Supply Chain Steps
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1. PURPOSE

The Purpose of this document is to provide the Overview of Supply Chain Steps for Order Fulfilment in ECommerce Business

2. STEPS FOR BUILDING A SMART SUPPLY CHAIN

2.1. Digital Inventory Management

Use integrated sensors and software systems to monitor and track stock levels in real time.

2.1.1. Overview

The Digital Inventory Management System is a centralized software solution designed to manage, monitor, and control inventory operations digitally. It helps organizations maintain accurate stock records, track purchases and issues, manage suppliers, monitor stock movements, and generate real-time inventory reports.

2.1.2. Objectives

- ☐ Maintain accurate and up-to-date inventory records.
- ☐ Automate stock-in and stock-out transactions.
- ☐ Track purchases, returns, transfers, and adjustments.
- ☐ Monitor minimum stock levels and expiry dates, where applicable.
- ☐ Reduce manual errors, stock shortages, and excess inventory.
- ☐ Generate reports for inventory valuation, consumption, and auditing.
- ☐ Provide role-based access and accountability.

2.1.3. Functional Models

1. Dashboard

   Displays total products, available stock, low-stock alerts, purchase activity, stock valuation, and recent transactions.

2. Product and Category Management

   Create product codes, categories, descriptions, units of measurement, barcodes, purchase prices, selling prices, and reorder levels.

3. Stock Inward Management

   Record goods received from suppliers, purchase references, quantities, batch numbers, and receiving dates.

4. Stock Outward Management

   Record goods issued to departments, branches, employees, customers, or other authorized recipients.

5. Purchase & Supplier Management

   Manage supplier details, purchase requisitions, purchase orders, goods receipts, supplier invoices, and returns.

6. Reports & Analysis

   Generate stock balance, transaction history, stock valuation, reorder, purchase, consumption, and audit reports.

2.1.4. User Roles and Permissions

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ROLE	RESPONSIBILITIES
Super Admin	System configuration, users, permissions
Inventory Manager	Inventory control, approvals, adjustments
Store Keeper	Receiving, issuing, stock counting
Purchase Officer	Suppliers, requisitions, purchase orders
Department User	Item requests and issue tracking
Auditor	Read-only access to records and reports

2.1.5. Key Functional Requirements

ID	REQUREMENTS
FR-01	Create, edit, view, and deactivate product records
FR-02	Record stock receipts and issues
FR-03	Automatically update stock balances after approved transactions
FR-04	Prevent unauthorized stock movements
FR-05	Generate low-stock and reorder alerts
FR-06	Maintain supplier and purchase records
FR-07	Support multiple warehouses or stores, if required
FR-08	Track user activity and transaction history
FR-09	Generate downloadable reports
FR-10	Support physical stock verification and adjustments

2.1.6. Inventory Workflow



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2.1.7. Database Design

Recommended core database tables:

TABLE	IMPORTANT FIELDS
users	user_id, name, email, role_id, status
roles	role_id, role_name, permissions
products	product_id, SKU, name, category_id, unit_id, reorder_level
categories	category_id, category_name
suppliers	supplier_id, name, contact, address, tax_id
warehouses	warehouse_id, warehouse_name, location
purchase_orders	po_id, supplier_id, order_date, status
goods_receipts	receipt_id, po_id, received_date, reference_no
stock_transactions	transaction_id, product_id, warehouse_id, transaction_type, quantity, date
stock_balances	product_id, warehouse_id, quantity_on_hand
department_requests	request_id, department_id, requested_by, status
audit_logs	log_id, user_id, action, timestamp

Important design rule: Stock transactions should be retained as an auditable history. Stock balances should be updated transactionally so that concurrent receipts and issues do not cause incorrect quantities..

