

Baja SAE Supply Chain Optimization & Decision Support System

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Personal Project, not affiliated with formal classes

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Section 1: Project Overview & Motivation

1.1 Motivation & Problem Statement

The Baja SAE environment is a high-pressure, student-led manufacturing ecosystem, which I explored for the sake of involvement at my first semester in my master's program in Industrial Engineering at the University of Central Florida (UCF). While the team at the University of Central Florida excelled at high-level mechanical engineering, design, and fabrication, the "back-end" of the operation—**parts flow and resource management**—remained largely informal.

During my tenure, I identified a significant gap: the team was comprised almost entirely of mechanical engineers focused on subsystem performance, leaving a vacuum in logistical oversight. Without a formal tracking system, the team faced several critical risks:

- **Operational Downtime:** Frequent "stock-outs" of low-cost consumables (like Grade 8 bolts or zip ties) halted high-value fabrication sessions.
- **Financial Inefficiency:** Lack of price tracking led to "budget creep," where small, unmonitored purchases accumulated into significant unallocated costs.
- **Compliance & Safety Risks:** Hazardous chemicals were stored without centralized Safety Data Sheets (SDS), creating potential safety violations and emergency response delays.
- **Information Silos:** Critical part locations and supplier lead times lived only in the memories of senior leads, creating a "single point of failure" for project knowledge.

1.2 The Analyst Approach

To solve this, I stepped away from the CAD station and into a logistical analyst role. My approach was rooted in **User-Centric Design** and **Process Observation**:

- **Internal Audits:** I performed "shop-floor" interviews with subsystem leads (Drivetrain, Suspension, Brakes) to map out how parts moved from a shipping box to the vehicle.
- **Workflow Integration:** I spent time in the workshops observing fabrication sessions to identify which "consumables" were most frequently used and where the organization bottlenecks occurred.
- **System Design:** Instead of a simple list, I proposed a dynamic, relational database that would automate procurement decisions and visualize financial health, allowing the mechanical leads to focus entirely on engineering.

1.3 Expected Impact

The implementation of this system transforms the Baja shop from a "hobbyist garage" into a **professional-grade manufacturing facility**.

- **Predictive Procurement:** By using Reorder Points (ROP), the team can now order parts *before* they run out, ensuring the "manufacturing line" never stops.
- **Financial Transparency:** Every dollar spent is categorized by subsystem and criticality, allowing the team to justify budgets to university sponsors with hard data.
- **Safety Excellence:** Centralizing chemical locations and SDS status ensures a safer working environment and full compliance with university safety protocols.

Section 2: Technical Implementation & Excel Toolset

2.1 Structural Foundation: Excel Tables

The core of the system is a relational database built using **Excel Tables**. By transforming a static list into a formal table structure, I enabled:

- **Dynamic Range Management:** Any new parts added (ID 140+) automatically inherit all formulas and formatting, maintaining data integrity.
- **Structured References:** Formulas utilize readable headers (e.g., [**@Unit Cost**]) rather than cryptic cell coordinates, allowing for easier auditing and scalability.

2.2 Advanced Logic & Retrieval

To handle the complexity of 139 unique items across multiple subsystems, I implemented:

- **XLOOKUP:** I transitioned away from legacy VLOOKUP to utilize XLOOKUP for the Search Dashboard. This provided a non-breaking retrieval system that could pull data regardless of column order, significantly reducing "lookup errors" for the end-user.
- **Nested IF Statements:** Used to create a "Clean Dashboard" effect. Formulas like `=IF(A13="", "", XLOOKUP(...))` ensure that the Purchase Order tool remains visually uncluttered by #N/A errors when not in use.
- **Data Validation:** Implemented dropdown menus linked to the Master Part ID list via the INDIRECT function. This prevents "Garbage In, Garbage Out" (GIGO) by restricting user input to valid part numbers only.

2.3 Visual Analytics & Interface

The system's "UI" (User Interface) was built to prioritize high-risk information:

- **Conditional Formatting:** I established a visual hierarchy. **Red Text** alerts for "REORDER" status take precedence over all other formats, ensuring critical shortages are never missed. I also utilized **Data Bars** for Total Cost and **Icon Sets** for Lead Time to provide a "Heat Map" of financial and logistical risk.
- **Slicers & Pivot Tables:** I built a suite of Pivot Tables to summarize high-level data. Slicers act as interactive filters, allowing the Suspension Lead or the Treasurer to see only the data relevant to their specific department with one click.

Section 3: Supply Chain Concepts & Application

In this project, I transitioned the team from "Manual Logging" to "Data-Driven Management." Below is the breakdown of the core Supply Chain (SCM) concepts I applied and how the specific Pivot Tables I built serve as the analytical engine for those concepts.

3.1 ABC Analysis & Value Concentration

The Concept: The Pareto Principle (80/20 Rule) states that 80% of your financial risk usually comes from 20% of your items. SCM professionals use ABC Analysis to prioritize high-value "A" items over low-value "C" items.

- The Pivot Table: *Spending by Criticality*
- Application: This table aggregates the Total Cost of the inventory by its Criticality rating. It allows the Treasurer to see if the budget is properly allocated toward high-impact components (Engine, Shocks) rather than being "leaked" into excessive stocks of low-value hardware.

