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Work-life balance and asset-maintenance mismatch in the Indian railways: A case study of the S&T department in east central railway

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Abstract
This paper examines the increasing mismatch between asset creation and maintenance efforts in the Signal & Telecommunication (S&T) Department of East Central Railway (ECR), India. Using expenditure data from five financial years, the study reveals a widening gap between the expansion of S&T infrastructure and the corresponding growth in human and financial resources for its upkeep. The findings highlight the implications for operational safety, reliability, and the work-life balance of maintenance staff, proposing a dual strategy involving both increased funding and manpower recruitment to mitigate these challenges. This paper analyses financial trend of capital creation and maintenance of Signal & Telecommunication (S&T) assets in the Eastern Central Railway (ECR) between 2020-2021 to 2024-2025. It is evident that asset creation and maintenance has steadily been increasing with a high positive correlation that shows that balanced investment leads to greater safety, reliability, and operational efficiency. The results indicate that sustainable budgeting, appropriate manpower, and technological advancement are necessary and the policies to encourage work-life balance of S&T employees are in demand. Such actions are essential in the sustainability of infrastructure performance and resiliency in the railway industry.

Keywords: Capital expenditure, signal and telecommunication assets, eastern central railway, Indian railways

1. Introduction

1.1 Evolution of Human Work and Social Structures

Human society has evolved over millions of years from the era of hunter-gatherers to the highly developed civilizations of today. This progress involved numerous transformations, shaping not only how we live but also how we work. Civilizations flourished by engaging people in various productive occupations, which became the foundation for societal growth. As a result, key social structures and institutions such as family and marriage emerged.

Throughout history, regardless of the time, individuals have always strived to ensure the survival of themselves and their families. This makes it clear that life itself is the utmost priority. However, work remains essential, as it plays a crucial role in sustaining human existence.

1.2 The Indian Railways in Context

The Indian Railways has a rich and long-standing history, dating back to the colonial era. It began as a means to expand the reach of troops and transport logistics. Over time, the railways evolved into a vital pillar of the Indian economy. Technological advancements have played a significant role in this transformation from the era of steam engines to diesel and eventually electric locomotives. The push for electrification reflects a conscious effort to reduce pollution and promote sustainability. The railway is a system that is means of transportation to the general population and the cheapest modes of transportation. Railways depend on the efficiency and effectiveness of the working environment which is determined by the existing work culture, job position of the employees, leadership styles, incentives and working conditions. Railway workers, administrative or operating personnel must deal with the commuters on a daily basis in different positions (Das & Singh, 2023) [1].

Significant progress has also been made in railway signalling, evolving from non-interlocked

systems to advanced electronic interlocking. Similarly, coaches, wagons, their couplings, and braking systems have undergone continual innovation, leading to enhanced ride quality and improved safety.

The railway track infrastructure has seen considerable upgrades as well from the older 50R rails to heavier and more durable options like 90R, 52 kg, and 60 kg rails, especially for heavy-duty routes. As we aim for higher speeds of 160 kmph and beyond, it is essential to further strengthen both our infrastructure and its maintenance systems.

2. Organisational Structure and Manpower Distribution

2.1 Departmental Overview

The Indian Railways is not a single entity, but a vast and intricate system driven by the coordinated efforts of multiple departments. It operates through a well-defined three-tier structure: at the top is the Railway Board, followed by 19 zonal railways and 5 production units, and then the divisions. These divisions serve as the operational core smaller yet highly active subsystems that work tirelessly to keep trains running 24/7, 365 days a year (Indian Railways, 2024).

Each division is structured along functional lines, with specific departments responsible for different aspects of railway operations. The Operating Department manages train operations, while the Engineering Department oversees track maintenance and civil infrastructure. The Mechanical Department handles carriages, wagons, coaches, diesel locomotives, and cleanliness. The Electrical Department is responsible for overhead equipment (OHE), electric locomotives, and general electrical services. The Signal & Telecommunication (S&T) Department manages signalling and communication systems.