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2.1.8. Non-Functional Requirements

- **Security**
  Authentication, role-based permissions, and secure password storage.
- **Performance**
  Efficient searching, filtering, and reporting.
- **Reliability**
  Database backups and transaction consistency.
- **Scalability**
  Support increasing products, users, and locations.
- **Auditability**
  Record who performed or approved each stock movement.
- **Usability**
  Responsive interface for desktop, tablet, and mobile.
- **Data Integrity**
  Validation of quantities, duplicate SKUs, and stock availability.

2.1.9. Technology Stack

LAYER	TECHNOLOGY
Frontend	React, Angular, or HTML/CSS/JavaScript
Backend	Laravel/PHP, Node.js, or Python/Django
Database	MySQL or PostgreSQL

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Authentication	Secure sessions or token-based authentication
Reporting	PDF, Excel, and CSV exports
Deployment	Cloud hosting or an organization's internal server

2.1.10. Implementation Phases

- ☐ Requirement gathering and process analysis.
- ☐ UI/UX design and database modelling.
- ☐ Product, supplier, and warehouse setup.
- ☐ Purchase, receiving, issuing, and stock tracking.
- ☐ Reports, alerts, and approval workflows.
- ☐ Testing, data migration, and user training.
- ☐ Deployment, monitoring, and maintenance.

2.1.11. Expected Benefits

- ☐ Improved inventory accuracy.
- ☐ Reduced stock wastage and shortages.
- ☐ Faster purchasing and issuing processes.
- ☐ Better visibility into stock availability and value.
- ☐ Improved accountability and audit readiness.
- ☐ More informed purchasing and operational decisions.

2.2. Warehouse Automaton

Warehouse automation uses technology, software, and machinery to run storage, picking, packing, and shipping processes with minimal human intervention. Deploy robotic equipment and smart conveyors to handle, sort, and process goods efficiently.

Warehouse automation transforms manual operational workflows into automated digital systems by combining advanced hardware with intelligent software layers.

Below is a comprehensive breakdown of the entire ecosystem, from the physical hardware to the digital core, alongside its strategic trade-offs and implementation stages.

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2.2.1. Levels of Automation

- **Basic Automation**

  Uses simple tools like barcode scanners, handheld devices, and standard conveyor belts to help workers.
- **System Automation**

  Integrates software like a Warehouse Management System (WMS), Automated Storage and Retrieval Systems (AS/RS), and Automated Guided Vehicles (AGVs).
- **Advanced Automation**

  Deploys full-scale robotics, Autonomous Mobile Robots (AMRs), and Artificial Intelligence (AI) to handle complex workflows autonomously.

2.2.2. The Warehouse Automation Stack

Modern automation operates in a multi-layered framework, moving from physical execution to high-level strategic intelligence.

- [Enterprise Resource Planning (ERP)] <-- Business Strategy & Financials
- [Warehouse Management System (WMS)] <-- Inventory, Orders, & Workflows
- [Warehouse Execution System (WES)] <-- Real-Time Routing & Dynamic Picking

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- [Warehouse Control System (WCS)] <-- Machine Directives & Hardware Control
- [Physical Automation Hardware (AMRs, AS/RS)]<-- Physical Product Movement

1. **Enterprise Resource Planning (ERP)**
   Manages the macro-business operation, including purchasing, finance, sales, and global supply chain data.
2. **Warehouse Management System (WMS)**
   Acts as the brain of the facility. It tracks exact stock locations, manages receiving, slotting optimization, cycle counting, and order batching.
3. **Warehouse Execution System (WES)**
   The bridge layer. It dynamically coordinates inventory flow and balances the workload between human labor and automation hardware in real time.
4. **Warehouse Control System (WCS)**
   The nervous system. It sends direct, millisecond-level commands to physical equipment like conveyors, sorters, and robotic cranes.
5. **Physical Hardware Layer**
   The physical muscle that moves, lifts, sorts, and stores items.

