Inventory Control and Monitoring System Project

Advisor

Dr. Bilal Al-Zoubi

Team Leader

Omar Ibrahim Al-Otoom ID: [232414]

Team Members

- Mohammadali Abd Al-Sater Nasr ID: [240641]
- Nawras Asim Mohammad ID: [232120]
- Arafeh Halawah ID : [221780]
- Zaid Abdulkarim Al-Harahasha ID: [230165]

Date

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The Integrated System for Inventory Management and Operations Research in Smart Warehousing

Analytical integration of Operations Research (OR), Supply Chain Management (SCM), and dynamic simulation techniques to transform data into a competitive advantage.

The Ultimate Structure - Presented by [Researcher's Name] - [Date]

Core Message: Shifting from reactive, traditional management to proactive management based on mathematical forecasting and optimisation.

Strategic and Operational Importance of Inventory

Inventory as a Financial Asset

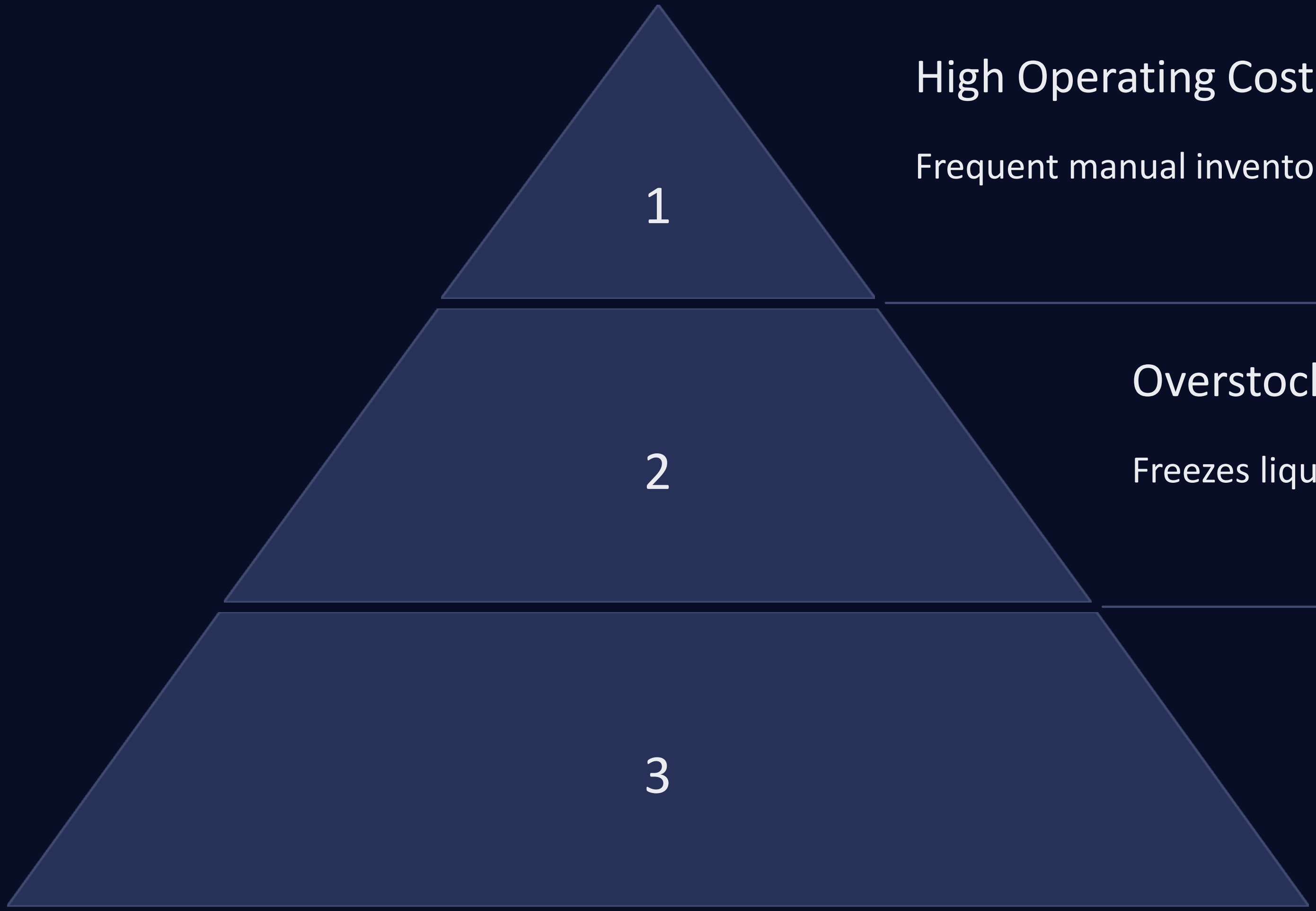
Inventory constitutes a significant portion of working capital. Effective inventory management directly impacts cash flow and financial health.

Core Functions

- **Decoupling:** Separating production stages to ensure continuity if one line fails.
- **Demand Fluctuation:** Protection against sudden demand changes or supply delays.
- **Economies of Scale:** Capitalising on bulk purchasing discounts.

In manufacturing, a single missing component can halt a multi-million-dollar production line. Inventory acts as an operational safety valve.

Analysing the Inventory Crisis: The Cost of Mismanagement



High Operating Costs

Frequent manual inventory counts and human data entry errors drive up operational expenses.

Overstocking

Freezes liquidity, increases obsolescence risk, and incurs high storage costs.

Stock-out Costs

Beyond lost sales, these include customer dissatisfaction, expedited shipping, and brand damage.

The scientific objective is to minimise the "Total Inventory Cost", not just the purchase price.

The Fundamental Distinction: Stock Control vs. Inventory Management

1 Stock Control (Tactical)

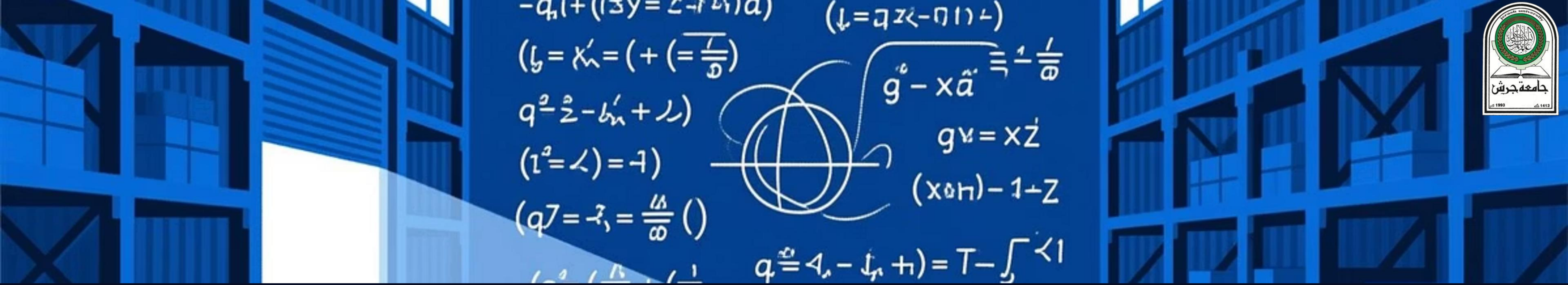
- **Focus:** "What is currently in the warehouse?"
- **Operations:** Physical inventory, receiving shipments, shelf organisation, and matching figures.

Stock control ensures data accuracy.

2 Inventory Management (Strategic)

- **Focus:** "What should we order for the future?"
- **Operations:** Demand forecasting, setting safety stock levels, and financial risk analysis.

Inventory management ensures sound decision-making.



Operations Research (OR): The Brains of the System

Scientific definition: Using mathematical models and algorithms to achieve "optimal solutions" under specific constraints.

Modelling

Translating warehouse movements into precise mathematical equations.

Trade-off Analysis

Balancing ordering costs against holding costs for optimal efficiency.

Results

Providing exact figures for "how much to order?" and "when to order?", moving beyond subjective estimates.

SCM Integration: Inventory as a Network Node

System Vision:

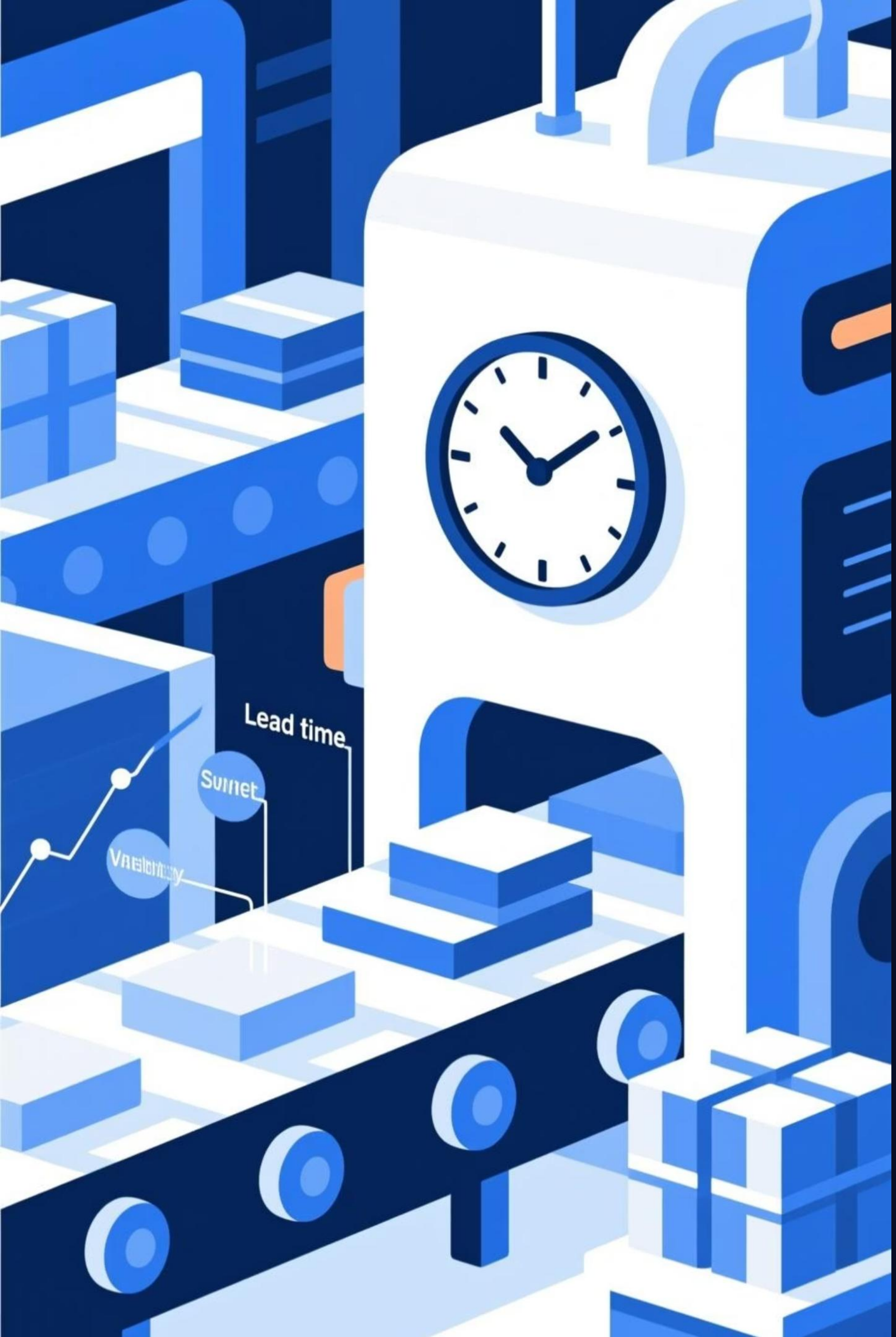
The warehouse is not an isolated entity, but a critical node within the broader supply chain network.

Supply Chain Impact

Integrating upstream supplier data and downstream sales forecasts to mitigate the "Bullwhip Effect", which causes unnecessary inventory fluctuations.

Logistical Efficiency

Aligning inventory decisions with transportation methods and shipping costs to ensure smooth material flow at the lowest possible cost.



Lead Time Analysis: Understanding Variability

Components of Lead Time:

Order processing time + Supplier manufacturing time + Shipping and customs time + Inspection and receiving time.

The Challenge of Variability

The issue is not just the duration but its instability (e.g., sometimes 5 days, sometimes 10 days).

