Enter the Manufacturing Metaverse

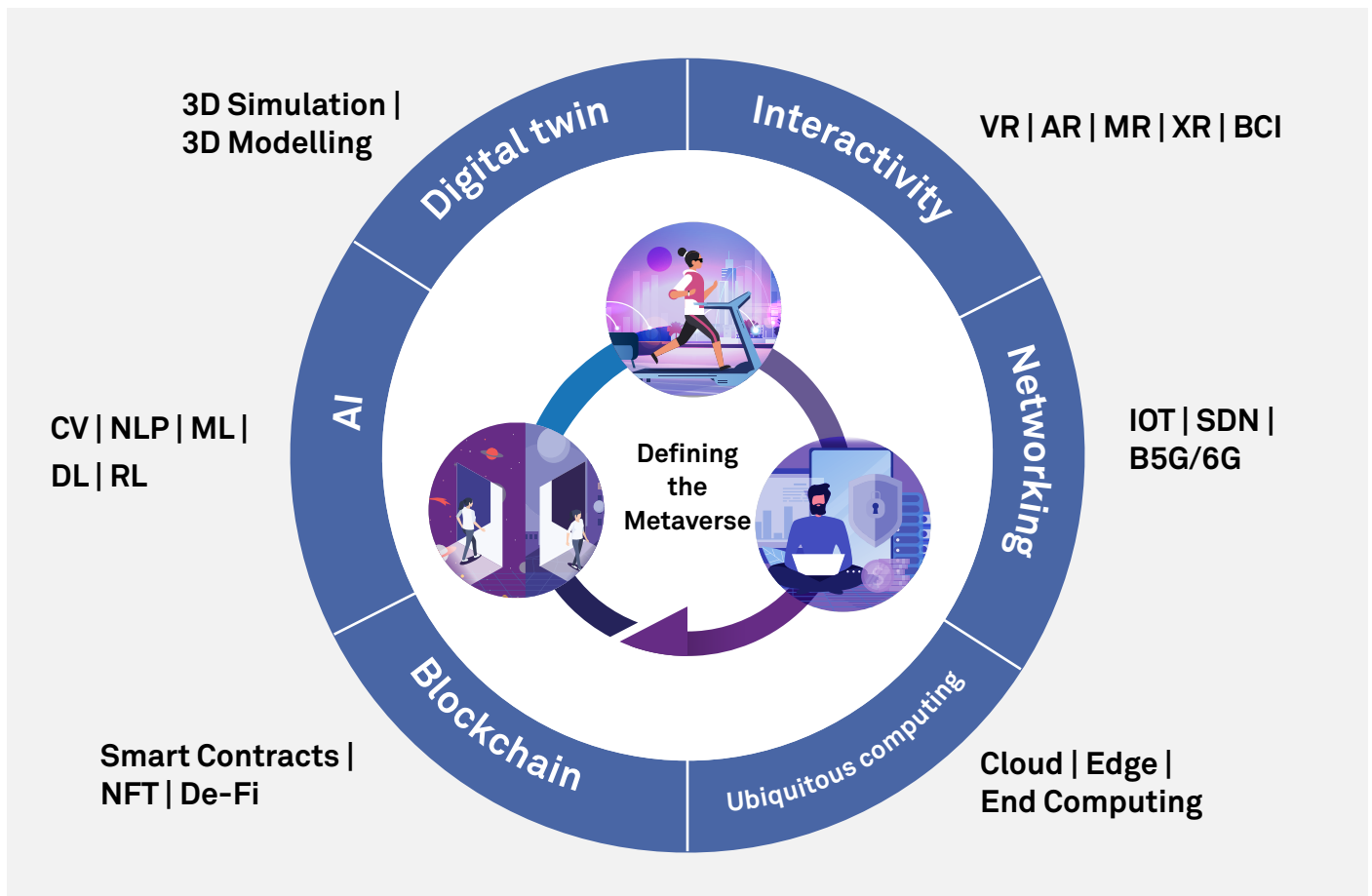## Explore limitless possibilities and learn through unique challenges

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What is defining the Metaverse?

Metaverse is a persistent 3D immersive space combining the physical and digital world to create a new dimension of interaction for an open enterprise driven by user communities and creators.

