International Journal of Science Academic Research
Vol. 06, Issue 04, pp.9681-9683, April, 2025
Available online at http://www.scienceijsar.com

ISSN: 2582-6425

Research Article

RE-ENGINEERING FOR RESILIENCE: ADAPTING TO TARIFFS IN US AUTOMOTIVE AND AEROSPACE INDUSTRIES

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Received 09th February 2025; **Accepted** 05th March 2025; **Published online** 14th April 2025

Abstract

The potential imposition of 25% tariffs on Canadian raw materials in 2025 presents a significant challenge to the US automotive and aerospace industries[1]. These sectors rely on specific raw materials and finished products sourced from Canada[2 3 5]; tariffs could disrupt supply chains and increase costs[5]. However, a proactive approach involves re-engineering existing products to utilize different, readily available materials. This is where systems engineers play a crucial role, designing innovative solutions to maintain performance and mitigate the impact of the tariffs on the economy and on the people of the United States and Canada.

Keywords:.Systems Engineering, Lifecycle Model, Raw Material Substitution, Substitution Strategy, Trade Disruption

INTRODUCTION

The potential imposition of 25% tariffs on Canadian raw materials in 2025 presents a significant challenge to US automotive and aerospace industries[1]. These sectors rely on specific raw materials and finished products sourced from Canada[2,3,5], tariffs could disrupt supply chains and increase costs[5]. However, a proactive approach involves re-engineering existing products to utilize different, readily available materials. This is where systems engineers play a crucial role, designing innovative solutions to maintain performance and mitigate the impact of the tariffs on the economy and on the people of the United States. Systems engineers are uniquely positioned to tackle this challenge. Their expertise in design, analysis, and optimization allows them to evaluate existing products[8], identify materials vulnerable to tariffs, and develop alternative material strategies. Hereare a few ways in which System engineers can help in re-engineering:

- **Material Supply and Acquisition[4]:** Systems engineers can help analyze the functional requirements of components and identify alternative materials with similar or improved properties. For example, if a specific aluminum alloy sourced from Canada is subject to tariffs, they might explore alternative aluminum alloys available domestically or from other reliable international sources. They can also evaluate the feasibility of substituting with composite materials or high-strength plastics, carefully considering factors like weight, durability, and cost. Their role in the agreement process will be significant

- **Design Optimization[4]:** Re-engineering is not just about swapping materials; it is also about optimizing the design to accommodate new materials and potentially improve performance. Systems engineers can use advanced modeling and simulation tools to analyze the behavior of different materials in specific applications. They can then modify the design to maximize the benefits of the new material, potentially reducing weight, improving strength, or enhancing other critical characteristics.
- **Process Adaptation and Tailoring[4]:** Switching to new materials often requires changes in manufacturing processes. Systems engineers can work with manufacturing engineers to develop and implement new production techniques.
- **Lifecycle Model Analysis[4]:** A crucial aspect of re-engineering is considering the entire lifecycle of the product. Systems engineers can evaluate the environmental impact of using different materials, ensuring that the chosen alternatives are sustainable and comply with regulations. They can also analyze the long-term cost implications, considering factors like material availability, processing costs, and recyclability.
- **Collaboration and Communication:** Successful re-engineering requires collaboration across multiple disciplines. Systems engineers act as integrators, working with material scientists, design engineers, manufacturing engineers, and procurement teams to ensure that the chosen solutions are technically feasible, cost-effective, and meet all requirements.

Re-engineering products to use different materials is a strategic approach to mitigate the impact of tariffs. By proactively adapting to changing market conditions, US automotive and aerospace industries can maintain their competitiveness, reduce reliance on specific suppliers, and build a more resilient manufacturing base. Systems engineers, with their holistic perspective and expertise in design and optimization, are essential to driving this transformation and ensuring the long-term success of these vital industries. To drive home the point about the relevance of Systems Engineering in a tariff regime, It is expedient to provide a practical example using a typical system of interest This is given below for GM Cars which are manufactured in the United States but require materials from Canada.

1. Environment of GM Cars as the System of Interest

The environment of GM cars encompasses the natural and man-made surroundings where these vehicles are utilized, supported, developed, produced, and retired.

A. Utilization and Support Environment

- **Urban & Rural Roads:** Highways, city streets, off-road terrains, and specialized driving conditions.
- **Traffic Systems:** Interaction with traffic signals, smart infrastructure, and connected vehicle ecosystems.
- **Weather & Climate Conditions:** Extreme temperatures, rain, snow, and humidity affecting performance and durability.
- **Fueling & Charging Infrastructure:** Gas stations, EV charging networks, and alternative fueling options.
- **Service & Maintenance:** Dealerships, independent repair shops, and OEM support centers.