2.2.3. Major Hardware Ecosystems

TECHNOLOGY CLASS	SYSTEM EXAMPLES	PRIMARY USE CASE	SCALING PROFILE
Fixed Automation	Conveyors, Garment On Hanger (GOH), Tilt-tray/shoe sorters	Rapid, high-volume routing of consistent parcels along predefined paths.	High initial capital expenditure (CapEx); difficult to reconfigure.
Automated Storage & Retrieval (AS/RS)	Unit-load cranes, Mini-load shuttles, Cube storage (e.g., AutoStore)	Maximum vertical density and high-speed automated parts retrieval.	Excellent space utilization; bounded by the structural grid footprint.
Mobile Robotics	Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs)	Point-to-point transport, goods-to-person picking, pallet moving.	High flexibility; easy to scale by adding more robots into the fleet.
Robotic Picking & Manipulation	Articulated arms with vision systems, automated piece-picking	Autonomous item sorting, kitting, and placing directly into cartons.	Software-dependent; advancing quickly with AI vision improvements.

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2.2.4. Comparing Strategic Solutions

Choosing an automation path depends heavily on your facility's layout constraints, budget flexibility, and throughput demands.

1. **AMR-driven systems (Low CapEx / High Flexibility)**
   Easy to implement in existing infrastructure. You can scale your fleet incrementally as order volumes grow, though it offers lower vertical storage density.
2. **Shuttle & Crane AS/RS (Medium-High CapEx)**
   Ideal for heavy pallets or standardized cases. It maximizes high ceilings but locks the warehouse into a fixed physical footprint.
3. **Cube Storage AS/RS (High CapEx / Ultra-High Density)**
   Eliminates wasted aisle space completely by stacking bins tightly in a grid. It

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delivers unmatched picking speed and space consolidation but requires a significant upfront financial commitment.

2.2.5. Step-by-Step Implementation Framework

Successful automation requires a phased approach to prevent operational disruption.

- **Phase 1: Data Audit & Baseline Definition**
  Analyze historical SKU velocity, picking frequencies, dimensions, and error rates. Document your current maximum throughput capacity and structural building limitations (such as floor flatness and clear ceiling heights).
- **Phase 2: Digital Foundation (WMS Deployment)**
  Clean your inventory data and roll out a robust WMS. You must achieve highly accurate, real-time manual inventory tracking before introducing complex physical machinery.
- **Phase 3: Islands of Automation**
  Target high-friction, low-skill bottlenecks first. Implement standalone mobile robots (AMRs) for long-distance travel, or add automated pack stations to instantly boost throughput without rebuilding the entire warehouse.
- **Phase 4: Full System Orchestration**
  Integrate high-density storage (AS/RS) with automated conveyors and sorting loops. Tie all hardware components into a unified WES layer to balance workflows smoothly across the building.

2.2.6. Key Technologies

- **Autonomous Mobile Robots (AMRs) & AGVs**
  Move inventory across the facility safely using sensors, lidar, and preset paths.
- **Automated Storage and Retrieval Systems (AS/RS)**
  Use automated machinery to stack and retrieve items from high-density racks.
- **Warehouse Management Systems (WMS)**
  Software that tracks real-time inventory, coordinates orders, and manages workflows.
- **Physical AI & Machine Learning**
  Helps machines adapt to changing real-world conditions like irregular shapes or mixed items.

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2.2.7. Core Benefits & Challenge

- **Benefits**
  Cuts operational and labor costs, increases order accuracy, speeds up fulfillment, and improves safety by removing workers from dangerous tasks.
- **Challenges**
  Requires high upfront capital investment and careful maintenance to avoid mechanical or software stoppages.

2.3. Predictive Demand Planning

Analyze historical and real-time data to forecast product demand and optimize inventory flow.

2.3.1. Purpose & Scope

Predictive demand planning uses data, statistics, and machine learning to estimate future demand so organisations can make better decisions about inventory, purchasing, production, staffing, and distribution.

