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Microfactories: The Next Big Thing in Automotive Manufacturing

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Microfactories-as-a-service: An Overview

The methodologies and systems adopted by manufacturers today, particularly in the automotive sector, stem from the revolutionary innovations introduced by Henry Ford, in 1913: a set of high-capital, mass-production methods designed for economies of scale and repetition—in short, the assembly line. Yes, the industry has adapted and retrofitted its methods to newer trends including more digitization of the overall supply chain, smart manufacturing as well as inclusion of better process management methods such as lean manufacturing, six-sigma, the theory of constraints, etc. But by and large, the industry continues to base its systems on the time-tested concept of the assembly line.

Global trends in the automotive industry reflect a sharp increase in demand for a digital experience, mass customizability, increased agility to adapt to new designs and upgrades, automation, sustainable manufacturing procedures, and more. While automotive manufacturers are investing heavily in automation today, Industry 4.0 is still a long way off. To bridge this gap, assembly line methods will need a drastic digital and agile transformation.

A path-breaking solution that is redefining the manufacturing space is an idea that originated in Japan in the '90s: the microfactory. Technological advancements in data, digital, and automation sectors can enable the transition toward a microfactory-as-a-service model in the automotive industry. Here, we look into what is a microfactory, advantages of the microfactory-as-a-service model, and how digital products and services can perhaps revolutionize the automotive industry. We will also examine a fascinating use case, Arrival, a UK-based startup that has challenged traditional auto manufacturing methods and employed the microfactory concept in its pursuit of building next-generation commercial electric vehicles.

What is a Microfactory?

Considered the next big thing in manufacturing, a microfactory is a small-to-medium-scale, highly automated, technologically advanced manufacturing setup. It reimagines the entire process of building an automobile, where a modular, manufacturing "cell" approach is adopted over the traditional assembly line. Technological advancements made in the fields of automation, big data, artificial intelligence, robotics, and smart manufacturing have made the microfactory a tangible reality today.

In a microfactory, each individual cell is capable of manufacturing, from the ground up, multiple vehicle designs created by the manufacturer. At Arrival, which uses the microfactory model for manufacturing, van designs are built in such highly automated cells. Most fabrication processes in these cells are programmed into a set of robots that manufacture the vehicle, with minimal human intervention.
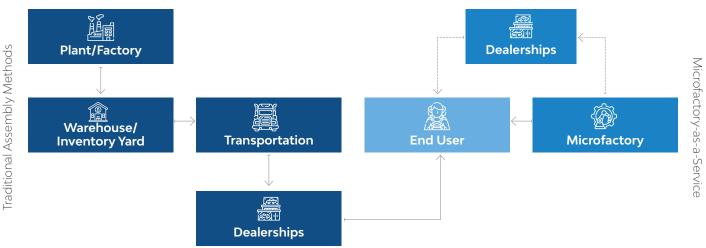
Microfactory-as-a-Service

Analysis of the automotive supply chain and the general revenue model used by a traditional automotive plant reveals key disadvantages:

▶ **High initial setup cost:** The cost of setting up a plant capable of large-scale mass production of vehicles is very high. It can take upto four years to build a new automotive plant and longer to start production.

▶ **High inventory cost:** The traditional plant has a business model that is supply-intensive. It can only be profitable if it is constantly producing cars in its assembly lines. This leads to increased inventory when the market demand for vehicles is low. This was sharply evident in 2020 with the post-pandemic automotive sales slump.

▶ **High transportation cost:** An automotive manufacturer on average has one to two plants in a target country. The manufactured vehicles must then be transported to the multiple dealerships and distribution centers. Not only is the cost of transportation prohibitive, but the process may often be challenging in developing countries.

▶ **Lower process adaptability, customizability, and innovation:** On average, it takes about five to seven years for an OEM employing the assembly line method to start mass production of a new design or product. An added concern are requests for mass-customizations that could overload the assembly lines, leading to creation of bottlenecks, in turn resulting in major inefficiencies in the production line.

