

# A STUDY ON COMPLEXITY MANAGEMENT METHODS AND TECHNIQUES FOR GREEN BUSINESS PRACTICES IN COMMERCIAL VEHICLE MANUFACTURING INDUSTRY

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## Abstract

Complexity exists in commercial vehicle manufacturing industry in various forms. By nature of the product design, commercial vehicle construes thousands of parts aggregated into sub-assemblies, finally to finished product and in the process leaves behind a plethora of complex, interconnected, duplicated organizational challenges leading to non-green business practices. This paper focuses on the different approaches and methods towards identification of complexities in commercial vehicle manufacturing industry at a gross level and possible reduction towards attaining a greener business practicing environment thereby leading to better business profitability. Typical examples and considerations on cost and management level impacts are also showcased.

**Keywords:** Complexity identification tools and techniques, organization complexity, process complexity, duplication, differentiated processes, complexity handling methods, etc.

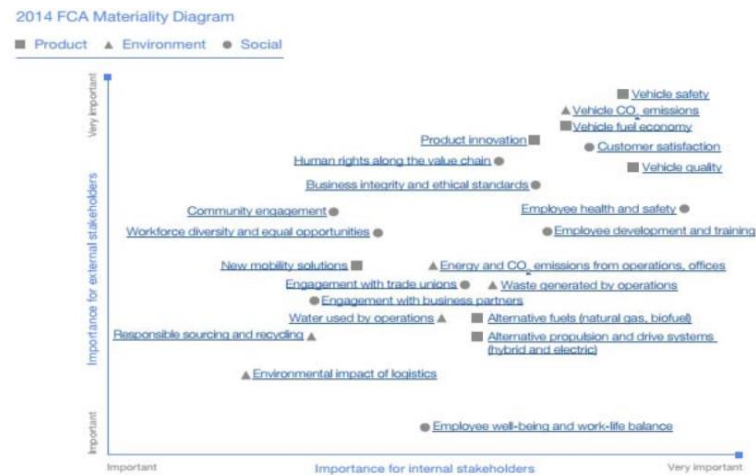
## 1. Introduction

Commercial vehicle is defined as “vehicles which are used for goods and paying people” as per European Union, EC Council Directive 68/297. Complexity is defined as “the state of having many parts and being difficult to understand” as per Cambridge dictionary. Complexity as applicable for a commercial vehicle industry is the state of product families with inter-related/unique parts leading to a variety of manufacturing, operational, organizational & eco system challenges for CV industry. This paper discusses about complexity associated at every level of the organization starting from design of a product, manufacturing process, operational process & impact on the organizational eco system within the commercial vehicle industry and methods to handle them from a green business perspective.

## 2. Sustainability issues for Fiat

Oana Apostol describes the various sustainability issues while dealing with best practices at Fiat in Figure 1, however does not cover the impact at the cost level and methods of handling the complexities.