Mathematical Impact

The system uses the standard deviation of lead time as a key factor in calculating "Safety Stock".

Increased Protection

Higher variability directly correlates with the need for greater protection against stock-outs.

Dynamic Supplier Performance Evaluation: Risk Scoring

Quantitative Indicators:

- On-Time, In-Full (OTIF) Rate:

  Ensuring deliveries are on schedule and complete with correct quantities.

- Quality Rate:

  Ratio of accepted items versus rejected items, measuring product quality consistency.

- Flexibility:

  The supplier's ability to respond to urgent or unexpected demands.

Converting Performance to Risk:

The system assigns a "risk score" to each supplier. A low-performing supplier automatically triggers higher safety stock levels for associated items, safeguarding operations.

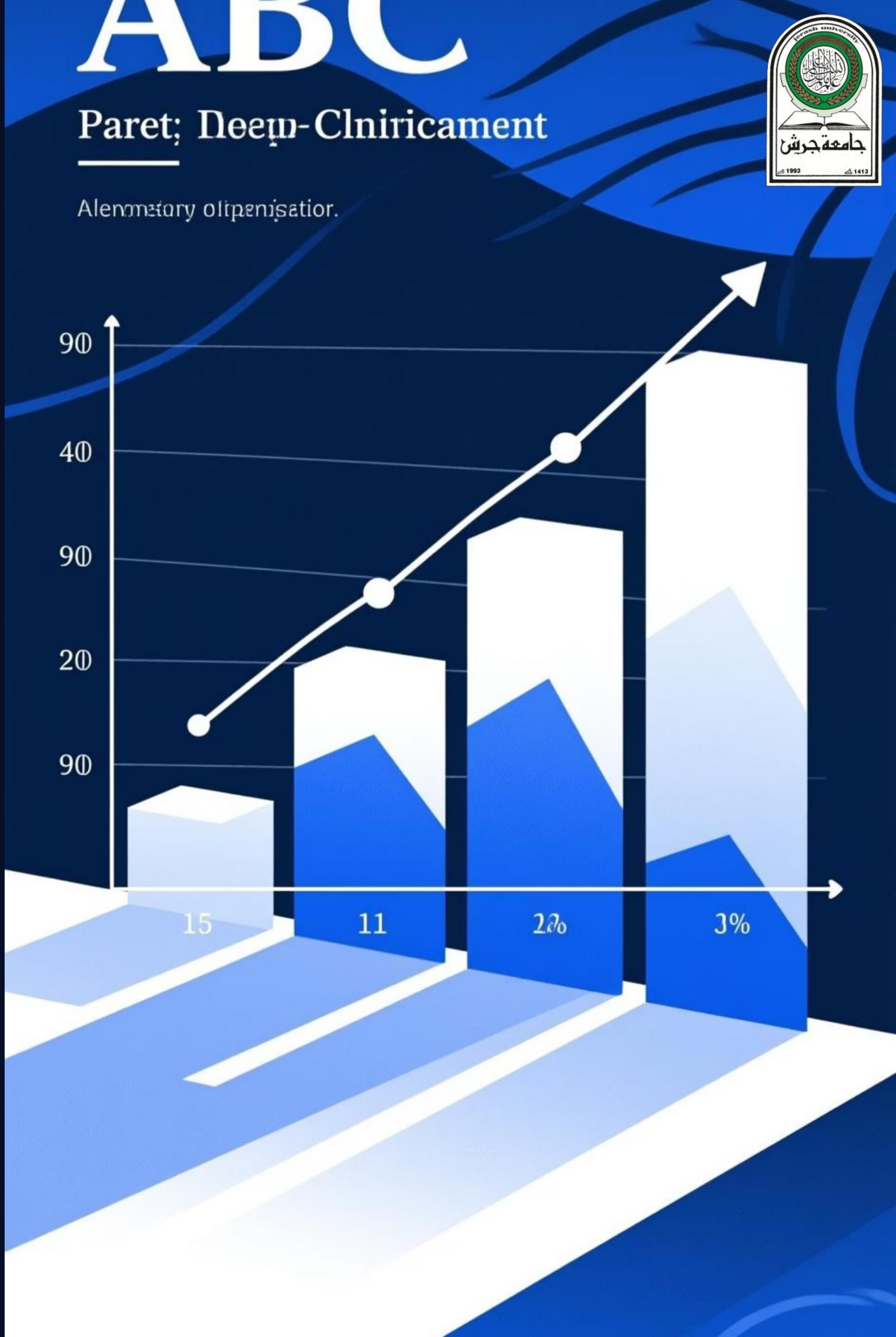
ABC Analysis: Financial & Value Classification

Pareto Principle (80/20 Rule):

- **Category A (Top):** 20% of items constitute 80% of inventory value. Requires daily checks and stringent control.
- **Category B (Medium):** 30% of items constitute 15% of value. Requires periodic monitoring.
- **Category C (Bottom):** 50% of items constitute only 5% of value. Managed simply and in large quantities to minimise ordering effort.

Managerial Impact:

Directing senior management attention to Category A items ensures optimal capital utilisation and minimises financial risk.



VED Analysis: Operational and Vital Classification

The VED (Vital, Essential, Desirable) analysis is a crucial inventory classification method, especially in industrial and service settings. It categorises items based on their operational criticality, ensuring uninterrupted business flow.

Vital (V)

These are "cannot operate without" items. Their absence brings operations to a complete halt. Inventory systems must ensure zero stock-out risk for these items.

Essential (E)

Lack of these items leads to reduced efficiency or partial breakdowns. They can be replaced, but only with difficulty and for a limited period.

Desirable (D)

These are supplementary items whose absence does not fundamentally impact core operational processes.

Mathematically, Vital items are assigned a very high safety stock (Z-Score) in operational research equations, reflecting their paramount importance.

FSN Analysis: Movement and Flow Classification

FSN (Fast, Slow, Non-Moving) analysis classifies inventory based on its consumption rate, providing insights critical for efficient warehouse layout and operational flow.

01

Fast (F)

These items have a high turnover rate. The focus is on storing them in easily accessible locations and ensuring rapid receipt and dispatch processes.

02

Slow (S)

Items with infrequent movement. The strategy here is to minimise order quantities to prevent stock accumulation and optimise storage space.

03

Non-Moving (N)

These items have shown no movement for an extended period. Decisions typically involve liquidation, sale, or disposal to free up space and capital.

The primary benefit of FSN analysis is its direct impact on designing an optimal warehouse layout, strategically placing items based on their movement velocity.

Economic Order Quantity (EOQ): Core Principles

The EOQ model is a foundational and robust mathematical tool in inventory management, providing a critical answer to the question: "What batch size achieves optimal balance?"

> The EOQ model serves as the 'ruler' against which we measure deviations from reality, providing a theoretical ideal for inventory levels.

Its core assumptions include known and constant demand, instantaneous replenishment, and no quantity discounts (in its basic form). While simplifying reality, it provides a powerful baseline for optimising order quantities.

The Ultimate Matrix: Integrated Decision Framework

The ultimate in inventory management combines ABC, VED, FSN, and HML analyses into a powerful, integrated decision matrix. This comprehensive approach provides precise data for operational research engines.

1

Intelligent Integration

The system masterfully combines all previous classifications to provide a holistic view of each inventory item.

2

Example: A-Vital-Fast-High (AVFH)

Consider an item classified as A (high value), Vital (critical to operations), Fast (high movement), and High (expensive). This item is the "backbone" of operations.

3

Strategic Implications

For an AVFH item, strategies include sourcing from multiple suppliers, maintaining high safety stock, implementing real-time inventory tracking, and storing it in the most secure warehouse location.

4

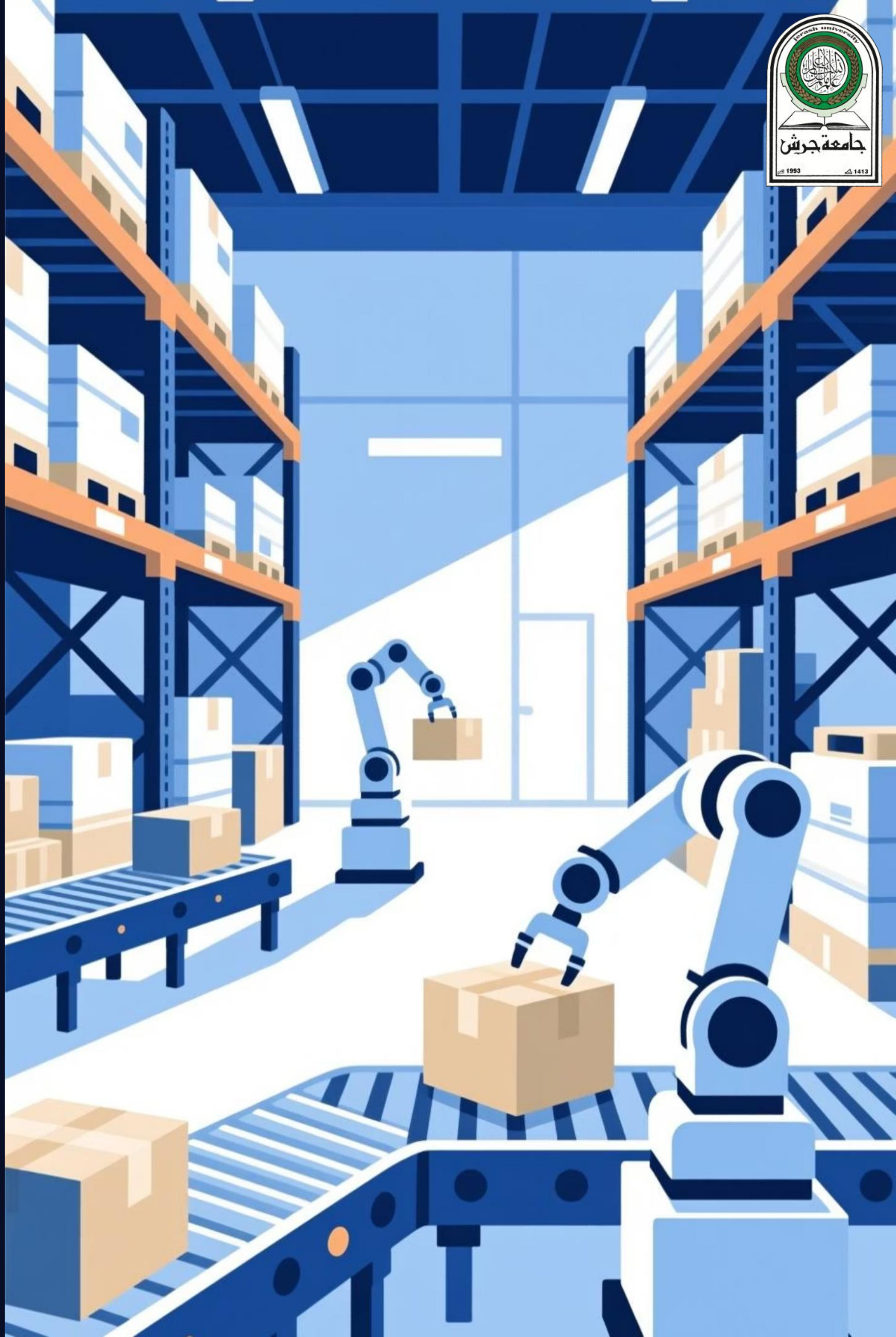
Data-Driven Decisions

This matrix feeds the "Operational Research Engine" with accurate data, enabling precise decisions on "how much" and "when to order," optimising efficiency and mitigating risks.

This integrated matrix is the cornerstone for sophisticated inventory management, enabling proactive and informed strategic decisions that drive operational excellence.

Optimising Inventory: The Science of Efficiency

This presentation explores the scientific principles and mathematical models behind effective inventory management, focusing on key strategies for professionals and managers in industrial and service sectors within Saudi Arabia.