2.3.2. Overview

a. Technical information

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The system combines historical sales and orders with inventory availability, prices, promotions, seasonality, holidays, product details, supplier lead times, and sometimes external signals such as weather. Data is cleaned and aligned by product, location, and time period before forecasting.

b. Business information

The business problem is to balance product availability with the cost of holding too much stock. Forecasts support sales and operations planning, procurement budgets, production schedules, working-capital decisions, and service-level commitments.

c. Applications

Retail replenishment, e-commerce, manufacturing, food and beverage planning, spare-parts forecasting, pharmaceutical distribution, seasonal goods, and workforce planning.

d. Benefits

Fewer stockouts, less excess inventory, better supplier coordination, reduced waste, more stable production, improved cash flow, and fewer expensive emergency shipments.

2.3.3. Technical Architecture & Methods

a. Data Inputs

Common inputs include point-of-sale data, orders, returns, stock levels, product catalogues, pricing, promotions, supplier lead times, calendars, and relevant external variables. Stockouts must be identified because recorded sales can understate true demand when products were unavailable.

b. Forecasting Methods

A practical system may start with seasonal naïve forecasts, moving averages, or exponential smoothing. Regression can model known drivers; machine-learning methods may capture more complex relationships. More complex models should be adopted only if they outperform a transparent baseline in testing.

c. System Architecture

A typical flow is: source systems (ERP, POS, e-commerce, warehouse) → data pipeline and storage → data validation → forecasting engine → planning dashboard → approved replenishment or production workflow. APIs or scheduled batch jobs can exchange data between systems.

d. Model Evaluation

Use time-based back testing rather than random train/test splits. Measure WAPE or MAE, forecast bias, and business outcomes such as stock-outs and inventory days. MAPE can behave poorly when actual demand is zero or very small.

e. Security & Governance

Control access to sales and customer data, document assumptions, track model versions, define data retention, and keep a record of human overrides and their reasons.

2.3.4. Business Model & Value

a. Business Problem

Over-forecasting ties up cash and increases storage, markdown, expiry, and obsolescence costs. Under-forecasting can cause lost sales, late orders, dissatisfied customers, and costly expedited freight.

b. Stake Holders

Demand planners, sales, procurement, manufacturing, warehouse operations, transport teams, finance, and leadership should share definitions and review significant exceptions together

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c. Costs & Investment

Costs may include software subscriptions, cloud or computing resources, data integration, data cleansing, training, and ongoing model monitoring. A pilot with a limited product range helps test value before a large rollout.

d. Value Measurement

Compare forecast error, service levels, stockouts, inventory value, waste, expedite costs, and planning time before and after implementation. Use comparable periods and account for changes in demand, prices, and product mix.

2.3.5. Implementation Plan

a. STEP 1: Scope

Select a product category, region, and forecast horizon. Define the decisions the forecast will support.

b. STEP 2: Baseline

Record current forecast accuracy, service level, inventory, waste, and manual planning effort.

c. STEP 3: Prepare Data

Identify data owners, clean product and location codes, and connect the most important systems.

d. STEP 4: Pilot

Compare a simple baseline with candidate models using historical backtests and a live shadow period.

e. STEP 5: Integrate

Send approved forecasts to replenishment, purchasing, or production workflows with sensible approval rules.

f. STEP 6: Improve

Monitor drift, investigate recurring errors, update assumptions, and retrain models when justified.

2.3.6. Risks & Limitations

a. Data & Model Risks

Missing data, inconsistent records, unusual promotions, new products, structural market changes, and sudden disruptions can reduce accuracy. A forecast is an estimate, not a guarantee.

b. Operational Risks

If teams do not trust the forecast or cannot act on it, the system may not create value. Human review and clear exception ownership are essential.

c. Mitigation

Use uncertainty ranges, scenario planning, fallback rules, periodic reviews, and a documented process for overrides. Avoid presenting a single forecast number as certain.

2.3.7. KPIs and Examples

a. Key Indicators

WAPE or MAE; forecast bias; stock-out rate; fill rate; inventory days; obsolete stock; waste; expedited freight cost; and planner hours spent on manual adjustments.

b. Illustrative Example

A supermarket chain expects higher beverage demand during hot weather and a local festival. It combines past store sales, promotions, weather forecasts, and inventory records to estimate demand by store, then adjusts

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replenishment and distribution. The result should be validated against actual sales and stock availability.