The Finance Department looks after budgeting and financial matters, while the Commercial Department handles passenger services, freight operations, and revenue generation. Public communication is managed by the Public Relations Officer (PRO), which also falls under the Commercial Department. The Personnel Department oversees HR and staffing matters, including the Legal Cell, which handles legal affairs. Security is maintained by the Railway Protection Force (RPF), while the Safety Department ensures operational safety and accident prevention. The Medical Department provides healthcare services, and the Stores Department manages procurement and bulk supplies.

2.2 Recruitment and Cadre Dynamics

Manpower across these departments is recruited and deployed based on merit through various channels. Class A posts are filled through the Union Public Service Commission (UPSC) with the Civil Services Examination (CSE) used for cadres like IRTS, IRPS, IRAS, and RPF, and the Engineering Services Examination (ESE) for technical services such as IRSE, IRSME, IRSEE, IRSSE, and IRSS. Class B officers are generally promoted officials, often on the verge of empanelment into Class A. The majority of the workforce falls under Class C, which includes multiple grades and constitutes the technical backbone of the railway system. While Class A officers serve in techno-managerial roles, formulating policy and managing operations, Class C employees are the hands-on workforce that directly executes and maintains the vast railway infrastructure.

In this complex and interdependent structure, the role of Class C employees becomes especially significant. Their continuous, round-the-clock efforts are critical to ensuring seamless railway operations. It is therefore essential to recognize how these employees manage the delicate balance between their demanding work responsibilities and personal lives, maintaining this equilibrium with steadfast dedication.

The uneven distribution of manpower across departments regardless of the phasing out of outdated technologies remains a separate topic of discussion. However, the primary focus of my article is the growing workload and its impact on the Group C maintenance cadre of the Signal & Telecommunication (S&T) Department in East Central Railway (ECR).

3. Methodology

3.1 Data Sources

To assess the growing workload and its impact on S&T (Signal & Telecommunication) staff, it is essential to evaluate the actual S&T assets created in relation to changes in the strength of S&T personnel. For this purpose, data from five financial years has been analyzed to identify emerging patterns.

To approximate the capital assets created for S&T, we have considered only those Plan Heads under capital expenditure that directly contribute to the development of S&T infrastructure.

- Plan Head 11 pertains to New Line projects, where the total expenditure is shared among three executive departments: Engineering, Electrical, and Signal & Telecom. Since S&T's share in such composite works is typically around 15%, we have considered this percentage as the representative contribution toward S&T assets.
- Similarly, PH-14 (Gauge Conversion) and PH-15 (Doubling) have also been evaluated with an assumed 15% S&T contribution. However, it is worth mentioning that only PH-11 and PH-16 works actually lead to an effective increase in the S&T asset base. In contrast, PH-14 and PH-15 primarily involve modifications or capacity enhancement without significantly altering the scale of S&T infrastructure they largely keep the asset base approximately intact.
- PH-16, which covers works aimed at enhancing traffic facilities, is directly related to S&T for instance, installation of Intermediate Block Huts (IBH), additional shunting signals, and provision of new loop lines. These works are fully considered as additions to the S&T asset base.
- PH-33, dedicated exclusively to S&T works, has been considered in full. However, it mainly includes works that improve reliability or replace overaged/overlived assets rather than expanding the asset base significantly.

Therefore, to assess the net effective growth in S&T assets over five years (taking FY 2020-21 as the baseline), only PH-11 and PH-16 expenditures are cumulatively considered. This focused approach allows us to accurately evaluate how much the physical infrastructure for S&T has expanded and how that expansion compares with the available manpower and maintenance effort.

3.2 Maintenance Effort Measurement

On the revenue side, maintenance of existing S&T assets is

supported through PU-32, which is allocated for contractual maintenance expenditure. Funds from this unit are primarily used to enhance the reliability of S&T systems through comprehensive or annual maintenance contracts.

Additionally, the salary expenditure incurred by S&T units of ECR (East Central Railway) reflects the government's investment in human resources for the upkeep of these assets and is directly proportional to the number of S&T employees in position.