Traditional Assembly Methods

Plant/Factory → Warehouse/Inventory Yard → Transportation → Dealerships → End User

Microfactory-as-a-Service

Dealerships → End User ← Microfactory

A microfactory can address all these concerns using the microfactory-as-a-service model. It can be set up at a much smaller scale, typically the size of a medium-to large-scale warehouse. Therefore, the capital required for construction of a microfactory is much lower. Rather than having one plant to cater to a large demographic, the manufacturer could build a network of microfactories in a country, with each plant closer to the target end users. The distribution and transportation cost can thus be

drastically reduced or even eliminated. With the microfactory being closer to its target consumers, the sales strategy can be optimized to a demand-based rather than supply-based model. The factory itself can function as a retail center and products can be manufactured once confirmed orders from the customers are received, thereby generating pull from the market. Also, the highly customizable cells of the microfactory can easily cater to unique demands of each customer. The microfactory-as-a-service model offers distinct advantages over the traditional assembly line (for suitable use cases), as seen below[5].

Description	Traditional Manufacturing	Microfactory Manufacturing
Required capital cost	Very high	Moderate
Transportation cost	25%-40% of the selling price of vehicle	5%-10% of the selling price of vehicle
Customization capability	Difficult to implement	Easily adaptable
Risk	High	Moderate
Company type	Product-based	Service-based
Break even volume of vehicles	High	Low
Environmental impact	High	Low
Profit margins	3%-5% of selling price of vehicle	20%-25% of selling price of vehicle

Automotive Trends and Microfactory-as-a-Service

What problems in the traditional manufacturing model does the microfactory address? How can we achieve Industry 4.0 with this model faster? Some of these questions and overall advantages of this model are discussed below in the context of trends in the automotive industry.

Key Automotive Consumer Trends	
Customizability	Increased demand for bespoke products.
Rapid innovation and process adaptability	Ability to adapt to newer technologies and technological trends such as 3D printing and smart manufacturing tech.
Smart products	Increased demand for data integration and human-digital interactions.
Supply chain resilience	Ability of the supply chain to withstand global calamities such as the COVID-19 pandemic.

Customizability

One major consumer trend in the automotive industry is the increased demand for bespoke products. Consumers seek more versatile and personalized products, and differentiation through features and variants alone is getting harder to achieve and sell.

Let us take the example of two fleet management companies such as a major delivery chain vs. a food truck company. The requirements for both these companies for the same product—a van—are vastly different. Delivery chain vans need to be optimized for the highest possible carrier volume with additional racks and storage options based on the needs of the customer. The food truck company, on the other hand, has very different needs such as an open side panel, cold storage facilities, longer wheelbase, etc.

At Arrival, which uses the microfactory model for manufacturing, this high degree of customizability has been achieved[7]. Their vans are built in highly automated "cells" where most of fabrication processes are programmed into a set of robots that manufacture the vehicle in the cell, with minimal human intervention. Customization is easily achieved by a simple change in program data sets fed to the system of robots.

A manufacturer with multiple functional cells can have each cell individually programmed to produce a different vehicle model. So, considering our delivery chain vs. food truck example again, the manufacturer can cater to both customers simultaneously just by feeding different data sets to each cell.

Companies looking to employ the microfactory-as-a-service model will need to create several "categories-of-personalization" program data sets. Unlike variants, where a traditional plant could produce up to nine variants on average, this method can produce nearly 30-40 categories-of-personalization and target a far wider market base. The programming of each cell can be modified according to the confirmed orders received by customers.

Rapid Innovation

Placing data and automation at the center of the microfactory model leads to greater convergence of the design and manufacturing disciplines. In a traditional factory establishment, the R&D departments are detached from the manufacturing plant. Iterative design and product testing, design analysis, and simulations cannot be directly put to practice and tested at the manufacturing plant. The impact of time and cost on several iterations is high in this model.

Microfactories on the other hand, allow for several tests and iterations to be performed on a small scale by product development and design teams without impacting time and cost. Design and testing teams can have dedicated test modules or "cells" directly in the plant where they can run iterative tests and simulations with no impact on the production cells. Harnessing advanced technologies such as artificial intelligence (AI), cloud computing, and data to automate design and manufacturing aspects as well as enhance the shared data experience can boost innovation and reduce costs.

These convergences point to a future of work where designers are freed from routine tasks and have more time to innovate. Executives will have more time to concentrate on business development. Working alongside robotics and automation, manufacturing workers will develop new skills while remaining connected to the whole supply chain 24/7. Employees will also enjoy safer and less physically demanding conditions. Remote work, whether preferred or required, will be more efficient thanks to the thorough line of a shared data experience.