The Inventory Trade-off: Balancing Costs

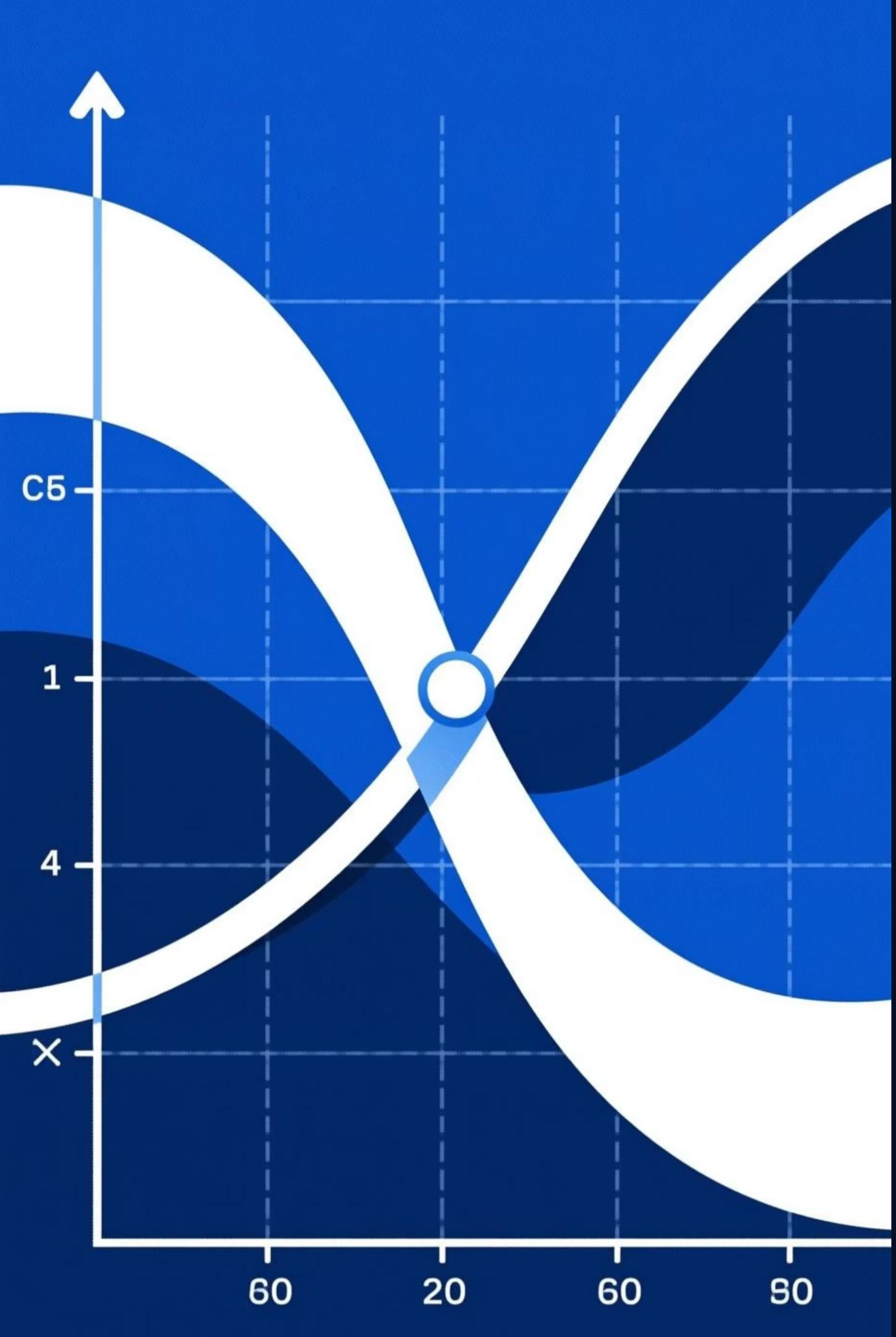
Ordering Costs

Placing large orders reduces shipping and administrative expenses per unit.

Holding Costs

Conversely, large orders increase storage, insurance, and the cost of capital tied up in inventory.

Effective inventory management is a delicate balancing act. The traditional challenge lies in navigating the opposing forces of ordering costs versus holding costs. The scientific objective is to identify the optimal point that achieves total cost minimisation for the enterprise.



Objective Function & Optimisation

Optimisation in inventory management involves formulating an 'Objective Function' to guide decision-making.

$$TC = \frac{D}{Q}S + \frac{Q}{2}H + C_{shortage}$$

Where represents the total cost. Our system employs mathematical differentiation of this function to find the value where the slope is zero, indicating the 'optimal quantity'. This approach ensures the most cost-effective inventory levels.

EOQ: The Mathematical Formulation

The EOQ formula enables precise calculation of the ideal order quantity.

$$Q = \sqrt{\frac{2DS}{H}}$$

Where:

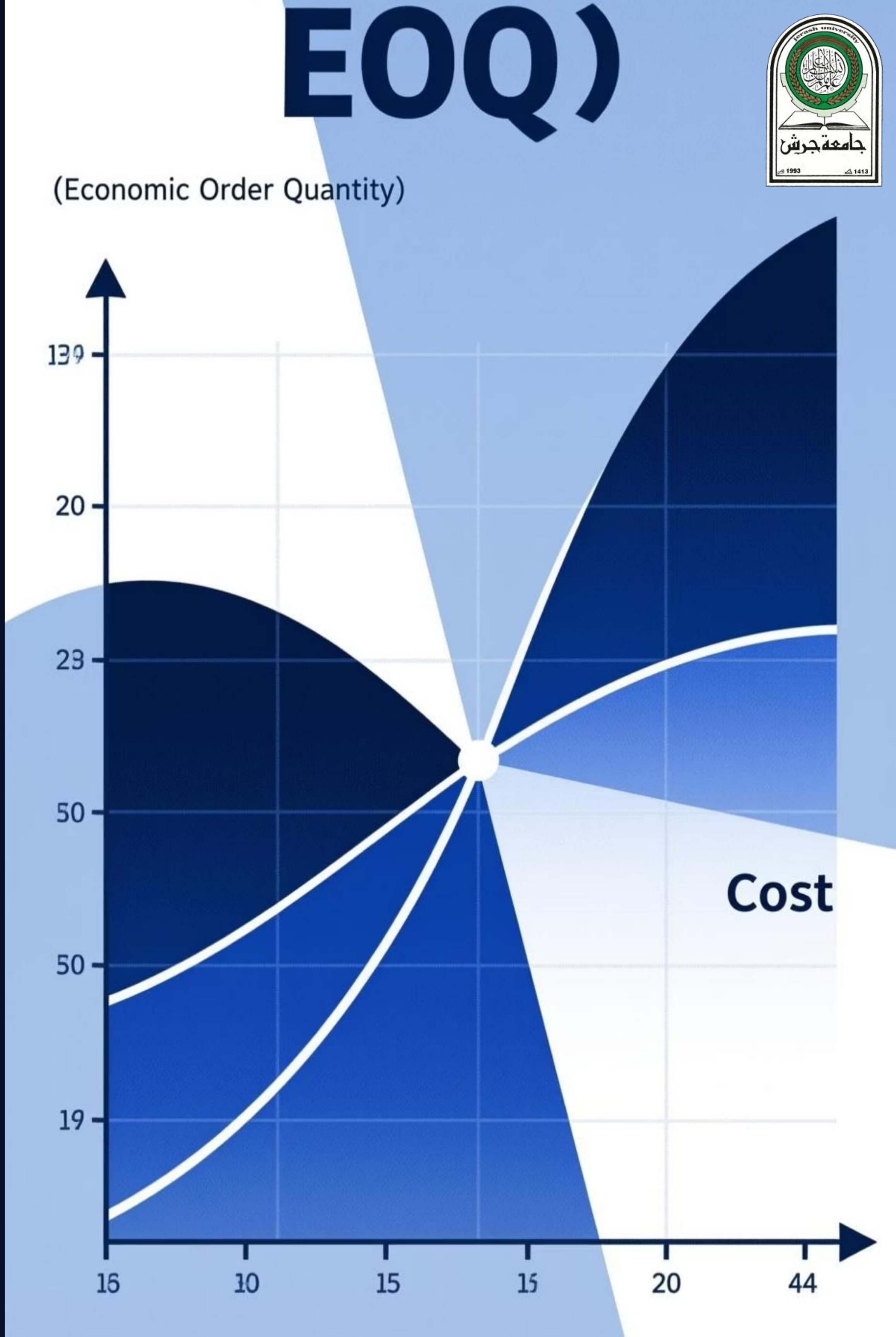
- : Optimal Economic Order Quantity.
- : Annual Demand.
- : Setup/Ordering Cost per order.
- : Carrying/Holding Cost per unit annually.

Our automated systems utilise this formula to calculate the optimal figure for each item, based on sales data and warehousing costs.

Visualising EOQ: Cost Curve Dynamics

The EOQ graph visually demonstrates the interplay between holding and ordering costs.

The holding cost curve ascends with increased quantity, while the ordering cost curve declines. The intersection point signifies the minimum total cost. Any deviation to the right results in excessive storage costs, while a shift to the left leads to inflated ordering expenses.



Reorder Point (ROP): When to Order

The Reorder Point addresses the critical question of "when to order" to ensure seamless operational continuity.

$$ROP = (DailyDemand) \times (LeadTimeinDays)$$

Where:

- : Daily Demand Rate.
- : Lead Time in Days.

For example, if daily consumption is 10 units and the supplier requires 5 days lead time, an order should be placed when inventory levels drop to 50 units. This prevents stock-outs during replenishment.

Safety Stock (SS): The Emergency Buffer

Safety Stock acts as an essential emergency buffer, crucial in a dynamic environment where demand is rarely constant and supplier lead times can vary.

$$SS = Z \times \sigma_{LT}$$

Where:

- : Service Level Factor (e.g., 1.65 for 95% service level).
- : Standard Deviation of Demand during Lead Time.

This buffer inventory is critical in preventing costly stock-outs and maintaining high service levels, safeguarding against unforeseen fluctuations in supply and demand.

Integrated ROP and Safety Stock: A Comprehensive Approach

The comprehensive formula integrates Reorder Point and Safety Stock for a robust inventory management strategy, forming the backbone of intelligent inventory systems.

$$ROP = (DailyDemand \times LeadTime) + SafetyStock$$

This formula ensures that the system accounts for both normal consumption () and provides additional protection against unexpected variations.

Economic Production Quantity (EPQ): Gradual Replenishment

In manufacturing environments, materials are often produced gradually at a specific rate ().

$$EPQ = \sqrt{\frac{2DS}{H(1 - \frac{D}{P})}}$$

The term represents the fraction of production that enters inventory after accounting for immediate consumption during the production process, optimising production batch sizes.

Economic Production Quantity (EPQ): Understanding Gradual Production

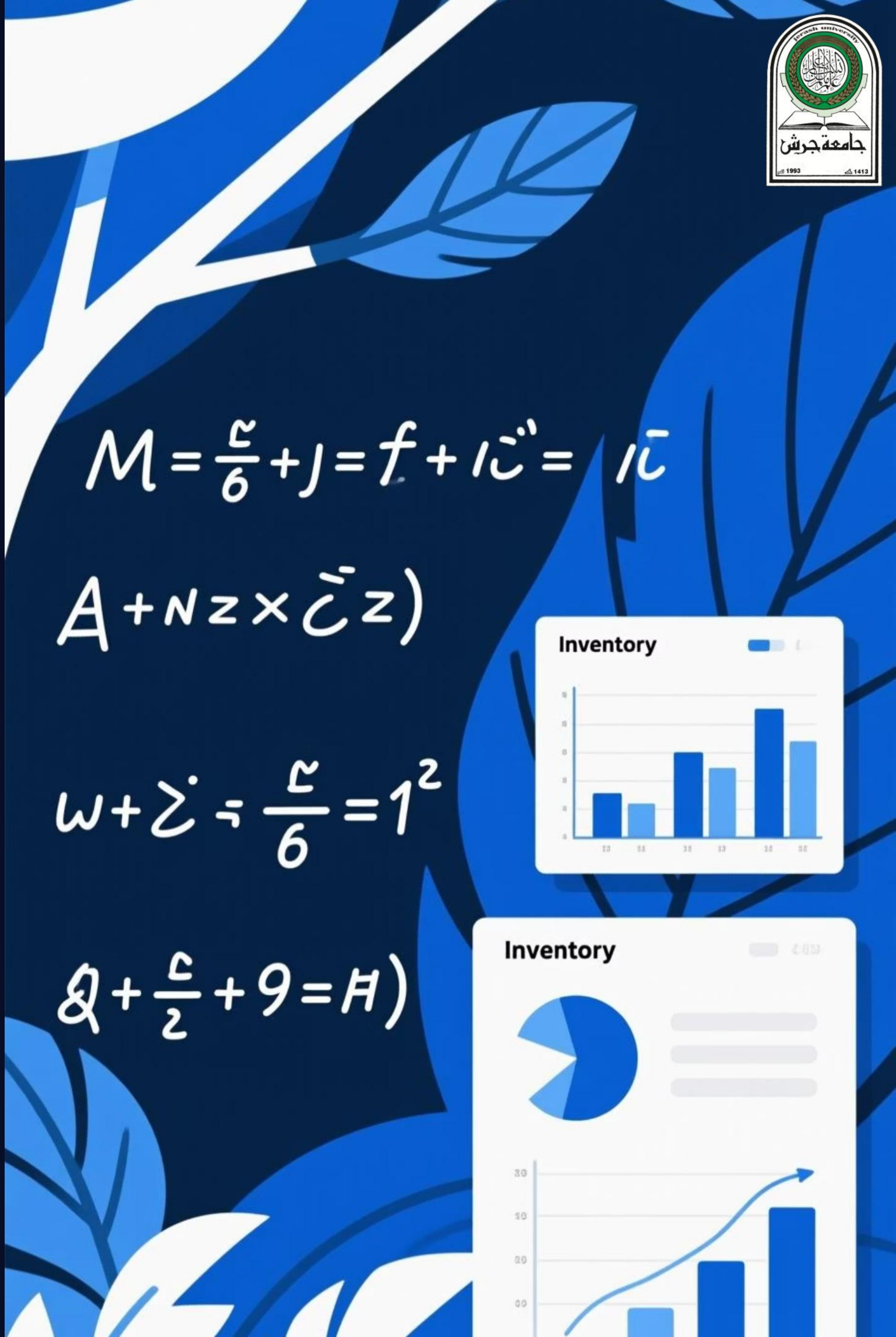
In manufacturing, materials are not received in a single batch but are produced at a continuous rate. This gradual production process requires a distinct approach to inventory management.