It will be insightful to analyze the relationship between capital expenditure (asset creation) and maintenance effort (both contractual and salary-based), to determine whether the increasing asset base is improving operational efficiency or placing a disproportionate burden on maintenance resources.

4. Results and Analysis

4.1 Actual Expenditure Financial Year Wise

The results of the real expenditures during the financial years 2020-21 to 2024-25 shows that there are different trends associated with particular plan heads in the budgeting system of Indian Railways. Under classification of capital works, a number of plan heads have specific functions: PH-11 is concerned with new line construction, PH-14 with gauge conversion, PH-15 doubling of lines, PH-16 traffic facilities including yard remodelling and PH-33 signalling and telecommunication works (Indian Railways, 2014). The table no:1 provides the results of Actual expenditure financial year wise (Fig in Crores)

- PH-11 (New Line Construction) states that the trend of continuous growth with an increase in revenue to 2024-25 by 124.27 percent. This is an indication of continued investment in the growth of the railway network by opening new lines.
- The PH-15 (Doubling) has the maximum expenditure with the highest in 2023-24 to be 3,731.90 crore then falling a bit, perhaps indicating the end of major doubling work.
- PH-14 (Gauge Conversion) shows an increase till 2022-23 and a sharp decline to 277.74 crore in 2024-25 either the project is complete or there is a diversion of funds.
- PH-16 (Traffic Facilities Yard Remodelling & Others) rises gradually up to 2023-24 and decreases, which means that priorities change or phases implementation plans.
- PH-33 (Signalling & Telecommunication Works) drops off in 2023-24 but shoots up to 284.04 crore in 2024-25, which shows that safety and technological upgrade is getting a new thrust.

Also, PU-32, the equivalent of bridge works, demonstrates gradual growth, as maintenance and capacity improvement work are being done. Salaries are on a steady upward trend, which reflects the growth in the number of employees and statutory increases.

Table 1: Details of Actual expenditure financial year wise (Fig in Crores)

AU	Plan head	Actuals 2020-2021	Actuals 2021-2022	Actuals 2022-2023	Actuals 2023-2024	Actuals 2024-2025
30-ECR	PH-11	855.56	1028.32	1457.79	2034.73	2098.13
30-ECR	PH-14	387.98	407.09	475.37	462.99	277.74
30-ECR	PH-15	3103.16	2936.96	3409.34	3731.9	3270.86
30-ECR	PH-16	41.49	74.2	146.26	218.8	170.39
30-ECR	PH-33	135.37	140.47	173.83	131.6	284.04
ECR	PU-32	23.42	25.42	29.26	34.4	35.77
	Salary	275.66	301.03	327.57	357.96	381.6

Source: (EAST CENTRAL RAILWAY, 2025)

4.2 Expenditure trend of Signal & Telecommunication

The expenditure trend of Signal & Telecommunication (S&T) assets during the seven years of 2020-21 to 2024-25 brings out a strategic thrust on creating capacity and capacity maintenance in the Eastern Central Railway (ECR). By the Railway Board standards, S&T spending is usually integrated into the larger infrastructure investments, where specific percentages are reserved to the construction of new lines, the gauge conversion, and the doubling of the existing ones (General of India, 2024).

4.2.1 Capital Expenditure Trends

- **PH-11 (New Line Construction:** 15% S&T allocation) indicates that it is a steady growth in terms of the number of rupees, i.e., 128.33 crore in 2020-21 to 314.71 crore in 2024-25, which indicates the growing S&T presence in the new routes.
- PH-15 (Doubling 15percent S&T allocation) is the only head that is larger than the rest of shared-plan heads and reaches a peak of 559.78 crore in 202324 before falling, as is characteristic of large doubling projects completion cycles.
- PH-14 (Gauge Conversion 15% S&T allocation) shows a modest growth till 2022-23 but steep decline in 2024-25 to 41.66 crore as there is reduction in gauge conversion work.
- The PH-16 (Traffic Facilities) and PH-33 (Signalling & Telecommunication) are purely S&T works and they have considerable peaks in 202324 and 202425 respectively representing specific modernization efforts and security improvement.