Lower Costs and Process Adaptability

Microfactories are also highly versatile in that processes can be rapidly adapted to newer developments and designed to be lean. Minimalistic design philosophies with a focus on reducing waste, reducing parts count, and cutting down material used to help reduce cost can be integrated into a microfactory model. At Arrival, composites are used for their vehicle body panels with the required color integrated into the composite. Employing such new materials is not only cost-effective but has helped eliminate the Paint Shop from their manufacturing process, one of the biggest and costliest processes of the assembly line method[7].

There is great scope for integrating newer technologies that are highly cost-effective and produce highly optimized designs such as large-scale 3D printing, giga-casting, etc. into the manufacturing workflow at a microfactory. Smart manufacturing technologies such as digital work instructions, computer vision, predictive maintenance, and health and safety solutions can also be easily integrated into the microfactory workflow.

Environmental Impact

The biggest challenge for traditional automotive manufacturing is the deleterious effect they have on the climate. The demand for electric vehicles has therefore seen a sharp rise in the last few decades with increase in consumer awareness and geopolitical concerns over the impact of fossil fuel-powered cars on the environment. Parts of the supply chain also add majorly to these harmful effects. High volumes of carbon emissions and harmful environmental effects are caused by traditional manufacturing plants, transportation of finished goods, and dumping of landfills with plastic waste from automotive parts. The supply chain urgently needs innovation and the microfactory-as-a-service model is a good place to start.

Increased Demand for Supply Chain Resilience

In 2020, when the pandemic impacted the relationship between manufacturers and their offshore suppliers, the presumption that procurement would just return to local onshore suppliers proved to be false. Even when local suppliers have the goods that manufacturers require and the capability to accept new orders, limitations such as lockdowns can keep workers away, disabling the supply chain.

Supply chains need to be flexible enough to scale as business ebbs and flows: 2020 demonstrated how brittle our supply chains are after years of cost optimization and how management strategies have impacted the supply chain. It also revealed how much manufacturers still rely on critical strategic providers who cannot easily be replaced. Reviewing supplier relationships to understand where critical capabilities might lie will help shield against the impact of disruption.

 The demand for strengthening the automotive supply chain can be met by the microfactory-as-a-service model. With several localized plants in multiple markets in the same country, manufacturers must rely on several local suppliers. In critical business situations, such as a pandemic, the manufacturer need not be reliant on just a few critical providers. Also, with every individual plant impacted differently, cross-reliance among plants can further facilitate resilience.
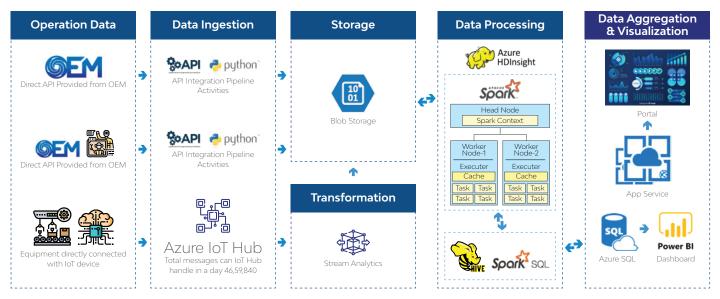
IT Services Enablement of Microfactories

Microfactories are high-technology-driven, and their efficiency depends on advanced computing, robotics, and AI tech. There is a host of solutions an IT services organization can use to enable the transition to a microfactory-as-a-service model and catalyze further development. Let us look at some examples.

Automation, IoT, AI, big data, and other Industry 4.0 solutions

a. Computer vision technologies with edge computing solutions can be applied to smart manufacturing procedures across processes in a microfactory. Robotics solutions with data-driven predictive learning, quality inspections, and joint and weld analytics can be enabled using computer vision solutions.

b. Artificial intelligence and data analytics, which include AI-powered material handling solutions, design data analytics and predictive solutions, design analysis and simulations solutions, etc.