EPQ Formula and Its Significance

The Economic Production Quantity (EPQ) model accounts for situations where inventory is built up over time as production occurs. The formula, therefore, includes a factor that reflects this gradual accumulation.

$$Q = \sqrt{\frac{2DS}{H(1 - \frac{D}{P})}}$$

The coefficient represents the portion of production that goes into storage after deducting what is immediately consumed during the production process. This factor is crucial for accurately calculating optimal batch sizes.



Key Differences: EOQ vs. EPQ

Understanding the core distinction between Economic Order Quantity (EOQ) and Economic Production Quantity (EPQ) is vital for appropriate application.

EOQ: Retail Applications

Suitable for retail businesses that receive finished goods directly from suppliers in single, discrete orders.

EPQ: Manufacturing Focus

Ideal for manufacturing companies that produce components internally, where inventory builds up incrementally.

Mathematical Implication

EPQ consistently results in a higher order quantity than EOQ because gradual storage allows for larger production batches with relatively lower holding costs.

Supplier Risk into Inventory Decisions

Connecting supplier performance with inventory decisions is a critical component of risk mitigation. A weak supplier rating directly impacts inventory parameters.

If a supplier's evaluation is poor, the system treats them differently from other suppliers. The "supplier delay rate" is translated into an increase in the standard deviation value used in the safety stock equation.

The Digital Twin Concept: Redefining Inventory Management

Simulation within this system transcends a mere computational tool; it acts as a "Digital Twin" of your warehouse. This sophisticated concept bridges historical data with present operational realities and future potential scenarios. While traditional mathematical models (OR) dictate ideal outcomes, our simulation unveils what truly unfolds amidst market uncertainties and dynamic environments.

Dynamic Stress Testing: Validating Inventory Decisions

Function: Stress Testing EOQ & ROP

Our primary function is to rigorously stress test your Economic Order Quantity (EOQ) and Reorder Point (ROP) decisions. This ensures the resilience of your inventory strategy.

Objective: Resilience Verification

Will your calculated quantities hold up if a supplier delays delivery by two extra days? Will they suffice if demand unexpectedly increases by 10%? Our system answers these critical questions.

Value: Virtual Failure, Real Confidence

Simulation allows for "virtual failure" rather than costly real-world mistakes. This provides absolute confidence to management before committing to any purchase orders.

Monte Carlo Simulation Method: Navigating Uncertainty

Scientific Foundation: Law of Large Numbers

This technique relies on the law of large numbers. Instead of using a single demand figure (e.g., 100 units), we define a "Probability Distribution" for both demand and lead time.

Mechanism: Generating Future Pathways

The system generates thousands of future scenarios or "Random Walks." In each path, random values for demand and lead time are selected based on their historical behaviour, and the outcome is calculated.

Output: Probabilistic Insights

The output is a probability map, indicating, for example, a "92% probability of success and an 8% risk of stock-out." This empowers informed decision-making.

Simulating Demand Volatility: Adapting to Fluctuations

Demand is rarely linear; it's dynamic and constantly fluctuating. Our simulation dives deep into "daily variability," revealing how consecutive days of high demand—even if within the average—can deplete inventory before new shipments arrive.

Analyse Daily Fluctuations

Understand how short-term demand spikes impact your stock levels.

Identify Breaking Points

Pinpoint the exact moments when your current inventory levels become unsustainable.

Optimise Safety Stock

Adjust safety stock levels to be more responsive and resilient to sharp demand changes.

Supply Chain Risk Simulation: Proactive Failure Modelling

Modelling Failure: Supplier Performance

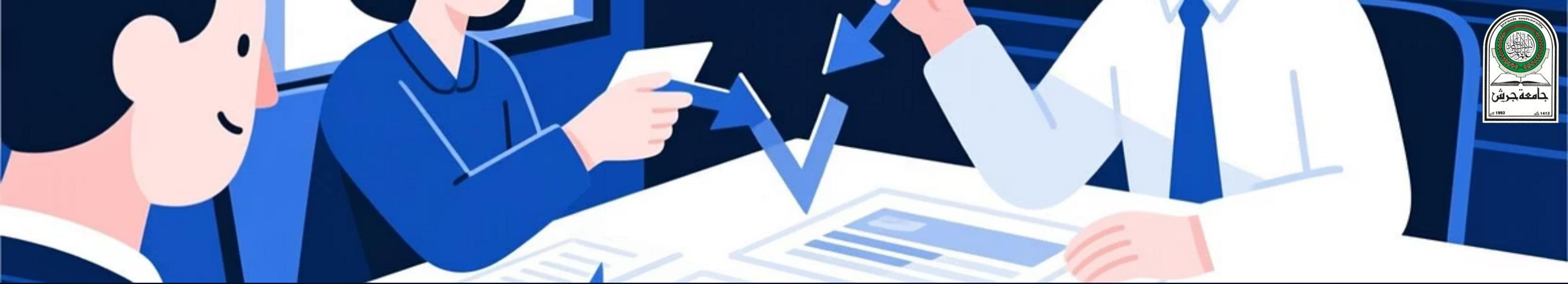
Here, we actively model failure by inputting the delay probabilities derived from our supplier assessments. This allows us to foresee potential disruptions.

Scenario Testing: Production Impact

The simulation tests critical scenarios: "If a supplier has a 15% chance of delay, how many times will production halt during the year?"

Key Metric: Stock-out Probability

By calculating the "stock-out probability," we determine whether alternative suppliers are needed or if immediate inventory increases are required.



Scenario Analysis & Decision Optimisation

Simulation serves as a powerful tool for strategic trade-offs and optimisation, allowing you to compare different supply chain strategies with precision.

Scenario A: Global Supplier

Lower purchase cost with longer lead times and higher risk.

Scenario B: Local Supplier

Higher purchase cost with shorter lead times and lower risk.

Optimised Decision

The system simulates the total cost, including potential stock-out costs, for each scenario, identifying the most cost-effective long-term choice.

Intelligent Forecasting: Powering Your Simulation Engine

Accurate forecasting is the fuel for our simulation engine. We leverage advanced statistical techniques to predict future demand with greater precision, reducing the gap between expectation and reality.

Moving Average

Ideal for stable demand patterns, providing a smooth estimation of future needs.

Exponential Smoothing

Prioritises recent data, making it highly effective for volatile and dynamic market conditions.

Trend Analysis

Detects sustained upward or downward movements in demand, essential for long-term planning.

Proactive Alert System: Beyond Reorder Points

ROP vs. Proactive Alert

- **Reorder Point (ROP):** A reactive alert based on current quantity, triggered after a situation unfolds.
- **Proactive Alert:** An anticipatory alert based on demand trends, preventing issues before they occur.

The Predictive Engine: Agility and Robustness

This predictive engine represents the "immune system" of your inventory management. Its ultimate goal is to transform management from "firefighting"—reacting to problems—to "fire prevention"—averting issues before they arise.

Enhanced Agility

Achieve swift adaptation to market changes and demand fluctuations.

Unmatched Robustness

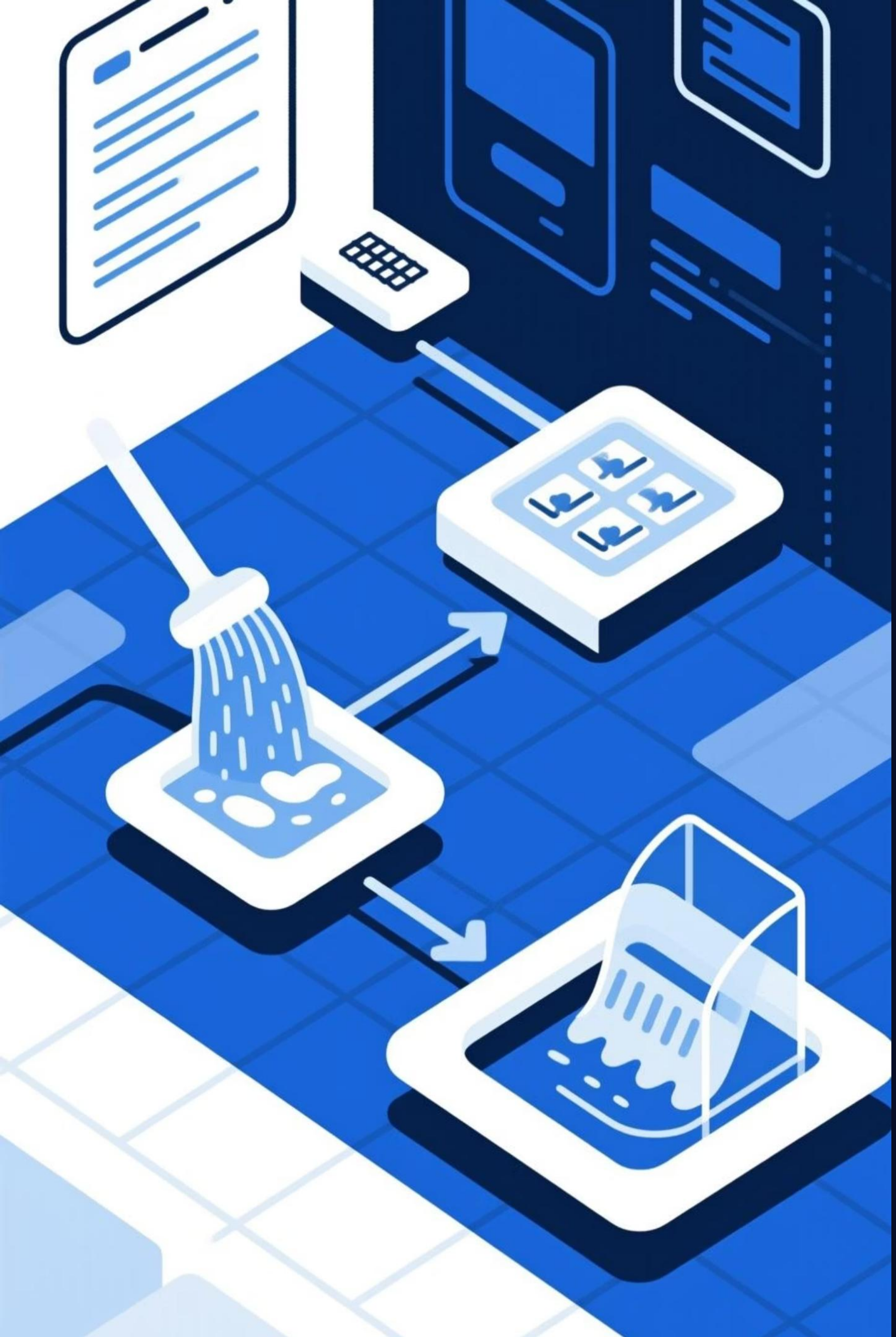
Build a resilient inventory system capable of withstanding global market volatility.