Cumulatively, the amount to be used to expand S&T assets through capital expenditure increases by 57 percent or 272.57 crore to 1301.43 crore in five years, 2020-21 to 2024-25.

4.2.2 Maintenance Expenditure Trends

The cost of the Annual Maintenance Contract (AMC), post PU-32 and the salaries and wages of S&T staff, combined, increase by 2024 25 to 299.08 crore 417.37 crore in 2020-21. Such a consistent development coincides with the growth in the volume of assets and the necessity of the qualified personnel and contractual assistance to provide operational stability (General of India, 2024).

4.2.3 Strategic Implication

The information shows a conscious swing in balance

between the creation of an asset (capital expenditure) and the maintenance of an asset (maintenance expenditure). Investments in PH-33 and PH-16 are indicators of modernization and automation: Increasing salary and AMC funding reveal some of the costs of operating an ever more complex network. This spending trend correlates with the modernization strategy of the Indian Railways that focuses on modernization through technology, safety, efficiency, and capacity building. The table no: 2 provides the Details of Actual expenditure for S&T Assets in Financial year wise (Fig in Crores).

Table 2: Details of Actual expenditure for S&T Assets in Financial year wise (Fig in Crores)

AU	PLAN HEAD	ACTUALS 2020-2021	ACTUALS 2021-2022	ACTUALS 2022-2023	ACTUALS 2023-2024	ACTUALS 2024-2025	Remarks
30-ECR	PH-11	128.334	154.248	218.6685	305.2095	314.7195	15% taken for S&T expenditure in New Line work.
30-ECR	PH-14	58.197	61.0635	71.3055	69.4485	41.661	15% taken for S&T expenditure in Gauge conversion work.
30-ECR	PH-15	465.474	440.544	511.401	559.785	490.629	15% taken for S&T expenditure in Doubling work.
30-ECR	PH-16	41.49	74.2	146.26	218.8	170.39	Totally S&T expenditure as it is Traffic facility Work.
30-ECR	PH-33	135.37	140.47	173.83	131.6	284.04	Totally S&T expenditure as it is for S&T works
Total Capital Expenditure to increase S&T Assets		828.865	870.5255	1121.465	1284.843	1301.4395	Total CAPITAL expenditures incurred on S&T.
ECR	PU-32	23.42	25.42	29.26	34.4	35.77	Expenditure in the AMC of S&T assets
	Salary	275.66	301.03	327.57	357.96	381.6	Salary drawn by S&T employees over ECR.
Total Expenditure on maintenance		299.08	326.45	356.83	392.36	417.37	Salary expenditure on man power and assistance in the form of AMC expenditure to help in effective maintenance of assets created.

Source: (EAST CENTRAL RAILWAY, 2025)

4.3 Capital Expenditure of Signal and Telecommunication

The table 3 analysis indicates that the capital expenditure of Signal and Telecommunication (S&T) assets in ECR has been on a steady increase with PH-11 and PH-16 being a major contributor. The capital investment was cumulatively increasing considering the period of 2020-21 to 2024-25 where it was 169.82 crores in 2020-21 and 1772.32 crores in 2024-25, which implies the continuous increase in the asset. Maintenance expenses, which are mostly made up of salaries, rose continuously and AMC expenses also went up, which indicates increasing dependence on technical support that is outsourced. The spending profile demonstrates a healthy mix of investment in asset creation and maintenance, which is in tandem with the safety and operational mandate of Indian Railways (P3), and thus achieves a sustainable increase in signaling and telecommunication infrastructure of the zone.