Smarter, digital products and solutions

IoT solutions can be built using sensors, RFIDs, and so on, which can form gateways for edge computing solutions, vehicle-to-vehicle IoT integration, communication platform and cloud-based analytics, autonomous driving, and more. Such solutions will help capture equipment parameters like engine parameters, fuel level, tire pressure, driver fatigue/drive patterns tracking, driver eye tracking, etc. Actionable insights can be derived from such monitored data and target faulty weighments, missed safety checks, driver risk assessment, predictive maintenance, and more. This will increase the overall safety and digital experience of the vehicle. A reference IoT architecture is shown below:

Robotics, data-customizations, and predictive analytics in manufacturing

Companies looking to employ the microfactory-as-a-service model will need to create several categories-of-personalization program data sets. Today, with big data, artificial intelligence, and deep analysis of market trends, it is possible to predict consumer trends. Systems and programs can be created to help manufacturers predict and decide the set of categories-of-personalization required for their local demographic. Target-based buying strategies and solutions can also be tailored to the local microfactory demographic.
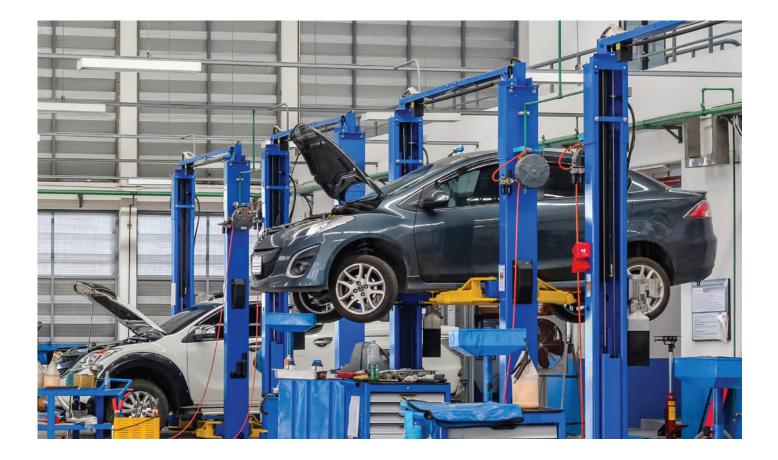
Yard management solutions

With reduced dependence on transportation systems in the microfactory-as-a-service model, the sourcing and delivering stages of the supply chain can be made robust with newer and smarter services and technologies. Some key improvements and levels of automation that can be achieved in the yard management system at a microfactory, as an example, are listed below:

c. **Decongestion at the gate:** Trucks arrive at the plant based on specific intimation from the plant on expected time of entry, or just-in-time yard management. This is easily achievable with a smaller fleet, as will be the case in a microfactory.

d. **Enhanced gate entry process:** Driver face recognition, automatic number plate recognition, entry gate pass generation, and tare weight taken.

e. **Movement within the plant:** Vehicle tracking, congestion management, avoidance of unauthorized parking/movement.

f. **Vehicle exit processes:** Vehicle and driver identification, time of departure, weighment analysis, material analysis.

g. **Vehicle tracking outside plant:** Location and movement tracking, goods parameters (container temperature/pressure/humidity monitoring, safety parameters monitoring—monitoring toxicity levels/hazardous contents/flammable contents—checking for spills/leakage in the container).

Microfactory supplier and inventory management solutions

With an increase in the number of plants in the microfactory model in a particular region (as compared to a traditional plant), the need for inventory management from suppliers as well as inter-plant inventory management is crucial for smooth operations and avoiding bottlenecks in the process. Inventory management and handling solutions that are tailored toward just-in-time manufacturing and data-enabled predictive constraint management can help optimize the microfactory model.

Companies That Can Adopt Microfactory-as-a-Service

With the global trends we are seeing in the pandemic-struck world of 2021, as well as grave concerns about climate change exacerbated by traditional manufacturing methods, there is an imperative need for change from the ground up in manufacturing. This holds particularly true for automotive manufacturing with most of the major global economies vowing to transition to electric vehicles and other low-carbon-emission models of manufacturing.

Microfactories do not promise to mass-produce automobiles on the scale of major automakers; nor is this their goal. The model significantly reduces costs, carbon footprint, and gives customers the ability to tailor designs for specific customers and markets.

The model is appropriate for certain sectors and scale of companies that can transition faster to a microfactory setup:

▶ **Large corporations:** The transition to microfactories will be most difficult for leading global corporations in their established markets, but not impossible. Large automakers could set up satellite microfactories in their established markets close to their target demographic. However, the push for microfactory-as-a-service in new and emerging markets will be much easier for them, owing to the much lower CAPEX required.

