

MSc in Computing (Information Systems Processes)

**Quality improvement of Customized Vehicle Fabrication**

**Using 3D Printers and CNC Machines.**

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# Chapter 1 Introduction:

Pakistan possesses a thriving customized vehicle manufacturing sector, where skilled fabricators create a diverse range of purpose-built vehicles. From ambulances and mobile health units to luxury vans and specialized fire vehicles, these customized solutions are essential to various sectors. However, there's always potential to further refine quality and efficiency within this industry.

Today, 3d printing and CNC machines is changing how factories work, making a big difference in manufacturing. This dissertation looks at how they helps make Fabrication better and fast, which is important because factories are always looking to make products better, reduce mistakes, and save money. (Lourdes Martinez Molina, Teti and Maria, 2023)

The reason we're talking about this now is because of something called Industry 4.0. This is a fancy way of saying that factories are using more computers and technology to become smarter. 3d printers and cnc are the big part of this change because it can look at lots of data to help fix machines before they break, make decisions without humans, and keep improving how things are made. (Lourdes Martinez Molina, Teti and Maria, 2023)

This image shows that the number of Vehicles produced in Pakistan as per Ministry of Industries and Production

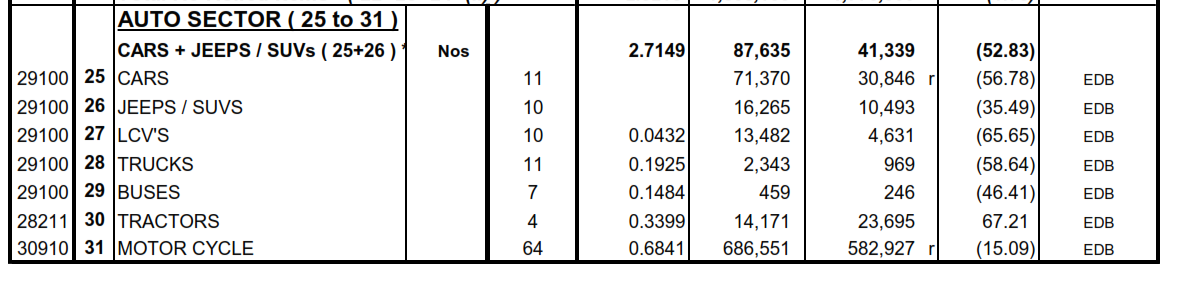


Figure 1 (Ministry of Industries & Production (MoI&P, 2023)

# Customized Vehicle Fabrication.

Sometimes, regular cars and trucks just won't do the job. That's where customized vehicle fabrication comes in. It means changing vehicles to make them perfect for specific tasks. In Pakistan, this industry is growing quickly because people have special needs that regular cars don't meet. (Ahmad Medix, 2019)

Here's a list of vehicles that can be customized:

**Emergency Vehicles:** Fire trucks for narrow streets, ambulances for remote areas, mortuary vans respecting customs.

**Mobile Businesses:** Food trucks, trailers turned into stores, labs on wheels, mobile health clinics.

**Luxury Vehicles:** Limousines, cars with fancy entertainment systems, and unique designs.

Customized vehicles help with emergencies, give people ways to start businesses, and reflect Pakistan's changing society. Skilled workers in workshops across Pakistan do this customization work. They use old-fashioned techniques due to which we lack in precision and quality. (Ahmad Medix, 2019)

# Enhanced Customization using 3D Printing and CNC Machining on Vehicle Manufacturing

**Ambulances:**

3D printing allows for the creation of patient-specific medical equipment and devices directly within the ambulance. This could include custom-fit splints, braces, or even prosthetic components. The interior layout and storage compartments of the ambulance can be tailored to the exact needs of the medical team or the specific types of emergencies they respond to. (Gaurav Prashar, Hitesh Vasudev and Dharam Bhuddhi, 2022)

**Fire Trucks:**

Specialized equipment holders and mounting brackets can be 3D printed, optimizing equipment layout and maximizing space efficiency. Custom nozzles and water distribution systems can be created for unique firefighting needs. (Gaurav Prashar, Hitesh Vasudev and Dharam Bhuddhi, 2022)

**Luxury Vehicles:**

Intricate interior details, dashboard elements, and unique trim pieces can be produced with 3D printing, enabling a level of personalization previously unattainable One-of-a-kind exterior accents and aerodynamic components can be fabricated for the discerning customer. (Gaurav Prashar, Hitesh Vasudev and Dharam Bhuddhi, 2022)

# Improved Quality and Precision:

**CNC Machining:**

Complex structural components can be machined with exceptional accuracy and consistency, enhancing vehicle strength and reliability. Allows for greater precision in parts essential to emergency vehicle performance (axles, suspension components, etc.) Flawless body panel fabrication for luxury vehicles emphasizes pristine aesthetics. (Inanc Kabasakal et al., 2017)

**3D Printing:**

Medical equipment within ambulances can be created with biocompatible materials, ensuring patient safety and high standards. Prototyping and testing of components is streamlined, allowing for rapid iteration and refinement of designs. This leads to a higher quality end-product. (Inanc Kabasakal et al., 2017)

# Benefits of using 3d printer and CNC

**Reduced Production Time:**

3D printing and CNC machining can significantly reduce the time needed to manufacture customized components, streamlining the production process. (Inanc Kabasakal et al., 2017)