**FIGURE 1**  
**Significant Sustainability Issues for Fiat**

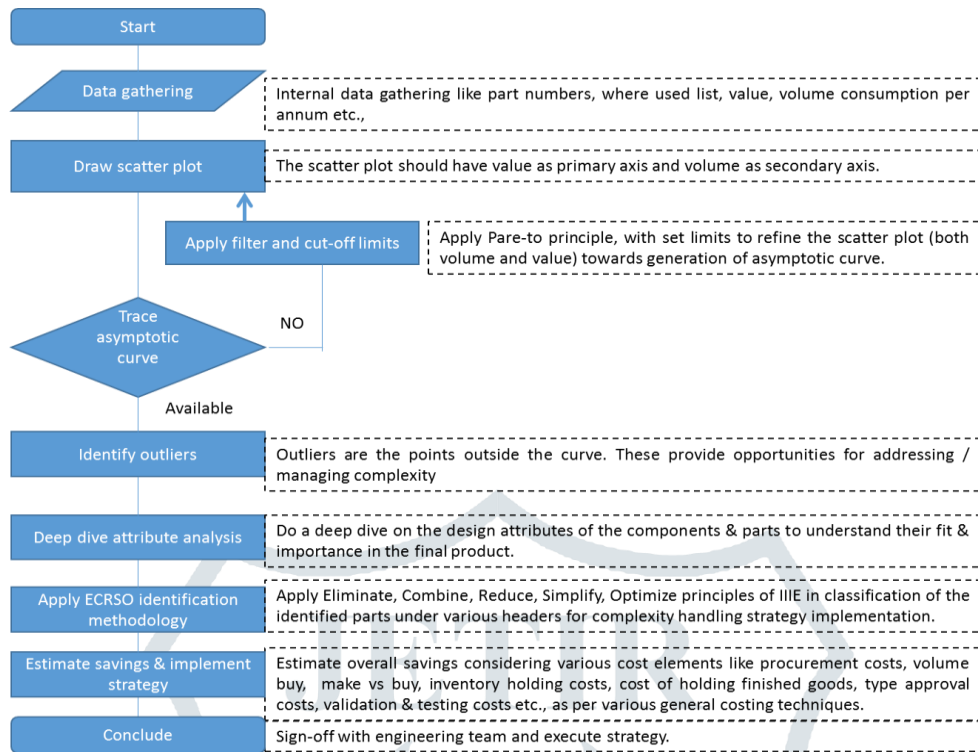


Source: Fiat 2014 Sustainability Report

## 3. Design level complexity

By inherent nature of the commercial vehicle construing typically about 3100 parts and more than 3300 product models, it becomes very challenging to check the proliferation of design at part level. However, it is simplified to filter out the outliers based on purchase price of parts using the ECRSO method of managing part level complexity briefed as per below process in Figure 2.

**FIGURE 2**  
**Product Design Complexity Management Methodology**



**FIGURE 3**  
**ECRSO Strategy for Part Level Complexity Management**

**ECRSO Strategy**

<b>Eliminate</b>	<ul style="list-style-type: none"> <li>▪ How can the design be changed to eliminate parts?</li> <li>▪ How can fixtures be eliminated?</li> <li>▪ How can we eliminate a special surface treatment?</li> <li>▪ How can we eliminate special finishing?</li> <li>▪ How can we eliminate some assembly / inspection task?</li> </ul>	<ul style="list-style-type: none"> <li>- Challenge Legacy</li> <li>- Duplicates</li> </ul>
<b>Combine</b>	<ul style="list-style-type: none"> <li>▪ Can two functions be combined in one part?</li> <li>▪ Where can two or more parts be combined in one?</li> <li>▪ Which parts can be combined into a module?</li> <li>▪ Where can parts be made to share common tools?</li> <li>▪ Which assembly task can be combined?</li> </ul>	<ul style="list-style-type: none"> <li>- Functional review</li> <li>- Modularization</li> </ul>
<b>Reduce</b>	<ul style="list-style-type: none"> <li>▪ How can we reduce the size?</li> <li>▪ How can we reduce weight of the part?</li> <li>▪ How can the number of different materials be reduced?</li> <li>▪ How can we reduce the number of special tools used?</li> <li>▪ How can manufacturing scraps or defects be reduced?</li> <li>▪ Which specifications need to be reduced to reduce costs?</li> <li>▪ How can we reduce the number of assembly/inspection tasks?</li> </ul>	<ul style="list-style-type: none"> <li>- Need analysis</li> </ul>
<b>Simplify</b>	<ul style="list-style-type: none"> <li>▪ How can the design be changed to simplify the assembly?</li> <li>▪ Which less costly part will perform the same function?</li> <li>▪ Can the inspection task be made simpler?</li> <li>▪ How to use a standard parts instead of a special component?</li> <li>▪ How can we simplify the assembly / inspection process?</li> </ul>	<ul style="list-style-type: none"> <li>- Standardisation</li> <li>- Off shelf substitutes</li> <li>- Alternates identification</li> </ul>
<b>Optimize (Material)</b>	<ul style="list-style-type: none"> <li>▪ Can the material be changed to to cost less?</li> <li>▪ Can the present assembly be purchased at lower cost?</li> <li>▪ Which less expensive materials can be used?</li> <li>▪ Which material can be changed to make the part lighter?</li> </ul>	<ul style="list-style-type: none"> <li>- Technical review</li> </ul>