2.3.8. Conclusion

Predictive demand planning creates value when dependable data and well-tested forecasts are connected to practical business decisions. The aim is not perfect prediction, but earlier, more informed action.

2.4. Smart Fleet Management

Optimize delivery routes using GPS data, automation tools, and advanced AI-driven algorithms.

2.4.1. Purpose & Scope

Smart fleet management uses connected vehicle systems, telematics, GPS, and analytics to improve vehicle utilisation, routing, maintenance, safety, service quality, and operating costs.

2.4.2. Overview

a. Technical information

Vehicles or mobile devices transmit location, distance, engine diagnostics, fuel or battery data, idling, and selected driver-behaviour events to a fleet platform. The platform presents maps, alerts, reports, and work queues.

b. Business information

Fleet costs include fuel or energy, maintenance, insurance, vehicle depreciation, downtime, labour, and missed delivery commitments. Fleet management aims to improve total cost and service reliability while protecting drivers and the public.

c. Applications

Delivery vans, long-haul trucks, public transport, field-service teams, construction fleets, rental vehicles, emergency services, and company cars.

d. Benefits

Better vehicle utilisation, fewer avoidable breakdowns, improved dispatch decisions, more reliable arrival times, reduced unnecessary mileage, and improved safety oversight.

2.4.3. Technical Architecture & Functions

a. Telematics & GPS

An in-vehicle unit or manufacturer interface collects vehicle signals and positioning data. Data is sent through cellular or satellite connectivity to a cloud or on-premises platform. Coverage gaps can delay updates.

b. Fleet Software

Dashboards combine vehicles, drivers, jobs, routes, maintenance schedules, and delivery status. Role-based access helps ensure staff see only the information needed for their duties.

c. Route Optimization

Optimisation tools can consider vehicle capacity, traffic, delivery windows, road restrictions, driver hours, depot locations, and stop priorities. Dispatchers should be able to review unusual recommendations.

d. Predictive & Preventive Maintenance

Engine fault codes, mileage, usage patterns, and service history can trigger inspections. Predictive maintenance estimates failure risk when sufficient reliable data exists; preventive maintenance follows planned intervals.

e. Integrations

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Fleet platforms may connect to transport-management systems, ERP, fuel cards, workshop software, HR scheduling, and customer delivery systems using APIs or file exchange.

f. Cyber Security

Use secure device provisioning, encrypted communications, access controls, software updates, audit logs, and an incident response plan. Assess vendors' data export and service-continuity provisions.

2.4.4. Business Model & Value

a. Cost Control

Track cost per kilometre, cost per delivery, fuel consumption, maintenance spending, idle time, and downtime to identify high-cost routes or vehicles.

b. Service Quality

Live vehicle status and exception alerts help dispatchers communicate delays and reassign work before customer commitments are missed.

c. Workforce & Safety

Driver coaching can address repeated risky patterns, but events must be interpreted fairly. A sudden brake may be caused by a pedestrian or road hazard, not careless driving.

d. Investment Considerations

Costs may include telematics devices, connectivity, software licences, installation, integration, training, and support. Start with the most valuable use case rather than buying every feature

2.4.5. Applications in Practice

a. Last-mile Delivery

Dispatchers group stops, monitor progress, and communicate estimated arrivals.

b. Heavy Transport

Managers monitor route compliance, vehicle health, driving hours where supported, and fuel efficiency.

c. Field Service

Jobs can be assigned based on technician location, skills, parts availability, and appointment windows.

d. Cold-chain Vehicles

Temperature sensors can report whether a refrigerated load remains within approved conditions, with alerts routed to responsible staff.

e. Electric Fleets

Charging status, energy consumption, range estimates, and charging schedules help match vehicles to daily routes.

