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Optimization of Dispatch Operations Through Improved Trolley/Bin Utilization and Trip Planning: An Operations Study at Belrise Industries Ltd., Chakan

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Abstract *- In the area of automotive component production, dispatch bay is the interface connecting production with the OEM production schedule, resulting in congestion, idle manpower, excessive handling and delivery risk if there are delays in the dispatch bay. In modern literature, Lean Manufacturing, Just-in-Time (JIT), material-handling theory and vehicle-routing concepts are used to create the foundation for cycle-time reductions and demand-driven planning rather than just asset additions. This is an applied operation study of outbound dispatch in Belrise Industries Ltd, Chakan with four lines being the Press Shop, CCB, K17 BD & EA and M&M. The main aims were to study the current dispatch process, review the trolley/ bin usage and routines, understand why the current trolley/ bin usage and routine are causing waiting times and unnecessary trips, develop a new approach to trolley/ bin utilisation and trip planning, and predict the impact of this new approach on efficiency and costs. The methodology started with direct observations of how the dispatch-bay was operated, followed by measuring the cycle time of trolleys and bins, space utilisation analysis, interviews with the operators and supervisors, and an Excel-based analysis of the dispatch-record, trolleys/bin-record and cost-record. Root causes were structured using process mapping, a 5M Ishikawa analysis and Pareto logic and took place during an On-the-Job Training (OJT) period from 13 April to 13 July 2026. All four lines run at a 100% utilization of staging space and have a significant amount of idle time for equipment and manpower, delayed trolley return, no real-time visibility of trolley movement and manual documentation. The estimated benefit is to reduce the requirement for trolleys from 84 to 75 units, resulting in capital expenditure being saved of ₹1,39,200 (Press Shop: ₹20,000; CCB: ₹1,19,200) with a 10% compression of the trolley cycle time. Expected operational savings: Pre-arrival dispatch readiness, load consolidation, rate and SLA measures estimated to bring down monthly operational savings of ₹1.2–1.4 lakh in addition to 5–10% productivity gain with no increase in manpower, 100% QR based trolley traceability, and 30–50% documentation time reduction. These statistics are estimates only, prior to audit. Finally, dispatch performance is not limited by fleet size, but by asset velocity, production – dispatch synchronisation and visibility. Management is recommended to use unique trolley/bin identification with QR tracking, Dispatch Readiness Checklist, Demand Planning, a controlled trolley buffer and line specific KPIs with a nine week roadmap starting with an Excel-based tracking system. The key words are: Dispatch Optimization, Trolley/Bin Utilization, Trip Planning, Cycle Time, Lean Manufacturing, QR-Code Asset Tracking, Automotive Components.*

Keywords— *Dispatch Optimization, Trolley/Bin Utilization, Trip Planning, Cycle Time, Lean Manufacturing, QR-Code Asset Tracking, Automotive Components*

I. INTRODUCTION

The automotive industry is a big manufacturing and employment chain followed by the raw material suppliers, Tier-3 and Tier-2 as well as Tier-1 component manufacturers and the vehicle OEMs, dealers and aftermarket [1, 2]. The auto-component sector had a turnover of around ₹7.59 lakh

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crore in FY2025-26, which rose by 12.7% year on year, and exports valued at US$24 billion [3]. A component supplier is evaluated by quality and price, and the timely arrival of the correct material to the customer. The dispatch Bay interface between production output and customer requirements can cause congestion, idle man power, excess handling, and delivery risks.

A study was designed and conducted at Belrise Industries Ltd., Chakan, a Tier-1 integrated automotive-component manufacturing company. It is covering outbound material movement and utilisation of tramp trolley/ bins across four lines including the Press Shop, CCB, K17 BD & EA and M&M, and includes the following topics: trolley/bin utilisation, trip frequency, cycle time, waiting, return movement, dispatch documentation and coordination between production, stores, material handling, logistics and customer receiving teams. Staging areas are used to the capacity of 100%, trolleys and bins are used and returned late, manual records are maintained and real-time asset visibility is limited. There were four recurring bottlenecks found: idle time associated with material handling; limited asset tracking; manual documentation weaknesses; and production and dispatch desynchronisation. In these situations, additional trolleys can exacerbate congestion, and the project focuses on reducing cycle-time, pre-arrival staging, load consolidation, demand-based trip planning, digital tracking and customer unloading discipline.

In response to these challenges, this paper introduces an applied investigation in three phases. To begin, the current dispatch process was mapped and measured for each line in terms of fleet size, number of trips, loads, waiting times and return cycles. Secondly, root causes were identified by applying a 5M approach that incorporates Ishikawa and Pareto logic and the asset and cost implications were quantified. Third, an enhanced framework of a Dispatch Readiness Checklist, demand-based trip planning, QR-code tracking and line-specific KPIs were designed and implemented as a 9 week roadmap. It includes physical staging and loading, trolley/bin circulation, trip scheduling, transport cost structures, dispatch documentation, and selected customer side unloading/return loops; upstream procurement, inbound logistics, core manufacturing transformation, and long distance multimodal transport are not included. The paper proposes a practical approach to measure cycle time, utilisation and waiting, and propose a KPI-based digital control system. It flows from the sector context, literature, methods, analysis and conclusions of the company.

II. SECTOR AND COMPANY BACKGROUND

A. Indian Automotive and Auto-Component Sector

The value chain starts from raw-material suppliers, then Tier-3, Tier-2 and Tier-1 component manufacturers, followed by OEMs, dealers/distributors, customers and the aftermarket. The major organised players in the auto components sector include Motherson, Bosch India, Bharat Forge, Sundram Fasteners, Endurance Technologies, Varroc, Sona BLW, Sansera, Schaeffler India, Lumax, Subros and Belrise. The industry as a whole makes up an estimated 6% of GDP; 49% of manufacturing GDP; and provides work for over 30 million people [3].