## 4. Manufacturing process complexity

Different manufacturing processes are adopted in a commercial vehicle manufacturing industry starting with machining of engine components like cylinder block, head, crankshaft, camshaft, flywheel, housings, transmission elements, axles etc., static members like frame punching which are typically material removal process followed by welding for cabins, frames, cross members which are typically material additive process. In addition to the same there are fitment processes leading to final assembly of aggregates like engines, transmission, vehicle and testing processes to ensure quality assurance. Complexity exists in each of the manufacturing processes leading to organizational efficiency challenges. Typical method of overcoming the manufacturing process level challenges are explained in brief using the ECRSO method for machining process complexity handling in Figure 4:

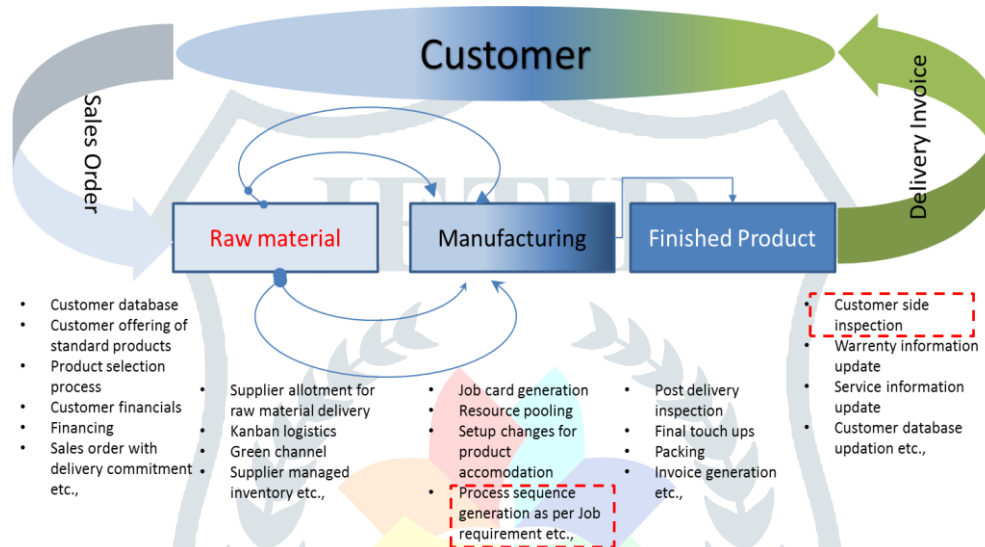
**FIGURE 4**  
**Machining Process Complexity Reduction using ECRO Method**

Eliminate	<ul style="list-style-type: none"> <li>▪ How can the process design be changed to eliminate duplication?</li> <li>▪ How can fixtures be eliminated through reduced setups?</li> <li>▪ How can we eliminate a special surface treatment?</li> <li>▪ How can we eliminate special finishing?</li> <li>▪ How can we eliminate some assembly / inspection task?</li> </ul>	<ul style="list-style-type: none"> <li>- Challenge Legacy</li> <li>- Duplicates</li> </ul>
Combine	<ul style="list-style-type: none"> <li>▪ Can two functions be combined in one part?</li> <li>▪ Where can two or more operations be combined into a module?</li> <li>▪ Which processes can be clubbed into a module?</li> <li>▪ Where process can be relooked to share common tools?</li> <li>▪ Which process task can be combined?</li> </ul>	<ul style="list-style-type: none"> <li>- Functional review</li> <li>- Modularization</li> </ul>
Reduce	<ul style="list-style-type: none"> <li>▪ How can we reduce the size- facility / pallet / material handling system?</li> <li>▪ How can we reduce weight of the fixturing?</li> <li>▪ How can the number of different setups be reduced?</li> <li>▪ How can we reduce the number of special tools used?</li> <li>▪ How can manufacturing scraps or defects be reduced?</li> <li>▪ Which drawing specifications need to be reduced to reduce costs?</li> <li>▪ How can we reduce the number of assembly/inspection tasks?</li> </ul>	<ul style="list-style-type: none"> <li>- Need technical process analysis ( technical knowhow / expertise)</li> </ul>
Simplify	<ul style="list-style-type: none"> <li>▪ How can the process design be changed to simplify the part flow?</li> <li>▪ Which less costly tool / facility will perform the same function?</li> <li>▪ Can the inspection task be made simpler?</li> <li>▪ How to use a standard processes instead of a special processes?</li> <li>▪ How can we simplify the assembly / inspection process?</li> </ul>	<ul style="list-style-type: none"> <li>- Standardisation</li> <li>- Substitutes</li> <li>- Alternate identification</li> </ul>
Optimize (Material)	<ul style="list-style-type: none"> <li>▪ Can the tooling / fixturing / facility be changed to cost less?</li> <li>▪ Can the present operations be purchased at lower cost?</li> <li>▪ Which less expensive tooling can be used?</li> <li>▪ Which material can be changed to make the fixturing lighter?</li> </ul>	<ul style="list-style-type: none"> <li>- Technical review</li> </ul>