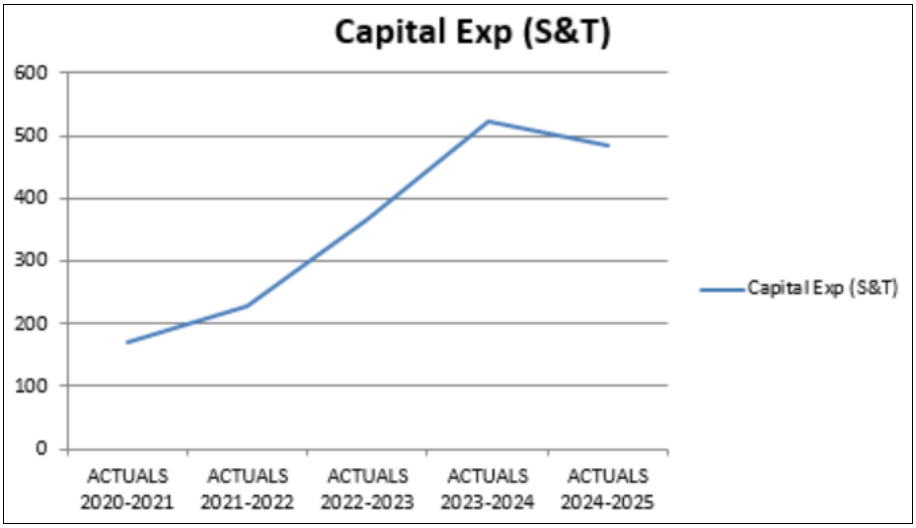
Table 3: Details of Actual expenditure for increase in S&T Assets in Financial year wise (Fig in Crores)

AU	PLAN HEAD	ACTUALS 2020-2021	ACTUALS 2021-2022	ACTUALS 2022-2023	ACTUALS 2023-2024	ACTUALS 2024-2025	Remarks
30-ECR	PH-11	128.334	154.248	218.6685	305.2095	314.7195	15% taken for S&T expenditure in New Line work.
30-ECR	PH-16	41.49	74.2	146.26	218.8	170.39	Totally S&T expenditure as it is Traffic facility Work.
Total Capital Expenditure to increase S&T Assets		169.824	228.448	364.9285	524.0095	485.1095	Total capital expenditures incurred in creating S&T assets.
Cumulative Total Expenditure to increase S&T Assets		169.824	398.272	763.2005	1287.21	1772.3195	Expenditure has been added as assets are cumulative and continuously increasing.
ECR	PU-32	23.42	25.42	29.26	34.4	35.77	Expenditure in the AMC of S&T assets
	Salary	275.66	301.03	327.57	357.96	381.6	Salary drawn by S&T employees over ECR.
Total Expenditure on maintenance		299.08	326.45	356.83	392.36	417.37	Salary expenditure on man power and assistance in the form of AMC expenditure to help in effective maintenance of assets created.

Source: (EAST CENTRAL RAILWAY, 2025)