The competitive and macro-environment of the sector is presented in Table I, by applying the Porter's Five Forces [4] and PESTEL analysis. Competitive rivalry is high, as do large OEMs buy in bulk, with influence on price, specification and schedule, productivity and dispatch efficiency are competitive levers and buyer power is high. The policies include ₹25,938 crore PLI scheme for automobiles and auto components [5] and ₹10,900 crore scheme PM e-DRIVE and ₹18,100 crore PLI scheme for Advanced Chemistry Cell battery manufacturing [6]. The safety, testing, standards and pollution control compliance is defined by MoRTH [7], ARAI, BIS and CPCB.

TABLE I.
ORTER'S FIVE FORCES AND PESTEL ASSESSMENT OF THE INDIAN AUTO-COMPONENT SECTOR

Factor	Assessment
Competitive Rivalry (Porter)	High: intense competition on price, quality, technology, delivery, and manufacturing capability; OEM cost pressure
Buyer Power (Porter)	High: large OEMs influence prices, specifications, schedules, and terms; customer concentration is a strategic risk
Supplier Power (Porter)	Moderate: steel, aluminium, polymers, and rubber affect margins; multiple sourcing reduces exposure
New Entrants (Porter)	Moderate to low: capital intensity, certifications, testing, and OEM approvals
Substitutes (Porter)	Moderate: EV transition reduces some ICE-specific demand; powertrain-agnostic products remain relevant
Political (PESTEL)	PLI-Auto, PM E-DRIVE, and localisation policies shape investment and supply chains

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Factor	Assessment
Economic (PESTEL)	Demand tied to GDP, income, interest rates, inflation, and fuel prices; commodity and exchange-rate effects
Social (PESTEL)	Urbanisation, rising incomes, and expectations for safety, efficiency, comfort, and technology
Technological (PESTEL)	EVs, robotics, AI, IoT, predictive maintenance, digital monitoring, automated inspection
Environmental (PESTEL)	Pressure to reduce emissions, energy use, waste, and carbon footprint
Legal (PESTEL)	Safety, emissions, labour, environmental, quality, and homologation requirements

Key trends are EV adoption, localisation, Industry 4.0, automation, supplier diversification, and supply-chain resilience, while challenges include raw-material volatility, semiconductor and component shortages, geopolitical disruption, exchange-rate movements, OEM price pressure, and the investment needed for new technology. Geopolitical conflict can raise freight and energy costs, EV manufacturing creates exposure to lithium, nickel, cobalt, and rare-earth supply, and tariffs or slowdowns in the US, Europe, or China can affect exports. The sector is consequently moving toward EV-ready and powertrain-agnostic products, domestic localisation, and digital manufacturing with robotics, AI-based inspection, predictive maintenance, and automated material handling. The relevance to this study follows a clear chain: higher vehicle demand raises OEM production, component demand, Belrise output, and material movement, which increases pressure on dispatch operations and creates the need for efficient trolley/bin utilisation and optimised trip planning.

B. Company Profile: Belrise Industries Limited

Belrise Industries Limited is an Indian integrated automotive-component manufacturer and Tier-1 supplier. Its promoter group traces its origin to 1988; the company was incorporated as Badve Engineering Private Limited in 1996, became a public company in 2008, and adopted the Belrise name in 2022. It is led by Managing Director Mr. Shrikant S. Badve, has its registered office at Waluj, Chhatrapati Sambhajinagar, and its corporate office in Pune, and has been listed on NSE (BELRISE) and BSE (544405) since 28 May 2025. The manufacturing network has grown to more than 20 facilities, serving domestic and international markets including Austria, Slovakia, the UK, Japan, and Thailand [8], [9]. Its vision is to offer engineering products globally through technology and become a trusted brand through customer delight; its mission is to be a leading global organisation for world-class products through continuous improvement and stakeholder partnership; and its core values are sustainability, agility, innovation, and excellence.

The portfolio covers metal processing (chassis and body-in-white parts, exhaust systems, press parts, seating components, and cross-car beams), polymer processing (fairings, seat and side covers, luggage boxes, helmets, and headlight housings), suspension (forks, shock absorbers, semi-trailing arms, and wishbones), mirror systems, foundry products, and e-mobility (EV chassis and frames, e-motors, controllers, and contract manufacturing), with strategic diversification into aerospace and defence engineering.

Table II presents the key financial parameters for FY2024 to FY2026. Revenue rose from ₹7,484 crore to ₹9,509 crore and EBITDA from ₹928 crore to ₹1,154 crore, while the EBITDA margin stayed broadly stable at about 12%. Profit after tax grew significantly and leverage fell sharply, with debt/equity declining to about 0.29x and net debt/equity to about 0.13x. ROCE was about 14.7%, and EPS was approximately ₹5.38–₹5.58 depending on the reporting methodology. Economic Value Added is not publicly disclosed, so no unsupported figure is reported [9].

TABLE II.
EY FINANCIAL PARAMETERS OF BELRISE INDUSTRIES LIMITED, FY2024–FY2026

Particular	FY2024	FY2025	FY2026	Analysis
Revenue (₹ cr)	7,484	8,291	9,509	Strong double-digit expansion
EBITDA (₹ cr)	928	1,021	1,154	Operating profitability improved
EBITDA margin	~12.4 %	~12.3 %	12.1%	Broadly stable despite cost pressure
PAT (₹ cr)	~314	355	497–502	Significant profit growth
ROE	~14.3 %	~14.1 %	~12.5 %	Moderated because of higher equity base
Debt/Equity	~1.07x	~1.09x	~0.29x	Major deleveraging
Net Debt/Equity	~0.99x	~1.06x	~0.13x	Strong balance-sheet improvement

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Particular	FY2024	FY2025	FY2026	Analysis
Current ratio	~1.52x	~1.34x	~1.97x	Liquidity position improved

Belrise competes across product categories with Bharat Forge, Uno Minda, Endurance Technologies, JBM Auto, Minda Corporation, Motherson Sumi Wiring India, and other specialists. Its strongest position is in two-wheeler metal components, with approximately 24% market share as of FY2024; a comparable company-wide five-year market-share series is not publicly disclosed and is not assumed. Table III gives the SWOT profile.