## 5. Organizational process complexity

Commercial vehicle manufacturing industries are typically large sized organization spanning thousands of personnel working round the clock starting from design, testing & validation, manufacturing, procurement, finance, logistics etc. The various organization processes and a typical case of existence of complexity are represented in Figure 5.

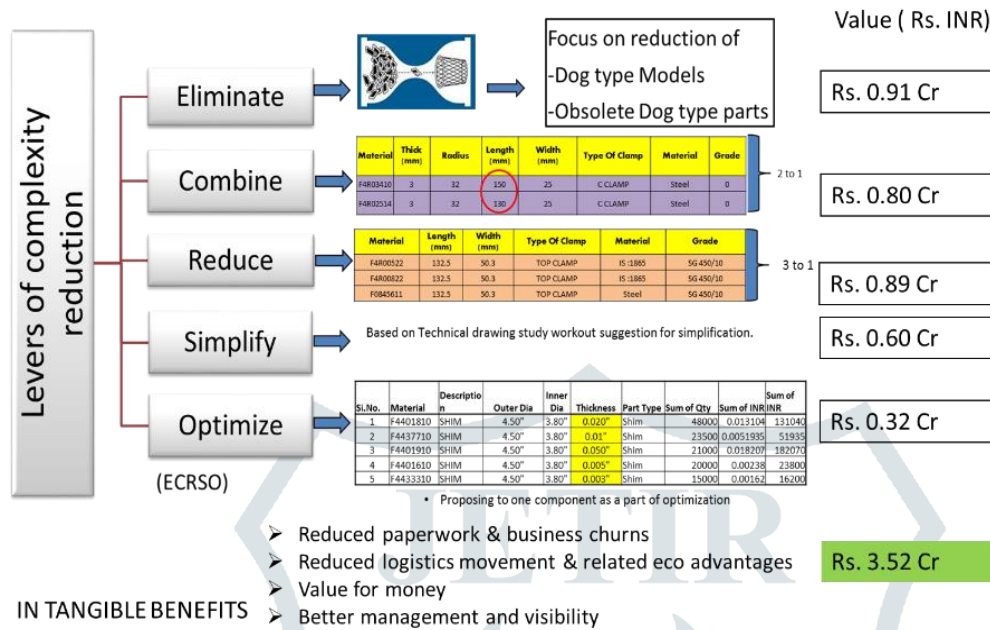
**FIGURE 5**  
**Example of Organizational Process Complexity**



It can be noted of multiple duplication of processes related to product specific manufacturing requirements like process sequence generation based on product model which can be overcome with online display and tagging of models, checking of the processes and product itself through inspection methods which are a non-value add from an end customers perspective, records updating at the end of the process, goods receipt note against a firm purchase order, duplication of resources for handling these complexities, etc.