▶ **Startups and medium to low-scale manufacturers:** Microfactories should be the go-to model for low to medium cap companies. Not only can microfactories comply with the growing sustainability norms, but the model is adaptable to the growing needs of a startup/medium scale company.

Global Governments and Microfactories

The microfactory offers unique advantages in the area of governance.

▶ **Green factory:** The microfactory is a highly clean, low-carbon-footprint model. With growing global concerns over climate change, governments can easily incentivize the microfactory model and match the demand for greener factories.

▶ **Decentralization of high skill work centers:** Most high skill labor is centralized in urban centers today. With automakers, high skill departments like design and R&D are usually separated from the manufacturing plant and are mainly located in urban centers. With the microfactory model enabling deeper integration and cross-reliance between the design and manufacturing sections, high-skill centers can be transferred to rural sectors. As more microfactories are set up in rural areas, they can boost rural skill development and attract more investments to rural sectors, promoting the government's development agenda.

Conclusion

Some salient points from this paper are listed below:

- A microfactory is a small-to-medium-scale, highly automated, technologically advanced manufacturing setup. Microfactories have redefined automotive manufacturing by switching to a modular process where each individual cell is fully capable of building, from the ground up, a defined vehicle model.

- Revenue generation in a microfactory-as-a-service model is demand-based, where plants manufacture volumes of vehicles depending on the number of orders they receive and have hence deviated from the traditional mass-scale assembly line methods we have seen automotive manufacturers employ to date.

- With a modular and lower-scale manufacturing process, multiple "micro" sized factories can be built in a target location or country, rather than one or two large-scale plants catering to the demands of the entire location. This drastically reduces the cost of operation and cost of setup for microfactories than traditional plants.

- New manufacturing trends observed in the 2020's such as a high demand for custom products, lower operating and product cost, rapid process adaptability, increased supply chain resilience as well as lean and sustainable manufacturing can be easily met by the microfactories-as-a-service model.

- Being a highly technologically dependent process, with the basic processes reliant on advanced robotics, new-age composites and materials, AI, IoT, Machine Learning, etc., the IT services industry will see a boom soon. New and existing manufacturers trying to employ the microfactory model or transform their existing setups will demand services such as – Computer Vision Integration and Support, automation, IoT, AI, big data, robotics, data-customizations, predictive analytics, 3D printing, and other management services (Supplier, Yard, Inventory, transport).

- As more microfactories are set up in rural areas, they can boost rural skill development and attract more investments to rural sectors, promoting the government's development agenda.

In all, many young and growing manufacturing companies have started investing into the microfactories concept. We are also seeing some established automakers, showing interest and researching into microfactories. Microfactories is a great new solution to the growing needs of the Auto industry and the global economy in general. This concept, with its high innovation adaptability and lean and sustainable methods of production with a focus on limiting costs and pushing towards further technological advancements can serve as a great wave in the automotive industry's push towards Industry 4.0.

References

1. What will manufacturing look like in 2021? Top 5 trends to watch for:
   https://www.industr.com/en/what-will-manufacturing-look-like-in-the-five-top-trends-to-watc-2585421#:~:text=2021%3A%20Manufacturing's%20year%20of%20digital&text=With%20its%20vast%20potential%20to,the%20sustainable%20transformation%20of%20industry.

2. 11 Trends That Will Dominate Manufacturing in 2021:
   https://global.hitachi-solutions.com/blog/top-manufacturing-trends

3. Why the Microfactory is the next big thing for manufacturing:
   https://techhq.com/2020/09/why-the-microfactory-is-the-next-big-thing-for-manufacturing/

4. How Microfactories are shaping the future of automobiles:
   http://blog.automotive-technology.com/how-microfactories-are-shaping-of-the-future-of-automobiles/

5. Microfactories: The next big thing in manufacturing:
   https://www.futurebridge.com/uncategorized/microfactories-the-next-big-thing-in-manufacturing/

6. Building cars in the 21st Century:
   https://www.manufacturingtomorrow.com/article/2019/07/building-cars-in-the-21st-century/13706

7. ARRIVAL UK:
   https://arrival.com/

8. Divergent 3D:
   https://www.divergent3d.com/

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