Optimised Costs

Ensure business continuity with minimal operational expenses and maximum efficiency.

The Nervous System: Orchestrating Inventory Excellence

Just as the human nervous system transmits vital signals to the brain, our integrated technological and human governance framework aims to bridge the gap between perceived and actual inventory. This system demands absolute precision to ensure the integrity of operational research and simulation outcomes.



Algorithmic Processing: Preparing for Precision

Before applying complex equations, the system undertakes critical pre-processing steps to ensure data quality and relevance.

01

Data Smoothing

Outlier values in demand (e.g., an exceptional, non-recurring order) are identified and removed to prevent skewing calculations.

02

Sorting and Classification

Inventory items are categorised to apply the most appropriate model. For example, EOQ for stable items, and other models for volatile items.

The Core Challenge: Data Integrity

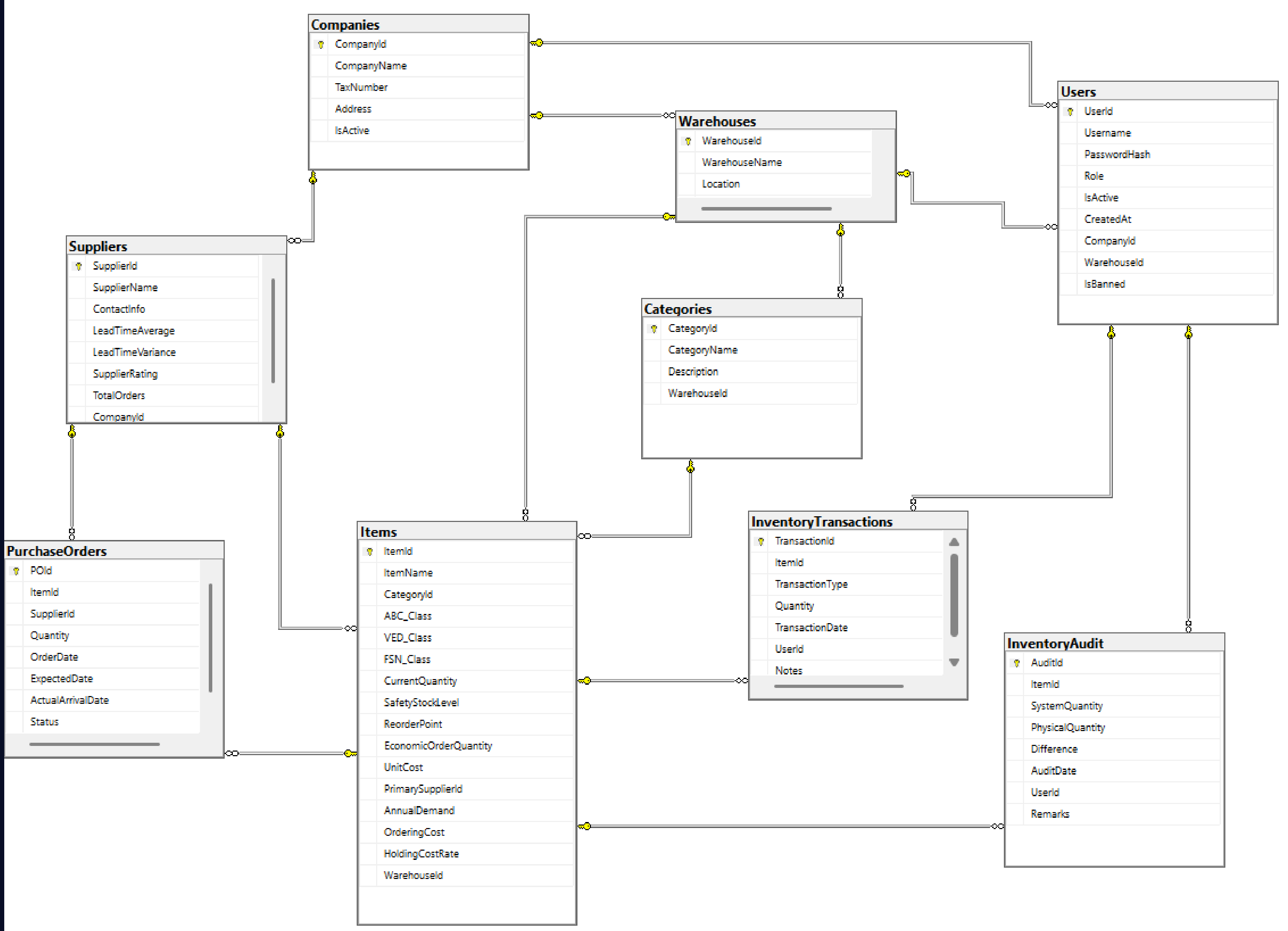
The greatest adversary to effective inventory management is data erosion. This decay is often caused by delayed recording, manual entry errors, and undocumented material exchanges.

Such issues lead to "data deviation," where critical calculations like the Economic Order Quantity (EOQ) are based on flawed figures, resulting in catastrophic decisions. Our solution: automate data entry to minimise human intervention.

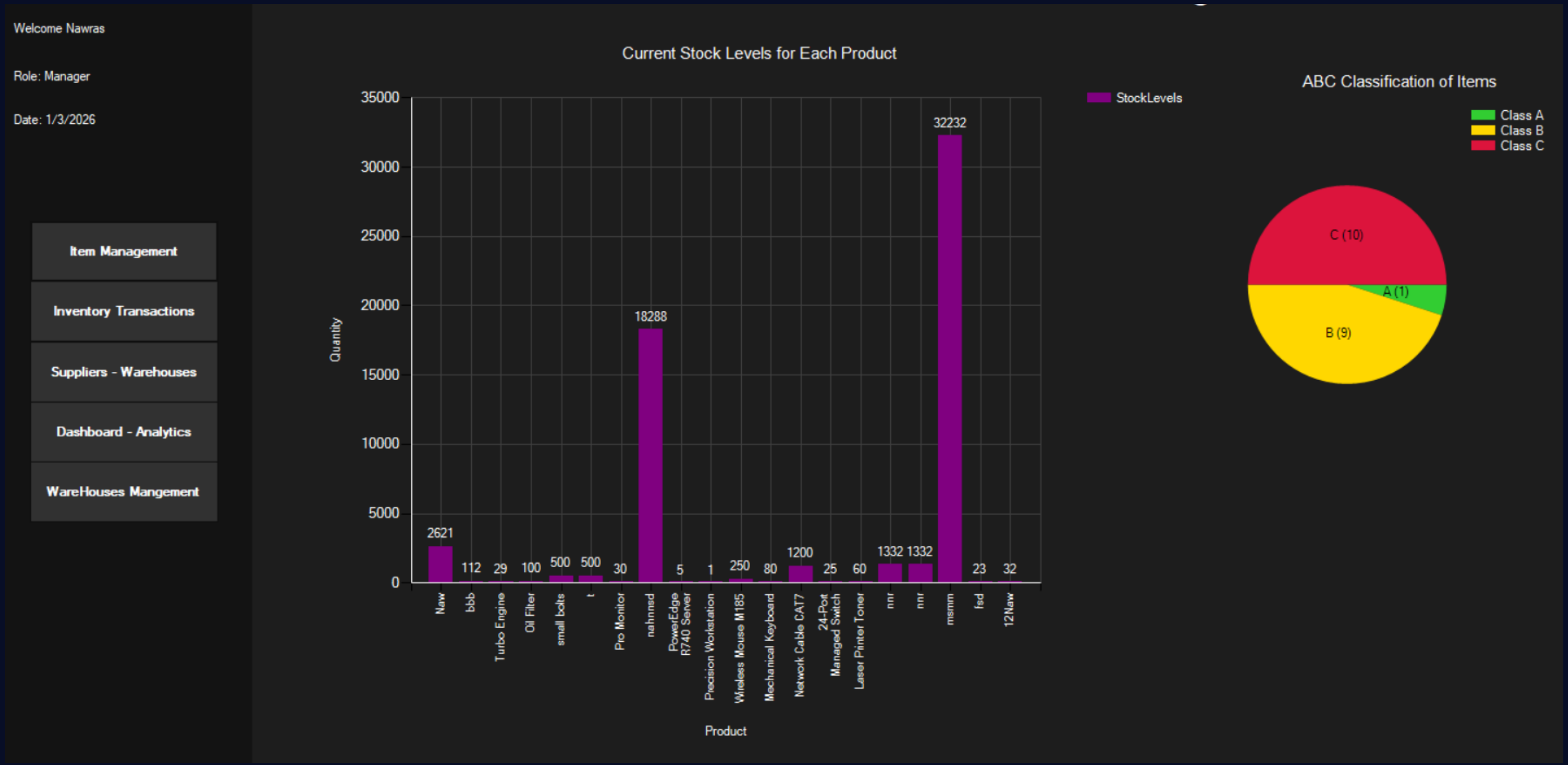
ItemId	ItemNam	Category	ABC_Cla	VED_Cla	FSN_Cla	CurrentQ	SafetySt	ReorderP	Economi	UnitCost	PrimaryS	AnnualD	Ordering(	HoldingC	Warehou
5	Naw	1	C	D	N	2621	50	50	7				2.00	3.00	1
7	bbb	1	C	D	N	112	50	50	39	4.00		23	4.00	3.00	1
11	Turbo ...	1	A	V	F	29	50	91	14	5000.00		1000	100.00	20.00	1
12	Oil Filter	1	C	E	S	100	50	55	69	50.00		400	30.00	10.00	1
13	small b...	1	C	D	N	500	50	50	100	1.00		50	5.00	5.00	1
14	t	1	C	D	N	500	50	50	100	1.00		50	5.00	5.00	1
15	Pro M...	1	B	E	S	30	50	54	19	300.00		200	40.00	15.00	1
16	nahnnsd	1	C	E	S	18288	50	103	31	55.00		293	77.00	88.00	1
18	Power...	1	B	V	S	5	10	25	5	4500.00		120	150.00	15.00	1

EconomicOrderQuantity

Data Flow (in DataBase):



Real-time Visibility: Tracking Location and Quantity



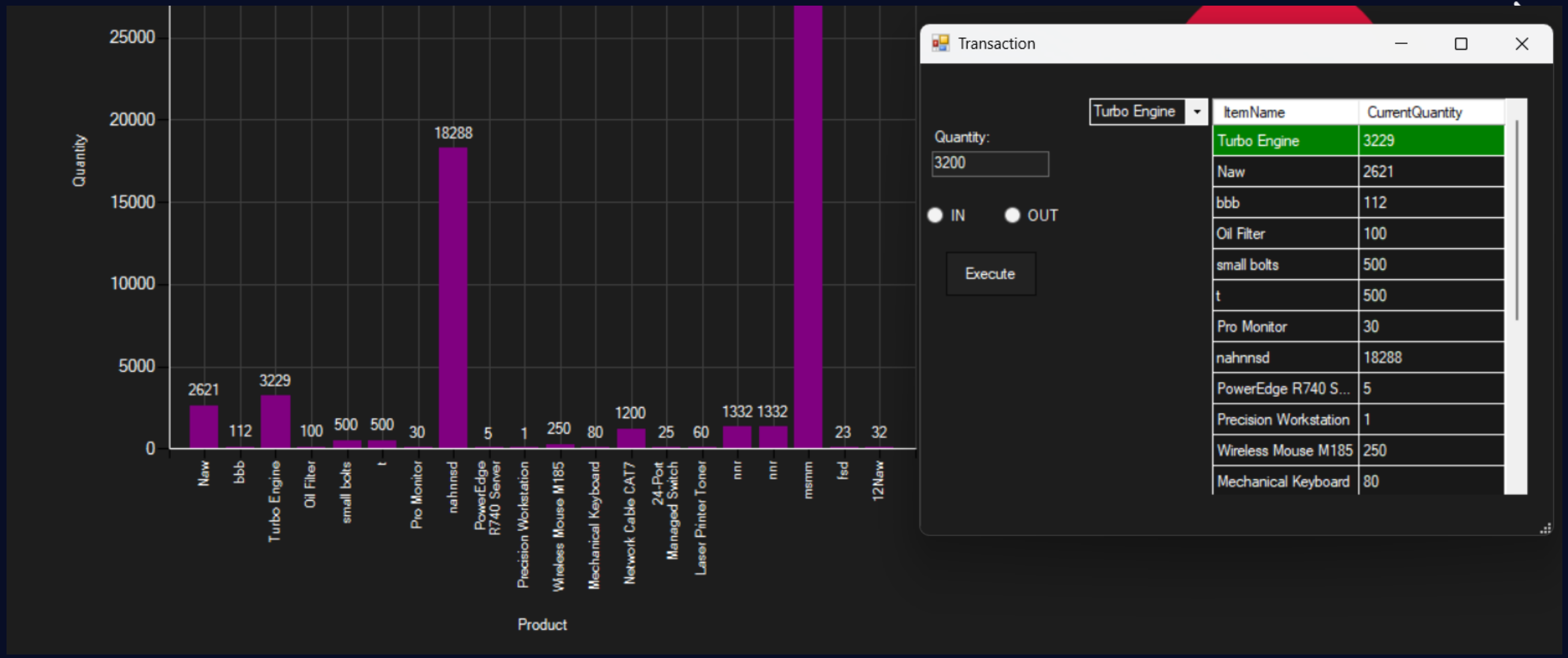
Computer Vision

Smart cameras monitor forklift movements and automatically confirm inbound and outbound parcels. This significantly enhances accuracy and reduces manual checks.