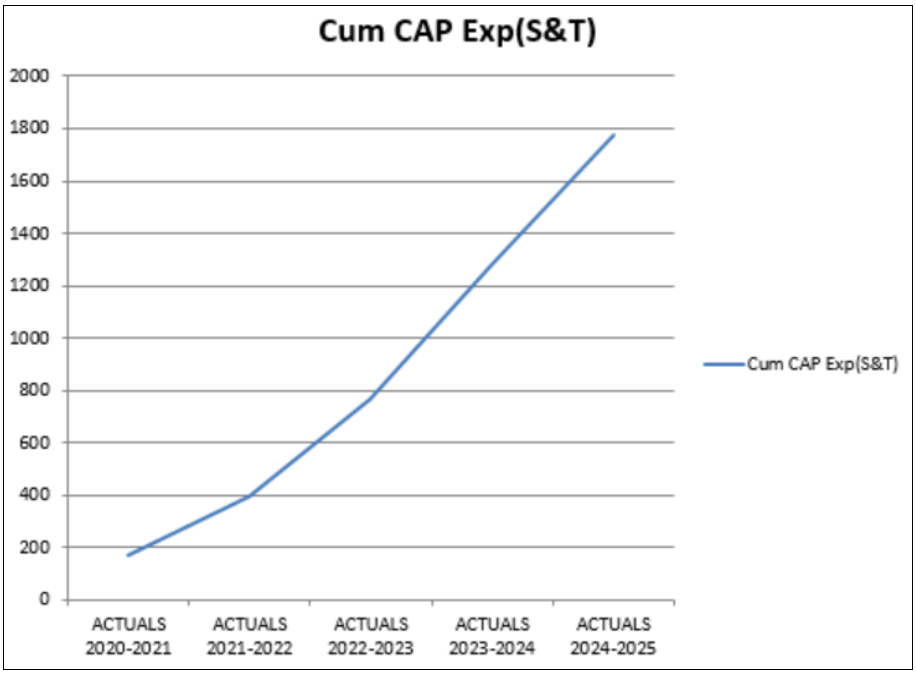
4.4 Graphical Representation

The fig shows that there is a consistent increase in the amounts of capital and maintenance spending of the Signal and Telecommunication (S&T) assets in ECR during the five years. As indicated in figure 1, cumulative capital expenditure is on a sharp rise, 169.82 crores in 2020-21 and 1,772.32 crores in 2024-25, which reflects asset creation is continuing. Annual capital expenditure is demonstrated in figure 2 as reaching its peak in 2023-24 and then a minor decrease in 202425. Figure 3 presents cumulative capital investment with maintenance cost, and the maintenance cost increases gradually over the years rising to 299.08 crores to 417.37 crores. The trend indicates that the Indian Railways have a balance between the expansion and maintenance, which guarantee efficiency in long term operations.



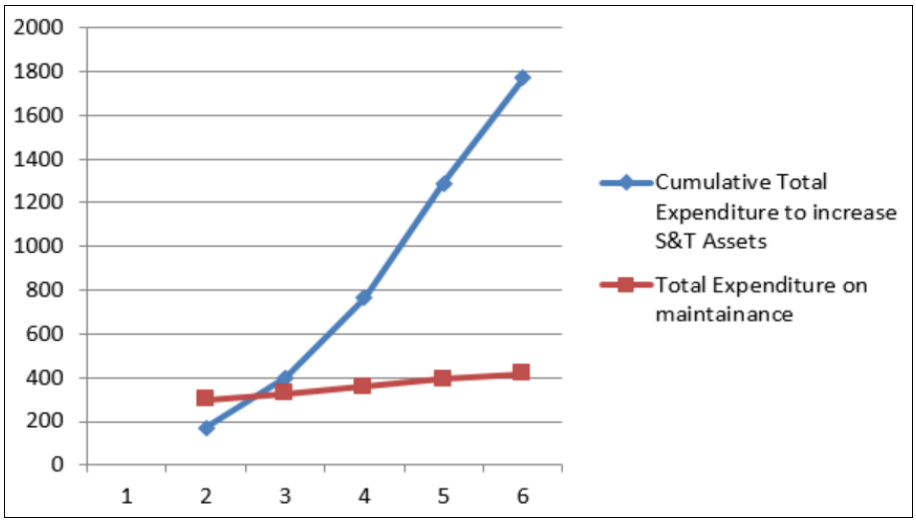
Source: Author's own

Fig 1: Capital Exp. (S&T)



Source: Author's own

Fig 2: Cum CAP Exp (S&T)



Source: Author's own

Fig 3: Compares cumulative capital investment with maintenance cost

4.5 Correlation Findings

Pearson Correlation Coefficient Calculation: The Pearson correlation coefficient stands at 0.991 which is a very strong positive association between capital expenditure and maintenance expenditure. It is a statistically significant correlation indicated in the p-value (0.0011) (Pearson, 2023).

Let:

- X = Cumulative Capital Expenditure
- Y = Maintenance Expenditure

The Pearson correlation coefficient (r) is calculated as:

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \cdot \sum (Y_i - \bar{Y})^2}}$$

$r \approx 0.991$

4.6 Growth in S&T Assets vs Maintenance Effort

Figures 1, 2, and 3 clearly illustrate a growing gap between the creation of S&T assets and the corresponding maintenance efforts. The visual trend highlights a consistent and widening divergence, indicating that while infrastructure continues to grow, the maintenance capacity is lagging behind.

