project data indicate the following technical requirements:**

| Technical Requirement | Findings |
|---|---|
| Interlocking adjustment | Additional capacity is required to accommodate new tracks. |
| Communication network upgrade | A communication system capable of supporting higher data volumes is required. |
| Addition of train detection devices | New tracks require additional train detection equipment. |
| Yard (station layout) reconfiguration | Some stations require layout reconfiguration to match new operational patterns. |

**3. Findings from International Comparative Studies**

Comparisons with reports from other countries reveal the following:

| Country / Project | Key Findings |
|---|---|
| Modernization projects in Europe | Construction of new tracks is always accompanied by upgrades to electronic signaling systems. |
| East Asian projects | New tracks are supported by data-based communication systems. |
| Urban rail transit projects (LRT) | Close-range control systems are used to increase train frequency. |

4. **Modernization Trends Identified in the Literature**

The following table summarizes modernization trends identified in the literature

| Category | Findings |
|---|---|
| Technology | Transition from relay/analog systems to electronic systems. |

| | |
|---|---|
| Capability | Modern systems support additional tracks without major system modifications. |
| Operation | Data-based control is used in many new systems. |
| Human resource readiness | Improvement of staff competency is an essential requirement. |

The results of this study indicate that the construction of new lines cannot be separated from the condition of the existing signaling system. The legacy signaling systems still in use in some locations have limitations in terms of capacity, communication speed, and the ability to manage increasingly complex lines and train movements. This finding confirms that adding lines alone is not sufficient to increase train service capacity if the system is unable to adapt to changes.

When compared with research and reports from various countries, the results of this study show a similar pattern. Many countries that increase the number of lines also undertake signaling upgrades at the same time. However, the differences lie in technological readiness and human resources. In some countries, communication and travel control systems are more modern, allowing for faster track additions. Meanwhile, in Indonesia, some locations still use outdated equipment, requiring more adjustments to the integration process.

Previous research has also emphasized the importance of updating electronic signaling and data-based communication systems. The findings of this study support this, especially when new lines require faster response and more flexible management. However, this study provides an important additional insight: the biggest challenge lies not simply in replacing technology, but in integrating new technology with legacy systems still in use daily.

This study has several limitations. The data used is largely derived from project documents and literature studies, thus not including direct observations at all locations of the new line. Furthermore, the study does not discuss cost aspects in detail, even though these factors influence modernization decisions. Further research should include more extensive field studies, including interviews with technicians and operators, to gain a comprehensive picture of the challenges of integrating new lines with existing signaling systems.

**Documentation**

The following image illustrates a general comparison between the old system and the requirements of the new route on the Kiaracondong - Cicalengka route:

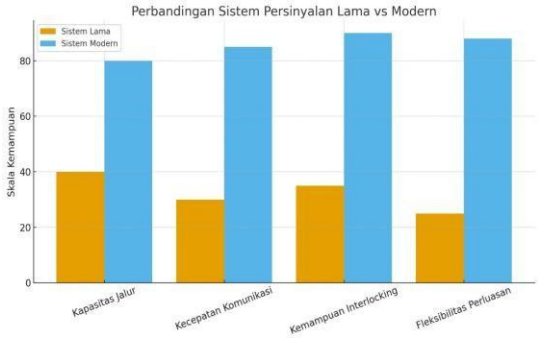
*Figures 1*

*Figures 2*

*Figures 1 and 2. Comparison of the Legacy System and New Line Requirements*

*The legacy system: limited line capacity, analog devices, interlocking with limited capabilities.*

*The new line: requires additional devices, faster communications, and interlocking capable of managing more lines.*




*The following graph illustrates the comparison of the capabilities of the old signaling system and the modern signaling system.*

## 3. CONCLUSION

This study demonstrates that a positive work environment positively impacts employee performance, both directly and indirectly through work motivation. A comfortable, safe, and supportive work environment makes employees more enthusiastic about their work, thus improving their performance. Data obtained from the questionnaire showed that the better the work environment, the higher the level of motivation and performance displayed by employees.

The contribution of this study is to provide a clear picture that companies need to consider factors such as workspace comfort, employee relationships, and supporting facilities to enable employees to perform optimally. These results can also be used as considerations in company policymaking related to increasing productivity.

### Recommendations

Companies are advised to continue improving working conditions, providing adequate facilities, and creating a healthy and supportive work atmosphere. Future research could include other variables such as leadership, organizational culture, or job satisfaction for broader and more in-depth results

### REFERENCES

Bang, S., & Lee, J. (2019). Modernization of railway signalling through digital interlocking systems. International Journal of Railway, 12(2), 55–66.

Bonnafous, A., & Jensen, A. (2021). European railway capacity, signalling upgrades, and interoperability challenges. Transport Policy, 103, 45–56.

Directorate General of Railways. (2020). Standar Persinyalan Kereta Api Indonesia (KP 411). Kementerian Perhubungan Republik Indonesia.

European Union Agency for Railways. (2023). ERTMS/ETCS System Requirements Specification. ERA.

Goverde, R. M. P. (2020). Railway signalling and train control: A systems engineering perspective. Journal of Rail Transport Planning & Management, 15, 100196.

Japan Railway Technical Research Institute. (2019). Advances in Communication-

Based Train Control (CBTC) Systems. Tokyo.

Kementerian Perhubungan Republik Indonesia. (2011). Peraturan Menteri Perhubungan No. PM 08 Tahun 2011 tentang Persyaratan Teknis Jalur Kereta Api. Jakarta.

Lai, Y.-C., & Barkan, C. P. (2019). Analysis of capacity improvements from railway double tracking and signalling upgrades. Transportation Research Record, 2673(2), 50–60.

Min, B., & Park, S. (2020). Implementation of data-based communication systems in East Asian railways. Journal of Transportation Technologies, 10, 320–330.

Network Rail. (2022). Digital Railway Programme: Modernising Britain's Signalling Systems. United Kingdom.

PT Kereta Api Indonesia (Persero). (2022). Laporan Peningkatan Jalur Ganda Kiaracondong–Cicalengka. Bandung.

PT Len Railway Systems. (2021). Modernisasi Sistem Persinyalan Elektronik di Indonesia. Bandung.

International Union of Railways (UIC). (2020). Signalling Principles (UIC Code 736). UIC.