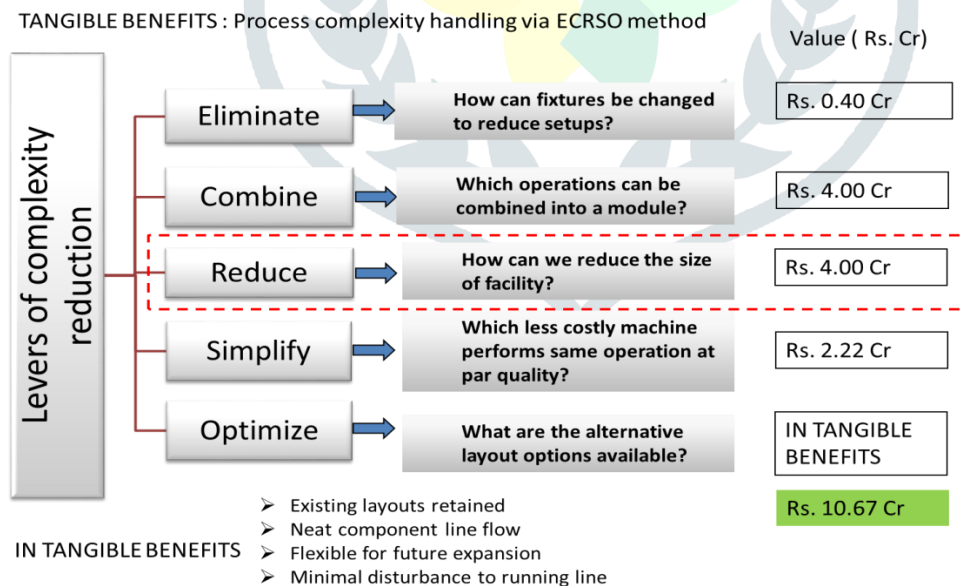
### 6. Part level complexity handling

**FIGURE 6**  
**Cost Benefit for Part Level Complexity Handling**



### 7. Process level complexity handling

**FIGURE 7**  
**Cost Benefit for Process Level Complexity Handling**



These benefits when viewed from a macro economic perspective yields a lot of return for running green commercial vehicle industry which also impacts the eco system surrounding the organization like roads, traffic density, better yield per logistic run and thereby paving a way to a greener economy.

## 8. Conclusion

The complexity observed across the organization needs to be managed strategically using the tools cited in the paper as a start point in reaping the benefits of running a greener business. In the present competitive scenario various cost saving measures need to be managed without compromise in quality to ensure business sustenance and longevity. This study is limited to commercial vehicle industry and paves way for future research applicable for other industries as well leading to global business green practices.

## 9. Reference

- Arvind, A. R., & Pon. Ramalingam (2018). Study of Tools, Techniques and Methods for Complexity Reduction. *International Journal of Mechanical and Production Engineering Research and Development*, 8 (6), 1131-1138.
- Arvind, A.R., & Pon. Ramalingam (2018). Identification of Complexity in Commercial Vehicle Manufacturing Setup. *International Journal of Mechanical and Production Engineering Research and Development*, 8 (6), 1125-1130.
- Breno Nunes., & David Bennett (2010). Green Operations Initiatives in the Automotive Industry: An Environmental Reports Analysis and Study. *Benchmarking: An International Journal*, 17 (3), 396-420.
- Everton Drohomerski, e al. (2015). The Application of Sustainable Practices and Performance Measures in the Automotive Industry: A Systematic Literature Review. *Engineering Management Journal*, 27 (1), 32-44.
- Hendri, et al. (2014). Method and Model Development for Manufacturing Cost Estimation during the early Design Phase Related to the Complexity of the Machining Processes. *International Journal of Technology*, 2, 183-192.
- Olivier Kerbrat., Pascal Mognol., & Jean-Yves Hascort (2010). Manufacturing Complexity Evaluation at the Design Stage for both Machining and Layered Manufacturing. *CIRP Journal of Manufacturing Science and Technology*, 208-215.
- Stephen T. Newman, et al. (2015). Process Planning for Additive and Subtractive Manufacturing Technologies. *CIRP Annals - Manufacturing Technology*, 64, 467-470.