TABLE III.
WOT ANALYSIS OF BELRISE INDUSTRIES LIMITED

Dimension	Key Points
Strengths	Strong position (about 24% share) in two-wheeler metal components; diversified and powertrain agnostic; long-term OEM relations; strong manufacturing and automation capabilities; improved balance sheet and lower leverage
Weaknesses	Exposure to automotive industry cycles, reliance on key OEM customers, capital-intensive operations, sensitivity to commodity expenses, organisational complexity due to rapid growth and international operations.
Opportunities	Growth in EV components, 4-wheelers and commercial vehicles, diversification into the aerospace and defence sectors, rising export volumes, rising content per vehicle, digital manufacturing and Industry 4.0, and strategic acquisitions.
Threats	The transition from ICE to EVs more quickly than initially forecasted; coming from larger global suppliers; raw-material price fluctuations; geopolitical and supply-chain risks; OEM cost-reduction pressures; technology obsolescence; foreign-exchange and regulatory risks

Finance-wise, this growth trend with better profitability and leverage enables operational projects to help enhance asset use efficiency and cost productivity. Belrise targets primarily B2B markets and its pricing principles are based on OEM negotiation, quality, engineering skills, reliability, cost and long-term commercial agreements - not on mass advertising, with the predominant channel being direct supply to OEM manufacturing ecosystems from geographically distributed plants. The extended 3Ps are people (engineers, production, quality and supply-chain teams), process (standardised manufacturing, TPM, SAP and automation) and physical evidence (plant, certifications, testing ability). HR priorities cover manpower planning, training, performance management, employee engagement, safety and 5S/IMS systems, and employee involvement is supported by TPM and Kaizen, however, company-wide attrition rate is not consistently reported and is not inserted. The CSR activities pertaining to education, health, women, children, senior citizens, community welfare$ etc. are monitored by a CSR Committee at the level of the Board and governance is provided by the Audit, Nomination and Remuneration, CSR, Risk Management and Stakeholders Relationship Committees. The Nifty Auto Index, a sector index, jumped from around 26,861 on 10 July 2026 to 29,648 on 7 August 2026 (Table IV) showing positive momentum in the sector, but not a direct measure of Belrise's performance [10]. Recent strategic moves have included the merger of promoter and entity as a result of which the company's operations have been consolidated, an acquisition of H-One India for high tensile steel stamping, chassis and body-in-white, and a subsequent acquisition of France's SDM for introduction into aerospace, space and defence machining operations in March 2026; an agreement with Plasan Sasa in December 2025 to acquire its ATEMM electric mission module for the Indian defence sector; and a QIP in July 2026 that raised ₹1,700 crore through the issuance of 77,272,727 shares at ₹220 per share. This expansion of system-integration, EV, aerospace and defence brings greater significance to the discipline of the supply-chain, the control of inventory, material handling and the optimisation of dispatch, which is the topic of the present study.

TABLE IV.
IFTY AUTO INDEX CLOSING LEVELS AT WEEKLY INTERVAL, JULY–AUGUST 2026

Week Ending	Nifty Auto Closing Level	Approx. Weekly Movement
10 July 2026	26,860.75	—
17 July 2026	27,099.75	+0.9%
24 July 2026	27,217.95	+0.4%
31 July 2026	28,744.15	+5.6%
7 August 2026	29,647.90	+3.1%

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III. LITERATURE REVIEW AND THEORETICAL BACKGROUND

A. Literature Review

Operations management is about using resources to convert inputs into outputs, and for cars the process of dispatch is part of the transformation-to-delivery stream; if the material does not get to the customer on time then the production is not complete [11, 12]. Lean production is popularised by Womack and Jones [13] and has been developed from Ohno's Toyota Production System [14] which are focussed on customer value and the elimination of waste; the wastes relevant to this are waiting, transportation, motion, excess inventory, over-processing, defects and underutilised human capability. Shah and Ward [15] and [16] analysed the correlation between the lean practice bundles and operational performance and created indexes of lean production, while Moyano-Fuentes and Sacristán-Díaz [17] reviewed the research and lean thinking. Just-in-Time (JIT) synchronises the material to the right place, at the right time, in the right quantity and in the right condition, without moving too early, and at the same time ensures no shortage; JIT and Kanban based control are explained by Monden [18] and standard work and waste reduction are explained by Shingo [19]. The target of material handling theory is to ensure that movement, protection, storage and control are achieved with minimum unnecessary distance, handling and waiting in order to measure trolley/bin performance to include load utilisation, number of trips per day, cycle time, waiting, and return time. Monitoring capacity utilisation and time availability together, as underloading will lead to more trips while overloading can lead to shortages and long return cycles will reduce effective availability. Transportation planning is a process of allocating limited capacity to meet demand: truck dispatching problem [20] and the savings heuristic [21] were early models in this area, and there are recent reviews on routing and inventory, routing and sustainability, outbound logistics, and routing and customer service. The Belrise application is not a classic multi-customer vehicle routing problem, but an internal dispatch-scheduling problem. Demand and Production Schedule, Material Requirement, Inventory Availability and Dispatch Planning are interdependent: Over dispatch results in congestion and excess inventory, while Under dispatch results in shortage and emergency movement [22] and [23]. Integration and agility in the supply chain are also important. Flynn et al. [24] report on the effects of supply-chain integration on performance, highlighting the need for coordination among functions, and Christopher and Towill [25] stress on agile and flexible processes in the supply-chain. The improvement cycle used here is as follows [26]: Identify problem, measure the current situation, analyse causes, implement countermeasures, measure results, standardise. There are a number of useful KPIs including: trolley utilisation, trips per day, parts per trip, cycle time, waiting time, loading/unloading time, return time, availability, cost per trip, on-time dispatch and consistent definitions turn observations into evidence. Digital tools like QR/barcode, real-time status, dashboards, automated alerts and historical cycle-time analysis enhance asset visibility and decision quality. Combining all the literature, the authors can establish a holistic approach to Lean, JIT, material handling, transportation planning, data, and continuous improvement thus giving reasons to the focus of this study on trolley utilisation, trip planning, cycle time, waiting, return control and digital visibility. Much of these sources are foundational or conceptual; this study will be a combination of these in a live multi-line dispatch environment.