There is a strong positive correlation between capital expenditure on S&T assets and the required maintenance effort, emphasizing that expanding physical assets inherently demand proportionate upkeep to ensure reliability and operational efficiency.

While enhancing revenue expenditure under PU-32 (e.g., for contractual maintenance) is one way to address this gap, it cannot be the sole solution. Recent incidents, including derailments with heavy casualties, have underscored the critical safety responsibilities of the Signal & Telecom department. Many safety-related tasks such as signal interlocking, block instrument, Failure rectification and maintenances related activity require skilled, trained in-house manpower rather than being outsourced.

Therefore, a balanced strategy is necessary: one that includes both the recruitment of additional S&T personnel for scheduled and safety-critical maintenance, and an increase in PU-32 funding for enhancing system reliability through contractual support. This dual approach is essential to meet the growing maintenance requirements of S&T assets while upholding safety, performance, and system integrity across the railway network.

It is evident that there is a systematic mismatch between the rapid growth of assets and the corresponding maintenance efforts, resulting in an increased workload that adversely affects the work-life balance of the maintenance staff.

5. Discussion

5.1 Implications for Work-Life Balance

The expanding infrastructure without proportionate increases in maintenance support leads to overburdened maintenance staff, especially in the Group C S&T cadre. These personnel are often required to be available 24/7 for critical fault rectification and routine upkeep, leaving minimal scope for rest or family life.

5.2 Impact on Safety and Reliability: Recent derailments and technical failures underscore the critical role of in-house, skilled S&T staff. Safety-critical work such as signal interlocking, block operations, and failure rectifications cannot be outsourced without compromising quality and reliability.

5.3 Operational Efficiency

There is strong correlation that indicates maintenance ought to be incorporated into capital planning to avoid bottlenecks and have resources when required.

5.4 Financial Planning

Forecastable association between maintenance and capital expenditures provides greater results in terms of forecasting and allocation of funds throughout the asset life cycle.

5.5 Long-Term Sustainability

Another aspect is that regular capital and maintenance investments mean that the functionality of infrastructure will be maintained and the safety of the infrastructure improved without the risk of costly breakdowns.

6. Policy Recommendations

6.1 Balanced Manpower and Outsourcing Strategy

A dual strategy is recommended:

- Augmentation of S&T manpower: Recruitment drives focused on skilled Class C staff.
- Increased PU-32 allocation: For reliability-enhancing AMC contracts and tools.

6.2 Institutional Reforms

- Department-wise manpower audits to identify gaps and realign recruitment.
- Work-life integration policies, such as shift rotations and time-off systems, to reduce burnout.

6.3 Integrated Budgeting

Budget maintenance and capital grants in an integrated fashion so that new S&T assets get timely maintenance.

6.4 Training and Capacity Building

Enhance the skills of technical staff in the emerging S&T systems to increase the capacity to effectively use and reliability.

7. Conclusion

The study confirms a systematic mismatch between asset growth and maintenance efforts in Indian Railways, specifically in the S&T domain of ECR. This imbalance not only threatens operational safety and system efficiency but also erodes the work-life balance of key maintenance personnel. Urgent policy interventions both financial and human resource-based are necessary to address this unsustainable trajectory. The discussion of the trend of expenditures on Signal & Telecommunication (S&T) assets indicates that there has been a constant growth in the investment in capital creation and maintenance over the years. A positive correlation between these two kinds of expenditures indicates that the reliability of assets and their safety is enhanced, in case the creation and maintenance are balanced. Nevertheless, to maintain efficiency, it is necessary to employ active budgeting, high-quality support of the workforce and constant technological updates. Work life balance of the S&T personnel is also important to be

addressed so as to ensure safety and reliability in work. Policy interventions driven by data and research can therefore improve the performance of infrastructure and the well-being of human resource towards long term excellence in the railway sector.

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