At the intersection of IoT, AI, blockchain and mixed reality, the metaverse enables virtual simulations of real-word places, objects, processes, and humans. The metaverse will usher in a paradigm shift in the way consumers, suppliers, partners and employees interact to create, buy, sell, spend, learn and collaborate. The new metaverse-led business models will be built on a boundaryless value creator economy controlled by user communities.

3D Simulation | 3D Modelling

Digital twin

Interactivity

VR | AR | MR | XR | BCI

AI

Networking

CV | NLP | ML | DL | RL

IOT | SDN | B5G/6G

Defining the Metaverse

Blockchain

Ubiquitous computing

Cloud | Edge | End Computing

Smart Contracts | NFT | De-Fi

The metaverse will have immersive 3D environments compatible with non-intrusive wearable tech such as virtual goggles/lenses, haptic gloves and body skins/suites, and electromyography (EMG) wristbands and bracelets. Industries can leverage these immersive environments for effective collaboration and deliver user-friendly experiences. Most applications are likely to use 'mixed reality', where data is overlaid onto the real world, enabling users to experience real-life-like collaboration. To support real-time applications and make them accessible to wide user bases and geographies, the metaverse will be built on high-speed low-latency networks. Technologies such as IoT, SDN, 5G/6G will enable data sensing and transmission for near-photorealistic synchronised interactions between objects and avatars in the metaverse.

Ubiquitous computing platforms in the metaverse will run on decentralized hardware infrastructure and internet hosting tools. Cloud-native services and edge computing devices will allow these infrastructures and tools to stream data in real time and build 3D models and content at scale.

Digital twins, built using 3D simulation and 3D modelling techniques, will offer high-fidelity ultra-realistic user experience and will facilitate remote on-site training and maintenance of machines and equipment. The metaverse will also utilize blockchain, primarily to ensure security and regulate functioning of the economic system. Software and hardware elements will include indigenous facets of security to protect integrity of the content developed by users and interactions between them. This will aid

in the formation of a global white-box penetration testing and validation system to protect against the breach of confidentiality. From an economic system standpoint, blockchain will enable creation of smart contracts and crypto currencies and tokenization of assets. NFTs that can track the transfer, ownership and properties of a unique digital asset will create user-driven monetization opportunities and enable the metaverse to become mainstream in the creator economy.

AI is perhaps the biggest driving force of the metaverse. AI will power cognitive automation platforms critical in delivering a seamless socio-cultural experience, just like in the physical world. AI will also enable interoperating between various metaverse platforms across the following standards:

Interoperability Standards

Model standard to reproduce properties, geometry, assets, and even behavior of real-world environments

Identity standard to assign unique credentials, which can be used across virtual world boundaries, to users

Protocol standard to enable interactivity and transactional contract between a virtual world user and the metaverse servers

Currency standard to define the value of virtual objects and creations, thus enabling their trade and exchange

Locator standard to help find places and landmarks across virtual worlds

The art of possible in manufacturing

The metaverse will indeed provide new opportunities and avenues to unlock greater efficiencies across the manufacturing value chain. Numerous possibilities spanning the product customer lifecycle — from design to supply chain to production to customer experience — will urge the manufacturing industry to embrace the metaverse.

Possibilities Across Manufacturing Value Chain

Design ingenuity	Agile supply chains	Production excellence	Personalized customer x
• Collaborative real-time design and testing • High-quality photo-realistic design rendering	• Remote audits of offshore suppliers • Improved visibility across product build, distribution, and sell phases	• Higher yield with accurate production plans • Ergonomically safe production, assembly lines	• Hyper-engaged B2B and B2C buying experience • Simulation-based real-time field service

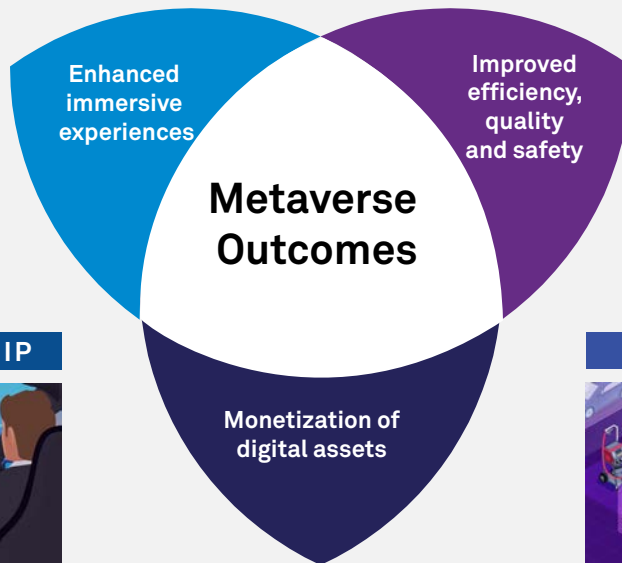# Exploring User (Avatar) Journeys Across the Automotive Lifecycle