B. Theoretical Background

The study is based on Lean Manufacturing, which is the main concept of JIT, that only those activities which add the value in the eyes of the customer must use the resource. Non value added activity in dispatch consists of unnecessary movements, repeated handling, searching, waiting, and duplicate documentation. A number of ideas are employed throughout. The cycle time for trolleys and bins is the time it takes from loading to dispatching the bin to its destination, unloading, and returning it, and the shorter the cycle time, the greater the effective asset availability. 100% space utilisation means that the staging space is full, more assets will only exacerbate congestion and flow velocity and turnover becomes the priority. Vehicle dwell or detention is non-productive time waiting for material, loading, clearance or documentation and may be an unnecessary cost. Pre-arrival dispatch readiness involves being ready for the vehicle with material, trolley, documents, labour and forklift before it arrives at the loading point. Digital asset traceability provides status and turnaround visibility by means of a unique QR/barcode identification at dispatch, arrival and return points. The Ishikawa diagram [27] is used to explore root causes under 5M format (Man, Machine, Method, Material, Measurement) and also Pareto logic is implemented to distinguish symptoms from root causes. There are a number of core KPIs and formulae which are used in the analysis and are listed in Table V.

TABLE V.
ORE DISPATCH KPIS AND FORMULAE

Metric	Definition / Formula
Trolley Utilisation (%)	Actual Load ÷ Available Capacity × 100
Total Cycle Time	Loading + Waiting + Transit + Unloading + Return

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Metric	Definition / Formula
Waiting Time	Total non-productive time attributable to material, asset, equipment, documentation, or receiving constraints
Effective Trolley Availability	Total Trolleys − Unavailable/Damaged Trolleys
Trolley Availability (%)	Available Trolleys ÷ Total Fleet × 100
On-Time Dispatch (%)	On-Time Dispatches ÷ Total Dispatches × 100
Cost per Trip	Applicable transport/detention cost ÷ Completed trips
Trolley Investment	Number of Trolleys × Cost per Trolley

IV. MATERIALS AND METHODS

A. Research Objectives

The study compares the existing dispatch process and identifies inefficiencies to use trolleys and bins, and to move materials, through data analysis and key performance indicators (KPIs); it determines the root causes of waiting times, unnecessary trips, inefficient trolley use, and delays in the dispatch cycle; it develops an alternative trolley/bin utilisation and trip-planning model that reduces waiting, non-essential trips, inefficient trolley use, and dispatch-cycle delays; and it measures the effect of the proposed improvements on the dispatch efficiency, resource usage and operational costs of Belrise Industries Ltd. They work together to improve dispatch management processes to be more demand-driven, measurable, resource-efficient, reliable and, of course, safe, while keeping materials available and customer-service requirements in mind. Process observation, KPI measurements, time and cycle analysis, root cause analysis, and existing and proposed operating condition comparison were used for each objective.

B. Research Design and Data Collection

It is applied, descriptive, analytical and exploratory, and follows a mixed research design of quantitative and qualitative approach, and is organised based on the case-study approach with predominant observational and non-experimental approach. The activities included current-state study, data collection, quantitative analysis, qualitative root cause analysis, improvement design and evaluation, which was conducted through cross-sectional observation within the OJT period from 13 April to 13 July 2026. There were eight stages: stage 1, problem identification; stage 2, process understanding; stage 3, data collection; stage 4, data cleaning and classification; stage 5, performance analysis; stage 6, identification of the root cause; stage 7, development of the improvement; and stage 8, before and after comparison.

Purposive sampling selected the dispatch lines relevant to trolley/bin movement, and a census approach was used wherever all relevant dispatch observations were available. The primary sampling unit is one completed dispatch trip or cycle; the sample size is the number of valid trip observations recorded in the study period, and the sampling frame consists of dispatch trips, trolley/bin movements, material loads, loading and unloading events, return cycles, and waiting events. No survey-population formula was used because this is an operational process study.

C. Analytical Framework and Limitations

The data analysis was carried out in seven steps: cleaning up data; classification of data based on lines, dates, trips, assets, quantities, time and destination; descriptive averages; comparative analysis; KPI analysis; root-cause analysis and assessment of improvement benefits. The formulae used to compute utilisation, cycle time, waiting time and return time are given in Table V, while the number of trolleys multiplied by the unit cost was used to compute the investment cost for the trolleys. For example, CCB movements of 42 and 48 trolleys per day at ₹23,840 correspond to ₹10,01,280 and ₹11,44,320, and Press Shop movements of 27 and 36 trolleys at ₹5,000 correspond to ₹1,35,000 and ₹1,80,000. The causes of the waiting time are ranked using Pareto logic for prioritisation for management to work on the high impact causes such as material readiness, trolley availability, forklift delay, documentation and receiving congestion. A reliable approach was undertaken with repeated observations, standardised sheets, checking of records, consistent definitions of the KPIs, comparison of primary and secondary information and the validation of this information with those responsible for it. The methodology is limited in terms of study duration, dataset, manual records, operational variation, human factors, and only optimises dispatch and trolley/bin. Financial estimates are projections that need to be tested against contract, trip and realised financial data, additional restrictions are discussed in Section VI.

V. DATA ANALYSIS AND DISCUSSION

Understand the current dispatch operations.Evaluate ongoing dispatch operations. Weaknesses such as the need to be at work early are being addressed by adjusting the "Dispatch Baseline" for Belrise Industries Ltd. at Chakan,

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line-wise.

TABLE VI.
INE-WISE DISPATCH BASELINE AT BELRISE INDUSTRIES LTD., CHAKAN

Line	Dispatch Unit	Trips / Day	Daily Movement	Unit Cost / Rate
Press Shop	9 trolleys per trip	3–4	27–36 trolleys	≈ ₹5,000 per trolley
CCB	6 trolleys per trip	7–8	42–48 trolleys	≈ ₹23,840 per trolley
K17 BD & EA	≈ 250 parts per trip	4–5	1,000–1,250 parts	≈ ₹1,200 per trip
M&M	40–50 bins per trip	4	—	Fixed ₹1.42 lakh per month

Offered ₹1.42 lakhs per month per fixed monthly payment. The cost structure of these four lines, as illustrated in Table VI, is very different, as is the dispatch unit and the frequency of trips, and it is for this reason that it would be inappropriate to set a single uniform target. From a trolley movement perspective, there is the greatest potential for optimisation of trolley movements at CCB, whereas for Press Shop there is the greatest potential in load consolidation and trip planning, and at K17 BD & EA the challenge is to incorporate parts-per-trip planning based on customer demand, in addition to a fixed monthly transport structure for M&M. There are tight space constraints for all four lines, which means asset velocity and scheduling are more important than fleet size.