3.2 Buffer Management & Service Level Risk

The Concept: Safety Stock is the "insurance policy" of a supply chain. It protects the build schedule against variability in usage or delays in shipping. When you dip into this buffer, your "Service Level" (the ability to provide a part when needed) drops to a critical state.

- The Pivot Table: *Safety Stock Violation Report*
- Application: This table uses a Calculated Field (Quantity - Safety Stock) to identify "Buffer Penetration." It highlights items where the current stock has dropped below the emergency threshold. This acts as a "Red Alert" system, identifying parts that are at an immediate risk of causing a total work stoppage.

3.3 Replenishment Strategy & Financial Exposure

The Concept: Efficient supply chains manage Cash Flow by only ordering what is necessary to return to an "Optimal Stock" level. Financial Exposure is the total dollar amount required to resolve all current shortages.

- The Pivot Table: *Cost to Restock*
- Application: By filtering for items with a "REORDER" status, this table calculates the exact capital needed to satisfy the Order Quantity for every subsystem. It transforms a list of "missing parts" into a Financial Forecast that can be presented to faculty advisors for funding approval.

3.4 Lead Time Variability & Bottleneck Analysis

The Concept: Lead Time is the time elapsed between placing an order and receiving the part. In SCM, long lead times create "Bottlenecks" that can delay the entire "Critical Path" of the vehicle assembly.

- The Pivot Table: *Lead Time Risk Assessment*
- Application: This table cross-references Stock Status with Lead Time buckets (e.g., 0-7 days, 14+ days). It isolates parts that are currently out of stock *and* have a long wait time. This allows the team to prioritize these specific orders above all others to minimize project downtime.

3.5 Vendor Performance & Strategic Sourcing

The Concept: Vendor Management involves evaluating suppliers based on their reliability and the volume of business they handle. Consolidating orders with fewer, more reliable suppliers can lead to shipping discounts and better relationship management.

- The Pivot Table: *Supplier Logistical Data*
- Application: This pivot table summarizes the Avg Lead Time and Total Spend per vendor. It identifies "Power Suppliers"—those who hold the most influence over the project's timeline and budget—allowing the team to focus on building stronger relationships with those specific companies.

3.6 Warehouse & Facility Logistics

The Concept: SKU Slotting and Location Auditing involve organizing parts based on where they are used to reduce "motion waste" (the time spent walking around looking for things).

- The Pivot Table: *Subsystem Logistics (Inventory Health)*

- Application: This table tracks the Count of Parts and their Stock Status across different physical locations (Fire Cabinet, Trailer, Shop). It provides a "Heat Map" of inventory density, helping the Shop Manager ensure that "Drivetrain" parts are actually stored where the Drivetrain team works.

Section 4: Summary of Impact

The implementation of the **Baja SAE Supply Chain Analytics System** transformed the team's back-end operations from a reactive, "tribal knowledge" model into a data-driven manufacturing environment. The impact of this system is categorized into three key areas:

4.1 Enhanced Operational Uptime

By establishing a rigorous **Reorder Point (ROP)** and **Safety Stock** framework, the team achieved a near-zero stock-out rate for high-frequency consumables during the critical final assembly phase. This minimized "work-stoppage" events, ensuring that the mechanical engineers remained focused on fabrication rather than emergency hardware store runs.

4.2 Financial Stewardship & Accountability

The system provided a "Single Source of Truth" for project finances. By linking every part ID to a specific subsystem and supplier, the team could generate instant reports on **Financial Exposure**. This level of transparency was instrumental in university budget audits and provided professional-grade documentation for corporate sponsorship proposals, demonstrating a high level of fiscal responsibility.

4.3 Institutional Knowledge Transfer

A primary risk in collegiate projects is the loss of knowledge when senior members graduate. This project successfully digitized the team's logistical history. **Lead times, storage locations, and vendor contacts** are no longer stored in individual memories but are housed in a protected, searchable database. This ensures that future seasons of the Baja team inherit a robust, functioning supply chain on day one.

4.4 Risk Mitigation & Safety Compliance

The integration of a **Chemical Inventory with SDS Tracking** moved the team into a state of full safety compliance. By identifying documentation gaps and centralizing storage data, the system reduced the risk of accidental chemical interaction and ensured that the team was prepared for university safety inspections and emergency response scenarios.

Section 5: Conclusion

This project represents a strategic pivot from purely mechanical design to Industrial Systems Engineering. While the competition vehicle is the primary product of Baja SAE, the system driving its construction is equally vital.

The development of this Inventory Optimization & Decision Support System demonstrates the ability to enter a complex, high-pressure manufacturing environment, identify operational bottlenecks, and build a technical solution that bridges the gap between Engineering Design and Business Operations.

Ultimately, this work underscores a core principle of modern Supply Chain Management: Physical success is predicated on data integrity. By treating logistics with the same rigor as mechanical engineering, the team is now equipped with a sustainable framework that prioritizes efficiency, safety, and strategic resource allocation—skills that are directly transferable to professional-scale manufacturing and global supply chain operations.