In this hypothetical yet plausible scenario, we see how a car manufacturer leverages the metaverse to streamline and optimize processes across the automotive value chain.

METADESIGN

Immersive, collaborative virtual design garage

METAFACTORY

Efficient, safer production via simulations

Enhanced immersive experiences

Improved efficiency, quality and safety

Metaverse Outcomes

Monetization of digital assets

METAOWNERSHIP

Personalized in-car experience and NFTs

METASERVICE

Faster service resolution and NFT service certificates

METAWORLD

Virtual showrooms, NFT-enabled vehicle add-ons and F&I

METAAUDIT

Streamlined and blockchain enabled procurement

METADESIGN

Context: CDO needs to synchronize with global teams — design, testing and CAD agency, for timely delivery of final designs.

Solutions:
- Create real-time photo-realistic design, rendering, simulation and virtual collaboration through design, prototyping, testing and validation processes.
- Provide a decentralized design platform such as vehicle algorithm modeling wherein users participate and design their cars (**PIX Moving**).
- Create Design for Manufacturing (DFM) products that will lead to improved product quality and service and reduce customer churn and product return rate.
- Launch a smart skateboard chassis, providing co-creation avenues for users to design the entire body of the car.

Outcome: Create an immersive, collaborative virtual design garage for designers, vendors and customers to co-create safe and production-optimized designs.

METAAUDIT

Context: For battery cells, CPO must audit new suppliers based in far east countries with limited travel options.

Solutions:
- Conduct virtual audit in supplier's metaverse plant eliminating the need to travel and provide physical ratification.
- Run simulations of various supply chain scenarios enabling all stakeholders to gain visibility into lead times, transit times, shipping delays and even real-time shipping costs
- Efficient and transparent purchasing by collaborating with vendor's vendor for innovating, cost engineering and effective cost negotiations.
- Warehouse simulation using digital twins to increase efficiency in logistics processes and supply chain operations.
- Blockchain enabled procurement platform for tracking supplier performance, contract management and payment evaluations.

Outcome: Streamlining procurement operations with increased transparency and real-time tracking of supply chain materials enabled by blockchain.

METAFACTORY

Context: Manufacturing Head wants to ensure high quality, safe, efficient processes from day one

Solutions:

- Conduct pre-production virtual simulation of end-to-end production cycle involving robots, digital twin(s) and line workers allowing trials and experimentation of complex processes, maneuvers in real time, without pausing the production process.
- Fulfill mass customization goals by effective changeover in product types while avoiding long down times and learning curves in factories.
- Implement a real-time mold-free forming technology that can form sheet metal without special molds and fixtures, reducing huge mold development and design costs.

Outcome: Build immersive virtual production plants capable of simulating actual production lines for designing efficient and safer processes in real world.

METAOWNERSHIP

Context: CEO wants to create a super-luxurious customer experience that would exponentially increase brand loyalty and vehicle adoption.

Solutions:

- Issue NFTs to owners for keepsake, future trading, to savor their EV experience and pass it on to friends and future generations.
- Offer virtual rides along with crypto tokens to users which can be used for purchasing the real car and other in-car services
- Take a family member along with you in the car enabled with extended reality (XR) ecosystem in the metaverse
- Empower new drivers to familiarise themselves with car's features and systems reducing risk of accidents in future
- Make virtual vehicle available on a racing metaverse platform to co-create and test functional and safety features
- Transform backseats into a virtual concert house or a virtual ballpark using the windshield AR glazing, car's infotainment, surround sound and 5G systems

Outcome: Deliver a unique in-car driving and ownership experience to foster brand loyalty and enhance customer lifetime value.

METAWORLD

Context: CMO needs to launch an omni-channel multimedia campaign to drive awareness and sales of EV.