Assess Trolley/Bin Utilisation and Trip Patterns Staging and storage capacity is running at 100% utilisation; no new assets should be acquired as a first priority and a significant amount of idle time of equipment and manpower was seen across all four lines. The high value of the K17 parts, coupled with the amount of time it takes to unload the returnables on the customers side, especially at M&M where it can take 2-5 hours, is compelling the need for item-level traceability and controlled staging. Manual documents and duplicate data lead to productivity loss. Effective trolley availability is more dependent on cycle time and return time than just fleet size alone: long customer unloading or return cycle, damage, wheel or structural defect problems, maintenance problems, poor handling and location in another department, etc. can all give an apparent shortage of trolleys despite a sufficient fleet. Utilisation targets are therefore based on safe practical capacity not theoretical maximum as weight, dimensions, stacking and stability restrict load capacity.

To the people of the world, directly and indirectly, who assisted me in the diagnosis of the Root Causes during this Internship, and to all those who helped complete this research study.

Diagnose Root Causes Using 5M Analysis

L

CAUSE-AND-EFFECT MATRIX (5M FRAMEWORK) FOR DISPATCH DELAYS PART-1

5M	Root-Cause Analysis	
	Root Cause Identified	***Supporting Observation***
Man	Idle manpower and poor coordination across production, stores, dispatch, logistics, and receiving	Personnel wait for vehicles and material; process knowledge is spread across departments
Machine	Forklift and vehicle waiting; damaged or unavailable trolleys	Equipment idle time on all four lines; wheel and structural defects reduce availability
Method	No dispatch readiness checklist; trip frequency fixed rather than demand-based; manual records	Dwell and detention while material, documents, or clearance are pending; repeated entry and delayed information
Material	Material readiness gaps; underloaded trips	Material not ready at the loading point; K17 at about 250 parts per trip
Measurement	No cycle-time or KPI monitoring; no real-time trolley status	Delays treated as resource shortage; limited structured historical data

TABLE VII.
AUSE-AND-EFFECT MATRIX (5M FRAMEWORK) FOR DISPATCH DELAYS PART-2

5M	Root-Cause Analysis	
	Operational Impact	***Recommended Countermeasure***
Man	Idle time; reactive dispatch; unclear loading responsibility	Standardised loading responsibilities; weekly cross-functional review

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5M	Root-Cause Analysis	
	Operational Impact	***Recommended Countermeasure***
Machine	Waiting for forklift or loader; reduced trolley availability	Pre-arrival confirmation of handling equipment; monitoring of trolley condition and repair cycles
Method	Detention cost; duplicate paperwork; late clearance	Dispatch Readiness Checklist; demand-based trip planning; digital documentation
Material	Delayed loading; avoidable extra trips	Pre-arrival staging; load consolidation where compatible
Measurement	Weak visibility; delays not attributed to causes	Unique trolley/bin IDs with QR tracking; daily dashboard and line-specific KPIs

The four problem areas—material-handling idle time, insufficient asset tracking, vulnerabilities in manual documentation, and production-dispatch desynchronisation—listed in Table VII and Table VIII are broken down into five systemic causes. The major non-value-adding element is waiting which can occur due to equipment not being ready, trolleys/forklift/loaders not being available, documents are incomplete, documents are pending/awaiting clearance, receiving congestion, delayed returns, and communications gaps. Pareto logic helps management prioritize those causes that can make a big difference like material readiness, trolleys, forklift delay, documentation, and receiving congestion.

Quantify the Capital Impact of Cycle-Time Compression

BASELINE VERSUS OPTIMISED ASSET REQUIREMENTS

Line / Asset Type (Unit Cost)	Before	After	Units Saved	Capex Saving (₹)
Press Shop Line: specialised trolley (₹5,000)	36	32	4	20,000
CCB Line: heavy-duty trolley (₹23,840)	48	43	5	1,19,200
Total capital impact	**84**	**75**	**9**	**1,39,200**

A 10% reduction in the trolley cycle time on the various operational loops is detailed in Table IX. The intent is to increase asset velocity, not asset size up: going round faster means a lower base requirement from 84 to 75 trolleys - which saves on 9 asset purchases, potential capital expenditure of ₹1,39,200 and does not increase the risk of stockout or breach the floor space rule. These are examples of baseline – proposed calculations, which may be validated following implementation.

Calculate logistics and operational costs savings Operational Cost Levers by Line.

TABLE VIII.
OGISTICS AND OPERATIONAL COST LEVERS BY LINE

Line	Lever, Baseline and Proposed Standard	Monthly Saving (₹)	Annual Impact (₹)
Press Shop	Waiting-time reduction: ₹500/hr detention fee, 4 trips/day; cut loading dwell time by 30 min/trip	25,000–26,000	3,20,000–3,30,000
CCB	Waiting-time reduction: ₹800/hr detention fee, 7–8 trips/day; cut loading dwell time by 30 min/trip	50,000–52,000	6,00,000–6,20,000
K17 BD & EA	Load consolidation: 250 parts/trip (5 trips/day) raised to 275 parts/trip (4 trips/day)	30,000–31,200	3,60,000–3,75,000
M&M	Rate renegotiation and SLA: ₹1,42,000 flat monthly transport; 50 bins/trip and 2-hr customer unloading	21,300–29,200	2,55,200–3,50,400

Figures are projected values and should be confirmed with actual contracts, trip records and achieved performance. The objective of the standardisation of the pre-arrival checklists is to reduce loading dwell time by 30 minutes per trip at Press Shop and CCB. At M&M, rate and SLA opportunities are aimed at reducing loading dwell time. A 10% increase in load density (from 250 to 275 parts per trip) reduces the number of trips by one per day directly saving ₹1,200 per day at K17 BD & EA. Table XI provides a summary of quantified benefits by focus area. The project gives a summary of the combined recurrent savings of about ₹1.2-1.4 lacs per month due to the reduction in waiting time and optimized transportation, in addition to the one-time capital saving of ₹1,39,200.