2.4.6. Implementation

a. Assess

Document fleet size, vehicle types, operating costs, current systems, safety concerns, and customer requirements.

b. Set Goals

Choose measurable outcomes such as lower unplanned downtime, improved on-time arrival, or reduced fuel per kilometre.

c. Pilot

Test a representative group of vehicles, device reliability, data accuracy, driver acceptance, and reporting.

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d. Integrate & Train

Connect only the systems needed for the use case and train dispatchers, maintenance teams, and drivers.

e. Scale & Govern

Expand after evaluating the pilot. Explain monitoring practices, limit access to driver data, set retention rules, and provide a way to challenge inaccurate records.

2.4.7. KPIs, Risks and Examples

a. Key Indicators

Vehicle utilisation; cost per kilometre; fuel or energy per kilometre; idle time; unplanned downtime; maintenance cost; on-time delivery; route adherence; safety incidents; and emissions.

b. Risks

Connectivity gaps, inaccurate sensors, excessive alerts, integration costs, vendor lock-in, poor staff acceptance, and misuse of location or driver data.

c. Illustrative Example

A company with 40 delivery vans uses telematics to spot recurring idle time, overlapping routes, and vehicles approaching service intervals. Dispatchers adjust routes and maintenance teams plan inspections. The company compares downtime, fuel, safety, and delivery results with its original baseline.

2.4.8. Conclusion

Smart fleet management combines technology with clear operating procedures. Its purpose is to improve safe, reliable, cost-effective vehicle operations—not simply to collect location data.

2.5. Transport Tracking Systems

Provide customers with continuous shipment visibility through secure and updated digital platforms.

2.5.1. Purpose & Scope

Transport tracking systems record the location and status of vehicles or shipments as goods move through pickup, hubs, transfers, and final delivery.

2.5.2. Overview

a. Technical information

Tracking can use GPS, barcode and QR scans, RFID, mobile applications, geo-fencing, telematics, IoT sensors, and system integrations. Shipment tracking follows a consignment; vehicle tracking follows a transport asset.

b. Business information

Tracking reduces uncertainty for dispatchers, customer service, carriers, warehouses, and recipients. It helps businesses respond to delays, document handovers, protect sensitive goods, and analyse service performance.

c. Applications

Parcel delivery, freight forwarding, e-commerce, retail distribution, pharmaceuticals, food cold chains, high-value cargo, and intermodal transport.

d. Benefits

Improved shipment visibility, more accurate customer updates, quicker exception response, stronger delivery evidence, and better analysis of recurring delays.

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2.5.3. Technical Architecture & Data Flow

a. Shipment Identity

Each shipment or handling unit receives a unique identifier. Labels and identifiers must remain readable and consistent across carrier and warehouse systems.

b. Event Capture

Barcode scans, RFID readers, driver applications, vehicle GPS, depot geofences, and IoT sensors generate events. Typical statuses include collected, loaded, departed, arrived, delayed, out for delivery, delivered, and returned.

c. Data Exchange

A tracking platform collects events through APIs, carrier feeds, mobile applications, or scheduled files. It maps different partners' status codes into a common event model.

d. ETA Estimation

Estimated arrival time can combine current location, planned route, traffic, stops, delivery windows, and historical travel times. ETA is a prediction and should update as conditions change.

e. Alerts & Dashboards

Rules identify likely late deliveries, unexpected stops, missing scans, route deviations, or temperature excursions. Alerts should be prioritised and assigned to staff who can act.

f. Reliability & Security

The system should show the last update time, distinguish confirmed events from estimates, handle offline scans, protect personal and commercial data, and maintain auditable event histories.

2.5.4. Business Model & Value

a. Customer Experience

Tracking pages and proactive notifications reduce uncertainty and repetitive 'where is my order?' enquiries.

b. Operational Control

Dispatchers can identify delays, coordinate handovers, prioritise urgent freight, and notify receiving sites

c. Risk Management

Route and event histories can support investigations of missing, diverted, or damaged goods. Tracking is a detection and evidence tool, not a guarantee against theft.

d. Cost Considerations

Costs include devices, labels, scanners, sensors, connectivity, software, integration, training, and support. The required level of tracking should match the shipment's value and risk.

e. Value Measurement

Assess event completeness, ETA quality, exception response time, customer enquiries, lost shipments, delivery disputes, and service-level performance.