Solutions:
- Build a virtual showroom offering smart, real-life-like test drive solutions
- Leverage digital billboards in the metaverse to advertise and generate footfalls.
- Issue exclusive NFTs/crypto tokens for purchase of car accessories and customized digital car arts, designs, icons, textures and paintworks

Outcome: Provide an enhanced immersive buying experience via virtual showrooms and NFT-enabled car add-ons.

METASERVICE

Context: Manufacturer wants to reduce vehicle downtime (due to repairs) thereby improving customer satisfaction.

Solutions:
- Enable technicians to remotely access an EV's digital twin in real time for technical diagnosis and repairs thereby reducing customer wait times and improving overall customer experience.
- Enable customers to perform DIY repairs in their EVs through AR/VR capabilities.
- Provide a NFT service certificate that tracks car's maintenance history, serviced by authorized service providers. This will serve as an additional source of credibility during resale with a positive impact on residual value for sellers and providing reassurance for buyers.

Outcome: Deliver a seamless after-sales experience for customers while significantly reducing service resolution times.

Measures to overcome challenges and realize the metaverse dream

The major challenge in the metaverse adoption is that its technological building blocks viz. wearable devices, connectivity and high-performance computing, are still in their infancy and a substantial advancement is still needed in these areas to be able to mass produce these in a productive, cost-effective and an environment friendly manner. The second concern is the cost versus perceived value of these innovations by the customers. Other concerns revolve around data confidentiality of users, need for a legal framework and physical and mental health of people.

	WHERE WE ARE	WHERE WE NEED TO GET TO
TECHNOLOGY CONSIDERATIONS		
WEARABLE TECH	• Limited user experience • Intrusive hardware design • Limited availability and premium pricing	• Electronics that can fully deliver a comprehensive virtual and augmented experience • Wireless compact devices (such as headsets, contact lenses) that are supported by high-end 3D sounds and graphics • Easily accessible and available at modular price points
CONNECTIVITY	• Low speed and latency issues • Symmetrical bandwidth issues • Network infrastructure issues	• Innovations in hybrid local and remote real-time rendering • Advancement in video compression, edge computing, cross-layer visibility • Spectrum advocacy, network optimizations
HIGH-PERFORMANCE COMPUTING	• High costs, low efficiency and node velocity • Risk to knowledge safety • Inefficient energy usage from idle servers	• Decentralized hardware infrastructure and internet hosting for HPC • Improving physics engines for simulation software • AI-enabled methods to create sensible grids as well as optimize power consumption
POLICY AND SOCIETAL CONSIDERATIONS		
DATA CONFIDENTIALITY	• Unsafe personally identifiable information (PII) and other sensitive data- voice, facial features, video footage, vital signs, location, financial records, etc.	• Incentive mechanism for better behaviors and positive interactions • Trusted developer ecosystems in building algorithms, structures, frameworks, regulations and policies.
LEGAL FRAMEWORK	• No legal framework against criminal actions, harassment, extremism, terrorism, financial fraud, IP disputes	• Introduction of a legal framework and judicial system with emergence of avatar lawyers in digital realms to provide services such as company incorporation, and arbitration of criminal, financial, state security, and IP and digital land disputes.
HEALTH	• Harm to users' physical and mental health due to warped reality and addictive metaverse usage	• Companies, governments to create regulations, set up mechanisms, and train users on the concept of 'time and space perception' to minimize harmful effects on their physical and mental health.

While the metaverse will take shape over the years to come, it will be a transformational opportunity for manufacturers who embrace it. With many large-scale metaverse platforms anticipated to become mainstream soon, manufacturers will need to invest in these evolving technologies and adjust their business models across the manufacturing value chain to improve the physical manufacturing world in a more scalable, sustainable and safer way. Early adopters of the metaverse will get an opportunity to redefine customer experience and derive outsized business benefits. In a world of identical products and services, they will be able to differentiate themselves and command a premium in the marketplace.

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Ankur provides leadership for the Digital business in Manufacturing globally and serves as a trusted partner to executives on their digital transformation journey. He is an avid believer in the power of Digital and its profound impact on business. He brings a deep understanding of IoT, Cloud, Design Thinking, and AI/ML in the manufacturing context to help customers harness the full potential of Digital.

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