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TABLE IX.

XPECTED IMPACT OF THE PROPOSED IMPROVEMENTS BY FOCUS AREA

Focus Area	Operational Mechanism	Quantified Impact / Benefit
Capex avoidance	10% cycle-time compression across active loops	9 trolleys avoided (Press Shop 4, CCB 5); ₹1,39,200 in total
Vehicle waiting cost	Pre-Arrival Dispatch Readiness Checklist; staging before vehicle arrival	Press Shop ₹25,000–26,000/month; CCB ₹50,000–52,000/month; K17 BD & EA ₹12,500–13,000/month
Freight and trips	Higher load density per trip; consolidated schedules by timing and destination	K17: 250 to 275–300 parts/trip (5 to 4 trips), ₹30,000–31,200/month; M&M: consistent 50-bin loading, ₹14,200/month (₹1.70 lakh annually)
Digital visibility	QR/barcode tracking on all trolleys and bins	100% traceability; 30–50% less documentation time; faster returns and less loss or damage
Customer unloading SLA	Standard 2-hour unloading limit with real-time QR notifications	Unloading cut from 2–5 hours to 2 hours; 12 asset-hours saved daily across 4 trips; ₹10,000–15,000/month
Labour productivity	Work-study elimination of NVA activity, duplicate handling, and redundant paperwork	5–10% productivity gain without added headcount; standardised loading responsibilities

a.

The difference in M&M savings based on case scenario: ₹14,200 per month for loading of 50 bins alone, and ₹21,300–29,200 per month in rate renegotiation and SLA case scenario of the cost table.

Assess Objective-wise OutEcomes

TABLE X.

BJECTIVE-WISE FINDINGS OF THE STUDY

Project Objective	Major Finding / Conclusion
To analyse existing dispatch operations	There is a large amount of trolley and parts movement throughout existing operations around CCB, Press Shop, K17 etc.
To evaluate trolley/bin utilisation	Utilisation should be measured against actual capacity to identify under-utilisation and avoidable movement
To analyse trip planning	The frequency of trips should be matched with the need of materials and production.
To identify operational inefficiencies	The areas that offer the best opportunities for improvement are: waiting, trolley availability, return cycles, tracking and coordination.
To recommend improvements	Tracking and monitoring trolleys, KPI monitoring, demand-based planning, reducing cycle time, line-specific controls

Examination of Table XII, which shows the number of times the analysis points to velocity, standardisation, and measurement, shows that this is generally the case. It can facilitate the transition from a high inventory buffer strategy to an agile, velocity based pull system, and different dispatch strategies on different lines.

Design the Improved Dispatch Framework

- The suggested chain of operation is the identification of trolleys, utilisation monitoring, trip planning, scheduling, cycle time monitoring, tracking return and review of KPI. It is primarily composed of the following elements.
- Dispatch Readiness Checklist: completed prior to the vehicle arriving at the loading point to ensure that material quantity and part identification match the plan, that the trolley/bin is in quantity, condition and identified, that the forklift/loader is available, that documentation and system clearance are in place, and that loading sequence and destination are correct. The vehicle is called to pick up only when the shipment is ready for pick up physically.
- Demand-Based Trip Planning: Ensure production call-out and material on hand, determine the quantity of material(s) that can be safely loaded into trolleys/bins, review when materials will be available and when they

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are expected to return, review and consolidate compatible loads, add trips only when the number of loads exceeds practical capacity and/or timing; review exceptions on a daily basis.

- QR/barcode tracking: a unique asset ID linked to trolley/bin type and line, scanned at plant dispatch, when the trolley arrives at the customer or when it is unloaded (if possible), empty return, trolley in maintenance or trolley as a failure/damaged trolley.
- Turnaround, dwell and return delays can be captured through accumulated timestamps and a QR code can be initially connected to an Excel or database record. Daily and weekly dashboard: date, line, trip number, trolley/bin ID, material, quantity, planned/actual dispatch, destination, time fields (loading, waiting, transit, unloading, return, total cycle time) and exception fields, including weekly KPIs and a management review of top recurring causes of delay, corrective actions, owners, and due dates.

Supporting controls: A controlled trolley buffer for normal variation, the condition of the trolley and repair cycles monitored, periodic time studies, line-specific KPIs and targets.

The future-state flow goes from the dispatch plan through a readiness check, asset allocation, loading, digital scan, dispatch, customer receipt, unloading, return scan, and finally the KPI update. The dashboard indicates a deviation from a standard cycle time, Pareto analysis sorts out the major causes of the problem, corrective actions are measured before and after and the successful actions are standardised using Kaizen.

Plan the Phased Implementation

TABLE XI.
INE-WEEK IMPLEMENTATION ROADMAP

Period	Key Activities	Stage
Weeks 1–2	Standardise definitions, asset IDs, dispatch sheet, and readiness checklist	Operational standardisation
Weeks 3–4	Baseline KPIs; focused cycle-time and time studies	Operational standardisation
Weeks 5–6	Pilot QR/barcode tracking and demand-based trip planning	Digital tracking deployment
Weeks 7–8	Extend controls to customer unloading and return loops (K17 and M&M); review SLA adherence	External collaborative integration
Week 9	Financial audit, before-and-after comparison, management review, and standardisation	Financial auditing and review
After Week 9	Weekly KPI review and periodic improvement cycles	Sustain and improve

The changes in Table XIII are phased to minimise disruption and to provide measurable control prior to digital expansion. A standardised excel sheet should be used to record date, line, trolley ID, material, quantity, dispatch time, return time and delay reason, with utilisation, cycle time, waiting time and trips per day calculated each day or week. A weekly review is then conducted between production, stores, dispatch and logistics which looks at delayed trips, shortages, damage, waiting, return delays and changes in requirements. The last step compares results with actual contracts and post-implementation documentation to ensure that any projected saving has been secured as a realised saving.