**Light weighting:**

The ability to create complex geometries with 3D printing and optimize parts with CNC machining allows for the use of lighter materials, improving vehicle efficiency and performance. (Inanc Kabasakal et al., 2017)

**Increased Durability:**

 Precision manufacturing through CNC machining leads to parts with greater strength and wear resistance, vital for the demanding conditions faced by emergency vehicles. (Inanc Kabasakal et al., 2017)

**Cost Savings:**

While the initial investment in 3D printing and CNC equipment may be substantial, the long-term benefits include reduced production costs, less material waste, and efficient prototyping. S

**The Future**

The integration of 3D printing and CNC machining into vehicle manufacturing holds immense promise. We can expect these technologies to lead to even greater levels of customization, improved efficiency, weight reduction, and the use of innovative materials within the ambulance, fire truck, and luxury vehicle industries.

# Role of Quality in Fabrication of Vehicle

Quality in manufacturing is like making sure every piece of a puzzle fits perfectly and the picture looks just right. It's all about making products that meet high standards, work well, and make customers happy. There are no sharp cuts, properly welded, proper cuttings and sizings.

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# Problem Statement

While customized vehicle fabrication is booming in Pakistan, it faces some hurdles. One challenge is finding ready-made parts specifically designed for these unique builds. Imagine needing a special bracket to hold equipment in a mobile lab – this part might not exist anywhere pre-made. This forces workshops to rely on either importing parts from abroad, which can be expensive and time-consuming, or having them custom-made locally, which also adds to the cost.

Another challenge is the way things are currently built. Many skilled craftspeople rely on their experience and traditional methods to create parts. While their skills are impressive, it can be difficult to ensure perfect accuracy every time. Imagine a carpenter hand-cutting a piece of wood for a vehicle interior – it might be great, but it might not be exactly the same size each time.

Here's where modern technology could be a game-changer. Using 3D printers or CNC machines (computer-controlled cutting tools) allows for creating parts with perfect precision, every single time. Plus, with these technologies, the designs can be saved digitally for future use. This means if a specific craftsman built a unique part in the past and isn't around anymore, the design can still be accessed and replicated.

Despite these challenges, the opportunities presented by customized vehicle fabrication are significant. By fostering innovation and entrepreneurship, this industry can contribute to Pakistan's economic development. It strengthens emergency response capabilities and improves access to essential services in remote areas. The ability to personalize vehicles caters to individual preferences and reflects a changing society.

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# 1.4 Research Objectives

To identify specific areas within customized vehicle fabrication where the implementation of 3D printing and CNC machining would offer the most significant benefits. This goes beyond simply automating existing tasks. By carefully analyzing current workflows, we can pinpoint areas where traditional methods struggle to achieve the desired level of accuracy, consistency, or complexity. For instance, 3D printing excels at creating intricate interior components with unique geometries, which can be challenging to fabricate using manual techniques. CNC machining, on the other hand, brings unmatched precision to the creation of structural components like engine mounts or suspension parts, ensuring a perfect fit and enhanced performance. By focusing on these areas where traditional methods fall short, we can maximize the impact of new technologies and streamline the overall fabrication process.

# 1.5 Research Questions

This dissertation will explore the following research questions:

* What are the principal technical, organizational, and financial barriers to adopting 3d printers , CNC ?
* Could CNC machining improve the fabrication of body panels for customized vehicles, ensuring a flawless finish and perfect fit?
* Where could the customization of interior components (trim, panels, equipment holders) benefit most from the intricate design capabilities of 3D printing?

# 1.6 Research Goals:

The goals of this dissertation are to

* To identify and analyze the key challenges (technical, organizational, and financial) hindering the widespread adoption of 3D printing and CNC machining in Pakistan's customized vehicle fabrication industry
* To evaluate the feasibility and potential benefits of using CNC machining for creating customized body panels, focusing on achieving superior surface quality and dimensional accuracy.
* To explore high-value applications of 3D printing within customized vehicle interiors, emphasizing complex designs, tailored equipment integration, and enhanced functionality.

# Chapter 3: Working Hypothesis

Hypothesis 1:  Limited access to capital and financing is a major barrier preventing customized vehicle fabricators in Pakistan from investing in 3D printing and CNC technologies.

Hypothesis 2:  CNC machining enables customized vehicle fabricators to achieve superior dimensional accuracy and consistency in body panel production compared to traditional hand-forming techniques.

Hypothesis 3. The ability to 3D print intricate interior details and unique design elements significantly raises the level of bespoke customization possible in customized vehicles.

# Chapter 4: Research Methods

Research Question 1:

What are the principal technical, organizational, and financial barriers to adopting 3d printers, CNC?

Research Method

Interview: Target managers from custom fabrication companies to get a complete picture of potential challenges.

Research Question 2:

Could CNC machining improve the fabrication of body panels for customized vehicles, ensuring a flawless finish and perfect fit?

Research Method

**Interviews:** Discuss with fabricators from each workshop their perceived improvements in quality, time saved, challenges encountered with each method.

Research Question 3:

Where could the customization of interior components (trim, panels, equipment holders) benefit most from the intricate design capabilities of 3D printing?

Research Method

**Interviews:** Talk to designers and customized vehicle owners to understand Current shortcomings in interior design (e.g., equipment fit) and How 3D printing could address these issues with its customization potential.

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