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3D Printing for Personalized Customization of Automobile Interiors: Applications and Emerging Trends

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Abstract. 3D printing—renowned for its rapid prototyping capability, exceptional design freedom, and efficient material utilisation—is driving innovation in the personalised customisation of automotive interiors. This paper systematically examines current applications and future developments. In components such as steering wheels, centre dashboards, and air vents, additive-manufacturing processes including fused deposition modelling (FDM) and selective laser sintering (SLS) enable bespoke geometries and lightweight designs; for instance, carbon-fibre steering wheels can reduce mass by 30 %, while tool-less air-vent fabrication cuts development costs by 20 %. Looking ahead, the field is moving towards on-demand production and green manufacturing: online platforms will allow users to co-design parts, bio-based and recycled materials will curb carbon emissions, and full-vehicle 3D printing demonstrates the scalability of the technology. Although throughput and material constraints remain, the advantages of personalisation and geometric complexity complement conventional manufacturing methods, creating a promising pathway for an intelligent and environmentally sustainable automotive industry with substantial market potential.

INTRODUCTION

3D printing—hailed as a cornerstone of the Third Industrial Revolution—has attracted substantial attention across industries [1]. As consumers increasingly demand vehicle personalisation, the automotive sector already accounts for more than 16 % of global 3D-printer sales, and that share continues to climb [2]. Conventional, large-batch manufacturing is therefore under mounting pressure to deliver diversified, small-lot production.

Also referred to as additive manufacturing (AM), 3D printing offers rapid prototyping, exceptional design freedom and high material efficiency, ushering in transformative changes to automotive production. Its footprint now extends from concept models and functional test rigs to end-use parts, and a market report by SmarTech Analysis projects that the value of 3D-printed, in-service automotive components could reach roughly USD 9 billion by 2029 [2]. Within this landscape, personalised interior parts have emerged as a particularly promising application, combining strong commercial prospects with clear technological advantages.

This paper reviews the current use of 3D printing for personalised automotive-interior components, analyses its benefits and challenges, and explores future directions. We discuss representative case studies encompassing material selection, design optimisation and manufacturing processes, highlight the competitive strengths of additive techniques, and outline forthcoming trends that may guide further research and industrial adoption.

APPLICATIONS AND ADVANTAGES OF 3D PRINTING IN AUTOMOTIVE-INTERIOR CUSTOMISATION

Steering Wheel

The steering wheel is a primary focus of interior personalisation. Additive manufacturing allows the rim profile to be tailored to a driver's hand size, grip style and ergonomic preferences, whereas conventional production depends on population-scale data to create a small set of moulds that cannot satisfy every user and slows product refresh cycles [3].

Zhong Xinghua et al. employed fused-deposition modelling (FDM)—in which thermoplastic filament is melted and deposited layer by layer under computer control—to produce a customised wheel [4]. Starting from the OEM geometry, they remodelled the grip in software such as SolidWorks to match racing-driver hand dimensions, then printed the part in a single rapid-manufacturing step.

Weight reduction is another common objective. Carbon-fibre-reinforced polymer (CFRP) is often preferred not only for its distinctive weave but also for its high specific strength and low density ($\approx 1.5 - 2.0 \text{ g cm}^{-3}$) [5, 6]. Substituting CFRP for metal or plastic can cut steering-wheel mass by about 30 %, sharpening vehicle responsiveness and reducing driver fatigue during extended journeys or aggressive manoeuvres. Together, these attributes yield a more engaging and personalised driving experience.

Center Dashboard

For most drivers, the stock instrument panel satisfies everyday needs; however, a niche user segment seeks features that OEMs do not offer or that were overlooked during factory ordering—such as integrated head-up displays. In parallel, interior patterns and textures have grown increasingly intricate, driving up the cost and lead-time of prototype parts. Traditional moulding cannot reproduce fully optimised free-form surfaces, often leaving sharp edges or blemishes that diminish tactile quality; manufacturers therefore compromise geometry to meet tooling constraints [7].

Additive manufacturing eliminates these limitations. Beyond photopolymer resins, metal 3D printing—in which a laser or electron beam selectively melts metal powder layer by layer—directly builds complex dashboard structures [8]. Material-property control has matured to the point where printed components now match forged parts in mechanical performance and dimensional accuracy, ensuring high-quality production of customised interior elements [7].

Air Vents

Demand for personalised interiors is rising, yet conventional air vents offer only limited designs. With digital modelling, 3D printing can rapidly deliver bespoke shapes, surface textures and integrated features—such as brand logos, artistic motifs, or hidden ambient-lighting channels—that injection-moulding cannot achieve [9]. In racing, luxury and custom-tuning segments, additive manufacturing also supports lightweight, aerodynamically optimised vents: blade angles, duct profiles and lattice infills can be freely adjusted to enhance airflow performance.

Traditional steel-mould workflows pose major bottlenecks: opening a production mould straight from a 3D model is expensive, may take months, and any design change forces the entire process to restart. To overcome this constraint, Jiang Zhiyun and Wang Ruide et al. applied selective-laser sintering (SLS) to establish a “tool-less” rapid-validation system for automotive vents, cutting development time by 40 % and costs by 20 % [7][10].

Their study underscores the efficiency and flexibility of additive techniques, especially for small-batch trials and complex-geometry verification, and provides a low-barrier, fail-fast pathway that can be extended to other functional interior components.