These technologies deliver end-to-end visibility, pinpointing the exact location of every item within the warehouse with over 99.9% accuracy.

Condition Monitoring: Predictive Maintenance with IoT

The Internet of Things (IoT) transforms static inventory into reactive assets. Sensors continuously monitor environmental conditions such as humidity, temperature, and vibration.



Dynamic Inventory Adjustment

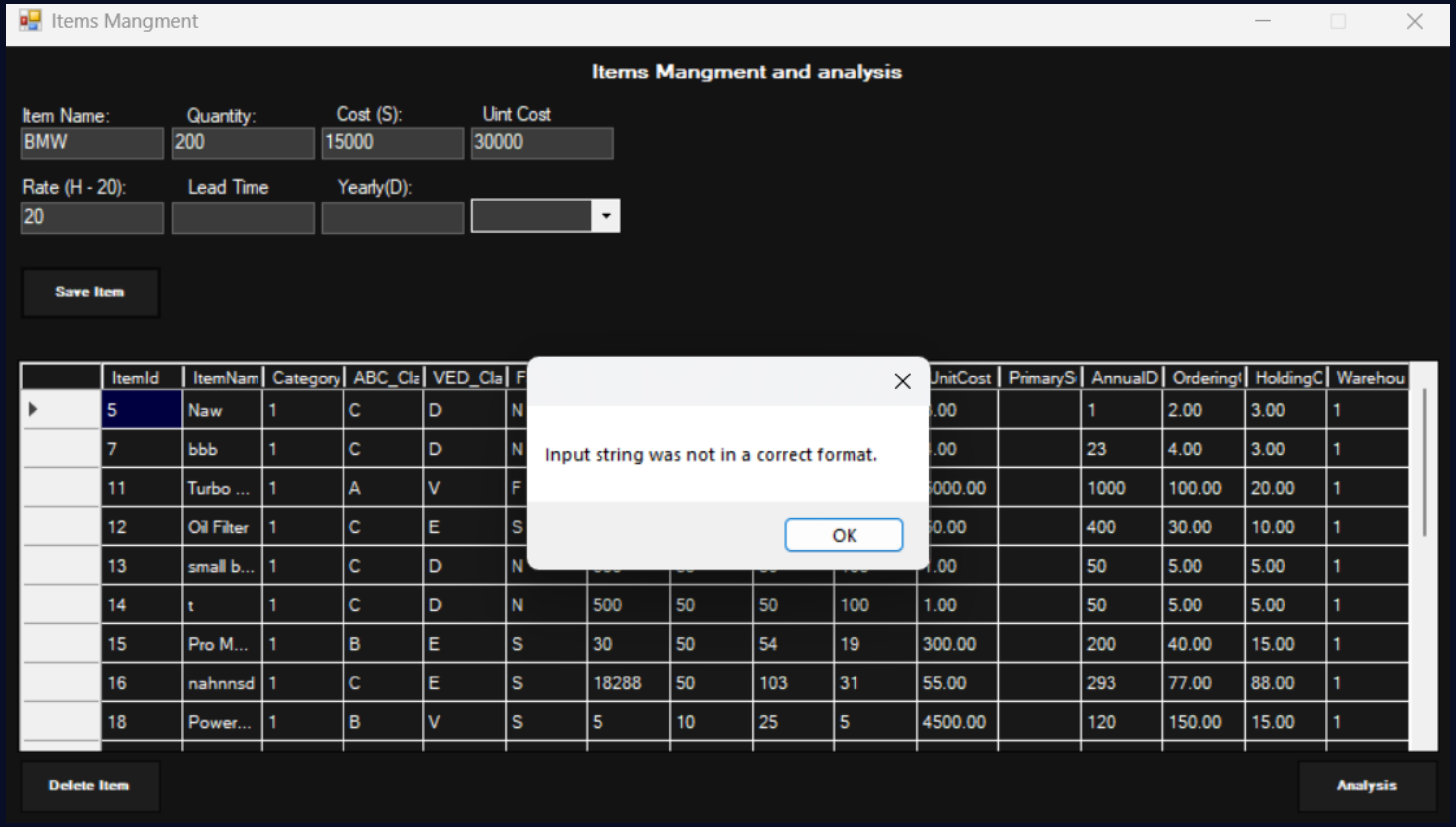
The system then deducts these quantities from available stock, categorises them under 'spoilage costs' in operational research models, and triggers immediate reordering.

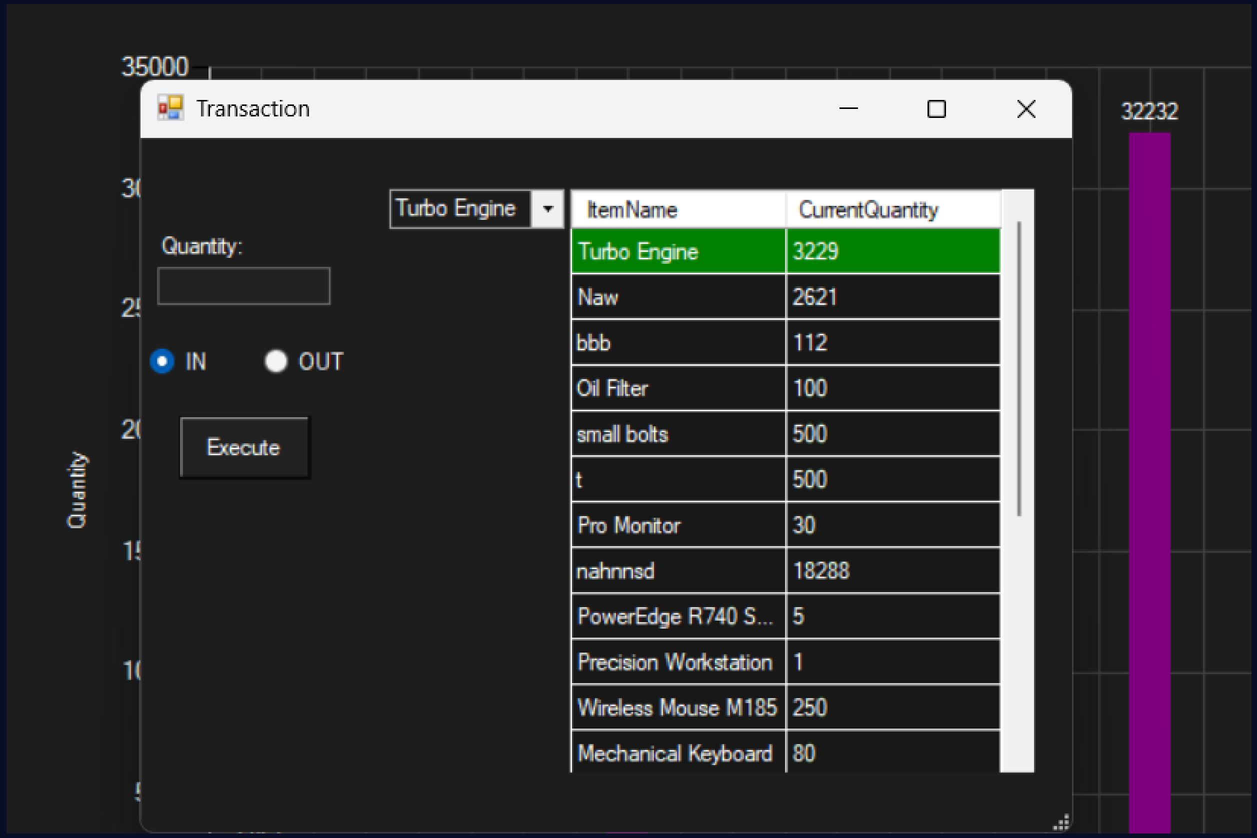
The GIGO Principle: Garbage In, Garbage Out

GIGO

This foundational principle in data science dictates that erroneous, outdated, or incomplete input data will inevitably lead to flawed outputs and poor decision-making.

Our project rigorously enforces data quality as a prerequisite for engaging any computational or predictive engine. This ensures that system outputs are actionable and reflective of real-world conditions, rather than mere theoretical figures.





Intelligent Verification: Multi-Level Data Validation

Logic Checks

Preventing the input of received quantities that exceed the designated shelf capacity within the system, ensuring physical constraints are respected.

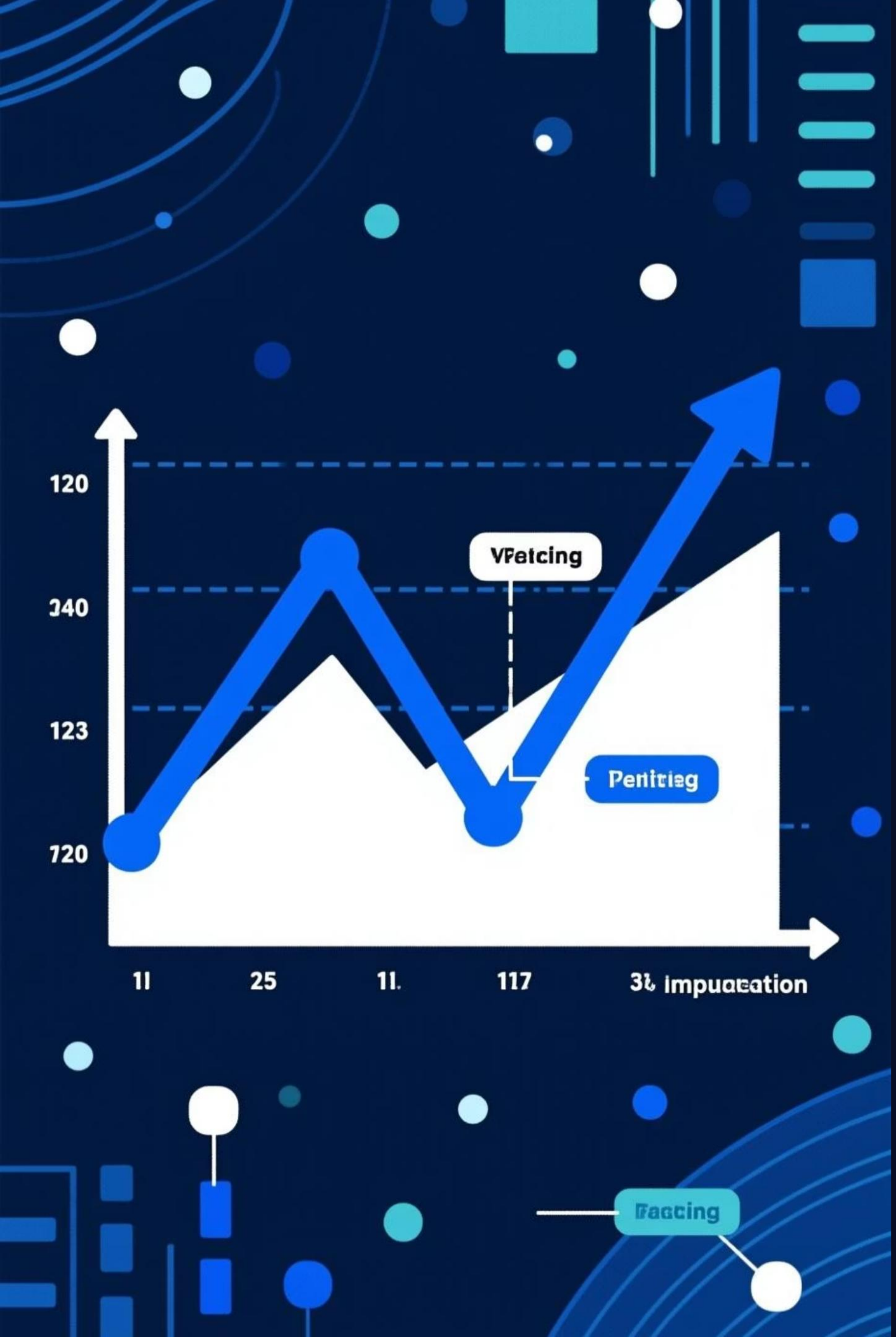
Comparative Validation

Comparing actual received quantities against the original Purchase Order. Significant discrepancies automatically halt transactions and require managerial approval.