VI. FINDINGS, CONCLUSIONS AND SUGGESTIONS

A. Findings

The following were found in the investigation at Belrise Industries Ltd. Staging and storage utilisation is at 100% on all four lines, so there is no longer a need to add assets and equipment and personnel idle times are significant. Utilisation of the trolley is tightly linked to the efficiency of the dispatch and cycle time and return time are more significant factors in effective availability than fleet numbers. At CCB, the high trolley movement (6 trolleys per trip, 7-8 trips per day) presents a high optimisation potential; Press Shop has load consolidating/trip planning opportunities; K17 BD & EA has demand driven parts-per-trip planning opportunities; and customer-side unloading delays are 2-5 hours at M&M lock (returnable assets). Productivity leakage is caused by the absence of real time visibility of the trolleys, manual paperwork and poor coordination between production, stores, dispatch, logistics and receiving. The estimated cost-saving comes from a 10% cycle-time compression (which saves trolleys, from 84 to 75 per month, and avoids capital expenditure of as high as ₹1,39,200 per month), 100% QR-based traceability, 30–50% documentation time reduction without the need for additional manpower, and monthly operating savings of approximately ₹1.2–1.4 lakh from pre-arrival readiness, load consolidation, and rate and SLA measures. The benefits are estimates that have been proposed for the project and are yet to be audited and validated.

B. Conclusions

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The five objectives of the study were met in the diagnostic and design phase: analysis of the existing dispatch process, evaluation of utilisation and trip patterns, identification of root causes, development of a new utilisation and trip-planning approach, and estimation of expected impact of the new approach. Dispatch optimization is not just about reducing trips; it involves optimizing capacity and cycle time, return movements, demand, scheduling, customer unloading, and cross-functional communication. Better utilisation, faster turnaround, demand scheduling and real-time visibility can do more to enhance dispatch performance without the proportionate increase in assets and manpower, so velocity, standardisation, measurement should be more important than more inventory. The sustainable way of working is: measure, analyse, identify bottlenecks, optimise, monitor and standardise. The impact assessment is based on projections of savings, and therefore is best understood as an operational-improvement and process-analysis study that serves as a guideline for future data-driven validation.

C. Suggestions

The plant should implement a staged, joint action plan to make real impact with all stakeholders: For Plant and Dispatch Management: Assign each trolley and bin a unique ID that will capture line, material, quantity, dispatch time, destination, return time and status, introduce demand driven trip planning based on actual production plans, material requirements and capacity, maintain controlled trolley buffer and use line specific KPIs and targets reviewed in a weekly meeting. For Production, Stores and Material Handling: Ensure everything is ready - material, trolleys, documents and labour before the forklift arrives, standardise loading tasks, and track the condition and repair cycle of the trolleys. Increase load density per trip, review load consolidation of compatible loads, review transport rates and agree on a standard 2-hour unloading time and notify using real-time QR. Use an existing, standardised Excel tracking and KPI system, then expand to QR/barcode tracking system and daily dispatch dashboard; periodically schedule time studies; review financial savings against actual contracts and trips before considering them realised; and audit and report on financial savings against actual contracts and trip records. The results of the expected outcomes would be improved visibility of the trolleys, improved capacity utilization, less unnecessary movement, faster cycle times, improved cross functional communication and coordination, and reliable historical data for future decision making on how many trolleys to buy, how often to run trips and what capacity can be expected.

D. Implications of the study

-
- The implications of this study have strategic and operational advantages for all the primary stakeholders: With Higher asset velocity, the capital expense on trolleys is eliminated, detention and transport cost is decreased, and dispatch reliability is achieved without additional manpower. Dispatch, Stores & Material Handling Teams: Readiness checklists & standard loading responsibilities minimize idle time, searching, duplicate documentation and ease the work of new/replacement team members. Production Planning & Logistics: Trip planning is based on demands and the shared dashboard synchronises production and dispatch and provides a factual basis for scheduling decisions. Customers & Finance: Disciplined and traced unloading reduces the cycle time for returning assets and validated KPI and cost data provide finance with a foundation to validate realised savings.

E. Challenges, Limitations and Learnings

The key issues were the lack of structured historical data, lack of real time trolley status monitoring, variable dispatch requirements, coordination between production, stores, dispatch, logistics and receiving, waiting and non value added activity, trolley damage, lack of a standard real time KPI system and safety constraints. There are 10 limitations of the study. There was no single system to provide the detailed historical records to allow trends and statistics and it was not possible to get day-wise loading, waiting, transit, unloading and return data for all cycles. The internship period did not encompass all seasonal or demand conditions, and production volume, material availability and quantities, breakdowns, manpower and customer requirements create variations in dispatch patterns. Outside scope included procurement, inbound logistics, demand forecasting, full warehouse optimisation and the entire transportation network. Some observations were based on employee discussion and manual records and theoretical capacity may not be the same as safe practical capacity. Realised savings are dependent upon labour, freight, maintenance, depreciation, fuel, avoided trips and actual avoided purchases - the figures are therefore based on opportunities and no post implementation long term data was collected. Sensitivity of operational, customer and financial information also precluded use of some information that would have been advantageous. The most significant limitation is that there is no detailed structure historical dispatch database. The OJT enhanced the learner's understanding of dispatch as a whole process and also built their competence in the various aspects of operational data collection, conducting analysis on excel, creation of KPIs, process mapping, time study, and also Root Cause Analysis. Inability to access all information helped with data validation and critical thinking, while cross-functional effort

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demonstrated a lack of process knowledge and value of shop-floor experience. The main learning is that sustainable improvement needs to be measured, thought about in terms of root cause, implemented in practice and monitored continually; the problem and root cause should be identified before more people, resources and trips are proposed. The best practices learned were: Solutions need to be practical, measurable and sustainable; Different lines require line-specific solutions; Cycle time is one important productivity measure and effective use of existing resources is the key to efficiency. The following table shows the mapping of the concepts applied in the MBA during project.