2.5.5. Applications in Practice

a. ECommerce Parcels

Customers receive milestone updates and delivery notifications, while support staff see the same event history

b. Freight & Container Movements

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Teams monitor transport legs and handovers between carriers, ports, depots, and warehouses.

c. Temperature Sensitive Goods

Sensors record temperature and alert staff to excursions so that the load can be assessed and corrective actions documented.

d. High Value Goods

More frequent location updates and carefully configured alerts can support response to unexpected stops or route deviations.

e. Proof of Delivery

Approved records such as timestamps, recipient confirmation, signature, or delivery photographs help resolve disputes.

2.5.6. Implementation Plan

a. Map the Journey

List each transport stage, handover, responsible partner, and event needed.

b. Define Statuses

Create shared meanings for events and rules for missing, late, duplicate, or conflicting updates.

c. Select Tools

Choose barcodes, RFID, GPS, mobile apps, or sensors according to operating conditions and risk.

d. Integrate Systems

Connect carrier feeds, warehouse management, dispatch tools, customer portals, and notification services.

e. Pilot Exceptions

Test weak coverage, missed scans, incorrect IDs, late deliveries, sensor alarms, and duplicate events.

f. Launch & Improve

Measure data completeness and alert usefulness, then refine rules and partner procedures.

2.5.7. KPIs, Risks and Examples

a. Key Indicators

Tracking-event completeness; percentage of timely updates; ETA accuracy; on-time delivery; exception response time; proof-of-delivery completion; lost-shipment rate; and customer enquiries per shipment.

b. Risks

Missing scans, poor connectivity, dead batteries, inconsistent carrier data, inaccurate timestamps, alert fatigue, privacy concerns, and cyber threats.

c. Illustrative Example

A distributor moves temperature-sensitive products to several stores. Each consignment has a tracking ID, the vehicle reports location, and a sensor records temperature. A delay or temperature excursion triggers an alert so staff can investigate and document the response.

2.5.8. Conclusion

A useful tracking system combines accurate event capture, reliable integrations, actionable alerts, and clear responsibility for resolving exceptions.

2.6. Sustainable Logistics Practices

Minimize packaging waste effectively and transition operations toward clean electric vehicle fleets.

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2.6.1. Purpose & Scope

Sustainable logistics reduces the environmental and social impacts of transport, warehousing, packaging, inventory, and returns while preserving reliable service and economic viability.

2.6.2. Overview

a. Technical information

Sustainability programmes use operational data such as fuel, electricity, distance, payload, tonne-kilometres, warehouse energy, packaging material, and waste. Route tools, telematics, energy monitoring, and carbon-accounting methods help quantify impacts.

b. Business information

The business case can include lower energy costs, less material waste, stronger resilience to resource-price changes, improved customer and supplier confidence, and readiness for applicable reporting requirements.

c. Applications

Road freight, last-mile delivery, warehouses, manufacturing distribution, retail, e-commerce packaging, cold chains, reverse logistics, and third-party carrier procurement.

d. Benefits

Lower avoidable emissions and waste, improved energy efficiency, better use of vehicle capacity, reduced operating costs in suitable cases, and clearer environmental reporting.