Type Checks

Strictly prohibiting textual entries in numerical fields to eliminate common data entry errors and maintain data consistency.

These robust programmatic constraints enforce data integrity at every input stage.



Handling Anomalies & Outliers in Data

Our system employs advanced statistical methods to manage anomalous requests effectively.

Statistical Isolation (Filtering)

```
// EOQ = sqrt(2DS/H)
1 reference
public int CalculateEOQ(int annualDemand, decimal orderingCost, decimal unitCost, decimal holdingCostRate)
{
    if (unitCost <= 0 || holdingCostRate <= 0) return 0;
    double D = annualDemand;
    double S = (double)orderingCost;
    double H = (double)(unitCost * (holdingCostRate / 100));

    return (int)Math.Round(Math.Sqrt((2 * D * S) / H));
}
```

Data Imputation

For incomplete data, techniques like data imputation are utilised to fill gaps based on historical averages. This ensures the continuous operation and reliability of our predictive models.

The Future of Inventory: Integrated Intelligence

The evolution of inventory management lies in the intelligent integration of advanced technologies, self-regulating inventory ecosystem.

This not only maximises efficiency but also anticipates future needs, ensuring resilience and adaptability in dynamic market conditions.

```
1 reference
public void RunFullScientificAnalysis(int warehouseId)
{
    DataTable dt = _itemDAL.GetItemsByWarehouse(warehouseId);
    if (dt.Rows.Count == 0) return;

    var itemsList = new List<KeyValuePair<int, decimal>>();
    decimal totalVal = 0;

    foreach (DataRow row in dt.Rows)
    {
        int id = (int)row["ItemId"];
        decimal cost = row["UnitCost"] != DBNull.Value ? Convert.ToDecimal(row["UnitCost"]) : 0;
        int demand = row["AnnualDemand"] != DBNull.Value ? Convert.ToInt32(row["AnnualDemand"]) : 0;
        decimal val = cost * demand;

        itemsList.Add(new KeyValuePair<int, decimal>(id, val));
        totalVal += val;


        string fsn = demand >= 1000 ? "F" : (demand >= 100 ? "S" : "N");
        _itemDAL.UpdateItemFSN(id, fsn);


        string ved = cost >= 1000 ? "V" : (cost >= 50 ? "E" : "D");
        _itemDAL.UpdateItemVED(id, ved);
    }
```

```
// EOQ = sqrt(2DS/H)
1 reference
public int CalculateEOQ(int annualDemand, decimal orderingCost, decimal unitCost, decimal holdingCostRate)
{
    if (unitCost <= 0 || holdingCostRate <= 0) return 0;
    double D = annualDemand;
    double S = (double)orderingCost;
    double H = (double)(unitCost * (holdingCostRate / 100));

    return (int)Math.Round(Math.Sqrt((2 * D * S) / H));
}

// ROP = (d * L) + SS
1 reference
public int CalculateROP(int annualDemand, int leadTimeDays, int safetyStock)
{
    double dailyDemand = (double)annualDemand / 365;
    return (int)Math.Round((dailyDemand * leadTimeDays) + safetyStock);
}
```

Role-Based Access Control (RBAC): Fortifying Inventory Security

Implementing Role-Based Access Control (RBAC) is paramount for robust inventory management. It establishes a framework for controlling digital access and operational functions within the system, ensuring accountability and preventing internal discrepancies.

Enforcing Segregation of Duties

This principle ensures that no single individual has complete control over a critical process, reducing the risk of error or fraud.

Defined Roles & Responsibilities

- **Receiving Staff:** Solely responsible for confirming goods inwards.
- **Accountant:** Validates pricing and financial costs.
- **System Administrator:** Approves major system modifications.

Benefit: Internal Fraud Prevention

By restricting each role to specific data scopes, RBAC significantly mitigates internal fraud and ensures data integrity across all inventory operations.

HR & Governance Strategy: Empowering Our Human Capital

Cultural Transformation

Shifting the role of warehouse personnel from manual labourers to skilled data entry operators and quality control monitors, embracing technology.

Continuous Training

Regular training programmes to ensure employees are proficient in operating and integrating with new technologies, such as RFID scanners.

Performance Incentives

Aligning employee rewards with system-recorded inventory accuracy, fostering a culture of precision and accountability.

Our system is not a standalone entity; it thrives through the diligent efforts of human intellect.

The Audit Trail: Digital Footprints for Accountability

A comprehensive audit trail is the cornerstone of accountability and transparency in any inventory system. It acts as a digital fingerprint, meticulously recording every action and change, enabling precise tracing and investigation when needed.

Timestamp

Exact time to the second.

User Identity

Authenticated user making the change.

Device & Location

IP address of the accessing device.

Value Before

Original data value.

Value After

Modified data value.

This detailed logging allows the system to conduct a "digital investigation" when discrepancies arise, identifying the root cause of errors and reinforcing a culture of accountability among personnel. It's a critical tool for maintaining data accuracy and operational integrity.

Strategic Problem Solving: Optimising Inventory Flow

Modern inventory management systems are equipped with advanced functionalities to proactively address common challenges that plague warehouses and supply chains. By leveraging data and automation, these systems convert potential issues into opportunities for optimisation.

Eliminating Dead Stock

'Aging Alerts' are generated for slow-moving items based on FSN analysis, prompting immediate clearance decisions to free up valuable warehouse space and capital.

ItemId	ItemNam	Category	ABC_Cl	VED_Cla	FSN_Cla	CurrentQ
11	Turbo ...	1	A	V	F	3229
12	Oil Filter	1	C	E	S	100
13	small b...	1	C	D	N	500

Minimising Inventory Errors

Intelligent Cycle Counting is implemented, with the system recommending inventory audits based on item importance (e.g., Class A items are counted more frequently), drastically improving accuracy.

The Synergy Conclusion: A Resilient Inventory Ecosystem

The true strength of an inventory management system lies in the seamless integration and harmonious interaction of its human and technological components. This synergy acts as the immune system of an enterprise, safeguarding it against inefficiencies and errors.

Data Integrity

Poor data quality renders all calculations and insights meaningless, leading to flawed decisions.

Technological Backbone

Without advanced technology, operations would be slow and inaccurate, hindering competitive advantage.

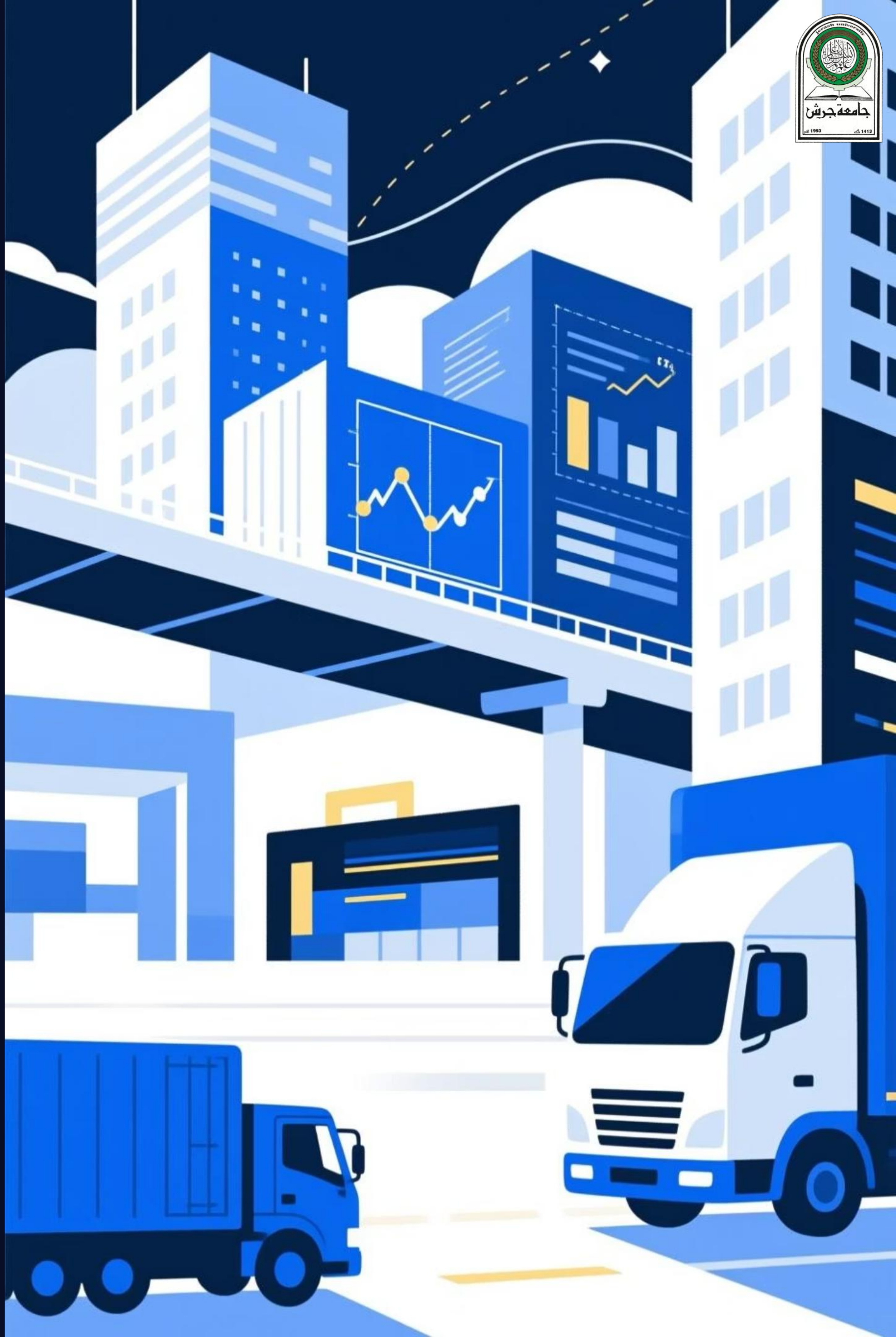
Human Governance

Lacking human oversight and discipline, even the most sophisticated system will lose its effectiveness.

The convergence of these three elements — human oversight, technological prowess, and impeccable data quality — is what forges an inventory management system that is truly smart, resilient, and reliable. This integrated approach empowers organisations to make critical financial and logistical decisions with confidence and precision.

The Validation Stage: Harvesting Value

This stage represents the 'harvesting phase' of our project. Following the meticulous construction and technical refinement of our Operations Research (OR) mathematical models through simulation and rigorous testing, we now present quantitative evidence demonstrating how this 'Quintuple Integration' has generated substantial value for the organisation. Our objective extends beyond merely presenting results; we aim to validate the project's **scientific maturity** by acknowledging its foundational assumptions and outlining its future growth trajectory.