B. Development & Production Environment

- **Manufacturing Plants:** Facilities where vehicles are assembled, including supply chain logistics.
- **Testing Facilities:** Wind tunnels, crash testing centers, and software simulation labs for performance assessment.
- **Regulatory Compliance Centers:** Government-mandated testing for emissions, safety, and roadworthiness.

C. Retirement & End-of-Life Environment

- **Recycling & Disposal Centers:** Facilities for dismantling, recycling, and repurposing vehicle components.
- **Secondary Markets:** Used car resale platforms, auction houses, and vehicle repurposing programs.
- **Environmental Impact Management:** Scrappage programs, emission reduction initiatives, and sustainable disposal practices.

This dynamic environment plays a crucial role in the life cycle of GM cars, affecting their design, performance, regulatory compliance, and overall impact on society and the ecosystem.

2. The Stakeholders

The various stakeholders for the GM car from whom requirements should be elicited are

A. Users & Customers (Direct Consumers)

- Individual car owners and drivers
- Fleet operators (e.g., rental car companies, ride-sharing services)
- Commercial customers (businesses that use GM vehicles)
- Automotive enthusiasts

B. Operators & Service Providers

- Dealerships and sales representatives
- Mechanics and repair shops
- Insurance providers
- Car rental agencies
- Roadside assistance services

C. Internal GM Stakeholders (Corporate & Employees)

- GM executives and management
- Engineers and designers
- Manufacturing plant workers
- Supply chain and logistics teams
- Research and development (R&D) teams
- Marketing and sales teams

D. Regulatory & Government Bodies

- National Highway Traffic Safety Administration (NHTSA)
- Environmental Protection Agency (EPA)
- Department of Transportation (DOT)
- Local and federal safety agencies
- Emission control regulators
- Consumer protection agencies

E. Suppliers & Partners (Enabling Systems)

- Parts manufacturers (e.g., tires, batteries, semiconductors)
- Raw material suppliers (e.g., steel, aluminum, plastics)
- Technology providers (e.g., infotainment, AI driving systems)
- Logistics and transportation companies
- Financial institutions providing auto loans

F. Society & Broader Stakeholders

- Communities affected by GM factories
- Environmental groups (concerned about emissions and sustainability)
- Public transportation agencies (integration with urban mobility)
- Media and automotive journalists
- Consumer advocacy groups

G. Production & Maintenance Systems

- GM's own production facilities
- Third-party manufacturing partners
- Maintenance and service centers
- Spare parts distributors

3. Technical Processes

Once suppliers are onboard, GM engineers integrate new materials into vehicle design using technical processes. This involves:

A. System Requirements Definition [SRD]

- Defining technical, safety, and performance requirements for the substitute material.
- Evaluating critical parameters (e.g., tensile strength, impact resistance, weight-to-strength ratio).

B. Design Definition [DD] & System Architecture Definition [SAD]

- Redesigning affected chassis, body panels, and structural components to maintain vehicle integrity.

- Updating CAD models, Finite Element Analysis (FEA) simulations, and digital twins to test new materials under various conditions.
- Crashworthiness Studies to ensure regulatory compliance with NHTSA, IIHS, and Euro NCAP standards.

C. Implementation [IMPL] & Integration [INT]

- **Pilot Manufacturing**: Testing the material in prototyping labs before full-scale production.
- **Assembly Line Adjustments**: Adapting stamping, welding, bonding, and coating processes.
- **Supply Chain Coordination**: Ensuring smooth logistics integration for the new material.

D. Verification [VER] & Validation [VAL]

1. **Material Testing**: Conducting stress tests, corrosion resistance assessments, and heat tolerance trials.
2. **Performance Validation**: Ensuring new materials do not compromise aerodynamics, fuel efficiency, or safety.

E. Transition [TRAN]

- Rolling out updated vehicle models featuring the new material.
- Training factory workers, suppliers, and service technicians on handling new components.

4. Technical Management Processes

Key Process: Risk Management [RM] & Decision Management [DM]

- **Risk Management**
  - Ensuring material availability and avoiding future tariff vulnerabilities.
  - Preventing recalls and warranty claims due to premature failures.
  - Compliance with EPA and CAFE (Corporate Average Fuel Economy) emissions regulations.
- **Decision Management**
  - Weighing the trade-offs of new material cost vs. weight savings vs. durability improvements.
  - Choosing between in-house R & D for materials vs. strategic supplier partnerships.

Conclusion

Through Systems Engineering, GM can ensure a structured, risk-mitigated, and efficient transition to substitute materials in response to tariffs. This approach balances cost, performance, safety, and sustainability, allowing the company to maintain resilience and competitive advantage in the evolving automotive landscape.

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