2.6.3. Technical Strategies

a. Route & Load Optimization

Plan routes and consolidate compatible loads to reduce empty kilometres and unnecessary trips. Constraints include delivery windows, capacity, road access, product compatibility, and driver safety.

b. Vehicle & Fuel Choices

Efficient vehicles, proper maintenance, tyre management, and eco-driving can reduce energy use. Electric vehicles can reduce tailpipe emissions, but lifecycle impacts depend on electricity generation, vehicle production, battery life, charging, and route suitability.

c. Mode Shift

Rail or water may have lower emissions per tonne-kilometre for suitable long-distance freight, but the comparison should include first- and last-mile transport, transfers, reliability, and total transit time

d. Warehouse Efficiency

Efficient lighting, insulation, building controls, refrigeration management, equipment maintenance, and suitable renewable electricity can reduce energy demand and operational emissions.

e. Packaging & Reuse

Right-sized packaging can reduce material use and shipping volume. Reusable packaging needs a workable return loop and should account for cleaning, reverse transport, losses, and the number of reuse cycles.

f. Carbon Accounting

Estimate emissions using activity data and appropriate, current emissions factors. Document boundaries, assumptions, data gaps, and whether figures are measured or estimated. Compare both total emissions and intensity metrics.

2.6.4. Business Model & Value

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a. Costs & Returns

Projects may require vehicles, charging infrastructure, building upgrades, reusable packaging, data systems, or supplier changes. Evaluate capital cost, operating savings, maintenance, reliability, and expected service life.

b. Customer & Market Value

Customers may increasingly request credible environmental information. Specific, substantiated claims are more useful than broad claims such as '100% green' without a clear basis.

c. Supply Chain Collaboration

Carriers, suppliers, warehouses, and customers often control different parts of the emissions footprint. Shared definitions and data exchange help avoid gaps or double counting.

d. Risk Management

Energy-price volatility, climate-related disruption, waste rules, and changing customer expectations can affect logistics performance. Sustainable practices can improve preparedness, though they do not remove every risk.

2.6.5. Applications in Practice

a. Urban Deliveries

Group orders by area, improve drop density, use suitable low-emission vehicles, and offer delivery windows that reduce failed attempts.

b. Long Distance Freight

Improve load factors, reduce empty running, assess rail or water options, and use reliable fuel and distance data.

c. Warehousing

Monitor electricity per order, improve lighting and refrigeration controls, and assess renewable power where feasible.

d. Packaging

Remove unnecessary void fill, select right-sized materials, and use recyclable or reusable systems supported by local collection and recovery.

e. Returns & Waste

Reduce product damage, improve demand planning, repair or refurbish suitable returns, and handle waste through documented processes.

2.6.6. Implementation Plan

a. Baseline

Measure fuel, energy, emissions, empty running, vehicle fill, packaging, waste, damage, service quality, and safety.

b. Priortise

Identify the largest sources of impact and select projects with measurable outcomes and responsible owners.

c. Pilot

Test route changes, load consolidation, packaging redesign, vehicle changes, or warehouse efficiency measures on a defined scope.

d. Verify

Compare results with the baseline using consistent boundaries and activity levels. Check that impacts have not simply moved to another supplier or transport leg.

e. Scale

Update procurement standards, operating procedures, carrier requirements, staff training, and reporting routines.

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f. Report Honestly

Explain methods, assumptions, limitations, and progress. Avoid unsupported environmental claims.

2.6.7. KPIs, Risks and Examples

a. Key Indicators

Total logistics emissions; emissions per tonne-kilometre or delivery; fuel or electricity per kilometre; vehicle fill rate; empty-running percentage; lower-emission transport share; warehouse energy per order; packaging per shipment; waste; damage rate; on-time delivery; and safety incidents.

b. Risks & Tradeoffs

Upfront costs, limited infrastructure, inconsistent carrier data, extra reverse transport for reusable packaging, lifecycle impacts, and pressure to deliver too quickly can complicate improvements.

c. Illustrative Example

A distributor measures fuel, distance, delivery volume, and empty kilometres. It consolidates compatible orders, improves sequencing, maintains vehicles, and reduces unnecessary packaging. It compares emissions and cost per delivered unit while also monitoring delivery reliability and damage.

2.6.8. Conclusion

Sustainable logistics works best as a measurable improvement programme: establish a baseline, target significant impacts, test practical changes, and verify outcomes without compromising safety or service.

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