Analysing the Synergistic Effect

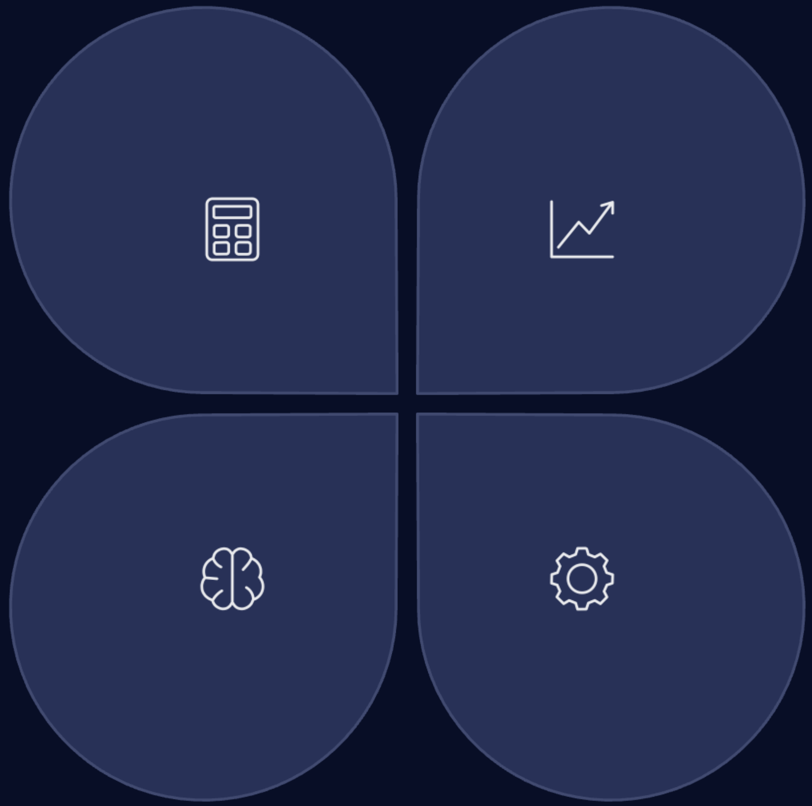
The true power of our system lies not in its individual components, but in their seamless **integration**. This strategic fusion transforms fragmented tools into a cohesive and intelligent business ecosystem.

OR + Cost

Provided the financial framework for substantial cost reduction, optimising resource allocation and expenditure.

Simulation + Risk

Established a protective shield against market volatility, safeguarding operations from unforeseen disruptions and economic fluctuations.



Integrated Business Intelligence

The integration elevated the system from a mere 'calculation tool' to a sophisticated 'integrated business intelligence system'.

Tech + HR

Ensured the availability of 'clean data' and a disciplined environment, enabling mathematical models to operate with unparalleled precision and reliability.

Proving System Scalability & Versatility

Our system has been engineered as a **flexible framework**, designed for robust performance and adaptability across diverse operational scales and sectors.

Vertical Scalability

- From small to large-scale inventory management
- Optimised database performance
- Seamless handling of growing data

Horizontal Scalability

Mathematical models like Economic Order Quantity (EOQ) and Reorder Point (ROP) are universally applicable. Consequently, the system can be deployed across retail, industrial, or even medical sectors, merely by adjusting input parameters.

- Adaptable to various industries
- Universal mathematical model applicability
- Customisable input parameters for specific contexts

Current Model Boundaries

Scientific integrity mandates a clear delineation of the model's current limitations. This version is an **'enhanced iteration'**, not a final one, with ongoing development planned.

Challenges of Major Random Events

Statistical models may not predict 'Black Swan' events, such as global pandemics or sudden geopolitical conflicts. These unpredictable occurrences represent inherent limitations in forecasting capabilities.

- Inherent unpredictability of extreme events
- Limitations in anticipating global crises
- Focus on typical market fluctuations

Future Recommendations: The Technical Roadmap

Our forward-looking vision is centred on embracing **intelligence and connectivity** to further enhance system capabilities and adaptability.

01

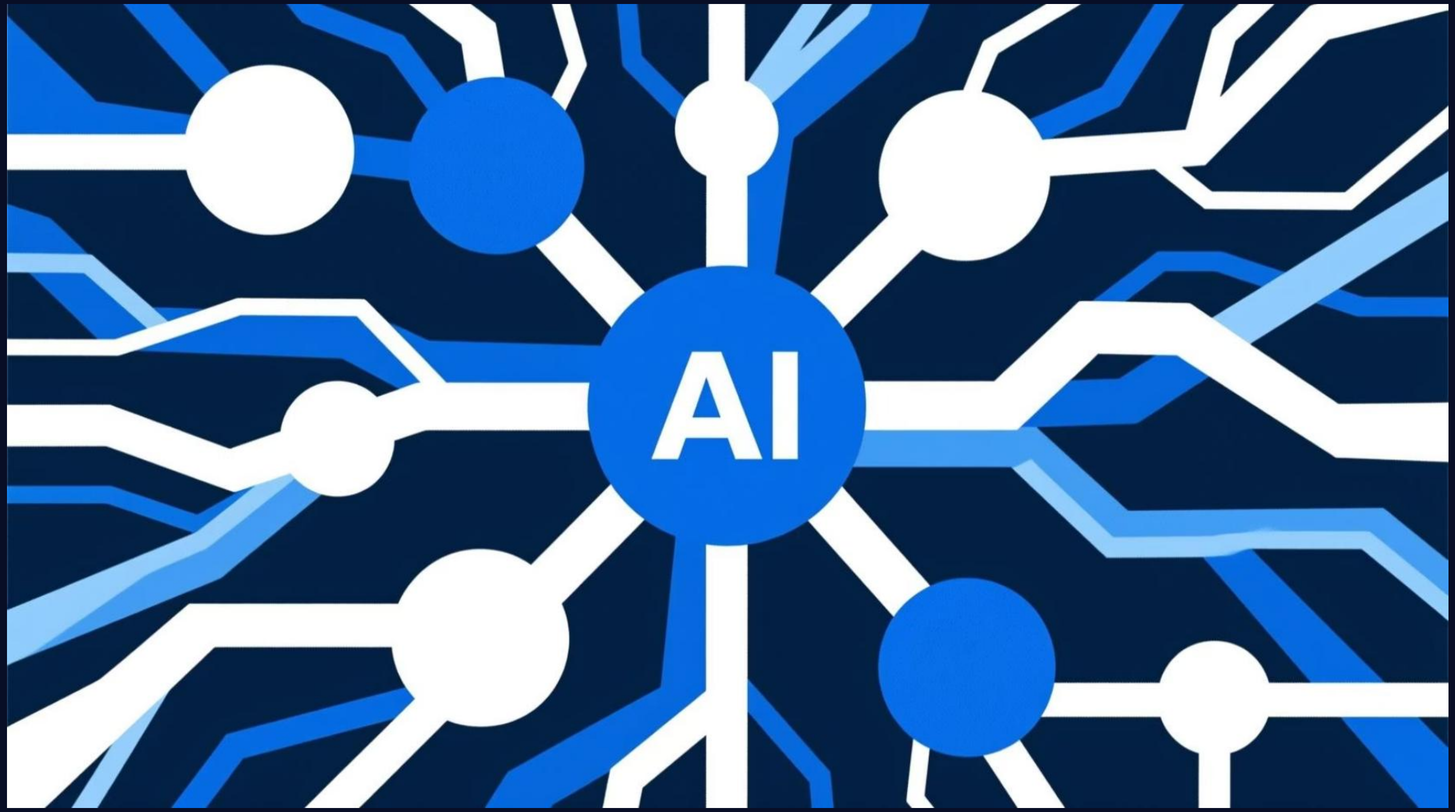
Cloud Transformation

Transitioning the system to a Software as a Service (SaaS) model, enabling remote management and enhanced accessibility from any location.

02

AI/ML Integration

Evolving from traditional statistics to 'Neural Networks' for hyper-accurate seasonal demand forecasting, leveraging advanced artificial intelligence.



03

Supplier API Integration

Directly linking the system to supplier inventories via Web Services, automating real-time shipment tracking without manual intervention.

04

Computer Vision

Implementing automated material counting within warehouses using smart cameras, enhancing accuracy and reducing labour costs.

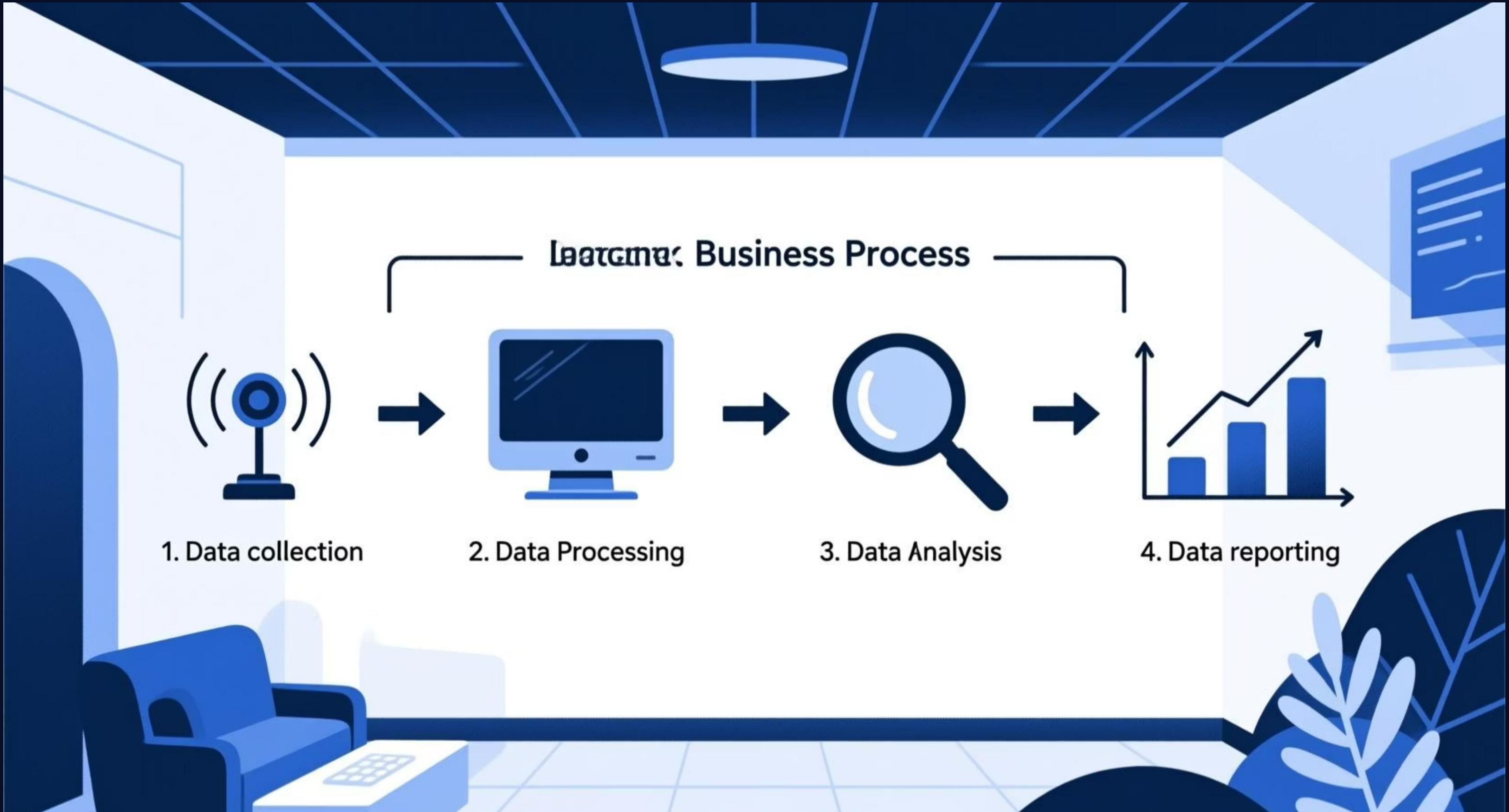
Future Recommendations: The Operational Roadmap

Our strategic objective is to transform this project into a **'mini-ERP'**, integrating various functions into a cohesive operational whole.

1

Vertical Integration

Connecting inventory with sales, procurement, and production to establish a unified **Data Flow**, ensuring comprehensive oversight and streamlined operations.



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Inventory Management: Non-traditional Applications - *Various Researchers*

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IEEE **IoT**

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Graphics:

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A Heartfelt Thank You!

We sincerely appreciate your presence and engagement throughout our presentation.

To Dr. Bilal Al-Zoubi

Our deepest gratitude for your invaluable guidance, unwavering support, and dedicated mentorship throughout this project. Your expertise was truly instrumental.

To Our Esteemed Team

A heartfelt thank you to every team member for your exceptional effort, dedication, and collaborative spirit. This success is a testament to our collective hard work.

We look forward to a future filled with continued innovation and successful collaborations.