TABLE XII.
PPLICATION OF MBA KNOWLEDGE DURING THE OJT

MBA Concept	Practical Application During OJT
Operations Management	Dispatch process and resource utilisation
Supply Chain Management	Material movement and coordination
Inventory Management	Material availability and movement
Lean Management	Identification of waiting and unnecessary movement
Quality Management	Standardisation and process consistency
Business Analytics	KPI and operational data analysis
Cost Management	Trolley and trip cost analysis
Project Management	Planning and execution of the project
Human Resource Management	Coordination with employees and operators
Strategic Management	Development of long-term improvement recommendations

F. Future Scope of the study

This research creates a tracking baseline and framework that provide opportunities for further investigation: QR/Barcode and Real-time Tracking: Adding real-time location, IoT monitoring and alerts on delayed returns would provide real-time visibility of all trolleys and bins. Remove Duplicate Entry: Eliminating duplicate entry would be achieved through digital documentation, automatic KPI dashboards and ERP integration, reducing response times. Once reliable historical data are available, the capacity constrained trip-scheduling problem can be solved using route optimisation and predictive planning. Further validation: Long-term monitoring (for several months before and after measurements) and a cost-benefit analysis with financing, which would be done in collaboration with other lines, plants and seasons would increase the generalisability of the results.

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REFERENCES

[1] India Brand Equity Foundation, “Automobile industry in India: Industry analysis, market size, trends and opportunities,” IBEF, 2026. [Online]. Available: https://www.ibef.org. Accessed: Aug. 21, 2026.

[2] Society of Indian Automobile Manufacturers, “Annual report 2024–25,” SIAM, New Delhi, India, 2025. [Online]. Available: https://www.siam.in. Accessed: Aug. 21, 2026.

[3] Automotive Component Manufacturers Association of India (ACMA), industry turnover, export and economic-contribution statistics, New Delhi, India. [Online]. Available: https://www.acma.in

[4] M. E. Porter, *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York, NY, USA: Free Press, 1980.

[5] Ministry of Heavy Industries, Government of India, “PLI scheme for automobile & auto components: Driving investments, employment, and growth,” Press Information Bureau, Mar. 27, 2025. [Online]. Available: https://pib.gov.in. Accessed: Aug. 21, 2026.

[6] Ministry of Heavy Industries, Government of India, “Automotive industry and government initiatives.” [Online]. Available: https://heavyindustries.gov.in. Accessed: Aug. 21, 2026.

[7] Ministry of Road Transport and Highways, Government of India, “Motor vehicle regulations and automotive standards.” [Online]. Available: https://morth.nic.in. Accessed: Aug. 21, 2026.

[8] Belrise Industries Ltd., “About us” and “Belrise Industries: Automotive component manufacturing,” company official website. [Online]. Available: https://www.belriseindustries.com. Accessed: Aug. 21, 2026.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

[9] Belrise Industries Ltd., "Investor relations: Financial documents, policies and corporate disclosures." [Online]. Available: https://www.belriseindustries.com. Accessed: Aug. 21, 2026.

[10] National Stock Exchange of India Ltd., Nifty Auto index closing levels, Jul.–Aug. 2026. [Online]. Available: https://www.nseindia.com

[11] N. Slack and A. Brandon-Jones, *Operations Management*, 10th ed. Harlow, U.K.: Pearson, 2022.

[12] J. Heizer, B. Render, and C. Munson, *Operations Management: Sustainability and Supply Chain Management*, 13th ed. Hoboken, NJ, USA: Pearson, 2020.

[13] J. P. Womack and D. T. Jones, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, 2nd ed. New York, NY, USA: Free Press, 2003.

[14] T. Ohno, *Toyota Production System: Beyond Large-Scale Production*. Cambridge, MA, USA: Productivity Press, 1988.

[15] R. Shah and P. T. Ward, "Lean manufacturing: Context, practice bundles, and performance," *J. Oper. Manage.*, vol. 21, no. 2, pp. 129–149, 2003.

[16] R. Shah and P. T. Ward, "Defining and developing measures of lean production," *J. Oper. Manage.*, vol. 25, no. 4, pp. 785–805, 2007.

[17] J. Moyano-Fuentes and M. Sacristán-Díaz, "Learning on lean: A review of thinking and research," *Int. J. Oper. Prod. Manage.*, vol. 32, no. 5, pp. 551–582, 2012.

[18] Y. Monden, *Toyota Production System: An Integrated Approach to Just-In-Time*, 4th ed. Boca Raton, FL, USA: CRC Press, 2012.

[19] S. Shingo, *A Study of the Toyota Production System from an Industrial Engineering Viewpoint*. Cambridge, MA, USA: Productivity Press, 1989.

[20] G. B. Dantzig and J. H. Ramser, "The truck dispatching problem," *Manage. Sci.*, vol. 6, no. 1, pp. 80–91, 1959.

[21] G. Clarke and J. W. Wright, "Scheduling of vehicles from a central depot to a number of delivery points," *Oper. Res.*, vol. 12, no. 4, pp. 568–581, 1964.

[22] M. Christopher, *Logistics & Supply Chain Management*, 5th ed. Harlow, U.K.: Pearson, 2016.

[23] S. Chopra, *Supply Chain Management: Strategy, Planning, and Operation*, 7th ed. Harlow, U.K.: Pearson, 2019.

[24] B. B. Flynn, B. Huo, and X. Zhao, "The impact of supply chain integration on performance: A contingency and configuration approach," *J. Oper. Manage.*, vol. 28, no. 1, pp. 58–71, 2010.

[25] M. Christopher and D. R. Towill, "An integrated model for the design of agile supply chains," *Int. J. Phys. Distrib. Logist. Manage.*, vol. 31, no. 4, pp. 235–246, 2001.

[26] M. Imai, *Kaizen: The Key to Japan's Competitive Success*. New York, NY, USA: McGraw-Hill, 1986.

[27] K. Ishikawa, *Guide to Quality Control*. Tokyo, Japan: Asian Productivity Organization, 1976.

[28] Belrise Industries Ltd., Chakan, "Dispatch records, trolley/bin records, SOPs, observation sheets, and cost data, April–July 2026," unpublished internal records, 2026.

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