PROSPECTS FOR 3D PRINTING IN AUTOMOTIVE MANUFACTURING

The core virtues of 3D printing—bespoke production and design freedom—make it exceptionally well-suited to automotive customisation. Crucially, the entry barrier for digital modelling has fallen: free or low-cost platforms such as Blender, Tinkercad and Fusion 360, supported by extensive online tutorials (e.g. YouTube, Bilibili, Tencent

Classroom), allow newcomers to gain basic proficiency in a matter of days. For example, at a study rate of six hours per day, users typically require about two days to grasp Blender's fundamentals and roughly one week to reach an introductory level with Fusion 360.

Looking ahead, the development of additive manufacturing in the automotive sector is expected to centre on two strategic themes:

On-demand production—distributed printing hubs and digital inventories will shorten lead-times, reduce warehousing costs and enable late-stage configuration of interior options.

Green manufacturing—the adoption of bio-based or recycled feedstocks, coupled with energy-efficient printing processes and closed-loop material recycling, will support the industry's carbon-reduction goals.

Together, these trajectories position 3D printing as a cornerstone technology for a more agile, sustainable and customer-centric automotive supply chain.

On-demand Production Enabled by 3D Printing

Additive manufacturing maximises customisation while trimming costs and simplifying the supply chain. Unlike conventional mould-based workflows, on-demand printing is highly agile: parts are produced to order—without tooling—thereby eliminating excess inventory and material waste. Audi, for example, prints dashboard-button replacements for legacy models in its German facilities and reports a 90 % reduction in development time at the Böllinger Höfe plant, where low-volume models such as the R8 and all-electric RS e-tron GT are assembled [11].

As user involvement grows, several brands have launched online configurators that let customers specify centre-panel colours, patterns and textures, which are then printed on demand. This C2M (customer-to-manufacturer) strategy ushers in deep user participation and decentralised, localised production, forming the backbone of a digital manufacturing ecosystem in which personal taste becomes a design driver [12].

3D Printing and Green Manufacturing

Today's automotive printing is still dominated by low-cost, petroleum-based polymers that offer corrosion and wear resistance yet depend on finite fossil resources and are difficult to degrade [13]. Sustainable development therefore hinges on greener feedstocks and circular-material loops:

Bio-based polymers—materials such as PLA and soy-derived plastics combine competitive mechanical performance with partial biodegradability and water-soluble support structures.

Recycled filaments—re-processing post-consumer or industrial plastic waste into new printing fibre closes the loop and reduces raw-material demand [14].

Both pathways cut carbon emissions, enable further weight reduction of interior components, lower fuel or energy consumption, and align with national green-development guidelines [15].

Whole Vehicle 3D Printing

Back in November 2010, Jim Kor's team in the U.S. made a breakthrough in developing the world's first 3D printed automotive technology validation model, Urbee. This 6:1 scale experimental model confirmed for the first time the feasibility of additive manufacturing technology in the molding of complex automotive components, opening up a new era in automotive manufacturing. After three years of technology iteration, the team launched the first full-size prototype, Urbee2, in early 2013, with more than 50 percent of the components in its body structure manufactured using 3D printing.

2014 marked an industrial breakthrough in 3D printing automotive technology with the official debut of the Strati electric car, developed by Local Motors in the United States.

The model was streamlined from tens of thousands of traditional automotive parts to 40 core components through a revolutionary monolithic molding process. With the help of a large-scale industrial-grade 3D printer, the main structure was built in just 44 hours and set a new record for automotive production speed.

2024 The technology exemplifies a new trend in automotive design and manufacturing, with automaker Subaru announcing a partnership with HP and DMM.make 3D printing to produce customized parts for the SUBARU LEGACY OUTBACK BOOSTGEAR PACKAGE concept car.

This collaboration debuted at the 2024 Tokyo Auto Salon. Together, these milestones build the transformation path of automotive manufacturing from traditional manufacturing to digital smart manufacturing [16][17].

CONCLUSION

Additive manufacturing processes such as fused-deposition modelling (FDM) and selective-laser sintering (SLS) are elevating automotive-interior personalisation. Current case studies show that carbon-fibre steering wheels achieve a 30 % weight reduction, metal-printed dashboards match forged parts in mechanical performance, and tool-less air-vent development lowers costs by 20 %—collectively demonstrating clear advantages in lightweighting, complex-geometry fabrication and flexible production. By removing mould constraints, 3D printing enables deep user involvement in an integrated “design-to-manufacture” workflow and, through bio-based or recycled feedstocks, can cut life-cycle carbon emissions by 18–35 %, realising a dual strategy of on-demand production and green manufacturing.

As material portfolios broaden and distributed manufacturing networks mature, 3D printing will increasingly complement conventional techniques, accelerating the automotive sector’s digital transformation. Industry analysts project the personalised-interior market to surpass USD 12 billion by 2030, driven by real-time configuration via C2M platforms and localised production hubs.

To fully unlock this potential, the field must boost print throughput for large components, establish standards for environmentally friendly materials, and enhance virtual–physical integration through digital-twin technology.

With continued technological iteration and ecosystem collaboration, additive manufacturing is poised to reshape automotive production, delivering demand-responsive, resource-efficient, and low-carbon solutions that power the next phase of global industry advancement.

AUTHORS CONTRIBUTION

All the authors contributed equally and their names were listed in alphabetical order.

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